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Governing the Transition to a Green Economy

*Drawing lessons from China, the United States and the European
Union*

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For Karin und Paul

EXECUTIVE SUMMARY

This doctoral thesis analyses the efforts by China, the United States and the European Union to transition to a green economy. It tackles two sets of research questions: *a) Which capacities to transition to a green economy do China, the United States, and the European Union have? How do they govern their respective transition processes?* *b) Are China, the United States, and the European Union advancing in their quest to decarbonise their economies?* The aim is to learn which capacities are needed for a successful green transition that reduces the environmental degradation caused by economic activity. The three political entities are chosen because they are central to a significant decarbonisation of economic activity. Worldwide they are the political entities with the highest pollution and economic output. The research is based on three in-depth case studies of the Chinese transport sector, the US electricity sector and the European grid infrastructure. Hence, the thesis applies a most different research design with regard to the entities in question, since China, the United States and the European Union differ significantly with regard to their institutional design, political culture and socio-economic development stage. The sectors analysed in the case studies share that they are central aspects of a green economy because they are key to achieving significant greenhouse gas emission reductions, in which the respective cases are putting significant efforts into greening and they exemplify strengths and weaknesses of each approach to transition governance. Different technologies are chosen to underline the broad scope of green economies. In-depth case studies, which triangulate data from various sources such as public documents, think tanks and press reports as well as academic literature, are chosen to gain a detailed understanding of the strengths and weaknesses of the respective capacities.

Transitions are complex and unsteady long-term processes based on a restructuring of societal preferences towards sustainability (German Advisory Council on Global Change, 2011). A successful transition is S-shaped: it starts slowly and then rapidly accelerates until it finds a new equilibrium (Rotmans et al., 2001). Key concepts in the transition literature such as the multi-level perspective (Geels and Schot, 2007) fail to explicitly conceptualise the normative dimension of sustainable transition meaning the envisioned reduction of environmental degradation. Furthermore, the role of actors remains unclear and the coevolution of various facets of such a profound change process is hardly elaborated (Foxon, 2011). Further literature demonstrates that states have not yet assumed environmental protection as a core function (Jänicke, 2007). This shows that the state is subject and object of the green transition: It is a key player in the transition process but at the same time needs to undergo

considerable change itself. Hence, public authorities need to learn how to integrate other players more efficiently. Civil society increases legitimacy and acts as a constant advocate for change. Business is key to financing the investments and developing cleaner technologies. Ecological modernisation is closest to combining these facets in a single analytical approach by establishing that green growth is possible through win-win trade-offs between and among the various actors (Giddens, 1998, Meadowcroft, 2005a). This thesis aims to add to the literature by bringing transition research and governance closer together.

Transitions to green economies will deeply affect politics, polity and policy and most likely will result in the profound overhaul of societies. This doctoral thesis develops a three-layered analytical model of the interplay of political leadership, institutional transmission belts (environmental policy integration and time consistency) and key policy functions (economic framework, innovation capacities and social fairness) that helps understand the interplay between top-down and bottom-up influences. However, the focus is on processes led by public actors initiated through political leadership as the key top-down mechanism (Meadowcroft, 2009a). The institutional design works as a transmission belt that needs to translate political leadership into action on the policy level. While various design features exist, two crucial components analysed in this thesis are environmental policy integration as well as ensuring time consistency of greening efforts. The model assumes that when top-level politicians take the lead and the transmission belts translate it into policy action, three functions are of highest importance for transition governance: the economic framework needs to include the negative externalities of fossil fuels in prices and steer investments towards low-carbon goods and services; the innovation cycle needs to foster the development and market penetration of green technologies; social policy must ensure a fair distribution of costs and rewards for a high degree of social acceptance. Since transitions are a coevolutionary process, these elements are closely intertwined through a variety of positive and negative feedback loops.

The case studies examine electrifying the Chinese transport sector, transitioning to renewable energy sources in the United States and deploying the smart grid in the European Union. The model helps understand which capacities are more important than others to explain the potential transition towards a green economy. Since China, the United States and the European Union differ strongly in their socio-political design and current status and start from very different starting points, they most likely will all follow different transition trajectories. Hence, the study can show which capacities are central for the cases despite their differences.

Electro mobility can be a key technology to reduce greenhouse gas emissions in China's transport sector. However, Chinese decision-makers primarily push the technology in an attempt to strengthen their domestic car industry. While the policy environment is supportive, the results are relatively poor as few electric cars are running on the streets (Earley et al., 2011). The transition has not yet entered the take-off phase despite large expectations. The case study finds that China's framework meets many conditions of the analytical model but most likely the key reason to explain the missing progress is that the integration of the various elements does not sufficiently work. This hampers the impact of considerable demand-side subsidies for electric vehicle buyers as well as research and development funding (Kubach, 2011). Policy integration fails because turf wars between the various ministries have created uncertainty about the government strategy. This leads political actors to overestimate the technological capabilities of industry and limits the scope for innovation because of strong involvement in industry. Hence, the measures that should ensure time consistency – such as guiding documents including targets – put too little emphasis on how to realistically achieve these goals.

The transition of the US electricity sector to renewable sources would mark a significant break with the status quo. It has been ongoing for several decades but so far has not accelerated. While the technological aspects are relatively mature, opposition against considerable greening is strong because it would profoundly change the industrial structure of the United States. Currently, renewables hold a steady share of roughly 10% of the electricity mix (U.S. Energy Information Administration, 2013). A key explanation is the lacking political consensus to mitigate climate change resulting in unsteady political support for renewable energies. As a result, most measures suffer from time inconsistency causing an unreliable framework. The industry undergoes boom and bust cycles depending on the political majorities. Under these circumstances, the decision for or against a generation source is largely based on market prices with renewables being comparatively expensive. While the transmission belts partly explain the political polarisation, they also enable bottom-up leadership through the states. California, for example, has implemented a very supportive framework. However, the unsteady federal support has negatively affected all three functions. For example, the United States has not established a nationwide carbon price and insufficient research and development efforts. Despite this rather glum outlook, President Obama has used the recent fiscal stimulus in response to the financial crisis of 2008/2009 to foster renewable energies showing that political leadership can achieve results.

The deployment of smart electricity grids in the European Union is expected to be a key enabler for many low-carbon technologies that are needed to reach Europe's climate and energy goals. Currently, the transition is in an early stage with some member states assuming a lead position while the European level is the framework setter that brings together key stakeholders (Hierzinger et al., 2012). Hence, a complex interplay of various actors explains the historical international green leadership position of the European Union. However, the smart grid despite being a key technology has not yet achieved a prominent position on the political agenda. In addition, the supranational actors have few resources at their disposal to ensure progress. While the 2009 Lisbon Treaty included for the first time an energy provision in supranational treaties, the consequences are rather limited (European Union, 2010). Thus, it largely depends on the member states to carry out major initiatives, which they do to varying degrees and the supranational actors can try to establish a comforting framework. One key instrument of the greening of the European economic framework is the Emissions Trading System that is supposed to reduce greenhouse gas emissions and channel investments into green goods and services. However, a low permit price significantly weakens its steering capacity and impact on innovation (Grubb, 2012). With regard to the smart grid, large-scale demonstration projects are lacking, which would foster knowledge development as well as teach lessons about the social consequences currently playing a negligible role in the European debate.

The thesis concludes that all three cases are still at the beginning of their green transition with regard to the areas analysed. Since transitions can easily accelerate, it remains largely unknown whether and when the change process might speed up. Hence, further research is needed at a later point in time. Despite this uncertainty regarding the outcome of the transition, some broader lessons can be drawn from the current status. All three cases underline the importance of political leadership to trigger the transition. Whereas this is given in China and the European Union explaining some of the changes to the framework, in the United States the federal level does not show lasting leadership explaining why little has changed over time. However, political leadership by itself does not seem to guarantee success. Rather, the study finds that the transmission belts are a key explanatory variable. Despite political leadership in China and the European Union, this has not resulted in significant results on the ground. The lack of steady two-way communication between the political layer and the various recipients that actually fulfil the functions hinders a lasting move from the carbon lock-in to a decoupling of pollution and production. In the United States the institutions that significantly shape the transmission belts are a key reason for the political

gridlock. Hence, again this dimension explains the lack of time consistent political leadership. This finding of the importance of the two-way communication embodied in the transmission belts is a significant contribution to the literature. It signals that the states so far have not assumed a subject role in the transition by adjusting to a significant greening. Since institutions only change slowly, this underlines the challenge at hand and that further research is needed how public actors can be supported in their move to lasting greening that can foster institutional adjustments.

ZUSAMMENFASSUNG

Diese Dissertation analysiert die Anstrengungen Chinas, der Vereinigten Staaten von Amerika und der Europäischen Union zu einer grünen Wirtschaft überzugehen. Die Arbeit zielt darauf ab zwei Forschungsfragen zu beantworten: *a) Welche Kapazitäten haben China, die Vereinigten Staaten und die Europäische Union für die Transformation zu einer Green Economy? Wie steuern sie die jeweiligen Transformationsprozesse? b) Kommen China, die Vereinigten Staaten und die Europäische Union voran in ihrem Bestreben, ihre Wirtschaft zu dekarbonisieren?* Das Ziel ist es zu lernen, welche Kapazitäten notwendig sind, um erfolgreich die Umweltzerstörung durch ökonomische Aktivitäten zu reduzieren. Die drei Fälle wurden ausgewählt, weil sie zentral für eine signifikante Dekarbonisierung wirtschaftlichen Handelns sind. Weltweit sind sie verantwortlich für die größte Verschmutzung und Wirtschaftskraft. Drei tiefgehende Fallstudien des chinesischen Verkehrssektors, des US-amerikanischen Stromsektors und der europäischen Netzinfrastuktur sind die Grundlage dieser Dissertation. Somit verwendet die Studie ein Most Different Forschungsdesign mit Hinblick auf die Auswahl der Staatengebilde, da China, die Vereinigten Staaten und die Europäische Union sich signifikant unterscheiden in ihren Institutionen, ihrer politischen Kultur und ihrem sozioökonomischen Entwicklungsstadium. Die in den Fallstudien untersuchten Bereiche haben gemein, dass sie zentral für eine Green Economy sind. Sie sind wichtig für relevante Minderungen des Ausstoßes von Treibhausgasen, die jeweiligen Staatengebilde zeigen ernsthafte Bemühungen für eine nachhaltige Entwicklung und sie Stärken und Schwächen der jeweiligen Herangehensweise an die Transformationsgovernance darlegen. Drei unterschiedliche Technologien wurden ausgewählt, um die Breite der Green Economy darzulegen. Tiefgehende Fallstudien, die Daten aus verschiedenen Quellen wie Regierungsdokumente, Presseberichterstattung und Studien von Forschungsinstituten sowie akademische Literatur triangulieren, werden genutzt, um ein detailliertes Verständnis für die Stärken und Schwächen der jeweiligen Kapazitäten zu entwickeln.

Transformationen sind komplexe und unstete Langfristprozesse, die durch eine Neuordnung gesellschaftlicher Präferenzen mehr Nachhaltigkeit erreichen wollen (German Advisory Council on Global Change, 2011). Eine erfolgreiche Transformation hat eine S-Form: sie beginnt langsam und beschleunigt dann schnell bis ein neues Equilibrium gefunden ist (Rotmans et al., 2001). Schlüsselkonzepte in der Transformationsliteratur wie die Multi Level Perspektive verfehlen es aber, die normative Dimension und damit die angepeilte

Verminderung von Umweltschäden explizit zu konzeptualisieren (Geels and Schot, 2007). Außerdem bleibt die Rolle der Akteure unklar und die Koevolution verschiedener Facetten eines solch tiefgreifenden Wandelprozesses ist kaum ausgeführt (Foxon, 2011). Weitere Literatur zeigt, dass die Staaten den Umweltschutz noch nicht als primäre Staatsfunktion angenommen haben (Jänicke, 2007). Somit ist der Staat Subjekt und Objekt der grünen Transformation. Er ist ein wichtiger Akteur im Transformationsprozess, muss sich aber gleichzeitig selber tiefgreifend verändern. Daher sollten die Behörden lernen, wie sie andere Akteure integrieren können: Die Zivilgesellschaft erhöht die Legitimität und fordert immer wieder Veränderungen ein. Die Wirtschaft ist wichtig zur Finanzierung der Investitionen und zur Entwicklung sauberer Technologien. Ökologische Modernisierung kombiniert am ehesten diese Aspekte in einem analytischen Ansatz, der aufzeigt, dass grünes Wachstum durch positiven Austausch zwischen den verschiedenen Akteuren möglich ist (Giddens, 1998, Meadowcroft, 2005a). Diese Dissertation will einen Beitrag zur Literatur leisten indem sie die Transformations- und Governanceforschung näher zusammen bringt.

Der Übergang zu einer Green Economy wird alle politischen Bereiche (Politics, Polity und Policy) stark beeinflussen, und sehr wahrscheinlich zu tiefgreifenden gesellschaftlichen Veränderungen führen. Diese Dissertation entwickelt ein dreischichtiges analytisches Modell des Zusammenspiels von politischer Führung, institutionellen Transmissionsriemen (Umweltpolitikintegration und Zeitkonsistenz) und wichtigen Policy-Funktionen (wirtschaftliche Rahmenbedingungen, Innovationsfähigkeit und soziale Gerechtigkeit), das dabei hilft das Zusammenspiel zwischen Top-Down-Steuerung und Bottom-up-Einflüssen zu verstehen. Der Fokus ist jedoch auf Prozesse, die von öffentlichen Akteuren ausgeführt und durch die politische Führung als wichtigstem Mechanismus von Top-Down-Steuerung initiiert werden (Meadowcroft, 2009a). Die Institutionen fungieren als Transmissionsriemen, die politische Führung in die Tat umsetzen. Während verschiedene Faktoren eine Rolle spielen, sind Umweltpolitikintegration und langfristig zuverlässige Signale an andere Akteure zu senden, zwei wichtige Komponenten, die in dieser Dissertation analysiert werden. Das Model geht davon aus, dass wenn hochrangige Politiker die Führung ergreifen und die institutionellen Transmissionsriemen dieses in veränderte Policy übertragen, drei Funktionen für die Umsetzung der Transformation von höchster Bedeutung sind: die wirtschaftlichen Rahmenbedingungen müssen die negativen externen Effekte der fossilen Energieträger in den Preisen reflektieren und Investitionen in grüne Waren und Dienstleistungen lenken; Innovationspolitik muss die Erforschung und Marktdurchdringung von grünen Technologien stärken; Sozialpolitik muss für eine faire Verteilung von Kosten und Nutzen sorgen, um

starke gesellschaftliche Akzeptanz zu gewährleisten. Da Transformationen koevolutionäre Prozesse sind, sind diese Elemente eng durch eine Vielzahl von Rückkopplungsschleifen miteinander verflochten.

Die Fallstudien untersuchen die Elektrifizierung des chinesischen Verkehrssektor, den Übergang zu erneuerbaren Energien in den Vereinigten Staaten und die Ausweitung der Smart Grids in der Europäischen Union. Das Model hilft dabei zu verstehen, welche Kapazitäten wichtiger sind als andere, um die potenzielle Transformation zu einer Green Economy zu verstehen. Da China, die Vereinigten Staaten und die Europäische Union sich stark in ihrem sozio-ökologischem Design und derzeitigen Stand unterscheiden sowie von sehr unterschiedlichen Startpunkten ausgehen, werden sie vermutlich sehr unterschiedliche Transformationspfade finden. Somit kann die Studie zeigen, welche Kapazitäten im jeweiligen Fall von besonderer Bedeutung sind.

Elektromobilität kann eine Schlüsseltechnologie sein, um die Treibhausgasemissionen in Chinas Verkehrssektor zu reduzieren. Aber chinesische Entscheidungsträger kümmern sich vor allem um das Thema, weil sie die heimische Autoindustrie stärken wollen. Während die politische Unterstützung stark ist, sind die Ergebnisse unbefriedigend, da nur sehr wenige Elektroautos auf den Straßen fahren (Earley et al., 2011). Die Transformation hat sich trotz großer Erwartungen noch nicht beschleunigt. Die Fallstudie zeigt, dass Chinas Herangehensweise viele Bedingungen des analytischen Modells erfüllt, aber das der Hauptgrund für den fehlenden Fortschritt die nicht funktionierende Integration der verschiedenen Elemente ist. Dies schränkt die Wirksamkeit der beträchtlichen Subventionen zur Stimulierung der Nachfrage nach Elektrofahrzeugen sowie für die Forschung und Entwicklung ein (Kubach, 2011). Die Politikintegration scheitert, weil Zuständigkeitsstreitigkeiten zwischen den verschiedenen Ministerien die Regierungsstrategie in Frage stellen. Das Ergebnis ist, dass die politischen Akteure die technischen Fähigkeiten der Industrie überschätzen und den Spielraum für Innovation durch ihren starken Einfluss auf die Wirtschaft begrenzen. Daher betonen die Maßnahmen, die Zeitkonsistenz gewährleisten sollen – wie Strategien samt klarformulierten Zielen – zu wenig, wie diese Ziele realistisch erreicht werden können.

Die Transformation des US-Stromsektors zu erneuerbaren Energien kann einen deutlichen Bruch mit dem Status quo markieren. Sie begann vor mehreren Jahrzehnten, hat sich aber bis heute nicht beschleunigt. Während die technologischen Aspekte ziemlich ausgereift sind, gibt es starke institutionelle Widerstände, weil die Transformation die industrielle Struktur der

Vereinigten Staaten zutiefst verändern würde. Derzeit halten erneuerbare Energien beständig einen Anteil von rund 10% am Strommix (U.S. Energy Information Administration, 2013). Ein Hauptgrund dafür ist der fehlende politische Konsens sich aktiv gegen den Klimawandel einzusetzen und die daraus resultierende unverlässliche politische Unterstützung für erneuerbare Energien. Deshalb sind die meisten Maßnahmen nicht dauerhaft, was unklare Signale sendet. Die Industrie erlebt dadurch Boom-Bust-Zyklen abhängig von den politischen Mehrheiten. Unter diesen Voraussetzungen sind die Entscheidungen für oder gegen eine Erzeugungsquelle weitgehend von den Marktpreisen abhängig und Erneuerbare sind verhältnismäßig teuer. Während die Transmissionsriemen die Polarisierung teilweise erklären, ermöglichen sie Bottom-Up-Initiativen durch die Bundesstaaten. Kalifornien hat zum Beispiel einen sehr unterstützenden Rahmen gesetzt. Trotzdem hat die unverlässliche Unterstützung durch die zentralstaatliche Ebene sich negativ auf alle drei Funktionen ausgewirkt. Zum Beispiel haben die Vereinigten Staaten noch keinen Kohlenstoffpreis eingeführt und es fehlen Anstrengungen in der Forschung und Entwicklung. Trotz dieser eher düsteren Ausblicks hat Präsident Obama die jüngste Konjunkturspritze als Antwort auf die Finanzkrise von 2008/2009 genutzt, um erneuerbare Energien zu fördern. Er demonstriert damit, dass politischer Wille Fortschritt bedeuten kann.

Es wird vom Einsatz von intelligenten Stromnetzen in der Europäischen Union erwartet, dass sie viele kohlenstoffarmen Technologien ermöglichen, die erforderlich sind, um Europas Klima- und Energieziele zu erreichen. Derzeit ist die Transformation in einem frühen Stadium, wobei einige Mitgliedsstaaten eine Führungsposition einnehmen, während die europäische Ebene Rahmen setzt und die wichtigsten Akteure zusammenbringt (Hierzinger et al., 2012). Daher erklärt ein komplexes Zusammenspiel verschiedener Akteure die historische internationale Führungsposition der Europäischen Union bei Klima- und Energiefragen. Während das Smart Grid eine Schlüsseltechnologie ist, hat es noch keine prominente Position auf der politischen Agenda in Europa erreicht. Darüber hinaus haben die supranationalen Akteure nur wenige Mittel zur Verfügung um die Umsetzung zu gewährleisten. Der Vertrag von Lissabon, der 2009 in Kraft getreten ist, beinhaltet erstmalig eine Energieklausel in den supranationalen Verträgen, aber die Auswirkungen sind eher gering (European Union, 2010). So hängt es weitgehend von den Mitgliedstaaten ab, größere Initiativen durchzuführen was unterschiedlich gemacht wird. Die supranationalen Akteure können nur die Rahmenbedingungen ändern. Wichtig ist hier zum Beispiel aus ökonomischer Sicht das EU-Emissionshandelssystem, das die Treibhausgasemissionen vermindern und Investitionen in grüne Produkte und Dienstleistungen lenken soll. Aber ein niedriger Zertifikatepreis schwächt

die Steuerungswirkung und die Innovationseffekte signifikant (Grubb, 2012). Für das Smart Grid fehlen in der Europäischen Union groß angelegte Demonstrationsprojekte, die den technischen Erfahrungsschatz vergrößern sowie Erkenntnisse über die sozialen Folgen aufzeigen würden.

Diese Dissertation kommt zu dem Ergebnis, dass alle drei Fälle noch am Anfang der Transformation in den analysierten Bereichen stehen. Da Transformationen sich rasch beschleunigen können, ist es derzeit ungewiss ob und wann der Wandlungsprozess Geschwindigkeit aufnimmt. Deshalb ist weitere Forschung zu einem späteren Zeitpunkt wichtig. Trotz dieser Ungewissenheit über den weiteren Verlauf der Transformationen lassen sich aus der derzeitigen Situation einige Schlüsse ziehen. Alle drei Fälle unterstreichen die Wichtigkeit von politischer Führung, um den Transformationsprozess zu beginnen. Während diese in China und der Europäischen Union gegeben ist und einen Teil des sich wandelnden Rahmens erklärt, zeigt die Regierung in den Vereinigten Staaten keine verlässliche Führung, weshalb sich historisch kaum etwas geändert hat. Die Fälle zeigen aber auch, dass politische Führung allein Erfolg nicht garantiert. Vielmehr zeigt die Dissertation, dass die Transmissionriemen eine wichtige erklärende Variable sind. Trotz politischer Führung in China und der Europäischen Union, gibt es kaum beobachtbare Ergebnisse. Das Fehlen einer stetigen beidseitigen Kommunikation zwischen der politischen Ebene und den unterschiedlichen Empfängern, die die Funktionen ausfüllen, verhindert einen nachhaltigen Wandel vom Kohlenstoff-Lock-In hin zu einer Entkopplung von Verschmutzung und Produktion. In den Vereinigten Staaten erklären die Institutionen, die die Transmissionriemen bilden, hauptsächlich den politischen Stillstand. Somit ist es wieder diese Dimension, die die fehlende belastbare politische Führung erklärt. Diese Erkenntnis über die Wichtigkeit der beidseitigen Kommunikation durch die Transmissionriemen, ist eine wichtige Erkenntnis für die Literatur. Es bedeutet, dass die Staaten momentan noch keine ausreichende Subjektrolle in der Transformation angenommen haben, da sie sich nicht auf ein bedeutsames Greening eingestellt haben. Da sich Institutionen nur langsam ändern, unterstreicht dies die bestehende Aufgabe und die Notwendigkeit weiterer Forschung, um herauszufinden, wie staatliche Akteure, in ihrem Bestreben sich langfristig von der Kohlenstoffabhängigkeit zu lösen und dafür die notwendigen institutionellen Änderungen vorzunehmen, unterstützt werden können.

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Acronyms

BEV	Battery electric vehicle
BYD	Build Your Dreams (Chinese car and battery manufacturer)
CME	Coordinated market economy
CPC	Communist Party of China
EPI	Environmental policy integration
ETS	Emissions Trading System
EU	European Union (when used as an adjective; if not indicated otherwise referring to the EU-28)
EU ETS	European Union Emissions Trading System
EUR	Euro (€)
FCV	Fuel cell electric vehicle
FYP	Five-year plan
G-20	The Group of Twenty
GDP	Gross domestic product
GHG	Greenhouse gas (includes all carbon equivalents)
HEV	Hybrid electric vehicle
ICE	Internal combustion engine
ICT	Information and communications technology
ITC	Investment tax credit
LME	Liberal market economy
MLP	Multi-level perspective
NEV	New energy vehicle
PTC	Production tax credit
R&D	Research and development
RMB	Chinese Remnibi (¥)
RPS	Renewable Portfolio Standard
SOE	State-owned enterprise
TIS	Technological innovation system
US	United States of America (when used as adjective)
USD	US Dollar (\$)

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1. Introduction

The basic assumption of this thesis is that governing responsibly in the 21st century means preparing for a low-carbon future. The predominant existing socio-economic framework relying on fossil fuels (oil, gas and coal) is unsustainable for two related reasons: rising energy prices because of higher demand and scarcer supply of cheap sources significantly increase economic costs and at the same time cause severe environmental damages – most prominently climate change because of excessive greenhouse gas (GHG) emissions.¹ Hence, it operates outside of the ecological boundaries of the earth. The fifth report of the Intergovernmental Panel on Climate Change published in September 2013 establishes that it “is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century” (International Panel on Climate Change, 2013).² This emphasis on human responsibility implies that human action can avoid dangerous climate change by significantly reducing the overall GHG concentration in the atmosphere. Hence, reducing the carbon emissions can help avoid the dramatic consequences of uncharted climate change.

Consensus exists that the global temperature rise must be limited to two degrees Celsius compared to pre-industrial levels in order to avert irreversible damages (United Nations Framework Convention on Climate Change, 2009). Limiting global warming to this level requires significant actions soon. Otherwise, the temperature increase will cause melting glaciers, sea level rise, more extreme weather events and the earth overall becoming a less welcoming planet. Unfortunately, the current trend points in this direction of increasing temperatures resulting in ecological damages. Recently the global CO₂ concentration has reached 400 parts per million for the first time since humans evolved which points towards a higher temperature increase (Gillis, 2013). The International Energy Agency (2012b) forecasts that because of population and economic growth, primary energy demand will rise globally which will exacerbate rather than solve the problem because it entails increasing GHG emissions under the current fossil fuel regime. In addition, it is unclear for how long fossil fuel reserves can serve growing demand, which mostly stems from emerging economies, such as China, and alters the international energy landscape (International Energy Agency, 2012b). The Stern (2006) Review on the economics of climate change has outlined

¹ Commonly all GHGs are calculated in carbon equivalents. For this reason carbon is often times used as another term describing a variety of GHGs. For a scientific explanation of the GHG effect see Pachauri (2007).

² According to the uncertainty guidance note published by the Intergovernmental Panel on Climate Change the term “extremely likely” denotes a probability of over 95%.

that economic reasoning calls for a fast action because the costs of inaction resulting in severe damages are higher than the costs of immediate action to mitigate climate change. This demonstrates that economic as well as ecological reasons call for reducing the fossil fuel reliance and entering a more sustainable pathway.

The green movement proposes in response to these challenges to decarbonise the economy in order to ensure inclusive economic well-being while not overreaching ecological limits at the same time. This calls for a profound overhaul of the existing governance structure in order to prepare societies and economies for this low-carbon future. Hence, the alternative to the current overuse of natural resources is transitioning to a green economy based on renewable energies, energy efficiency and innovative technologies that use fewer ecological resources. A successful transition results in an economic framework operating within the carrying capacities of the earth. Others have described the required transition as from “fuels from hell” (polluting fossil fuels found underground – coal, oil, gas) to “fuels from heaven” (clean, renewable sources found above ground – sun, wind, water) (Rochelle Lefkowitz cited in Friedman, 2009a: 69).³ Various landmark reports by national (German Advisory Council on Global Change, 2011 on Germany) and international organisations (Organisation for Economic Co-operation and Development, 2011d, United Nations Environment Programme, 2011) published to date, elaborate how such a transition can take place and which challenges it must overcome. They show that such a change process entails more than a change in the economic resource base. It involves far-reaching socio-economic and political changes guided by the principle of sustainability.⁴ This means that environmental concerns need to gain the same status as economic considerations, which is not given under the status quo. Hence, it is for good reason that the green transition has received the label of the “third industrial revolution” (Eisgruber et al., 2008) following the introduction of coal-powered steam engines around 1780 (first industrial revolution) and the beginning of the crude oil reliance starting approximately in 1890 (second industrial revolution). Polanyi (1944) labelled the latter famously the “Great Transformation”. All three transitions share that they transform an entire economic system instead of an industrial sector or singular product.

³ Nuclear power assumes a special role in this dichotomy. Advocates of the technology point out that it produces energy while generating very few GHG emissions. Opponents of the technology point out the inherent danger of catastrophic accidents as witnessed in Tchernobyl and Fukushima. The author assumes the position that the risks of the technology outweigh the chances, in particular since other low-carbon energy sources, such as renewable energies, do not pose the same threats. Hence, they are not included in the green economy definition applied in this doctoral thesis.

⁴ The Brundtland Commission has given the best-known definition of sustainable development as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (World Commission on Environment and Development, 1987: 43).

Key political leaders have stated their desire to move to a green economy but it remains largely unclear how they aim to achieve it. This is understandable because “[T]here are many routes to a low-carbon economy, all politically problematic” (Hale, 2010: 259). Besides adjusting the resource base consumption habits as well as innovation patterns, “broader change in the mix of industries within national and global economies” (Foxon, 2011: 2258) will have to take place. Hence, it requires changes to the taxation system, the labour market, innovation systems, welfare regime and other key socio-economic areas and policies. Furthermore, all these changes interact because of existing feedback loops. Since these differ widely according to political cultures, this transition will take place according to different domestic circumstances, “as it depends on the specifics of each country’s natural and human capital and on its relative level of development” (United Nations Environment Programme, 2011: 21) which transition pathway it will follow.

1.1. Research questions and method

This doctoral thesis analyzes the transition to a green economy in order to avoid dangerous climate change and ensure future prosperity. According to Meadowcroft (2005a) it has been shown that a decoupling of economic growth and environmental degradation is possible for single firms and whole industrial sectors (for example forest products in certain countries); national economies have achieved progress for certain substances (for example sulphur dioxide); an example of a whole national economy with all its parts decoupling growth from resource use and environmental degradation is still missing. However, no obvious reason exists why it should not be possible.

This doctoral thesis focuses on the world’s biggest economies, energy users and environmental polluters – the People’s Republic of China, the United States of America and the European Union – because they are key to a global overall reduction in GHG emissions.⁵ Because of their size, if they do not decarbonise their respective economy the three chosen political entities are easily capable of offsetting GHG emissions reductions of smaller countries since they are responsible for over 50% of global GHG emissions. This focus does not mean that the actions of smaller countries are irrelevant but a regional limitation is necessary to carry out in-depth case studies. Furthermore, the choice of these three cases results in a most different research design because they share few socio-political indicators

⁵ For the sake of simplicity the following uses the short versions: China, United States and European Union. The text follows this order because the case studies have been researched and written in this sequence.

and diverge on most of them. Nonetheless, the political leaders of the three cases have publicly articulated the goal to transition to a green economy:

- Xi Jinping, China’s president and head of the Communist Party of China (CPC) has stated: “The global climate change is deeply affecting human beings' living and development. Our country, now in a stage of fast industrial and urban development, is facing obvious environmental pressure. The whole society should continue to intensify the campaign of saving energy and reducing emission of greenhouse gases in a deep-going way and put into effect the national scheme for the climatic change” (cited in China Association for Science and Technology, 2012).
- Barack Obama, President of the United States, has stated in his second inauguration speech: “We will respond to the threat of climate change, knowing that the failure to do so would betray our children and future generations.... The path towards sustainable energy sources will be long and sometimes difficult. But America cannot resist this transition, we must lead it. We cannot cede to other nations the technology that will power new jobs and new industries, we must claim its promise. That’s how we will maintain our economic vitality and our national treasure – our forests and waterways, our crop lands and snow-capped peaks.” (Obama, 2013a)
- Jean-Claude Juncker, President of the European Commission, has stated in his speech before the European Parliament ahead of the approval of his Commissioners: “In tomorrow's increasingly competitive world, Europe will only be able to thrive if we get it right on Energy Union. In view of the discussions that will take place in the coming days on this, I would plead with Member States to find an agreement in the European Council so that we can go to Paris with a clear mandate. We all have to be pulling in the same direction if progress is to be made.” (Juncker, 2014)

However, making these claims is much easier than backing them up with significant action. So far, it remains largely unknown whether the leaders follow up their rhetoric with deeds and how far they have advanced their quest. Hence, it is of major interest, which paths they enter and which measures they implement to put their respective economies onto a pathway towards a green economy.

Before this background, the thesis’ two research questions are presented:

a) Which capacities to transition to a green economy do China, the United States, and the European Union have? How do they govern their respective transition processes?

b) Are China, the United States, and the European Union advancing in their quest to decarbonise their economies?

The first question is mostly concerned with the governance regime in place to steer this profound change process. Since the framework varies considerably among the three cases, it is of interest which common capacities are key for a successful green transition despite the differences. The case selection of three key but highly different cases results in a most different research design which “allows the researcher to distil out the common elements from a diverse set of countries that have greater explanatory power” (Landman, 2008: 70). Hence, the aim of the case studies is to understand which capacities are required for a successful transition. It will be of interest to see where similar capacities are required and where they can differ widely. The expectation is that political leadership is crucial to trigger the transition process, whereas institutional features determine whether the political will translates into policies that can fulfil the necessary functional changes in the social, economic and innovation functions.

The second question aims to find out how far advanced the three cases are in the analysed transition by scrutinising the transition stages. Answering this question will identify the position in which the three world powers put themselves for the expected future “Energy-Climate Era” (Friedman, 2009a: 63). This is crucial because it shapes global power structures for decades to come. This has been proven by the second industrial revolution, for example, which reshaped the world by giving leadership to Western superpowers (German Advisory Council on Global Change, 2011). Friedman (2009a: 64) states, “the countries that inspired and invented the big solutions to the big problems of the past led the eras that followed. And those countries that failed to adapt fell by the sideways”. Hence, it is plausible that the progress of the three cases will not only decide whether humankind successfully mitigates climate change but also which position they are likely to assume in a future low-carbon world. This can define their global role for decades to come.

The research design is based on the analysis of in-depth case studies that attempt to explain why the cases behave the way they do. In-depth case studies are chosen because they have a distinct advantage when dealing with a how or why question regarding a contemporary issue and when the investigator has little or no control over the relevant behaviours (Yin, 2009). Furthermore, they are better capable to deal with topics within their real-life context in which phenomenon and context are not easily discernible. The research design aims to present a detailed picture of each case and give an outlook how transition trajectories might look like in

order to assess which position they will assume in a carbon constrained world. Each case study stresses the historical dimension in order to establish significant changes over time. Valid and reliable answers to these questions require the analysis of existing governance regimes of the respective cases as well as the transition process that is required to reach a new low-carbon equilibrium.

Since the green economy is too large to analyse all aspects for all three entities, the case studies focus on particular subfields: The units of analysis are electro mobility for a green transport sector in China, renewable energies for a clean energy sector in the United States, and the deployment of a smart grid in the European Union. This in-depth analysis can yield important insights about the strengths and weaknesses of the three cases in their quest to decarbonise their economies. Whereas the selection for the political entities is based on their importance and their strong differences, resulting in a most different research design, the selection of the areas analysed is based on several important similarities. The fields share that they are of high importance for significant GHG emissions reductions and the cases have already taken measures towards decarbonisation in these areas. However, focusing on various technologies and sectors brings challenges with it. For example, the different technologies cover different scopes of the green economy resulting in a different level of discussed detail. While electro mobility in China can be broken down into the different means of transport available, the case study focuses on road transport because from it stems the most GHG emissions. The US case study of renewable sources for electricity generation discusses a variety of technologies (geothermal, wind, hydro, solar) because they all play a relevant share in the energy mix and most support mechanisms in place target them all. Hence, a variety of technologies are analysed within one case study. In case of the smart grid in the European Union, the focus is on the two-way communication within the grid enabled by smart meters. This is the furthest advanced part of this significant overhaul of the energy infrastructure in the European Union. The alternative would have been to compare the same area in the three cases. However, that would have not captured the entire green economy and it would have been difficult to find an area that would exemplify the status of the three cases similarly well. By focusing on three different areas, the scope of the transition to a green economy becomes clearer. Nonetheless, careful interpretation of the results is important. Most importantly, drawing direct comparisons from one case study to another is not valid because of the described differences between the technologies under scrutiny. Rather, the analysis focuses on learning about the capacities of each entity as demonstrated with regard to the analysed sector.

The limited scope of the case studies allows only a snapshot of the green economy transition of each entity.

This study applies mostly qualitative methods to understand what changes take place in the cases. The empirical data stems from various sources such as government documents, academic literature, think tank studies and press reports. The emphasis put on the various data sources depends on the situation in each case. While in China the access to reliable government data is limited because of the language barrier and a history of false or non-reporting, independent research as well as academic research and press coverage is more important. In the European Union the deployment of the smart grid is still at the beginning, limiting available statistics and putting the emphasis on policy documents and exploratory research. Data of all kinds is available on renewables in the United States because of the long history of the technology allowing research to take place, statistics to gather data over time, the government to publish documents and the press to report. Following Denzin (1970) it makes use of data triangulation.

Research stays in China and the United States supported the work on the respective case studies. In China, the author spent eight weeks from February to April 2012 at the Institute for Policy and Management of the Chinese Academy of Sciences. In the United States, the author spent nine weeks in October, November and December 2012 with Scott Sklar and the Stella Group in Washington, DC. These stays helped identifying key players as well as collecting data and government documents. In particular the stay in a Chinese research institution supported the author in gaining a deeper understanding of the Chinese governance regime that goes beyond textbook knowledge. The analysed time horizon for each case study differs depending on the emergence of the technology and policy field. For capacity reasons a coherent international comparison within the case studies is beyond the scope of this thesis. Nonetheless, at given points anecdotal comparative statements are made in order to put developments into perspective. The case studies also analyse whether each case resembles a transition process that encompasses profound change or whether it is rather a switch from polluting to cleaner technologies, which is of lesser difficulty.

As the following overview of the structure of the thesis shows, “the mode of generalization is analytical generalization, in which a previously developed theory is used as a template with which to compare the empirical results of the case study” (Yin, 2009: 38). Chapter 2 is concerned with the question how a sustainable transition takes place. Hence, it critically reviews the existing literature to identify crucial characteristics and challenges of the

transition process and discusses the role of various actors. This is followed by chapter 3 that is concerned with the question what changes in the governing architecture affecting the trias of politics, polity and policy of a jurisdiction need to take place. In doing so it develops an analytical model that forms the basis for the case studies. It also entails a discussion of major socio-economic and political differences among the three cases. Chapters 4-6 carry out the in-depth case studies of selected policy fields and technologies to analyse whether a transition to a green economy can be observed in the respective political entity. Chapter 7 concludes by establishes the key findings from the case studies and drawing broader lessons.

1.2. Case selection

The case selection is a crucial decision of every research project that strongly influences the research outcome and is in particular important when looking at a few countries. Analysing a small number of countries has the advantage of being case-oriented and allowing a more intensive concentration on case particularities (Landman, 2008). Theoretically, several points are of relevance when settling on the cases. First, selection bias and inference problems are avoided when cases are selected according to “the key causal explanatory variable” (King et al., 1994: 137). Hence, the dependant variable must differ within the chosen cases because otherwise no causal links can be established.

The selected political entities – China, the United States, and the European Union – stand at the centre of the issue: They represent the world’s three largest economies and GHG emitters (see below). Hence, if they do not reduce their GHG emissions, they will offset the efforts by a large number of smaller countries. In addition, they fulfil all criteria outlined above as they vary considerably in their social, economic and political structure. Hence, they form the basis for a most different research design that allows for analysis of transition processes from various angles. Given their various starting points, they are expected to choose different pathways towards the green economy. This has advantages when discerning which transition capacities are crucial under very different starting conditions.

A second, equally important decision is the topic of each case study. Since this doctoral thesis aims to analyse the transition to a green economy, and not the transition to electro mobility, renewable energy or smart grids, a range of topics is chosen for various reasons. First, looking at differing technologies and policy areas underlines various aspects of the green economy and exemplifies the broad scope of this transition process. Crucial aspects for a green transition amongst others are using renewable sources of energy generation, cleaner modes of

transport, emissions reductions from housing, and increasing emissions-efficiency of agriculture (German Advisory Council on Global Change, 2011, Mehling et al., 2010). Second, the three areas chosen are all relevant for significant GHG emissions reductions. Whereas the Chinese transport sector currently contributes relatively little to the GHG emissions total, it would be a significant factor when it reaches the level of industrialised economies. Hence, it would be an important step towards a green economy to find alternatives that can significantly reduce the emissions intensity such as electro mobility. Renewable energies in the United States can help reduce the output of the sector with the highest GHG emissions output by transitioning to cleaner alternatives. In the European Union the smart grid does not reduce GHG emissions by itself but is a key enabler for a variety of clean technologies that are gaining traction in the member states. Third, the case studies are focusing on areas on which the political entities are concentrating to transition to cleaner alternatives. In China, the political leadership strongly pushes electro mobility. In the United States president Obama has used the fiscal stimulus after the financial crisis in 2008/2009 to push forward renewable energies. The smart grid in the European Union is a key technology to integrate the European energy infrastructure and has entered the supranational policy realm for this reason.

Nonetheless, this approach faces a share of problems: The cases reflect various degrees of difficulty of achieving the three goals although they all represent an important part of the green transition and include a combination of industrial sectors. The US case looks at the most basic issue since the technology is already developed and only the infrastructure needs to change. The China case is more difficult because a new technology must be developed and the infrastructure must be adapted to changing needs. Finally, the EU case is most difficult because many of the technological fixes are not yet developed and it remains unclear how the future infrastructure will look like since little experience exists. Furthermore, the three cases are currently in very different stages of their socio-political and socio-economic development. This reflects in their current GHG emissions trajectories, economic maturity and development as well as progress of decoupling economic growth from ecological destruction. Hence, this dissertation applies a most different research design with regard to the political entities.

1.2.1. Greenhouse gas emissions trajectories

Since 2007, when it overtook the United States, which had held this position for a long time, China has been the annual biggest emitter of GHGs. In 2012, China emitted 8.3 gigatons CO₂ (26% of global GHG emissions), the United States 5.1 gigatons CO₂ (16% of global GHG

emissions) and the European Union 3.5 gigatons CO₂ (11% of global GHG emissions) (International Energy Agency, 2014).⁶ This means that the three entities are responsible for 16.9 of 31.7 gigatons CO₂, more than 53% of the global total.⁷ It is of little surprise that the three entities are also the three biggest electricity producers and consumers as well as the consumers of the most refined petroleum products (Central Intelligence Agency, 2013). As a result, attempts to mitigate climate change without these three entities will have only moderate impacts on global GHG emissions totals. They easily offset even significant reductions by smaller countries when they continue with or even increase their current output. While the latest global financial crisis starting in 2008 temporarily slowed global growth of GHG emissions, emissions output accelerated again in 2010.⁸ Pollution remains closely linked to economic development and a meaningful decoupling is not yet taking place.

The three entities are on diverging pathways: In the time frame 1990 to 2012 Chinese GHG emissions have increased by 262.2%, US emissions have increased as well, but only by 4.2% while GHG emissions in the European Union have decreased by 13.8% (International Energy Agency, 2014). A different picture emerges when looking at per capita GHG emissions: the United States has by far the highest output of the three cases with 16.2 tons CO₂ per capita in 2012 followed by the European Union with 6.9 tons CO₂ and China at 6.1 tons CO₂ (International Energy Agency, 2014). It is worth noting that all three are above the world average of 4.5 tons CO₂ per capita. While China has the lowest per capita GHG emissions of the three, they have been rapidly increasing by 204.4% since 1990; in the European Union and the United States per capita GHG emissions have decreased by 17% and 18.9% respectively during the same period (International Energy Agency, 2014). It seems likely that without far-reaching policy intervention future trajectories continue along these trend lines: rapid Chinese economic growth will drive GHG emissions upwards; the European Union has enacted legislation to continuously reduce GHG emissions, hence, it probably proceeds with lowering overall emissions output; the development in the United States is less certain, but large changes in either direction appear rather unlikely.

⁶ The Chinese data – even though published by the International Energy Agency – needs to be treated with caution. Guan et al. (2012) have found large differences between regional and national reports of GHG emissions in China. However, in order to ensure comparability, the following relies on International Energy Agency data only.

⁷ In general, the responsibility for GHG emissions is put on the country in which they were produced and not consumed. However, in a highly globalised economy, trade causes the picture to look very different when responsibility is based on consumption. For example, China, the production hub of the world economy, exports a high percentage of products that caused GHG emissions (Peters and Hertwich, 2008).

⁸ This is the latest year for which reliable and comparable data is available.

1.2.2. Economic development

While gross domestic product (GDP) is only an incomplete proxy for economic performance, it remains the most widely used indicator to compare the size of national economies.⁹ In 2011, the European Union generated the biggest GDP worldwide, followed by the United States and China (Central Intelligence Agency, 2013).¹⁰ However, the World Bank (2012) assumes that even with modest growth only, China becomes the world's biggest economy before 2030. This rapid growth comes at the price of increasing pollution as the Chinese level of environmental degradation and resource depletion is assumed to cost roughly 9% of gross national income (World Bank, 2012).¹¹

The situation is different when looking at a worldwide comparison of annual per capita GDP in 2012: The United States ranks 14th with approximately 50,700 USD (38,702 EUR), the European Union ranks 41st with circa 35,100 USD (26,794 EUR) and China ranks decidedly lower at position 123 with 9,300 USD (7,099 EUR) (Central Intelligence Agency, 2013).¹² This demonstrates a wide spread in economic development and living conditions. Whereas the United States and the European Union are industrialised economies, China is best described as a rapidly developing country. This is underlined by the yearly growth patterns: China has experienced GDP growth rates of roughly 10% over the last two decades. In contrast, GDP in the United States and the European Union has been growing by less than 2% annually over the last 10 years with negative growth rates during the last major global economic crisis.

⁹ Burda and Wyplosz (2009: 27) give three definitions: 1) “the sum of final sales within a geographic location during a period of time, usually a year”; 2) “the sum of value added occurring within a given geographic location during a period of time”; 3) “the sum of factor incomes earned from economic activities within a geographic location during a period of time”. Critics of GDP have pointed out that all the definitions focus on monetary values (Jackson, 2009) and ignore consequences of economic activities to non-priceable issues, such as the global climate. This means that GDP grows even though economies destruct their resources base to generate monetary values (United Nations Environment Programme, 2011). Proposals to improve the measure of GDP include “some account of positive benefits from things like household work, adjusting for the depletion of capital (both human-made and natural), subtracting external environmental and social costs and taking account of defensive expenditures” (Jackson, 2009: 126). This would help to avoid the current misperception that the excessive use of natural resources results in positive economic growth numbers.

¹⁰ The presented economic data is based on the Organisation for Economic Co-operation and Development (2013) and Central Intelligence Agency (2013). Other sources either do not aggregate the data for the European Union (World Bank) or do not include China in their dataset (Eurostat).

¹¹ Gross national income is closely related to GDP. However, the calculation is based on citizenship rather than territory.

¹² The monetary values are always presented in the currency that the original source uses. Hence, they are either in USD, RMB, or EUR. In order to make them comparable, they are converted into EUR if this is not the currency they are presented in. The conversion rates are: 1 EUR = 1.31 USD and 1 EUR = 8.27 RMB – approximately the average exchange rates of the last two years (European Central Bank, 2013).

1.2.3. Linking greenhouse gas emissions and economic trends

Theoretically, the ‘environmental Kuznets curve’ elaborates that the relation between income and environmental performance is an inverted U-shaped curve. With very low national income, environmental impact is low, as countries industrialise, they rapidly increase their pollution up to a turning point from where it falls (Tietenberg and Lewis, 2009). More investment by richer countries into pollution abatement and a higher ranking of environmental preferences explain this trend (Fiorino, 2011). In order to compare countries, the International Energy Agency (2014) has developed an indicator that measures the CO₂ emissions divided by the national GDP based on purchasing power parity on a base year. Based on 2005 USD, China has the highest pollution intensity of the three cases. It is twice as high as in the United States and almost three times as high as in the European Union, which is currently the most GHG emissions efficient entity of the three. However, over the period 1990 to 2012 China has reduced its emissions intensity by 52.3%, the European Union by 40.6% and the United States by 39.7%. This means that certain decoupling is taking place in all three cases. However, this does not take rebound effects into account which describe an “overcompensation of the decarbonisation progress” (German Advisory Council on Global Change, 2011: 7) – the goods production emits less GHGs but more of them are bought resulting in an overall increase of pollution. While the economies become more efficient, higher consumption could result in an overall pollution increase. Table 1 gives an overview of key indicators.

Table 1: Comparison of economic and greenhouse gas emissions indicators

	China	United States	European Union
Gigatons CO₂ emissions in 2012	8.3	5.1	3.5
Change of CO₂ emissions between 1990-2012 in %	+ 262.2	+ 4.2	- 13.8
Tons CO₂ emissions per capita in 2012	6.1	16.2	6.9
Change of per capita CO₂ emission between 1990 and 2012 in %	+ 204.4	- 17.0	- 18.9

GDP 2011 in billion USD¹³	11,300 (8,626 billion EUR)	14,991 (11,444 billion EUR)	16,455 (12,553 billion EUR)
GDP per capita 2012 in USD¹⁴	9,300 (123) (7,099 EUR)	50,700 (14) (38,702 EUR)	35,100 (41) (26,794 EUR)
Annual change of GDP between 2001 and 2010 in %	+ 10.5	+ 1.6	+ 1.4
Change of GDP between 1990 and 2010 in %	+ 630.1	+ 63.5	+ 43.2
CO₂/GDP (kgCO₂ per 2005 USD) in 2012	0.62	0.36	0.25
Overall change of CO₂/GDP (kgCO₂ per 2005 USD) between 1990 and 2012 in %	- 52.3	- 39.7	- 40.9

Sources: Central Intelligence Agency (2013), (International Energy Agency, 2014), Organisation for Economic Co-operation and Development (2013)

1.3. Defining key concepts

The title of this doctoral thesis includes three key terms: governing, transition and green economy. Since research on sustainable transitions is a rather new field of academic study, these terms are not yet clearly defined in this context. A short discussion of each term clarifies their meaning before the following chapter reviews the literature in more detail.

1.3.1. Governing

Governing, governance and government are three closely intertwined concepts dealing with socio-political decision-making. According to Pierre and Peters (2000: 1) they “take a central place in contemporary debates in the social sciences” and are highly contested. However, agreement exists that they differ in the processes they describe.

- Government is the narrowest of the three terms as it describes when only state actors are involved in governing. The claim “governance is what governments do” (Paavola, 2007: 94) holds only true when no additional actors are involved in societal steering activities which is rarely the case in modern times. A key explanation is that

¹³ The numbers are calculated as current prices under current purchasing power parity.

¹⁴ The number in parentheses indicates the position of the international ranking by the Central Intelligence Agency (2013).

governments as a solution to societal problems has slowly gained a more negative connotation (Pierre and Peters, 2000). This shift has given rise to governance.

- Governance describes manifold stakeholders, such as civil society and business partaking in the social decision-making process in addition to government. Hence, it describes “the whole range of institutions and relationships involved in the process of governing” (Pierre and Peters, 2000: 1) which have grown into a diverse mix that often times change according to the issue at hand. While government remains a key point of reference, business, civil society, and international networks occupy a growing role. Hence, governance describes “how societies, organisations and networks are collectively steered and governed” (Atomium Culture and Lund University, 2009: 8). Pierre and Peters (2005: 3-5) elaborate “four activities in governance”: First, defining common priorities of a society, a task mostly assumed by government. Second, ensuring that these goals are coherent across all policy areas. Third, steering society to these coherent goals by finding ways to achieve them. The changing actors constellation readjusts the instrument box as well.¹⁵ Finally, the actors delivering governance need to be held accountable for their deeds in particular if they do not reach the goals.
- Governing is mostly concerned with procedural issues. Kooiman (2003: 4) defines it “as the totality of interactions, in which public as well as private actors participate, aimed at solving societal problems or creating societal opportunities; attending to the institutions as contexts for these governing interactions; and establishing a normative foundation for all those activities”. Hence, this doctoral thesis is concerned with the actions to achieve the green economy rather than the framework as it explicitly focuses on governing. Importantly, governance frameworks are always in flow as it is a steady “process of reflexivity (multiple interactions which alter the medium and scale of interaction) and reflection (self-monitoring to ensure that useful re-alignments and policy developments can occur)” (Fitzpatrick, 2011b: 164). This means that constant change occurs and it requires persistence to reach a defined goal.

The sub-field of environmental governance aims to answer the rising demand for governance of the environment because of the impact of human actions. One attempt to define it more precisely is: “Environmental governance is the use of institutional power to shape

¹⁵ Policy instruments are generally divided into four categories: First, regulatory instruments meaning public authorities set targets and their violation is punished; second, market-based instruments aim to change the economic incentives; third, informational instruments describing the behaviour change of social actors through education; finally, voluntary targets are pledges by industry to public actors (Jordan et al., 2011).

environmental processes and outcomes. ... [i]t is synonymous with interventions aiming at changes in environment-related incentives, knowledge, institutions, decision-making, behaviours, and identities.” (Lemos and Agrawal, 2009: 71) Environmental governance most of the time is related to multi-level governance as global ecological problems are dealt with at the sub-national, national, regional and global level – climate change for example. However, in the study the domestic level stands at the fore for the reasons discussed above.

1.3.2. Transition

The term transition has had a variety of different academic meanings. Prior to its use in the ecological context, it has been applied to the areas of “evolutionary biology, demography, and studies of former communist economies and developing countries undergoing a transition to a market economy” (van den Bergh et al., 2011: 8-9). The latter understanding has been most prominent as the term is used interchangeably with transformation and regime change.

In the ecological context the term is rather new and often confused with transformation. For example, the German Advisory Council on Global Change (2011) has entitled its flagship report “World in Transition. A Social Contract for Sustainability” which advocates a ‘great transformation’.¹⁶ It understands transformation “to describe an all-encompassing transition” (German Advisory Council on Global Change, 2011: 83). A similar definition is put forward by Rotmans and Loorbach (2010: 110), two important scholars of the Dutch sustainable transition community: “A transition occurs when a regime is transformed or replaced.” Hence, transformation describes the process of change that takes place within a transition that is the broader long-term process. This thesis will make use of the term transition in this understanding which Rotmans and Loorbach (2010: 109) define “as a fundamental change in structure, culture and practices”: Structure is understood broadly to encompass physical infrastructure, economic infrastructure and institutions. Culture “refers to the collective set of values, norms, perspective ... and paradigm” (Rotmans and Loorbach, 2010: 109). Practices refer to the behaviour and practical handling at the individual level. Hence, a transition is a profound change process that involves various policy areas and actor groups over long time frames. Importantly, it entails technology change but does not limit itself to it. This means that shifting from a polluting technology to a cleaner alternative does not by itself describe a transition process as it can largely neglect the culture and structure.

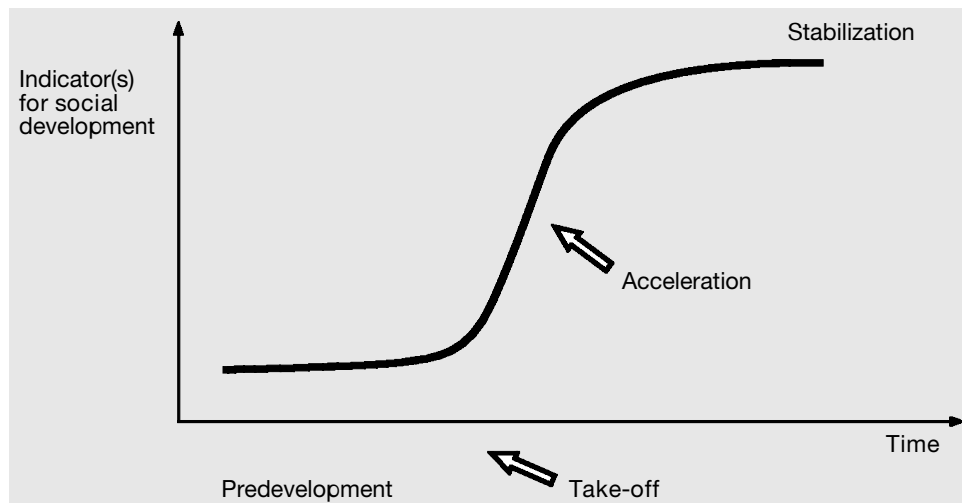
¹⁶ The German title is „Welt im Wandel. Gesellschaftsvertrag für eine große Transformation.“ This is a good example of the inconsistent use of the terms transition and transformation, in particular in different languages.

A variety of lock-in effects into the existing high-carbon economy prohibit a swift transition to a green economy (Geels, 2011). Most importantly, carbon lock-in, “a path-dependent process driven by technological and institutional increasing returns to scale” (Unruh, 2000: 817) is the result of systemic forces that eliminate alternative technologies from the marketplace. This means, the transaction costs of changing are higher than continuing the status quo (Barbier, 2011). These lock-in effects of technologies translate to the surrounding networks and institutions and strengthen the existing infrastructure. Hence, switching to clean alternatives is a long-term task that requires persistence and exogenous involvement. While Unruh (2002) assumes that overcoming these lock-in effects requires a major external shock (like environmental catastrophe), it seems rather plausible that a shift in public opinion for a variety of reasons can also change course.

The study of transitions as a highly complex long-term process of change has intensified in the past decade. It has led to the emergence of “the field of sustainability transitions research” (Farla et al., 2012: 991) represented by the ‘Sustainability Transitions Research Network’ as well as a relatively new journal, ‘Environmental Innovations and Societal Transitions’ and annual international academic conferences. Dutch researchers dominate this school of thought in which transitions share four characteristics: First, they are “co-evolution processes that require multiple changes in socio-technical systems or configurations” leading to the development and use of new innovations; second, they are “multi-actor processes” involving a variety of actor groups; third, they are “radical shifts from one system or configuration to another”; fourth, they are “long-term processes” (Geels and Schot, 2010: 11).¹⁷ While these points capture the essence of a transition, they do not ensure that the outcome is a decarbonised economy. However, it is in particular the normative dimension that separates the third industrial revolution from its predecessors during which technological progress improved living standards. This time, the transition needs an external trigger in order to secure existing living standards, which is a weaker driver for change.

According to Rotmans et al. (2001) a transition moves through four phases as indicated in figure 1: First, the existing regime destabilizes while trying to achieve slow progress of the status quo (predevelopment). Then, developments on various levels start the modernisation process (take-off). Next, the regime mobilizes capital and innovation due to internal and/or external pressure (acceleration). Finally, a new dynamic equilibrium is found that causes the change to slow down (stabilization).

¹⁷ Long-term process means between 25 and 50 years in this understanding.

Figure 1: Transition stages

Source: Rotmans et al. (2001: 17).

The S-shape symbolises that a transition starts slowly and then rapidly accelerates until it finds a new equilibrium. However, not every initiated transition reaches the aspired goal, and many other outcomes are possible. The process allows for steering but given the complexity of the task the result of interventions is not always known in advance. This can cause the need to readjust.

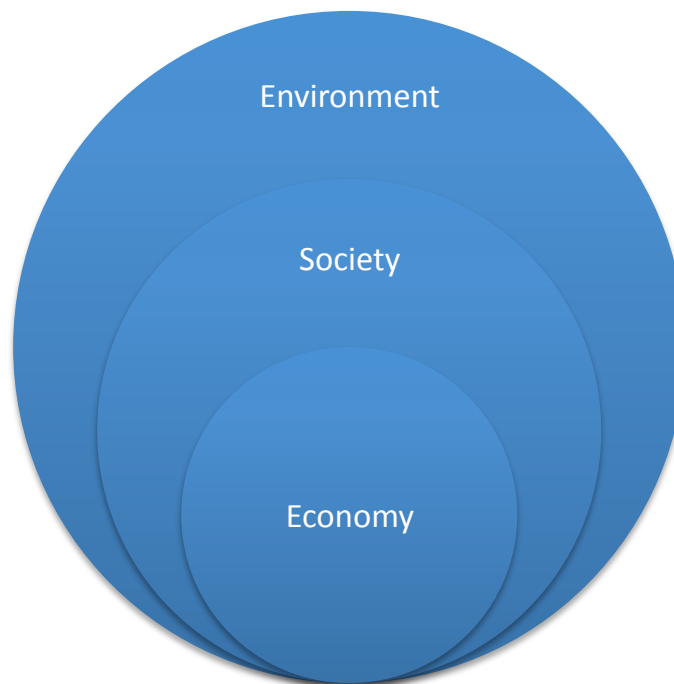
1.3.3. Green economy

Research on the green economy is closely related to research on environmental policy and sustainable development in general and climate change governance in more detail to name only a few of the most prominent catch-phrases. These are often times difficult to distinguish in practice since academic literature as well as policy documents often adopt overlapping understandings of the terms. This doctoral thesis applies the term green economy because it is currently the predominant discourse in the field. The United Nations Environment Programme (2011: 16) has been a key protagonist in defining a green economy as one that “results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities”. Hence, it combines environmental, economic and social well-being not only in some sectors but in the entire economy. Importantly, Achim Steiner, head of the United Nations Environment Programme (2011), points out that achieving a green

economy does not imply a particular state or economic design. Hence, industrialised and developing economies can realise it. The overarching aim is to direct public and private investments towards low-carbon technologies such as renewable energy and energy efficiency in order to break the growth-pollution link and achieve a significant decarbonisation of the economy through decoupling. At the same time ensuring social inclusiveness and increasing life quality in order to find social acceptance for the necessary profound changes is important.

Many of the issues touched upon clearly affect society rather than the economy. This leads some authors to talk about a green society (for example Atomium Culture and Lund University, 2009). The following focuses on a green economy and not society in order to limit the scope: While “[N]o society could, naturally, live for any length of time unless it possessed an economy of some sort” (Polanyi, 1944: 45) a “man’s economy, as a rule, is submerged in his social relationships” (Polanyi, 1944: 48). While it is important to earn an income on which one can subsist, this does only partly explain a person’s societal standing. Hence, the economy is a subsum of society.

Figure 2: Economy as a subsystem of society



Source: Author’s graph based on United Nations Environment Programme (2011: 510).

A prominent debate in the environmental community is whether a green economy can include economic growth. Two competing lines of thought exist: One stream argues that economies can continue to grow albeit slowly while completely decoupling GHG emissions from

economic activity. The other stream argues that in order to rescue the environment no more economic growth is possible. This is because no matter how “much material efficiency you squeeze out of the economy, eventually you’ll reach a limit, at which point continued growth will push material throughput up again” (Jackson, 2009: 130). The proponents of green growth argue in contrast that a stagnating economy will not gain “the necessary acceptance for the change” (Jänicke, 2011: 3) necessary towards a green economy. This leads to the conclusion that “neither total economic stagnation nor shrinkage is desired” (Jänicke, 2011: 13) but rather a slowly growing economy. However, which size of GDP growth remains unstated. Some analysts even argue that moving to a green economy in a development context will result in higher growth figures than a business as usual scenario (United Nations Environment Programme, 2011). This thesis assumes that a certain level of economic growth will continue to take place in the future.

The green growth literature assumes that efficiency gains (mostly due to new technologies) reduce environmental impacts. However, they face a variety of questions. First, how much growth is possible without harming the environment? An answer to this question does not yet exist. However, it is obvious that the growth level has to result in a significant GHG emissions reduction. Second, who is responsible for GHG emissions? Many industrialised economies have achieved their emissions reductions by moving the dirty production processes outside of their borders from where they import the finalised goods. They secure their economic well-being by moving from the dirty production of goods towards far less GHG emissions-intensive service delivery. This means that the same GHG emissions arise, albeit in the developing rather than in the developed nations. For example, in 2001 22% of global carbon dioxide emissions were embodied in trade (Peters and Hertwich, 2008). Hence, “[W]here the reductions are made should be separated from the question of who should pay for them” (Bowen, 2009: 12). The responsibility has to shift from those who generate the GHG emissions to those who consume them. Third, how to deal with rebound effects? Increases in consumption can reduce the achievements of decoupling when more consumption of more efficiently produced goods results in an overall GHG emissions increase. Many consumers regardless of their size aim to reduce the pollution they cause but underestimate or do not recognise the rebound effect at all (van den Bergh et al., 2011). Hence, educating about these effects supports lasting GHG emissions reductions.

1.4. Expectations

This thesis aims to find evidence that transitions can be managed. Since governance, as discussed above, means that a variety of actors are involved but the state still assumes a key steering role, this thesis expects that the state plays a key role in shaping transitions. However, the three cases examined in this research context are very different polities. The state as well as market and civil society play a very different role in each case. While the European Union is a collaborative effort of 28 nation states, the United States is an industrialised country with one of the highest GHG emissions per capita and China is a rapidly industrialising country led by an authoritarian regime. Hence, the expectation is that they will all follow very different paths in the transition to a green economy and use different instruments to come to a similar result. In China, the all-potent state most likely plays a central role, whereas the United States is more market-driven and the European Union based on supranational negotiations. Despite these differences they should all be capable to find ways to successfully implement a green transition. While a key research interest is whether any of these three cases is better suited for the transition than the others, they are still expected to need to address similar areas that need to change for successful greening. For example, a green transition is always reliant on new technologies and goods to gain large market shares and support by a strong part of society. Hence, the thesis aims to find out which capacities are needed in different political settings for a green transition.

2. A critical review of the literature

While various strands of existing literature are of relevance in this research context, a coherent approach to explain how sustainable transitions take place and how they can be steered remains lacking. The existing literature on sustainability transitions focuses mostly on innovation and technology development in protected niches in order to overcome lock-in effects. This chapter presents literature on the distinct characteristics of a green transition process in the first part of the review and identifies two shortcomings of the existing literature. First, it lacks a coherent discussion of the role of actors that have become increasingly important. Hence, the governance dimension is largely ignored meaning that it does not explain how interventions can affect the change process. Second, the literature largely puts forward a technology-driven transition understanding. It lacks a normative dimension that ensures that the newly found equilibrium after the transitions reduces the negative impact on the environment. Hence, the second part of this chapter elaborates the literature on environmental and climate change governance as well as on sustainable development which emphasises the necessary restructuring of societal preferences in order to improve environmental performance. It establishes that currently states continue to treat environmental issues as less important than key state functions, such as creating economic growth and securing social welfare. This poses a major challenge for the green transition. The chapter concludes by presenting ecological modernisation, the most accomplished analytical approach to bring these strands together.

2.1. Distinct characteristics of a green transition

Since it holds true that “each transition displays unique characteristics, dynamics and history” (Berkhout et al., 2004: 8), various transition pathways to a green economy exist. There is not a single blueprint that each case needs to follow. Rather, the process shares four similarities that manifest differently according to domestic circumstances and external shocks:

- Normative guidance towards sustainable development that ensures that the economy decarbonises
- Profound changes result in altered institutions
- Long-term processes of 25 to 50 years
- Progress and roll-back alternate without a clear endpoint instead of a linear development

A key distinction between the green and former industrial transitions is the normative dimension of the current challenge. Hence, sustainable transitions are ‘purposive’ meaning pollution problems need to be solved and they are not ‘emergent’ because newly-developed technologies create new business opportunities (Geels, 2011). This means that legitimate actors, in general publicly elected officials need to change the decision structures towards solving these problems. However, key decision-makers also need to generate demand for such a reconfiguration. For this reason, establishing a societal consensus that the green economy is a worthy goal and what it entails is an important first step to trigger the change process. On this basis all relevant actors can become change agents within their domain. It is key to understand that this “redefinition of societal interests ... implies political engagement to build reform coalitions, create new centres of power, buy off powerful lobbies, isolate die-hards, compensate losers, and so on” (Meadowcroft, 2011: 73). This is more easily realised when the new societal discourse adopts an “appealing narrative” (Atomium Culture and Lund University, 2009: 34) which fosters public support.

These coalitions for change must initiate highly complex and interrelated changes to a variety of variables to overcome path-dependency and carbon lock-in effects. The role of governance in this complex situation “is to create some capacity for action in the midst of all the barriers and the divisions, and in the presence of uncertainty” (Pierre and Peters, 2005: 13). Hence, the transition process requires the establishment of new as well as modifications and removal of existing institutions. A key institutional dimension that needs to change are “economic frame conditions” (Geels, 2011: 25) in order to allow low-carbon niche innovations to reach the market and ensure wide diffusion to increase their environmental impact. The current institutional design has emerged during the fossil fuel era and caters to its needs but discriminates against cleaner alternatives because it does not include the societal costs of pollution. In addition, large companies control central economic sectors like power and transport, which are responsible for a large share of GHG emissions. These companies hold strong market power because they “possess ‘complementary assets’ such as specialized manufacturing capability, experience with large scale test trials, access to distribution channels, service networks, and complementary technologies” (Geels, 2011: 25). Low-carbon alternatives have few chances to become competitive under the current regime. At the same time, shifting the economic resource base affects every member of society and creates many distributional issues and power struggles between old and new vested interest. Since everyone is a potential veto player, the transition requires strong political support – otherwise the

opposition can stall progress (German Advisory Council on Global Change, 2011).¹⁸ Public actors must support the civil society and consumers in order to overcoming the lock-in of established vested interest.

While a sustainable transition requires a long time frame, little time is left to successfully mitigate climate change without creating irreparable damage. Hence, the green transition needs to be planned and carried out under immense time pressure and everyone involved must adopt a “changed time regime” (German Advisory Council on Global Change, 2011: 90). As a result far-reaching change needs to be accelerated while assuming a long-term stability and predictability. However, similar to the introduction of the welfare state, the green transition is not a linear process and the speed of change will differ over time (Meadowcroft, 2005b). Change might come fast at times, be rolled back at others and an in between completely new problems emerge. There is no clear endpoint to the transitional period as the outcome is only relatively stable and requires permanent readjustment.

The Dutch school of transition studies is rooted in evolutionary economics and policy thinking that focuses on process (Dosi, 1982, Nelson and Winter, 1982). Evolutionary thinking describes „an adaptive policy approach that is concerned with the dynamics of variation, selection and retention” (Nill and Kemp, 2009: 669) to overcome the fossil fuel era status quo. The primary agents are firms that are bounded rational and adapt to changing circumstances within their regimes. The evolutionary concept is critical of the neo-classical assumption that firms have full information but rather assumes that firms have only limited capabilities to process information. “Incumbent firms tend to overlook or ignore radical innovations, because existing competences and routines blind them to alternatives outside their focus.” (Geels, 2010: 498) Hence, transitions are a result of changes to the variation side (development of new technologies) and selection environment (regulation and behaviour change). This happens more in a trial and error fashion focused on processes rather than on Pareto optimal outcomes. Transitions are not planned at the outset from beginning to end but reflect constant muddling through.

The focus of evolutionary transition studies is on radical changes rather than incremental adjustments because of the scope of the change process. Various analytical frameworks exist that aim to explain green transitions. Most important are the multi-level perspective (MLP) and the technological innovation system (TIS) approach (Farla et al., 2012, Markard et al.,

¹⁸ Veto players are defined as “individual or collective actors whose agreement is necessary for a change of the status quo. It follows that a change in the status quo requires a unanimous decision of all veto players” (Tsebelis, 2002: 19).

2012). Both focus on innovations by stimulating variety and later selecting the best choices. They are not yet empirically tested because they are rarely implemented in policies (Nill and Kemp, 2009). However, both approaches are rather descriptive and largely neglect the normative dimension.

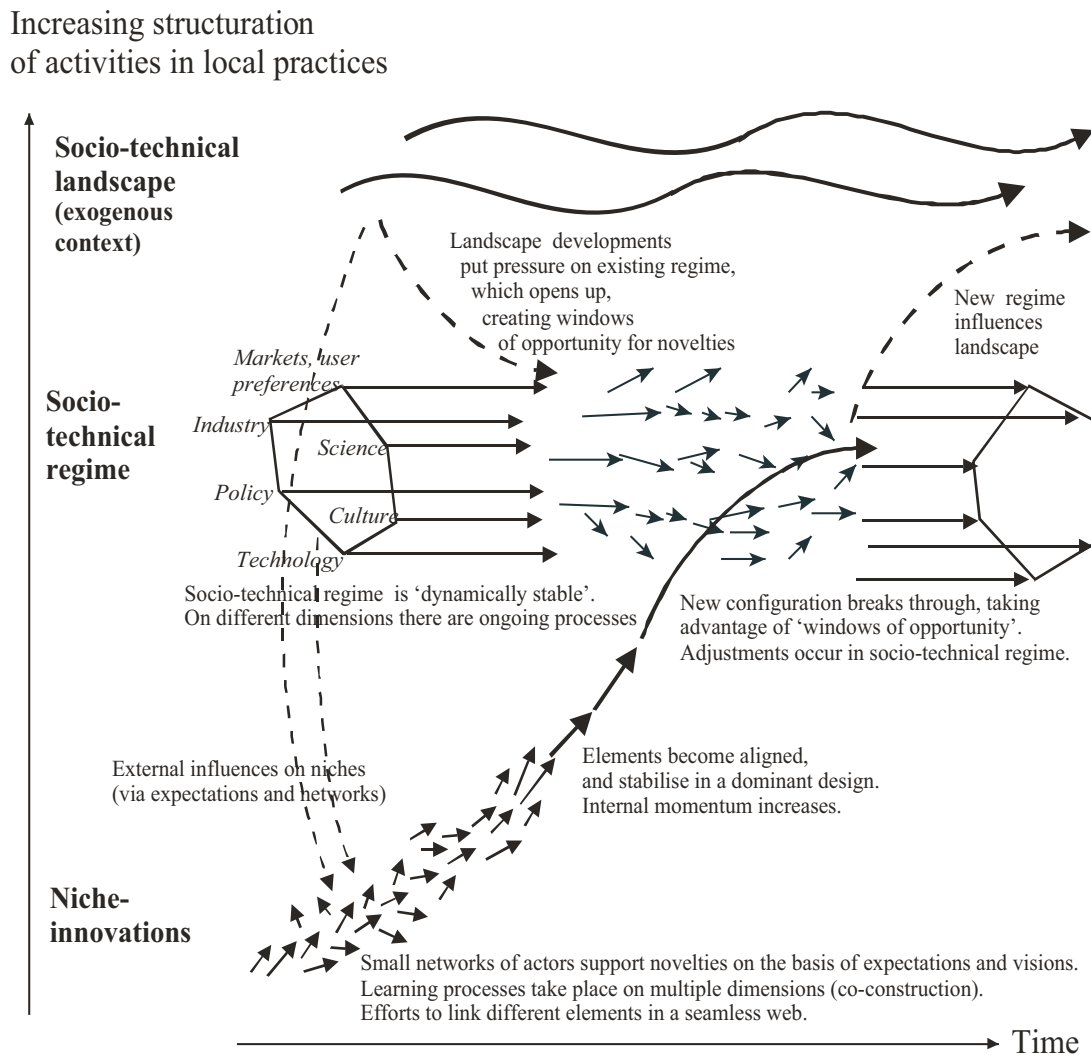
2.1.1. Multi-level perspective

The MLP on socio-technical transitions consists of three layers:

- Niches form the micro-level where radical innovations can develop while protected from market pressures. This means that “small networks of dedicated actors, often outsiders or fringe actors” (Geels and Schot, 2007: 400) come together to develop technological novelties that have the potential to run from bottom to top.
- The socio-technical regime, the heart of the MLP, is “a coherent, highly interrelated and stable structure at the meso-level characterized by established products and technologies, stocks of knowledge, user practices, expectations, norms, regulations, etc” (Markard and Truffer, 2008: 603). This regime changes in a successful transition and gives direction and logic to the process. Importantly, it often times does not explicitly involve actor interaction.
- On the macro-level, socio-technical landscapes are given exogenous factors such as infrastructure, cultural change, global developments, which are more robust than regimes and are beyond the reach of actors for immediate change (Geels, 2005).

The interplay of the three layers explains transitions of socio-technical regimes: “(a) niche-innovations build up internal momentum, through learning processes, price/performance improvements, and support from powerful groups, (b) changes at the landscape level create pressure on the regime and (c) destabilisation of the regime creates windows of opportunity for niche-innovations. The alignment of these processes enables the breakthrough of novelties in mainstream markets where they compete with the existing regime” (Geels and Schot, 2007: 400). However, a variety of transition pathways exist that can explain how change takes places. While Smith et al. (2005) argue that either the external selection pressures can become greener or the regime itself can become aware of environmental issues and trigger change from within, Geels and Schot (2007: 414) argue that the pathway are only established over time and agency is reflected in the MLP but “does not always come through strongly in stylised case-studies“. Hence, they do not give a complete overview of all key stakeholders and are weak in explaining the transition governance.

Figure 3: Transitions in the ‘multi-level perspective’ framework

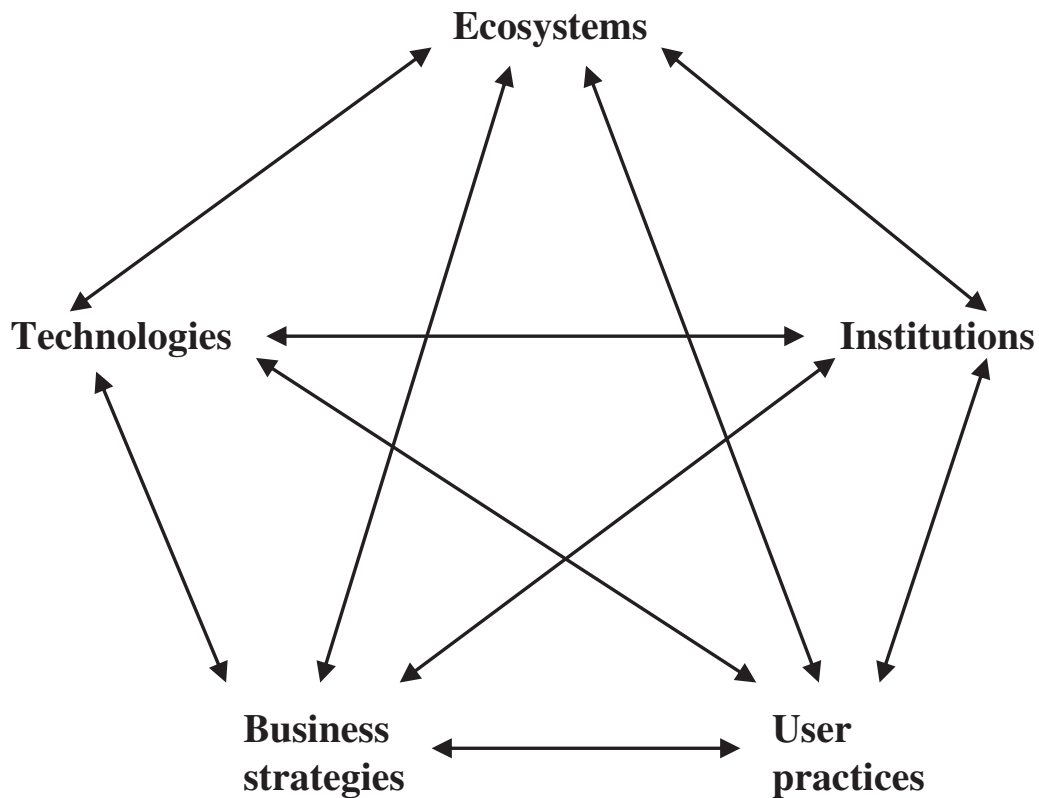


Source: Geels (2011: 28).

The MLP framework has been influential in at least three ways: First, it fosters the understanding that institutional adjustments follow technological change; second, it shows the relevance of the interplay of the three layers; third, various historic examples have been researched using this approach (Berkhout et al., 2004). Furthermore, the framework is capable to integrate exogenous shocks through the landscape (Markard and Truffer, 2008). Hence, it has been labelled a “useful analytical framework to understand transitions” (Whitmarsh, 2012). However, the literature also offers various critical remarks. First, socio-technical regimes are not coherently defined. In particular the scope of what is included in the regime varies and sometimes resembles the system understanding laid out below (Markard and

Truffer, 2008). Second, “the landscape remains something of a ‘black box’ in which anything that does not readily fit at lower levels is placed” (Whitmarsh, 2012). This creates analytical confusion. Third, the role of actors is not clearly defined which leaves out relevant power struggles (Markard and Truffer, 2008, Shove and Walker, 2010). For example, people and their everyday life are often not taken into account. This is in particular problematic for sustainable transitions because they involve constant power struggles and a reconfiguration of societal preferences as has been laid out above. While proponents of the MLP assert that “agency influences whether, how and how fast a particular transition will develop” (Grin et al., 2011: 79), it remains largely unclear from their work how they conceptualise this variable. Fourth, Foxon (2011) criticizes the multi-level perspective for putting too little emphasis on price incentives and investments. He proposes a “coevolutionary approach”, that, “seeks to identify causal interactions between evolving systems“ (Foxon, 2011: 2262). Relevant coevolving systems are “ecosystems, technologies, institutions, business strategies and user practices” (Foxon, 2011: 2261) including key explanatory variables. Each of the systems is assumed to have an internal logic and dynamic but key are the feedback loops that interact between the separate systems. This dynamic can establish common structures on the macro-level but they remain fragile and are endangered by external shocks.

Figure 4: Co-evolutionary framework



Source: Foxon (2011: 2262).

Largely ignored in the literature on the MLP is the lacking normative guidance. While it does explain how technologies can emerge from protected niches, the MLP does not elaborate convincingly how it can ensure that they help to decarbonise the economy. Solely focusing on the transition process itself ignores the possibility that unsustainable solutions prevail. Hence, a key ingredient of green transitions is missing as they clearly articulate the goal to improve the ecological situation. This desire stems from the problem description of climate change being caused by excessive GHG emissions. Hence, it is irritating that the sustainable transition network gives little explicit impetus to the sustainability outcome.

2.1.2. Technological innovation systems

Altering the innovation systems that frame the interaction between technology and its systemic development is a crucial part of the green transition. Potential focus points are regional, national, sector or technology-specific systems (Markard and Truffer, 2008). The latter are most relevant in this research context. Key structural parts are actors, networks and institutions (Bergek et al., 2008). TIS approaches analyse which institutional changes need to take place for them to nurture new technologies (Markard et al., 2012). They are defined as “a network of agents interacting in a specific economic/industrial area under a particular

institutional infrastructure or set of infrastructures and involved in the generation, diffusion, and utilization of technology” (Carlsson and Stankiewicz, 1991: 111). Since this definition does not differentiate between radical new and refining existing technologies, Markard and Truffer (2008: 599) specify by distinguishing “an innovation part that creates, diffuses and uses new products (or technologies) and a production part, which is ‘responsible’ for the established products (or technologies)”. The discussed lock-in effects that slow down development and limit choice typically hamper these systems. The aim is to accelerate and steer the highly complex innovation process towards low-carbon technologies. This means that a green transition entails a reconfiguration of the TIS towards technologies that emit less GHGs and decarbonise economic activity.

The formation of a new TIS takes place in four steps: First, firms and other actors enter in the supply chain; second, political, social and industry networks form and start collaborating; third, institutions align to these new realities; fourth, accumulation of knowledge and artefacts transforms the system (Jacobsson and Bergek, 2011). However, this is a fixed system that cannot react to the described co-evolution of systems and limits itself to innovation. Functions approaches aim to overcome the static TIS framework by including dynamic interactions and constant feedback loops between the various functions (Bergek et al., 2008, Hekkert et al., 2007). Table 2 gives an overview of the two functions approaches that are generally discussed. While both lists look similar at first glance, they differ when analysed more closely: Bergek et al. (2008) is broader and more descriptive whereas Hekkert et al. (2007) is narrower and more prescriptive. According to Hekkert et al. (2007: 426) three common “motors of change” are: first, the “guidance of the search” is directed towards sustainability goals which increase activity; second, entrepreneurs lobbying for more resources for research and development (R&D); third, entrepreneurs lobby for market formation. Bergek et al. (2008: 422) see economic growth potential and R&D support policies as “inducement mechanisms”.

Table 2: Functions of ‘technological innovation systems’

Hekkert et al. (2007)	Bergek et al. (2008)
Knowledge diffusion through networks	Knowledge development and diffusion
Guidance of the search	Influence on the direction of research

Entrepreneurial activities	Entrepreneurial experimentation
Market formation	Market formation
Creation of legitimacy/ counteract resistance to change	Legitimation
Resources mobilization	Resource mobilization
Knowledge development	Development of positive externalities

Source: Author's compilation based on Bergek et al. (2008), Hekkert et al. (2007).

While a key advantage of the functions approach is that it allows discerning entry points for clear policy recommendations, it has been criticised as “inward oriented” by largely ignoring exogenous factors (Markard and Truffer, 2008). Hence, it can easily miss critical developments. This is particularly troublesome because innovation policy is only one steering mechanism for the green transition. This means, TIS focus on an important dimension of the transition but ignore other crucial dimensions of statehood.

2.2. The emerging environmental state

This review of the literature on transitions has shown that it can explain the process but lack elaborations on how to steer this process. Hence, it currently lacks an integration of governance literature. Many scholars working on environmental and/ or sustainable governance (particularly climate change mitigation) see the state represented by government and its bureaucracy as the key actor (Atomium Culture and Lund University, 2009, Christoff, 2005, Dryzek, 2005, Eckersley, 2004, Fiorino, 2011, Giddens, 2009, Jänicke, 2007, Meadowcroft, 2007). This is primarily because public actors hold the legitimacy and resources to manage the transition process. While it is crucial to understand how the state handles these issues, the more important question is whether it is capable to manage a process of this scope in particular as it has to change itself. The state is a key object as well as subject of the transition, which is a delicate position.

Since the state is “a messy concept” (Mann, 1984: 187) as most definitions combine functional and institutional dimensions, it is important to clarify its meaning in the given context. Commonly, the triad of the monopoly of force, a defined territory and people characterise a state (Lauth and Wagner, 2010). Tilly (1990: 1) defines states “as coercion-

wielding organizations that are distinct from households and kinship groups and exercise priority in some respects over all other organizations within substantial territories” that exist for more than 5,000 years. Since then they have proven their “superior survival value” (Mann, 1984: 195) compared to non-state social organisations. Hence, chances are high that they find ways to solve the ecological crisis and manage the green transition. The political organisation of a state based on different types of legitimacy can take various forms: the predominant ideal types are democracy (famously defined by US President Abraham Lincoln as “government of the people, by the people, for the people” (Lincoln, 1863)), dictatorship and many grey areas in between. Democratic regimes are in general either majoritarian or consensus oriented (Lijphart, 1984).¹⁹ Geddes et al. (2014) have developed a typology that classifies autocratic regimes according to their leadership either as dominant-party-dictatorships, personalised dictatorships, monarchies or rule by the military institution.

States extract the necessary means for their existence from their people to defend them against other states. This shows that the primary state function is to protect its citizens against internal and external threats (Mann, 1984). Later in history, as this basic security function had been realised, states turned towards their citizens’ social well-being. The motivation was to ensure good production capacities as the foundation for economic growth rather than individual well-being (Tilly, 1990). After this was achieved, governments to varying degrees assumed a redistributive role by establishing welfare states that guarantee social welfare for their citizens (Esping-Andersen, 1990, Gough and Meadowcroft, 2011, Meadowcroft, 2005b). Starting in the second half of the 20th century, in particular civil society groups started arguing that state (in-)action has caused severe environmental degradation. The environmental movement in many countries has emerged in opposition to government by declaring “state failure” as public actors did not ensure the provision of public goods (such as an intact environment) (Jänicke, 1990). Hence, they put the issue on the agenda. The activists argued “that the pursuit of economic growth – or more precisely, the wrong sorts of economic growth – has done little to improve the quality of life, welfare and well-being of people” (Catney and Doyle, 2011: 95). Over time, this forced state authorities to engage with environmental problems. It caused rethinking environmental policy from focussing on interventions after the damage had occurred (end-of-the-pipe technologies) to a more pro-active approach that aims to avoid pollution in the first place. This marked the shift from government to governance in

¹⁹ According to Lijphart (1984) characteristics of majoritarian states are concentrated executive power, two-party systems, plural electoral systems and unitary governments whereas characteristics of consensus states are executive power-sharing, multiparty systems, proportional representation and federalism.

ecological issues. Nevertheless, it remains a struggle for environmental concerns to compete with others, for example economic concerns.

Table 3: State functions

Security	Ensuring the safety of citizens against external and internal threats
Economic growth	Safeguarding economic prosperity through, for example, designating property rights
Social welfare	Protecting citizens in times of economic hardship by redistributing wealth
Environmental protection	Avoiding overuse and pollution of the resource base

Source: Author's compilation.

This emerging environmental state function can take different forms. Achieving a negative environmental state function is key but only a positive understanding is slowly gaining ground (Jänicke, 2007). The negative protection dimension stresses the importance of avoiding environmental collapse by ensuring that economy and society operate within the given ecological limits. The positive function turns environmental policy into a competitive advantage by creating green markets and turning them into a profitable business opportunity and creating new employment opportunities. This green market is slowly growing internationally demonstrating constantly increasing demand for these goods and services. It protects economic well-being and strengthens social peace because environmental degradation has the potential to hamper economic activities causing social unrest. However, this emergence of a weak environmental state function and green markets does not entail an absolute decoupling of economic growth from resource depletion.

Dryzek et al. (2011) correctly argue that government failure on one of the core state functions (safety, economic prosperity, social safety) immediately threatens its power but the same does not hold true for the performance on environmental issues. For this reason, the environment ranks lower on the government's priority list, which hinders triggering the green transition process. Hence, in order to preserve the ecological basis and to establish a green economy, states must adopt environmental protection as a key state responsibility resulting in stringent

measures to reduce GHG emissions and other forms of environmental pollution (Jänicke, 2007, Meadowcroft, 2005b). Sustainability needs to become a guiding principle that all government actors and agencies follow by implementing environmentally friendly policies throughout all sectors (for example transport, housing, agriculture). Without the environmental state function, environmental affairs continue to remain sidelined when crucial decisions are taken. The literature uses a variety of terms to describe states that adopt environmental protection as a core state function: “green state” (Eckersley, 2004), “ecostate” (Meadowcroft, 2005b), “environmental state” (Mol and Buttel, 2002) and in the German debate “Umweltstaat” (Jänicke, 2007). Following the shift from government to governance, these states comprise not only public actors but include other crucial actor groups. Meadowcroft (2005b) establishes that such a state needs to perform the following tasks:

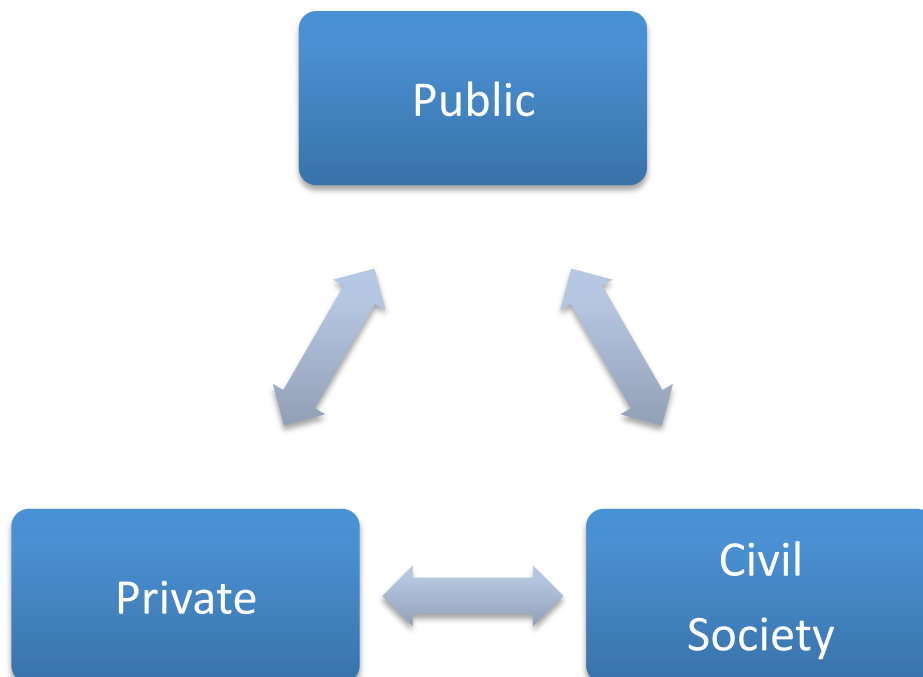
- Assume a steering role including decisions on policy tools and a stable policy framework. Set medium and long-term targets in a transparent and accountable way.
- Establish a new macroeconomic framework and be a core actor in financing the required investments.
- Assess risks, establish a guiding vision, negotiate trade-offs with other societal issues and actors and deal with the distribution of social costs.
- Observe and report on the state of the environment and predict future developments.
- Shape the international climate policy realm and adjust national actions accordingly.

As mentioned before, transitions can result in multiple ends. A successful transition towards a green economy entails the task to adopt environmental concerns in the state’s core. Hence, the state remains a key protagonist but needs to adjust to new realities and challenges. Since the state itself often times does not recognise the new problems, external actors point towards them and enter the governance framework. While the historical development has shown that states are only slowly beginning to assume an environmental state function, such a function requires severe changes to the state itself. This underlines that the state is subject and object of the transition. Currently, public authorities are not capable or willing to tackle the environmental problems with the necessary urgency, which necessitates a profound overhaul of existing routines. This can result in conflicts within the state actors. Since continuing with the status quo is often times much easier than transferring to a new status, it remains to be seen whether states are capable of going through this necessary transition.

2.3. Actors in the green transition

The presented evolutionary transition approaches have been criticised for neglecting actors who are an important factor. Hence, the following reviews actor-centred analytical approaches. While public actors remain key, they need to collaborate with the civil society and business (Christoff and Eckersley, 2011, German Advisory Council on Global Change, 2011). This raises the question which role each actor group should assume. Lemos and Agrawal (2009: 79) assign “the capacity for action across jurisdictions backed by state authority” to public actors, “the mobilization of basic human incentives through market exchanges” to private actors and, “time-and-place-specific knowledge embodied in communities” to the civil society. The different actor groups take different approaches in at least two major dimensions: organisational forms of how to carry out governance (hierarchy by government and other public actors, market by private actors and networks by civil society actors) and rationalities concerning the logic underlying governance forms (administrative by public actors, economic by market forces and deliberative by civil society) (Kronsell and Bäckstrand, 2010). Figure 5 illustrates the interplay of the various actors relevant in environmental governance.

Figure 5: Interaction of actors in environmental governance



Source: Author's graph based on Lemos and Agrawal (2009: 78).

The actor interplay takes place on a variety of political levels since states consist of a variety of sub-layers below the national level – including regional and municipal administrations and interact with each other on the international level. So-called multilevel governance is becoming a more important part of governance studies. While Lemos and Agrawal (2009) have identified a decentralization of environmental governance the national level remains the key level for a transition of this scale.²⁰ However, the state exists at various administrative layers as well and competing preferences among the layers exist (Giddens, 2009). This results in a constant struggle for influence by the different state actors.²¹

2.3.1. Public actors

Public actors describe the actions of government and its institutions. However, governments have lost some of their steering capacity to other actors because of globalisation and economic liberalisation resulting in the shift to governance (Catney and Doyle, 2011). In general, economic liberalisation frames environmental concerns as slowing down economic growth, the primary objective. As a result, governments face higher political costs if they enact ecologically motivated policies because they must overcome stronger opposition (Bailey et al., 2011). For this reason, many analysts have feared that globalisation could result in an environmental ‘race to the bottom’ since governments have incentives to lower their environmental standards in order to attract business and become so-called ‘pollution havens’. However, the opposite, a ‘race to the top’ of environmental standards, is empirically observed (Jänicke and Jacob, 2004). Despite this debate on the state’s waning influence, they remain key for the governance of the transition to a green economy for several reasons. States are the

- cornerstone of existing governance regimes since “[T]here is no functional equivalent to national governments as highly visible, legitimized and competent territorial actors and protectors” (Jänicke and Jacob, 2004: 30).
- only actors with the institutional capacity for the necessary strategic planning and to adjust the macroeconomic framework and other policy areas (German Advisory Council on Global Change, 2011).

²⁰ In case of the European Union, the supranational level can be seen as the national level because the member states have transferred crucial competences to the supranational level.

²¹ See ‘3.2.1.2. Vertical environmental policy integration’ for a more detailed discussion of the interplay of the state layers.

- main actors in the multilateral negotiations on mitigating climate change as only they are legitimized to sign and ratify binding international treaties (Meadowcroft, 2009a, Underdal, 2010).

2.3.1.1. *'Administrative rationalism'*

The historically predominant governance framework in developed countries is that the state bureaucracy implements government decisions. Dryzek (2005) labels this problem-solving discourse 'administrative rationalism' in which governance is almost equivalent to government. The approach highlights "the role of the expert rather than the citizen or producer/consumer in social problem solving, and ... stresses social relationships of hierarchy rather than equality or competition" (Dryzek, 2005: 75). The focus is on bureaucrats working in ministries – understood as silos that rarely cooperate and interact across thematic boundaries – solving problems with their topic-specific expertise. This specialisation has created high degrees of knowledge on specific issues while neglecting cross-cutting problems (Kemp et al., 2005). As a result, authorities implement regulatory policies and institutions based on precise cost-benefit evaluation of the impact. Hence, the primary approach is top-down regulation instead of more flexible alternatives. Transition governance will continue to rely on regulation as an important part of the instrument mix, but it "will have to be more collaborative, flexible, and performance-based than it has been" (Fiorino, 2009: 64). However, public actors face additional structural challenges besides improving regulations.

While some countries deal with environmental affairs in environment ministries, they are in general politically weak and lack sufficient resources (Fiorino, 2009). Environmental policy integration (EPI) meaning the integration of environmental concerns in other policy fields is rarely taking place because of the strict boundaries between the various ministries.²² Hence, administrative rationalism is largely incapable of handling long-term and cross-cutting topics, especially since it is "often constrained by lack of political will, weak penalties, imperfect information, or high transaction costs" (Lyon, 2009: 48). The result is fragmented policymaking. In addition, the strict hierarchies within the silos hamper the capacity for meaningful engagement with other relevant stakeholders. In particular bottom-up groups are marginalised. "Governing is therefore not about democracy, but about rational management in the service of a clearly defined public interest, informed by the best available expertise." (Dryzek, 2005: 87) This must change since including a broad array of actors is a prerequisite for a successful low-carbon transition. Coming back to the subject and object role of the state

²² See chapter '3.2.1. Including the entire government in the transition process' for more details.

it is problematic that existing bureaucratic structures require external pressure to reform for which they leave little room.

2.3.1.2. *'Ensuring state'*

In Giddens (2009) 'ensuring state' public actors are not solely responsible for steering the process, but state authorities monitor public goals and ensure that they are achieved "in a visible and acceptable fashion" (Giddens, 2009: 69). The German Advisory Council on Global Change (2011: 395) proposes a similar understanding under the label 'proactive state', which combines "on the one hand empowerment of a state which actively determines priorities in the political multilevel system and underlines these with clear signals ... and, on the other hand, the provision of more extensive participation opportunities to citizens to make their voices heard, get more involved, and join in decision-making processes". These two approaches are clearly separating themselves from administrative rationalism by engaging public actors with other stakeholders to ensure the public good. The state is no longer the only actor but the most important of many.

Amongst other tools Giddens (2009) envisions an independent body that makes sure that targets adopted by governments are met and not abandoned over time. This generates long-term stability by binding later governments to the reached consensus. In order to give this body enforcement power, he wants to enable it to take governments to court when they breach announced targets or weaken existing policies. In addition to controlling the executive branch, Giddens (2009) puts strong emphasis on involving different actors, many of which are bottom-up groups, in the decision-making process. It becomes a key task of government to offer societal actors opportunities for meaningful participation. This can include reliable macroeconomic signals to business, strengthening environmental education, engaging cities and rural areas, fostering sector-specific stakeholder input and encouraging public discourse (Meadowcroft, 2009a). The ensuring state approach takes up the challenge of finding ways to allow for EPI by increasing the number of players involved. While this by itself does not ensure more coherent policies but potentially increases turf fights, it significantly alters state structures to generate more consistent outcomes. This is an important step away from bureaucratic silos with public actors remaining in control since "despite the apparent weaknesses of the state to address complex, long-term cross-boundary social and environmental problems, it provides a more stable counterweight to both the fluidity and lack of citizen responsibility found in marketplaces and civil society" (Catney and Doyle, 2011:

100-101). The challenge is to find the right balance between state leadership and interaction with other stakeholders.

2.3.1.3. 'Critical Political Ecology'

Eckersley (2004) normatively deliberates creating a green state from the starting point of the liberal democratic state. She assumes that the state is the venue in which ecological governance is implemented. Her analytical approach 'Critical Political Ecology' envisions creating an ecological democracy by enshrining environmental rights into an outward looking society. Eckersley (2004) specifies these rights and responsibilities as follows:

- Access to all relevant environmental and risk-associated information,
- participation in environmental impact assessments and decision-making on new technologies,
- compensation when environmental damage is suffered,
- litigation rights for non-governmental organisations to ensure that environmental standards are upheld,
- constitutional changes that ensure independent authorities to represent environmental concerns and public consultations on (transnational) issues, and
- federal states must tackle environmental issues on the federal level with the power to override local authorities.

Such a governance framework would significantly strengthen non-public actors. It “would help integrate the diversity of groups whose activities are relevant to climate change policy” (Giddens, 2009: 119) like non-governmental organisations and businesses which have in the past defined themselves against each other. Hence, it would foster a perception that all actors are relevant for the final outcome, which is crucial to achieve a societal consensus. In addition, Eckersley (2004) aims to include the effects of national decision on people who are living in other countries in the decision-making process. Her motivation “is not to replace states but rather to find more effective and more legitimate ways of addressing the shortcomings of exclusive territorial governance” (Eckersley, 2004: 193). It indicates a relevant issue: The global nature of environmental problems such as climate change challenges the boundaries of sovereign nation states. Hence, national action must be embedded in international action to avoid the discussed problem of free-riding. While this thinking is rather abstract, it gives practical advice on how to form such a green state for example by establishing a “green constitution” which ensures ecological protection would be

a first step as progress towards a transnational green state depends on a “broad cultural shift” (Eckersley, 2004: 245). This requires the interplay of various actors resulting in a vivid public sphere arguing for environmentally friendly behaviour.

McCarthy (2007: 184) concludes that the approach is “powerful, and an important counterpoint to many current political projects that seem prepared to give up on the modern state”. Nevertheless, he points out a relevant weakness: Eckersley (2004) assumes that democratic polities want to build a green state. This must not be the case as they can knowingly decide that they want to ignore climate change. This gives rise to the argument that a strong steering organisation in form of the state that bases its decision on scientific knowledge and is legitimised to act must govern the sustainable transition. When existing structures have failed to tackle environmental problems in the past it was the civil society that drew attention to excessive pollution and environmental degradation.

2.3.2. Civil society actors

An effective and legitimate transition must be “agreeable to large majorities, obtain general consent, and invite their cooperation” (German Advisory Council on Global Change, 2011: 67). This requires collaboration with civil society representatives early in the process because an environmental state “cannot occur without strong political interventions from civil society to overcome resistance to green governance by established forces in the state and industry” (Christoff, 2005: 294). Hence, the civil society assumes an important role as trigger and constant advocate for change. Hale (2010) supports this point by arguing that a major responsibility of environmental activists is to pressure politicians and the public to actively mitigate climate change. In addition, public participation offers improved functionality, fairness and more opportunities for the fulfilment of those that participate (Meadowcroft, 2004). However, the question “[W]here is the support for ecological changes supposed to come from, the support which in many cases would undermine their lifestyles, their consumption habits, their social status and life conditions in what are already truly very uncertain times?” (Beck, 2010: 255) is not yet finally answered. The civil society can be interpreted from a variety of perspectives. It is not a coherent actor but rather a forum of constant exchange and debate. According to Meadowcroft (2004) effective participatory approaches need to adequately represent differing interests, invite participation of stakeholders, show openness to various forms of knowledge and foster societal learning.

Bäckstrand et al. (2010: 3) call the inclusion of the civil society in environmental governance “the deliberative turn” which puts more emphasis on “procedural qualities such as participation, dialogue, transparency and accountability”. The aim is to increase the legitimacy of decision-making. However, including the civil society in a governance regime that remains effective while giving all societal actors access to decision-making procedures is a challenging task. Deliberation is not a cure-all solution. Bäckstrand et al. (2010) identify three lines of critique: First, empirical evidence that higher legitimacy because of public deliberation increases environmental policy output is scarce; second, market forces undermine public deliberation processes; third, it can cause conflicts and resource inequality resulting in interest group politics meaning a scattered landscape of civil society voices with some articulating themselves more effectively than others.

2.3.2.1. ‘Democratic pragmatism’

Dryzek (2005) has labelled the problem-solving discourse concentrating on the civil society ‘democratic pragmatism’. It does not argue for anarchistic self-governing of citizens but aims to include them in the decision-making procedures. It promises to add “legitimacy for decisions by involving a larger public” (Dryzek, 2005: 101) which in turn should increase the effectiveness of decisions. In a later publication Dryzek (2009: 1382) establishes the concept of a deliberative capacity “defined as the extent to which a political system possesses structures to host deliberation that is authentic, inclusive, and consequential“. Polities showing “a high degree of authentic, inclusive, and consequential deliberation” (Dryzek, 2009: 1382) have the most elaborated deliberation system. While no blueprint exists, key components of such a system are: a public space enabling free deliberation, an empowered space that is capable of making decisions, as well as transmission reams that hold the empowered space accountable to the public space and translate the results of the deliberative process into action. While this underlines the importance of the institutional design of a polity, it gives only a vague description how to improve the deliberative capacity.

A variety of policy instruments are available to engage the civil society and contextual variables determine which are best suited. Direct public consultations and legally-binding referendums are the most direct (Meadowcroft, 2004). Other tools at hand are the right to start public consultations and inquiries, require government to ask stakeholders for input to conduct relevant environmental impact assessments and implementing legislation that allows citizens more and easier access to public documents (Dryzek, 2005). While they all mark an important step forward, government remains in firm control of the process. In theory,

deliberative decision-making is based on political equality since by means of “open and reasoned argument, free from manipulation and the exercise of power, better and more legitimate decisions will arise” (Bäckstrand et al., 2010: 5). The proposed policy instruments would not achieve this ideal type, as potential venues of interaction remain limited and state-controlled. This demonstrates the challenge for civil society actors to create new modes of interactions by themselves. Government officials remain the most powerful force because they control the framework.

Civil society groups cover a broad spectrum of topics and advocate contradictory positions. This means that they challenge each other in their quest for influence. For example, while environmental groups call for a green economy, representatives of the fossil fuel era want to sustain the status quo. The latter are particularly important players because they have experience, know how to spin issues in their favour and have ample financial resources. The most influential business companies have emerged during the fossil fuel era and want to avoid major changes that could undermine their strong position. Consequentially, the fossil fuel industry is the driving force of climate change denial (McCright and Dunlap, 2011a). Since governments in capitalistic societies need to “maintain business confidence” (Dryzek, 2005: 118) officials are more likely to listen to representatives of the existing regime as they rely on their cooperation to generate employment possibilities and economic wealth than to proponents of radical change. This underlines that strong influence of current benefitters can stall any progress when they turn into veto players (Christoff and Eckersley, 2011). Hence, civil society actors representing the interest of the fossil fuel era have a stronger negotiating position with government than advocates for radical change. This shows the differing starting points for the various civil society groups in the public deliberation. Adopting the ecological function in their core would strengthen green transition supporters in public deliberations. However, this requires states to change themselves without significant external pressure, which is unlikely given the historical development.

The political culture of some states offers better opportunities for civil society actors than others. Dryzek et al. (2003) determine the scope for societal actors by analysing two dimension of the state structure.

- States are either “inclusive or exclusive in their structure when it comes to interest representation” (Dryzek et al., 2003: 6) of civil society actors. In exclusive states, the number of public actors representing state interests is very small leaving little space for civil society actors to interact with them. Inclusive states offer social movements

many points for interaction or even directly integrate them into the decision-making procedures.

- States are “either passive or active in the kinds of interest representation they allow or seek” (Dryzek et al., 2003: 6) from the civil society. Passive states do not openly approach civil society actors whereas active states engage with the civil society and aim to incorporate its positions.

Combining these two dimensions yields a two by two matrix with four ideal types. Active inclusive states, for example Norway, leave little space for civil society actors because government absorbs their demands in its actions. Under these circumstances few people actively pursue their interest because they are already represented. Hence, an inclusive state can dampen democratic practices if inclusion is too far-reaching. Passive inclusive states like the pluralist United States are different in this regard. Such a state “accepts and accommodates whatever constellation of interests, groups, and movements that social forces generate” (Dryzek et al., 2003: 7). Environmental groups are fighting with other civil society actors over influence on decision-makers. The strongest social groups can likely convince policymakers to take their preferences into account. This gives environmental groups an opportunity to make their case and should foster their growth. However, they often times lose out to stronger lobby groups, in particular business representatives who have more (financial) resources at hand and focus on the impact of certain policies on growth and employment opportunities. Despite these challenges, a passive inclusive state is preferable from an environmental point of view to active exclusive states like the United Kingdom under Prime Minister Thatcher and other countries “under the sway of market liberal ideology” (Dryzek et al., 2003: 9). These states openly fight against societal actors that promote issues contrary to the government doctrine. This undermines organised environmental movements that radicalise. Authorities suppress and marginalise them with all means necessary turning it into the worst setting for social movements. Passive exclusive states on the contrary are most comforting to environmental activists. One example is the legal corporatism of Germany that largely ignores social movements which “can be surprisingly, if unintentionally, beneficial for the democratic vitality of society” (Dryzek et al., 2003: 104). This ignorance “provided the space and impetus for the development of a green public sphere” (Dryzek et al., 2003: 190) resulting in an environmentally conscious bureaucracy.

Table 4: Impact of state structure on social movements

		Structure for civil society representation	
		Active	Passive
Allowed civil society representation	Inclusive	Integrative Norway	Pluralist United States
	Exclusive	Market liberal United Kingdom under Thatcher	Legal corporatism of Germany

Source: Author's compilation based on Dryzek et al. (2003).

In any setting, social movements should aim to develop a “‘dual strategy’ involving action in the state along with continued confrontation from the public sphere” (Dryzek et al., 2003: 193). This ensures that environmental issues remain key priorities under changing political circumstances. Social movements stand a better chance to achieve their goals when environmental protection is at the core of the state since “truly effective inclusion in the state is possible only when the environmental movement (or sections of it) can align its interest with one or more of the imperatives that define the core of the state” (Dryzek et al., 2003: 78). Otherwise, they can only achieve progress in the periphery and have no influence in core topics like security, economy and welfare despite the resources (time and money) they put into their effort.

2.3.2.2. Citizens as ‘change agents’

Leggewie and Welzer (2009) warn that a transition that focuses primarily on output faces an implementation challenge because it ignores civil society, which needs to support the transition as it otherwise will become a crucial veto player. They argue to pay closer attention to behavioural change rather than focussing on innovation that is steered by a “green enlightened monarchy” (Leggewie and Welzer, 2009: 135). Their argument is that a green transition can only succeed if citizens adopt it as their personal project and become “change agents” (Leggewie, 2010: 42). It is primarily the citizens who need to adjust their lifestyle according to new principles. Without behavioural change new low-carbon technologies will not be taken up. The people have the power through their day-to-day behaviour to override profound changes that governments implement top-down. For this reason, the proponents of the low-carbon transition need to develop smart incentives to stimulate less polluting

lifestyles. In addition, (potential) losers of the transition, for example poor households suffering from higher energy prices or people employed in the fossil fuel industry, require a special focus and should be compensated. Otherwise the societal losers will do everything in their power to cling to the status quo and obstruct the transition. It is crucial to convince that part of the civil society that is not closely related to the existing framework of the necessity to initiate a profound change process.

2.3.2.3. 'Transition management'

The Dutch authors who have developed the MLP have presented 'transition management', a concept that describes the transition governance. It can be characterised as "a form of participatory policymaking based on complex systems thinking" (Foxon, 2011: 2259). It aims to foster radical system innovations on the production and consumption side in order to solve environmental problems by transforming the socio-political regime. Transition management envisions to do so by convening everyone interested in so-called 'transition arenas' with the aim of creating radical niche innovations. The arenas should "operate separate from regular policy arenas but the activities of the arenas should influence regular policy" (Nill and Kemp, 2009: 675). The questions arise how this can take place in a real-life context and whether the actors coming together in "any given niche do indeed reflect a new constituency of social interests and opinion" (Berkhout et al., 2004). While Rotmans et al. (2001) argue that government remains a key player encouraging others to participate, independent landscape developments and exogenous shocks limit government capabilities. Hence, transition management "is a new steering concept that relies on 'darwinistic' processes of variation and selection rather than the 'intelligence' of planning" (Nill and Kemp, 2009: 672).

In response to transition management, several critical arguments have been raised. First, transition management puts strong emphasis on the bottom-up dimension which is troublesome because the interaction between the three layers of the MLP is little elaborated (Markard and Truffer, 2008). Hence, it does not recognize innovations ignited at the landscape or regime level as a source of positive change. While this focus on bottom-up niche innovations results in a very optimistic outlook (Meadowcroft, 2005a), it is more likely that a low-carbon future requires a combination of bottom-up and top-down actions (Jänicke, 2008). Second, transition management assumes that niche innovations are in line with the goals of a green economy. However, this does not have to be the case, in particular given the lack of a normative dimension of the MLP. Furthermore, given the innovations decarbonise the economy, transition management assumes that the niche actors develop the adequate

instruments to overcome veto points in the socio-technical regime and landscape. This neglects the political dimension that is necessarily involved in setting societal preferences (Meadowcroft, 2009b) and points again to the lack of normative guidance of the MLP and transition management. Third, since the innovation niches are populated by very few people, democratic concerns arise as it is taken for granted that “the visions and policies emerging from transition arenas will be accepted and deemed legitimate by the broader public” (Hendriks, 2009: 343). Hence, transition management is an approach that introduces management into the MLP but shows the same weaknesses that have been discussed above.

2.3.3. Private actors

Private actors are a key group in the green transition process. For example, the discussion of civil society actors has touched upon the important influence of fossil fuel representatives. A successful transition requires that private actors assume a greener stance to push public actors into greening the macroeconomic framework conditions. Analytical approaches addressing the role of private actors vary widely in their intent, depending on their ideological basis. A majority of strands of economic thinking are represented – from neo-Marxist to neoclassical. Nonetheless, the growing size of the green economy attracts more businesses and consumers. This is important since business “will have to supply a good deal of the funding and also pioneer new technologies” (Giddens, 2009: 123) during the transition process.

2.3.3.1. *The neo-Marxist ‘treadmill of production’*

While the first environmental activists arguing in economical terms developed the neo-Marxist ‘treadmill of production’ approach, its influence has vanished in recent years. It takes a hostile stance towards business by assuming that the economic rational always outweighs other considerations. Its major concepts are ‘withdrawals from’ and ‘additions to’ the environment for reasons of production. “These ecological withdrawals”, which are essentially environmental resources used for production, “led to one set of environmental problems, natural resource depletion”, and the second ecological problem “termed additions to the ecosystem” (Schnaiberg et al., 2002: 16); that is, pollution from all kinds of production processes that is not cleaned up.

The approach assumes that the primary goal of businesses is economic expansion at all costs – best achieved by large firms. Their creation requires alliances among capital, labour and governments. This means that the state for the most part cedes its power to intervene to private actors. Proponents of this school of thought argue that “it is increasingly true that any

environmental policymaking is subject to more intensive economic scrutiny, while economic policies are subject to less and less environmental assessment” (Schnaiberg et al., 2002: 21). In this context of economic primacy it would be almost impossible to achieve ecological preservation in particular because the companies have no inherent interest to reduce environmental degradation. Schnaiberg et al. (2002: 29) argue that firms that improve their ecological performance do so for one of three reasons: “(1) firms were forced by regulation or social movement action to make improvements; (2) they made improvements only when their economic bottom line would be secure; or (3) they achieved the appearance of improvements through ‘creative accounting’ or misreporting.” In general, the treadmill of production approach does not allow any change towards the better under the existing political and economic framework. It argues for a revolution to solve environmental problems. This approach has lost influence with the growing green economy because it can hardly explain this development. Hence, newer approaches develop various economic incentives to behave environmentally friendly and include market-based tools.

2.3.3.2. *‘Economic rationalism’*

Another extreme is to understand people as economic humans. In this understanding they become consumers guided by “selfish materialism of consumer values” in contrast to citizens which “are more concerned with collective, community-oriented values” (Dryzek, 2005: 113). Hence, in theory, consumers act purely out of their economic self-interest rather than to achieve a larger normative goal for society. However, Spaargaren and Mol (2008) note that this clear distinction between citizen and consumers is blurring as citizens become active in the marketplace and consumers exert their influence on public goods. The environment is regarded as an economic resource base without any inherent value. The entire social life is regulated by market activities, which are triggered by price signals. Dryzek (2005: 121) labels this problem-solving discourse ‘economic rationalism’ which “may be defined by its commitment to the intelligent deployment of market mechanisms to achieve public ends”. From this perspective, state regulation is always a reason for market failure that disturbs the most efficient resource allocation. Public actors only assign and enforce private property rights. Hence, proponents of a radical understanding of economic rationalism often forget that it is government that establishes and frames markets. The ambiguous treatment of government as the advocates of this radical understanding cannot solve this paradox. This has resulted in “economic rationalists who advocate not wholesale privatization and private property rights, but rather market-type mechanisms and economic incentives to induce environmentally

appropriate behaviour” (Dryzek, 2005: 128) gaining influence. In this moderate approach consumers regain their citizenship. So-called “citizen-consumers” break down “the separation of nationally articulated political preferences of sustainable development and globally organised economic practices” (Spaargaren and Mol, 2008: 355).

This perspective materialises in market-based or economic environmental policy instruments, such as, “eco-taxes and subsidies based on a mix of regulation and market incentives, voluntary agreements, certification and eco-labelling, and informational systems” (Lemos and Agrawal, 2009: 76) which have gained prominence as they are more efficient than command and control regulation.²³ Their success depends “on the internalization of positive environment preferences among relevant stakeholders, most importantly citizens and consumers” (Lemos and Agrawal, 2009: 77). Markets achieving environmental ends require the state to implement the price incentives in the macroeconomic framework, businesses that respond to these signals by reducing pollution in order to lower prices and citizens that base their buying decision on prices and ecological impact. Depending on the innovations that are taking place, this requires adjustments to existing market designs (Matthes, 2009). Public planning must set the framework and ensure long-term stability underlining the importance of collaboration between the actors.

2.3.3.3. Greening the marketplace

Economic rationalism has demonstrated that business and consumers are two sides of one coin: Demand for green goods creates supply and this results in new and improved goods stimulating demand. However, the green market does not necessarily lower the amount of consumed goods but it ensures that the environmental quality of the purchased products is better. For example, less or recycled resources are used in the production chain, new and more environmentally friendly production techniques have been implied. While the evolving green market is an important factor of the transition process, it can easily result in rebound effects, which can potentially increase overall GHG emissions.

The question “who has the power and motivation to act to change consumer behaviour – the consumers themselves, the producers, the government” (Witt, 2011: 113) or someone else, remains unanswered. Various preconditions need to be met for green consumption to become a major market force: consumers must believe that climate change is happening, comparable alternatives must be available and consumers must be motivated to buy low-carbon

²³ See chapter ‘3.3.1.1. Pricing carbon to level the playing field’ for a discussion of carbon pricing mechanisms.

alternatives which they trust to make an environmental impact (Szusz, 2011). While these preconditions are difficult to meet, the number of market participants including ecological concerns in their buying decision is growing steadily. Citizens become change agents by making conscious and informed decisions. Demand for green goods should also stem from the public sphere. States are a huge source of demand in a national economy: If they turn themselves into green consumers, they can significantly influence the marketplace.²⁴

Besides increasing demand for green goods and services, two other reasons explain the emergence of environmentally sensitive businesses: “the external pressures on businesses that stem from governments, markets and civil society, and the internal conditions within businesses that relate to their governance structures, corporate cultures and capacities for innovation“ (Gouldson, 2008: 4618). The Porter induced innovation hypothesis supports the view that business can profit from environmental regulation “that are more stringent (or are imposed earlier) than those faced by their competitors in other countries” (Porter and van der Linde, 1995: 98). This would result in an increase of competitiveness of private actors because of state actions. While empirical evidence supporting the Porter hypothesis is inconclusive, “it reminds us that a particularly ingrained piece of conventional wisdom (‘environmental regulation reduces firm competitiveness’) is frequently wrong” (Tietenberg and Lewis, 2009: 586).

While environmental front runners can make large profits in this growing green market, remaining within the fossil fuel status quo promises even bigger profits in most cases (Dryzek et al., 2011). Nonetheless, many companies have identified this green market potential and adopt their business model voluntarily. The motivation to do so varies: It can be “in response to price mechanisms or to other incentives, to comply with specific emission reduction regulations (or in their anticipation), in order to enhance their reputation, to differentiate products and to attract investors” (Organisation for Economic Co-operation and Development, 2010: 52). Many companies even adopt their business models voluntarily at the price of increasing production costs. This is surprising from a theoretical point of view: Neoclassical economics assumes that business only acts on environmental issues that are associated with additional costs if they are forced to do so by public regulation. Hence, other reasons must explain this behaviour. One reason is “the opportunity to influence public or private politics that makes corporate environmentalism profitable” (Lyon, 2009: 58). Furthermore, businesses adopt voluntary measures because they fear more stringent

²⁴ See chapter ‘3.3.2.2. Innovation stage’ for a more elaborated discussion of public procurement.

regulation in the future (Baron and Lyon, 2011). Hence, the state is key since the threat of regulation causes action. As a result, many ecological front runners request reliable and realistic long-term plans from governments as the basis for their planning (Organisation for Economic Co-operation and Development, 2010). Finally, Giddens (2009: 122) argues that businesses become more environmentally aware “because the message of need for change has struck home”. This would be an important step for the green transition since it is difficult to reverse and would signal a low-carbon lock-in.

Companies can face a trust issue when promoting themselves as green. While many companies work closely together with environmental non-governmental organisations to reduce their environmental footprint, companies are criticised for not living up to their promises (Baron and Lyon, 2011). So-called ‘green-washing’ describing that companies create “a green ceremonial façade” (Forbes and Jermier, 2011: 561) is a major problem that undermines trust. It is not limited to the private sector but can also describe government action (Fitzpatrick, 2011b). Focussing on a few environmental achievements while neglecting a variety of other issues is an often-applied strategy in this context. However, meeting certain standards, such as achieving GHG emissions reductions throughout the supply chain as well as measuring and verifying the results by third-party auditors and publishing the results, can overcome these concerns.

2.4. Ecological modernisation integrates key theoretical ideas

This review has shown “theoretical fragmentation and eclecticism” (Meadowcroft, 2005a: 483) in the field of transition studies and environmental governance. In this situation ecological modernisation makes “the strongest claim to the status of a ‘general’ theory” (Meadowcroft, 2005a: 481). It describes how a reorganization of existing structures in government, business and society combined with technological innovation can achieve improved environmental protection within free-market economies. Hajer (1995: 25) defines it “as the discourse that recognizes the structural character of the environmental problematique but nonetheless assumes that existing political, economical, and social institutions can internalize the care for the environment”. This means that green growth is possible by identifying win-win trade-offs between economic and environmental issues resulting in profits for business and a reduction of environmental degradation. This means that a decoupling between economic growth and ecological degradation is possible when environmental protection becomes a state function. Different positions are articulated whether this decoupling is relative (the environmental impact is reduced in relation to GDP) or

absolute (the impact on the environment declines in absolute terms none withstanding economic development) (Jackson, 2009). The thinking has been applied as a policy prescription: Several western European governments have been inspired by it and Giddens (1998) has dedicated a sub-chapter in his landmark book ‘The Third Way’ to ecological modernization.²⁵ On the policy level, it is based on environmental planning, ecological tax reform and targeted support for green innovation (Jänicke et al., 2003). Hence, it combines many ingredients of a green transition.

Christoff (1996) has introduced a useful distinction between weak and strong ecological modernisation. Whereas weak ecological modernisation addresses environmental concerns in the free-market framework of production and consumption, it does not entail a profound transformation of state, society and business along green lines and “amounts to little more than a cost minimization strategy for industry” (Eckersley, 2004: 70). Others assume that “weak ecological modernization ultimately fails to deliver on its promise of securely connecting ecological aims to core state imperatives” (Dryzek, 2005: 168). Strong ecological modernisation in contrast “resists subordinating ecology to economics, is attentive to interactions among a broad array of political, economic, and social institutions, favours communicative rationality and participatory public deliberation, accepts and indeed requires movement activism, and recognizes transnational aspects of nature” (Dryzek et al., 2003: 169).

This understanding of ecological modernisation is closely related to the transition to a green economy. Political innovations similar to the ones discussed above such as market actors pushing for environmental protection and the civil society closely involved in the decision-making process are key elements (Mol, 2006). The existence of a strong environmental movement as the voice that advocates further change when progress is stalling is of particular importance (Dryzek et al., 2003). To achieve strong ecological modernisation, states need good “communicative, strategic, integrative, and implementation capacities” (Christoff, 2005: 296). The communicative competence addresses the creation of open spaces for all societal actors to engage in an exchange of ideas in order to increase the legitimacy of the decision-making process. The strategic dimension offers a point of view “from which to recognize environmental problems, develop policy, and make strategic decisions that would lead to ecologically sustainable outcomes for the “whole of society” and the “whole of nature” if implemented effectively” (Christoff, 2005: 297). This integrative function has an external

²⁵ This book strongly influenced the programme of ‘New Labour’ and the Tony Blair-led government in the United Kingdom.

focus, involving “the state in generating, participating in, and perhaps managing policy coalitions and networks that reach beyond itself – connecting government, industry, and community, both sectorally and cross-sectorally”, as well as an internal focus that “involves policy integration that leads to the comprehensive, consistent, and effective incorporation of ecological principles into policy work” (Christoff, 2005: 298). Finally, the results of these three capacities need to be implemented. Hence, the implementation capacity reflects “the state’s bureaucratic/ administrative, economic, legal, regulatory/ enforcement, and cognitive/ informational activities” (Christoff, 2005: 299).

2.5.Recapitulation

This chapter has critically reviewed the existing green transition and environmental governance literature. It establishes that transitions are complex and unsteady long-term processes based on a restructuring of societal preferences towards sustainability. Key concepts in the transition literature are the MLP and TIS approach. However, both fail to explicitly conceptualise the normative dimension and the role of actors in the green transition. In response to this shortcoming the review turned to literature on the development of the environmental state and the role of various actors. States have not yet assumed environmental protection as a core function as they have done with generating economic growth and securing social welfare. Nonetheless, they are a crucial steering actor. This shows that the state is subject and object of the green transition: It is a key player in the transition process but at the same time needs to undergo considerable change itself. It needs to cooperate with the civil society and private actors who assume key roles. Public authorities need to learn how to integrate the other players more efficiently: The civil society increases legitimacy for environmental governance and acts as a constant advocate for change. However, it is multi-faceted and will include many members of the fossil fuel regime that cling to the status quo. Private actors can green the marketplace by supplying and demanding green goods and services. In addition, they play a key role in financing the transition. Table 5 gives an overview of the various analytical approaches discussed.

Table 5: Academic discourses on green transition governance

Academic discourse	Key authors	What is the driving force?
Administrative rationalism	Dryzek (2005)	Public bureaucracy

Ensuring state	Giddens (2009)	State actors assume a coordinating role
Critical political ecology	Eckersley (2004)	State actors open up to the civil society
Democratic pragmatism	Dryzek (2005)	State enables civil society
Change agents	Leggewie and Welzer (2009)	Citizens as change agents
Transition management	Rotmans and Loorbach (2010)	Small networks of fringe actors
Treadmill of production	Schnaiberg et al. (2002)	Business activity necessarily destroys the environment
Economic rationalism	Dryzek (2005)	Market actors

Source: Author's compilation.

Ecological modernisation is closest to combining these aspects in a single analytical approach. It establishes that green growth describing a decoupling between environmental degradation and economic growth is possible. A key distinction is made between weak and strong ecological modernisation with the first having little impact and the latter representing a clear break with the status quo and a profound overhaul of the economic system. This requires strong communicative, strategic, integrative, and implementation capacities by a polity. While this would be an important step towards a green economy, it has not yet been achieved in reality to date.

3. Analytical model of green transition governance

The transition to a green economy is a profound overhaul of existing socio-economic structures. It will deeply affect politics, polity and policy and result in the profound overhaul of societies. Hence, it affects existing institutions, actor constellations and a variety of policy fields, such as the taxation, employment, innovation and welfare to name just a few. New technologies will prevail that require an adapted infrastructure and different behavioural patterns. The literature review has shown that a comprehensive theory capable of predicting future success remains missing but that it requires a reconfiguration of the entire political trias consisting of politics (process of resolving conflicts that result in the decision-making procedures), polity (formal, value-oriented and institutional organisation of a state) and policy (contextual to the policy field (economic, social, etc.) that it analyses. At the same time, little real-life experience exists as there is “not a single low-carbon model country to serve as an orientation guide for reform processes in other countries” (German Advisory Council on Global Change, 2011: 83), and thus, there is no blueprint to follow. However, the complexity does not mean that the transition cannot be managed as postulated by Shove and Walker (2007). This chapter introduces an analytical model that establishes several points of potential state intervention. Because of various feedback loops and the coevolutionary nature of the transition, in particular the indirect consequences of interventions are largely unknown.

This analytical transition model points out primarily for public actors how to govern the transition process. Since the state is object and subject of the transition at the same time, the model demonstrates the importance of the state as a driving force while also elaborating how several of its functions need to change to achieve a significant decoupling of economic activity from environmental damage. The result is a three-layered analytical model, which describes transitions largely from a top-down perspective but also enables bottom-up initiatives even if they assume a lesser role. The model captures profound green transitions that encompass broad-reaching change processes over long time frames governed by various actors. The goal is to support decision-makers governing a green transition with an analytical lens to study their efforts. The following elaborates the three layers – political leadership, transmission belts and key functions – in more detail:

- The green economy requires a strong political will to break with the existing fossil fuel era. Public actors need to show leadership by putting the transition on the agenda and driving it forward. Meadowcroft (2009a) states that political leadership is the single most relevant variable for successful climate change governance. Since this area

is closely related to the green economy, the model assumes that this holds true as well for transition governance. The findings of the case studies underline this assumption. Political leaders, in general the heads of government, have the power to rank societal priorities with lasting impact on spending decisions, infrastructure development and the economic framework (Meadowcroft, 2009b). Furthermore, they can elevate environmental issues on the agenda. When this takes place, like in the European Union and in China, it results in a radical “change in criteria that actors use to judge the appropriateness of products, services and systems” (Kemp and van Lente, 2011: 122). Without this societal agreement, like in the United States that is characterised by political polarisation resulting in a stalemate, decision-makers lack the necessary support to take adequate action. A green transition without public authorities taking the lead the green transition is almost inconceivable despite the potential of civil society and/or business to pressure for change because their activities depend on state interaction.

- Transmission belts need to translate the political will into a reconfiguration of key functions that have an impact on the ground. Ensuring a coherent green governance regime requires institutional change because the existing regime has been built to cater to the needs of the fossil fuel era. While polity is in general the most stable element of the trias, a rearrangement of societal preferences challenges it to adopt accordingly. Since social change often precedes institutional change in democratic societies, growing environmental awareness in society helps to adjust the polity accordingly (Unruh, 2002). Two key challenges face the green transition governance in this regard. First, it must ensure that all public actors across thematic as well as regional boundaries adopt the green transition as a cross-cutting task. EPI on the horizontal and vertical level is crucial in this context. Second, the governance regime needs to solve the problem of time inconsistency “defined as a situation in which an actor’s best plan for some future period of time will no longer be optimal when that time actually arrives” (Underdal, 2010: 387). This means that measures need to be in place that once started the change process can withstand changing political majorities to guarantee a stable framework over a long time frame. While institutions, “the rules of the game in a society” (North, 1990: 3), change only slowly, solving the coordination and time consistency problems at short notice is feasible. Since all polities are capable of implementing the necessary changes according to their political tradition and existing

frameworks, a broad array of set-ups is likely to arise. Similar interventions can result in contradictory outcomes.

- Three key functions – economic framework, innovation capacity and a fair distribution of costs and rewards – need to adapt to realise a meaningful greening of reality. The economic and social function mirror the respective state function whereas the innovation function reflects the TIS approach and ecological modernisation, which both stress that through innovation a decoupling of environmental degradation and economic growth can take place. Adjusted policies foster a transition in these areas. The economic framework is crucial to greening the markets and shifting employment opportunities as well as setting incentives for green innovation. Greening the innovation cycle in order to develop low-carbon technologies and goods is crucial. History underlines the importance of innovation since the second industrial revolution (end of the 19th century) became a success because of “close links between invention, innovation and diffusion processes” (German Advisory Council on Global Change, 2011: 89). An innovative mindset met circumstances that allowed new ideas to be turned into reality. This means that during the second industrial revolution a well-trained workforce was capable of applying the latest research results and operating the resulting technologies and market penetration was ensured because of high investment quotas. Social justice of the process is key in order to ensure broad public support.
 - Greening the economic framework: Currently, most marketplaces ignore environmental degradation. Since the price mechanism does not include negative externalities, it favours fossil fuel based technologies despite their negative impact on the environment and hinders the development and deployment of green goods and services. A reconfigured macroeconomic framework must channel investments into a decarbonisation of production processes.²⁶ This requires carbon pricing in order to include the environmental costs in market transaction and a revision of the subsidy regime. The strong vested interest of currently profiting industries needs to be overcome (Barbier, 2011). These changes would significantly alter the labour market by strengthening green jobs that require a different skill set than existing employment opportunities.
 - Enhancing green technological innovation: Innovation policy is at the “core of transforming an economy“ (Organisation for Economic Co-operation and

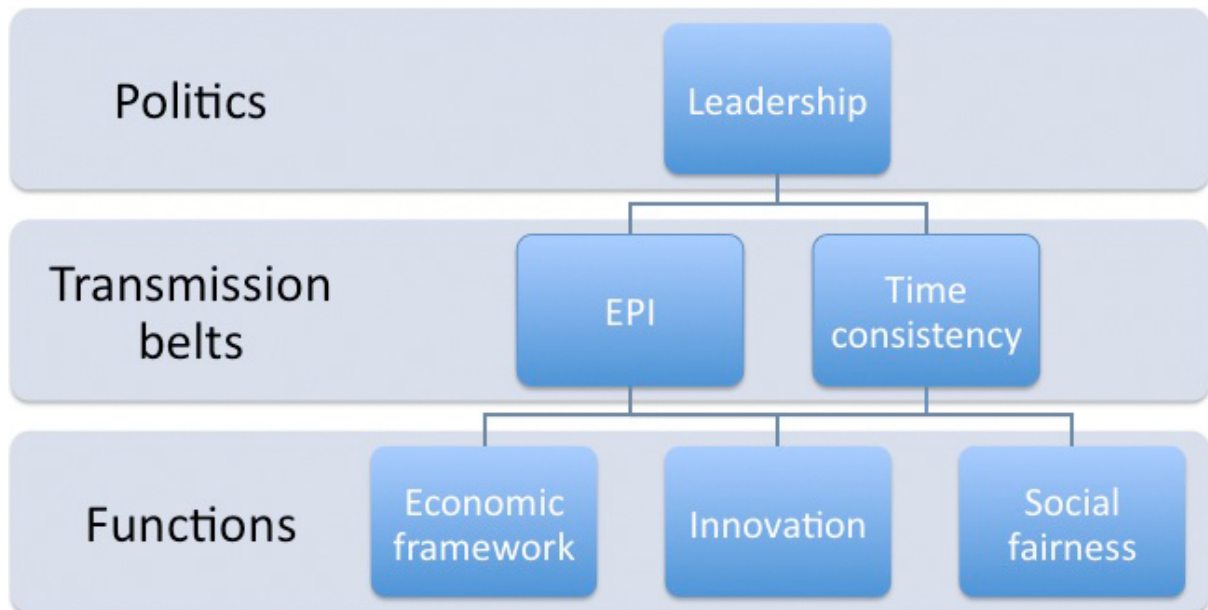
²⁶ Macroeconomics studies economy-wide phenomena and collective behaviour, which is shaped by individual decisions on a variety of markets that are studied by microeconomic analysis (Burda and Wyplosz, 2009).

Development, 2011d: 51) since it produces new technologies. Decoupling GHG emissions from economic growth will require radical technical and social innovations. The discussion of the innovation-centred transition literature has shown that normative considerations play a key role for green innovation. While innovation in the traditional understanding aims to stimulate economic growth, sustainable innovations aim to reduce resource use, which is not necessarily economically efficient. The emphasis on reducing the environmental impact of goods and services is not yet included in market prices without carbon pricing in place. This calls for government to shape innovation systems that strengthen green innovations through all stages of the innovation cycle.

- Distributional fairness of costs and rewards: Transitions resulting in shifting markets create winners and losers. As cleaner technologies increase their market share, fossil fuel intense industries will see either have to significantly alter their business models, which is costly and reduces their benefit margins or see a reduced role. This creates strong opposition from these industries and its allies, which are in a strong position because they are crucial pillars of the fossil fuel era. Hence, compensating them could avoid creating insurmountable veto players.²⁷ While addressing them does not solve all problems, neglecting them will most likely lead to opposition (De Serres et al., 2011). This is particularly important since it will take time until the benefits of a transition manifest themselves.

Figure 6: Analytical model of green transition governance

²⁷ However, some legal constraints might have to be overcome since international trade rules could pose a challenge to compensation.



Source: Author's compilation.

The coevolutionary framework points out that all these aspects are interrelated through a fine net of feedback loops. As a result, it assumes that the profound change process is severely more than just a change from one technology to another. It is important to elaborate possible links between the six dimensions in order to understand the complexity of the endeavour. The case studies will show that a variety of positive as well as negative feedback loops are already taking place at the early transition stages whereas other are expected to manifest at later stages of the transition.

- Political leadership is in general time limited. Hence, the long-term outlook depends on measures to overcome time inconsistency. Otherwise political leadership does not result in lasting change. On the other hand, politicians need to prevail over institutional barriers such as political fragmentation. This means that political leadership must reach all government levels and administrative layers as otherwise the impact of leadership is limited. The functions have strong impact on leadership potential: A growing green economy is a strong argument for politicians whereas a collapse of the old economy without growth in the new economy spells trouble. Innovations can potentially increase the speed of change and signal success. The social dimension is important politically as unfair distribution of costs can undermine public support and negatively affect the political agenda.

- Transmission belts have strong implications towards political leadership and the functions since they link the two. If they do not work properly, political leadership does not translate into action but remains limited to rhetoric. Hence, political leaders need to find ways to change the functions by being time consistent and establishing the green transition as a cross-cutting issue. The interplay of the long- and short-term dimension of the polity is mutually reinforcing: Strong signals for a stable framework over time signal to all government actors that the transition is serious. This means that the policymakers follow it and when they are taking a more proactive role they become part of a time consistent framework. Otherwise, decision-makers in highly complex bureaucratic organisations can undermine political leadership through turf wars and other measures at their disposal. However, the institutions also need to take into account the bottom-up feedback from actors that carry out the functions. Hence, the transmission belts need to communicate to the political leaders whether the business community that largely carries out the economic function, the technological community that carries out the innovation function and the civil society that carries out the social control function is following this greening path. Without this feedback, the political level will miss critical information needed to map a realistic transition pathway. Hence, the transmission belts need to work well in order to ensure a smooth cooperation of bottom-up and top-down mechanisms.
- The functions interact with each other as well as with the other layers of the analytical model as has been elaborated above. From the point of view of the functions, the institutional framework needs to offer opportunities to enter key innovations in their respective fields into the overall design of the transition governance. Otherwise, it limits the scope of action for the actors in their fields and they might feel ignored. In addition, they can enter coalitions with the political leadership and try to do their best to keep the issues high on the agenda.

More difficult is the interplay of the three functions: The shifting economic and innovation landscapes challenge the welfare system because they result in significantly altered redistribution of costs and rewards. Two outcomes are possible: Either tools such as carbon pricing generate new revenue sources that can be used to fund welfare benefits or the necessary investments to decarbonise the economy put financial pressure on the welfare system. For this reason, opportunity costs need to be analysed since money can only be spent once. An unjust distribution of social costs can derail a transition process by creating strong veto players that will oppose change

because they fear losing their current position. This means that the economic function needs to set the right incentives for innovation without overburdening society with additional costs either through spending or burdens on the existing economy. The innovation capacity depends partly on the macroeconomic framework (for example whether carbon pricing is in place) and only partly on its own creativity and design. However, it can lessen the burden on society by developing smart appliances that are user-friendly and reduce costs for parts of the society.

In order to demonstrate these feedback loops in more detail Table 6 presents an overview of feedback loops within the analytical model as found in the case studies. The emphasis is on positive trade-offs for a green transition process. Improvements in one can positively affect other areas. However, the case studies will also show that lacking action in certain areas can trigger negative feedback loops.

Table 6: Feedback loops within the analytical model²⁸

	Political leadership	EPI	Time consistency	Economic framework	Innovation	Social fairness
Political leadership	=====	In the EU, multi-level negotiations deeply entrench the green transition	In the EU, political capital invested in strategies and targets gives the transition governance credibility	In the EU, a carbon price is the key political framework change to	In China, the push for electro mobility enable high investments into R&D policy	In theory, political leadership can use social policy to buy-off opposition to the green economy
EPI	In the US, state initiatives partly fill the federal leadership void	=====	In the EU, despite EPI being a key governance principle, it has so far rarely improved time consistency	In theory, EPI can translate changing economic incentives to all relevant policy areas	In theory, EPI can bring new business sectors into contact to develop low-carbon innovations	In theory, the distribution effects of various policy fields can require social intervention

²⁸ The table always concentrates on the impact of the left-hand side on the top row.

Time consistency	In the EU, strategies bind future decision-maker to the long-term approach	In the EU, the strategy approach has brought together policy areas that were treated separately before	=====	In the US, the lack of time consistency has avoided crucial long-term investments	In the US, the lack of time consistency has avoided R&D efforts	In theory adopting the complex welfare net depends on time consistency to avoid quick fixes
Economic framework	In the US, growing employment in renewables is a strong political argument	In the EU, a broader carbon price supports greening in other economic sectors	In theory, consistent investments into green goods and services can stabilise the industry	=====	In the EU, the carbon price should steer investments towards low-carbon technologies	In theory, new revenue sources can allow new welfare benefits
Innovation	In theory, new and cheaper technology can generate public support	In theory, it can bring co-existing sectors into contact (for example, auto and energy in China)	In theory, new and improved technology can create low-carbon lock-in effects	In the US, falling prices because of innovations increase the economic viability of renewables	=====	In the EU, new technology can allow fairer pricing mechanisms
Social fairness	In theory, social fairness stabilises political leadership by avoiding veto players	In theory, a fair distribution of cost and rewards can overcome tension between policy areas	In theory, a growing share of transition winners generates public support	In theory, welfare benefits can offset rising prices	In theory, a working social safety net can avoid strong social turbulences through innovation	=====

Source: Author's compilation.

The necessary changes and their inter-relatedness underline that the states needs to steer the transition process, in particular at the beginning when the support is not yet fully secured. However, as mentioned, it is a subject of the transition as well as shown through the need for changing functions. Currently many policy instruments needed for greening are not in place because the incentive structure for state actors currently points towards upholding the status quo. Thus, for a successful green transition, the ecological state function needs to achieve a

similar standing as the economic state function. This would improve the standing of ecological issues but touches the core of the state. Hence, this needs to undergo a severe shift to support and steady the green transition. Otherwise, the fossil fuel dependence engrained in the current status quo is likely to return despite temporary progress towards a green economy.

The following elaborates the analytical model in more detail. While so far, the three layers have been introduced and a first overview of feedback loops has been given, the following will look at each part of the model in more detail. In order to follow the three layers, it starts with political leadership followed by the transmission belts that are analysed in this model namely policy integration and a stable framework over time before taking a closer look at the three key policy functions, the macroeconomic framework, the innovation cycle and the distribution of costs and rewards. For each of the six parts the following elaborates more closely what is meant with the dimension and which steering potential exists. In addition, the following will give a first broad and brief overview over the current status of the three cases in order to lay the groundwork for the case studies to follow later. This will show the significant differences that exist between the three cases. However, it will also map out how their respective transition trajectories might look like, which particular capacities they hold and which challenges they face. This is only a prelude to the in-depth case studies to follow below.

3.1. Political leadership

Leadership is “a process of influence that occurs between leaders and their followers and involves establishing direction (a shared vision), aligning resources, generating motivation and providing inspiration” (Taylor et al., 2012: 84). The realignment of societal priorities – a key part of the green transition – is a highly political task underlining the importance not only of leadership, but of political leadership (Meadowcroft, 2009b, Shove and Walker, 2007). Because of the hierarchical nature of politics ‘formal leaders’ who assume the leadership role through their formal position are more important in this context than ‘emergent leaders’ who deliberately embrace this position (Taylor et al., 2012). Political leaders are in general legitimated to enact binding measures for a society; they have the power to steer the transition process. This stresses that legitimacy and credibility are key to successful leadership (Parker and Karlsson, 2010) since otherwise leadership is unlikely to result in change. This points to a key feedback loop for any type of political leadership: If leadership limits itself to rhetoric without action, it is meaningless. Hence, decision-makers need to ensure that transmission belts translate their changed set of preferences into reality.

Green leadership can take three forms: structural meaning the “ability to take actions or deploy power resources that create incentives, costs and benefits in a particular issue area”, directional as “unilateral action ... is accomplished by the demonstration effects of leading by example”, and idea-based involving “problem naming and framing and the promotion of particular policy solutions” (Parker and Karlsson, 2010: 926). Coming back to the dual role of the state as subject and object of the transition, several explanations are available why political leaders that have failed to tackle environmental problems in the past, will do so in the future. One argument is that they are now morally motivated to lead the sustainable transition: growing environmentally consciousness (for example within members of green parties) increases the chance of taking leadership in environmental policy (Knill et al., 2010). Hence, it is another key task for the transmission belts to allow decision-makers to assess how much support they have for their shift to a green transition. This determines how much political capital decision-makers invest even though short-term political and financial costs continue to influence their decisions. Furthermore, politicians who want to retain their position need to respect the respective socio-political context. In democratic states politicians must ensure their re-election and in authoritarian regimes they need to ensure the approval of other key actors (Harrison and McIntosh Sundstrom, 2010). This means that electoral approval is a key explanatory variable of the behaviour of politicians. Hence, changing public opinion can have a lasting impact. If voters’ preferences are ambiguous, politicians rely more strongly on special interest groups. Political leaders have a hard time leading without grass-roots support in pluralistic societies. Hence, top-level decision-makers are more likely to achieve progress when they collaborate with civil society and the private sector. These so-called reflexive planning approaches face a dilemma: “On the one hand, the requirement is not to suppress diversity, but to nurture bottom-up spontaneous developments that are open to ambivalence and contestation, and to retain adaptability towards the complex dynamics of change. On the other hand, there remains a requirement to achieve coordination, to take a synoptic view on broader developments, to close down contingency, to fix long-term goals for orientation and mobilization.” (Voß et al., 2009: 289)

A key task for political leaders who pursue the green transition is to keep it on the public agenda against their opponents. The agenda according to a seminal study by Kingdon (1995: 3) “is the list of subjects or problems to which government officials, and people outside of government closely associated with those officials, are paying some serious attention at any given time. ... Out of the set of all conceivable subjects or problems to which officials could be paying attention, they do in fact seriously attend to some rather than others. So the agenda-

setting process narrows this set of conceivable subjects to the set that actually becomes the focus of attention.” Hence, putting issues on the decision agenda for government is the first step in the policy cycle (Howlett et al., 2003).²⁹ Pralle (2009) takes four insights from the broader agenda-setting literature: First, a public agenda deals with the electorate, a governmental agenda bundles government institutions, and a decision agenda are the issues that government authorities decide on; second, a ‘carrying capacity’ limits the issues that each of these agendas can handle; third, issues rather move on a continuum on the agenda-setting scale than that they are on or off the agenda; fourth, highly salient issues are most relevant for the decision-making agenda. It is of particular importance to use arising windows of opportunities.

The salience of an issue is influenced by its severity, incidence, novelty, proximity, and crisis nature (Rochefort and Cobb, 1994). Problems that need to be taken more seriously because of their consequences are higher on the agenda. Hence, extreme weather events that manifest a changing climate increase the salience. Since climate change is already on the agenda, other issues might begin to overshadow it. Hence, it is important to constantly redefine information. Proximity describes that the closer the impact is to personal life, the higher the salience. Finally, crisis nature describes the perception of a problem. In order to increase the crisis nature, concentrating the support in an advocacy coalition for climate change action makes the green transition highly salient to as many decision-makers as possible. This can shift electoral incentives (Harrison and McIntosh Sundstrom, 2010). Pralle (2009) recommends several other activities to increase the salience of climate change on the policy agenda which could be taken up by the advocacy coalition: report key data and stress the academic consensus that climate change is anthropogenic, point to growing public concern and arising local problems, emphasize human health impacts and depending on the circumstances stress the moral dimension. Most importantly, solutions to the climate challenge need to be presented because “problems without attached solutions are less apt to rise high on governmental agendas and are unlikely to make it onto decision agendas at all” (Pralle, 2009: 793). From an environmental perspective, countries that frame the challenge in terms of energy security rather than climate change are said to have an advantage (Giddens, 2009). This reflects that economical concerns remain key to decision-makers under the existing framework. Hence, combining environmental with economic reasoning is beneficial from an ecological point of view.

²⁹ While various models of the policy cycle have been presented, the following steps generally are: policy formulation, decision-making, policy implementation and policy evaluation. From this point the cycle starts again.

3.1.1. Operationalisation and current status of the three cases

To operationalise leadership is difficult. It is best recognised when actually taking place. However, only relevant political actors can carry out political leadership. Hence, identifying them is a first step of analysing their leadership efforts. Furthermore, statements and actions by top-level politicians show whether they aspire to green leadership. However, only when statements are followed up by significant action they mark real political leadership. The overview has shown that besides legislative and policy initiatives, efforts to put the greening high on the political agenda are key indicator of political leadership. However, another factor influencing the position on the agenda is the public perception of environmental problems (in particular climate change). For this reason the following maps for each case the key political actors that can show leadership as well as the public opinion on the issue. A more detailed analysis of each case follows with regard to the chosen technology area in the case studies. However, already it becomes obvious that the three cases start out their transition efforts from very different starting points. This shows that various types of political leadership are the drivers of the transition efforts.

China

China is an authoritarian regime – electoral incentives do not exist and the role of non-state actors is limited. The president, currently Xi Jinping, is at the same time the party leader (General Secretary of the Central Committee and Chairman of the Central Military Commission) and the Premier of the State Council, currently Li Keqiang, is at the same time the Party Secretary of the State Council. Often times, government authorities are the public face, whereas the true power lies within the CPC, which is very secretive (McGregor, 2010).³⁰ The main central state actors on electro mobility are the Ministry of Science and Technology, the Ministry of Industry and Information Technology, the National Development and Reform Commission (in particular the Energy Bureau) and the Ministry of Finance (Kokko and Liu, 2012, Liu and Kokko, 2013). They all are responsible for certain parts of the framework (elaborated below) and need to interact in order to establish a coherent framework. The automotive industry is dominated by state-owned enterprises and international joint ventures (Gallagher, 2006). Given this state-centred one-party system, policies require strong political backing to be implemented since private actors and civil society actors are widely state-controlled. This means that political leadership is equal to finding support among other key

³⁰ The importance of documents reflects this, too: Party documents are more important than a law (Liu et al., 2011).

CPC officials. While Chinese political leaders have recognised that they need to improve their capabilities to keep a thermometer on social developments, they are at times isolated from societal developments. Historically, Chinese ruling elites have been in power for about ten years before they were replaced by the following generation. The current leadership entered office between the fall of 2012 and spring of 2013. Hence, they stand at the beginning of their reign. For this reason little is known about their planned actions. However, signing for the first time a bilateral accord to mitigate climate change with the United States shows that they are willing to take the lead on these issues (Landler, 2014). Since the model assumes that political leadership is a key variable explaining progress in the sustainable transition, this a good sign.

Despite the limited influence of the public on decision-making, it is worth presenting some findings from a review of public opinion polls. It finds that between 70 and 80% of the Chinese population are aware of climate change and support action (Kim, 2011). This is a rather high share in a developing economy context. For approximately 40% is the issue ‘very serious’, which is comparatively low. However, in Asia the support for costly mitigation policies is generally low. According to this review Chinese citizens in contrast to their government are in favour of a global climate deal and do not call for developed economies to act only.

United States

The United States is a federal presidential democracy. While the US President is often called the most powerful person worldwide, the constitutional reality looks different: In most areas, he can only act upon legislation of Congress consisting of the Senate and the House of Representatives (Harrison, 2010, Skodvin and Andresen, 2009).³¹ In addition, the 50 states hold crucial competences limiting the power of the federal level. However, the president has the power of rhetoric and focus on his person as well as some executive powers that sidestep congress or through the veto powers at his disposal (see for example Canes-Wrone and de Marchi, 2002, Howell, 2003).

The US two-party system stemming from a majority electoral system has resulted in a high political polarisation. This limits room for bipartisan compromises, in particular on climate change – an ideological wedge issue (McCright and Dunlap, 2011b). Hence, leadership largely depends on the party holding the presidency: Historically, Presidents from the

³¹ So far in history only men have been elected as US president.

Democrats mostly favour mitigation efforts while Republicans mostly oppose action and in some cases even doubt the science. On the state level, the picture is more nuanced with the energy industry in the state playing a more significant role. For example, politicians from coal-dependant states are less likely to support strong measures than politicians from states that are home to a growing renewable energy industry. However, support from both parties is a prerequisite for action because of the majority requirements in Congress. Passing an international treaty, such as the Kyoto Protocol requires a two-third majority in the Senate as well as approval by the president and domestic action requires a majority in both houses of Congress and the support from the president who can otherwise veto legislation (Harrison, 2010). In addition, Repetto (2011) argues that the impact of lobbyist in particular in financing election campaigns prevents climate leadership. Since election campaigns in the United States are very costly, politicians depend on contributions to cover the costs. Hence, their needs reflect partly in the political debate. For example in states that are highly coal-dependant, the fossil fuel lobby is unlikely to support candidates that want to weaken the industry. From a point of view of the parties, Republican candidates are more likely to have a close relationship with the fossil fuel industry. As a result, the political polarisation reflects in the opinion on the issue of the electorate (McCright and Dunlap, 2011b).

The actions of past presidents reflect this polarisation: William Clinton (Democrat) tried to ratify the Kyoto Protocol but could not find a two-third majority in the Senate. President George W. Bush (Republican) largely ignored the issue by taking a soft law approach to climate policy based on voluntary measures (Skodvin and Andresen, 2009). His successor, Barack Obama (Democrat), takes a more proactive approach by using the means at his disposal without being forced to consult Congress but has failed to get Congress to pass comprehensive climate legislation, largely because of Republican opposition and shying away from the fight (see Lizza, 2010 for a discussion of the latest climate change legislation efforts).³² With an economic recession, two wars (in Iraq and Afghanistan) as well as the overhaul of the health care sector on top of his political agenda, climate change took a back seat (Brewer, 2011). Nevertheless, Obama embraces the green economy in his speeches and committed a considerable amount of the fiscal stimulus package to overcome the economic crisis to green industries. This short historical overview underlines Repetto (2011) argument that a lack of consistent political leadership resulting in time inconsistency is the main hindrance to a green transition in the United States.

³² However, the 'Waxman-Marley bill' passed the House of Representatives and lacked the necessary 60 votes in the Senate. In addition, the Environmental Protection Agency was granted the right to regulate GHGs. A decision that was upheld by the Supreme Court.

Public opinion polls underline the polarisation and show that currently “the American public generally has a relatively shallow understanding of the climate issue and a broad but low level of concern” (Repetto, 2011: 161). In a review of the development of the public perception from 2002 to 2010 Brulle et al. (2012) find that the salience of environmental issues in general and climate change in particular is low. Historically, the level of concern has been very stable with an increase in 2006/2007. Back then, Republicans under the leadership of John McCain who became their presidential candidate in 2009 wanted to cooperate with Democrats to enact comprehensive energy and climate legislation. Furthermore, Bill Clinton’s Vice President Al Gore gave the issue mass appeal with the documentary ‘An Inconvenient Truth’. Hence, a rare time of political agreement, awareness-raising by civil society actors, and strong media coverage during times of economic stability explain this shift of public opinion (Brulle et al., 2012). With the beginning of the financial crisis in 2008 economic issues overtook the agenda and concern for climate change dropped to historic low levels. Scruggs and Benegal (2012) show a clear correlation between public engagement with the topic and economic cycles over time. Recent polls show an upward trend in the belief in human-made climate change and the need to act probably resulting from extreme weather events and an improving economic situation (Leiserowitz et al., 2012, Pew Research Center, 2012).

European Union

The European Union is a multi-level governance framework in which the member states constantly interact with supranational institutions.³³ The key supranational organs are the European Council in which the heads of government of the member states meet, the European Commission that holds the right to start policy initiatives and whose president (currently Jean-Claude Juncker) is elected by the member states, the Council of Ministers in which representatives of the member states meet according to various topics, the European Parliament that is elected by popular vote in all member states and whose role has been largely increased with recent treaty changes, the European Court of Justice and the European Central Bank (McCormick, 2011). This list of key actors already demonstrates that a single unity that can carry out leadership is lacking. In general, the EU institutions can only act when the member states have transferred competences to the supranational level. Hence, the multi-level arrangement leaves various actors the chance to assume leadership on various issues in Europe – member states that were holding the rotating Presidency of the Council could push

³³ A key theoretical debate is whether the European Union is moving towards a federation or remains an intergovernmental organisation.

their agenda, the Commission, the Council and the Parliament with its increased decision-making powers can push issues forward.³⁴ While the European Union can hardly enforce legislation on the member states against their opposition which severely limits its leadership potential, the European Union and its member states are an international leader on climate change with different representatives assuming key roles at various points (Schreurs and Tiberghien, 2010). This shows that European leadership is based on a delicate power balance rather than a single body assuming a key role. This increases the importance of the transmission belts.

A recent European Commission (2011e) survey finds that the European public sees climate change as the second most pressing global issue (behind poverty, hunger and a lack of drinking water but ahead of the economic situation). However, member states that feel the pain of the ongoing economic crisis (Greece for example) rank economic concerns higher than climate change. According to the poll, 89% of Europeans rate climate change as a fairly or very serious problem. Interestingly, 41% said that they think national governments are responsible to answer climate change whereas 35% said it is the European Union and the same number put the responsibility on industry. Less than half of the population thinks that they hold personal responsibility, hence, a majority sees the responsibility to act with public actors. Almost 80% of the people asked (29% totally and 49% tend to) agreed that fighting climate change has economic advantages. Similar to the United States, public opinion in the European Union shows a historical correlation between economic well-being and climate change concern (Scruggs and Benegal, 2012).

3.2. Institutional transmission belts

Political leadership is a key component given the public steering and planning capacities in explaining success and failure; leadership needs to be translated into policy action to be effective. Institutional features that facilitate this translation play a key role in explaining success and failure (Scruggs, 2003). They are the transmission belts that translate political leadership into changing functions through adjusted policies. These transmission belts are the second layer in the three-layered analytical model. Two tasks are key in this regard: The framework needs to reach the entire government through policy integration and be time consistent meaning that it is predictable over the entire time frame of the transition (between 25 and 50 years). EPI should ensure that political leadership results in changes across all

³⁴ This is no longer possible since the latest amendments of the European treaties, the Lisbon Accord, has introduced a permanent President of the Council.

levels and sectors of government. This means that the green transition becomes a central task cross-cutting all thematic silos throughout multi-level governance regimes. In addition, transition leaders need to ensure that their actions last beyond their time in power. These two areas closely interact: Making the green transition a predominant task for all government organs as well as institutionalising them strengthens it against roll back at later times in time. At the same time, measures that ensure time consistency become guiding principles for current government activities and show each body what is expected of it in the long run. This can strengthen the current activities. Without the long-term orientation it becomes much more difficult to make the necessary adjustments.

Since the case studies carry out an in-depth analysis of each case, the following points out how they should differ with regard to their basic organisation. The institutional design of a polity should enable good interaction between top-down and bottom-up initiatives since the environmental capacity increases when the participative, integrative and strategic action capacities are high (Jänicke, 2002). Since deep-entrenched institutions do not change easily, a green transition needs to take place under the existing regime. A key institutional feature is whether polities are governed as democratic or authoritarian regimes. With regard to the case studies, China falls in the latter whereas the United States and the European Union are democratic entities. The literature points out that these differences have consequences for the respective transition.

Theoretical arguments as to why democracies as well as autocratic regimes perform better on environmental indicators exist. Reasons supporting democracies as stronger performers are: public awareness and with it the salience of sustainability on the public agenda is higher because of environmental interest groups, electoral accountability makes decision-makers more responsive to expressed environmental concerns, acceptance of the rule of law, and public masses are more environmentally minded than autocrats (Li and Reuveny, 2006). Arguments that autocratic regimes perform better are: democracies might overuse public goods, national democracies have problems to address global environmental problems, and business interests outweigh environmental concerns in market democracies resulting in inaction (Li and Reuveny, 2006). While empirical evidence suggests that democracies in general perform better (Fiorino, 2011, Li and Reuveny, 2006), it is not fully conclusive (Bernauer and Koubi, 2009). The actors-centred discussion in the previous chapter also indicates that democracies perform better because they leave more space for civil society and

state-independent business to articulate their interests, which are mostly suppressed in autocratic regimes.

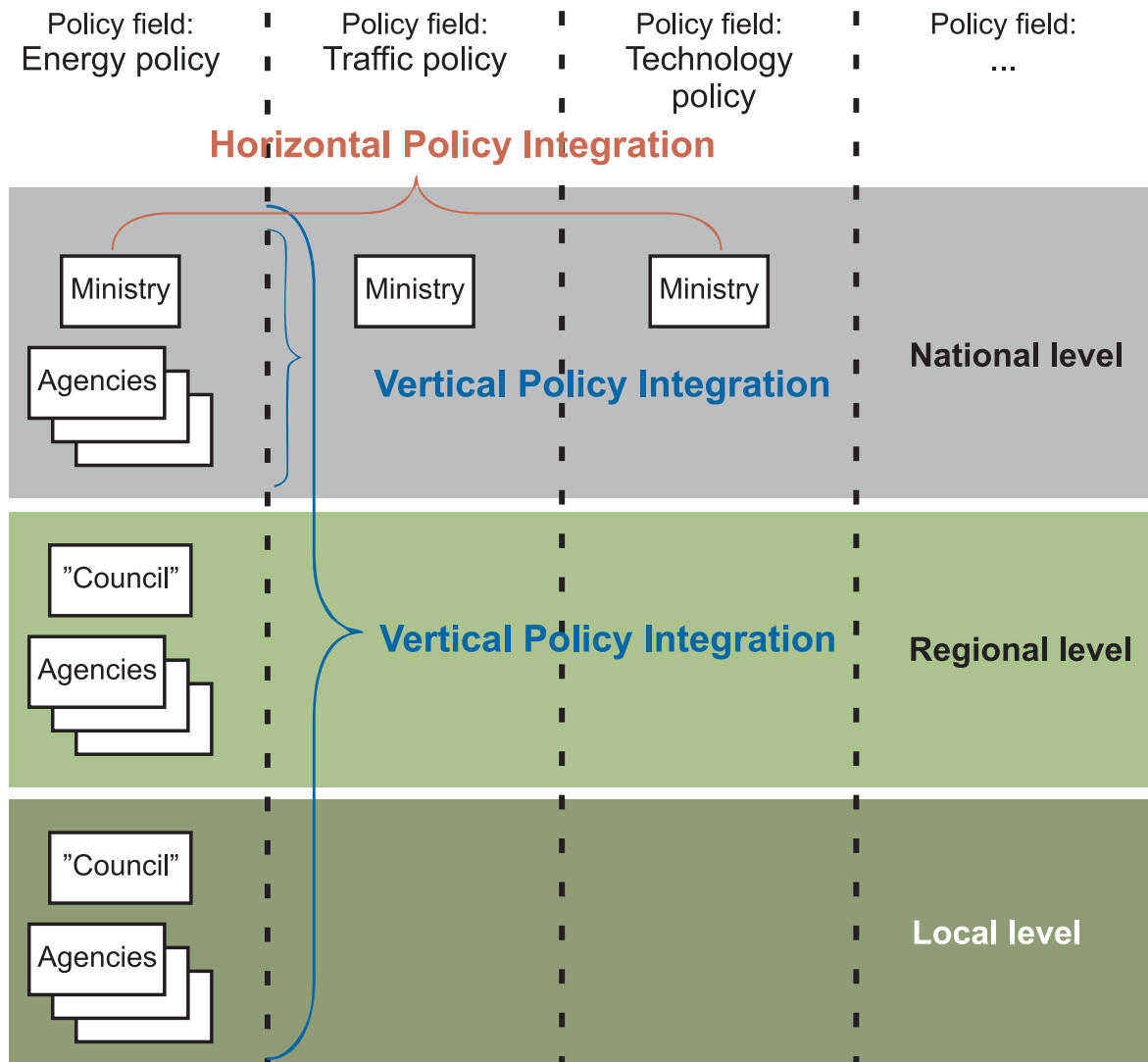
In democratic entities the electoral regime affects the environmental performance. Several studies find a better environmental result for proportional representation over majoritarian voting systems because they increase the impact of green parties and reduce the local emphasis on selecting politicians (Christoff and Eckersley, 2011, Scruggs, 2003). Further, differences exist between presidential such as the United States and parliamentary systems. Christoff and Eckersley (2011) argue that presidential systems are less likely to protect and provide public goods since they have more checks and balances in place which result in strong lock-in effects that hinder change. This means that stringent climate policy is more challenging under a presidential system because stronger opposition requires investment of more political capital. In particular as the president and the majority of lawmakers can stem from different political opposite to parliamentary systems where parliamentarians elect the government (Dolsak, 2001). However, Bernauer and Koubi (2009) argue that presidential systems ensure better air quality than parliamentary systems. While strong environmental movements can emerge without a green party playing a significant role (Poloni-Staudinger, 2008), “the programmatic orientation of the government’s parties on environmentalism” (Knill et al., 2010: 302) has a strong impact on the environmental policy of a country. This is supported by several studies that find that green parties have a positive influence on stronger climate policy (Bernauer and Koubi, 2009, Christoff and Eckersley, 2011, Knill et al., 2010).

3.2.1. Including the entire government in the transition process

The fundamental institutions of a political entity are very unlikely to change in time to significantly alter the transition trajectories. Nonetheless, the case studies show that the institutional transmission belts are key explanatory variables for the green transition. One part that needs to be addressed is including the entire government in the change process. Since the transition to a green economy will require a profound overhaul of the entire governance regime based on rearranged state preferences, it needs to be implemented in all government actors. Otherwise pockets of resistance within government might endanger and slow down the transition process, integrating cross-cutting policies and actors and overcoming resistance throughout the governance framework is important. Successful policy coordination is “an end-state in which the policies and programmes of government are characterized by minimal redundancy, incoherence and lacunae” (Peters, 1998: 296). One concept to implement sustainability and the green transition as a cross-cutting issue is EPI. It should take place

vertically (cross-sectoral integration throughout one or several political levels) and horizontally (integration across thematic silos/boundaries) as presented in figure 7.

Figure 7: Horizontal and vertical policy integration



Source: Mickwitz et al. (2009: 21).

The understandings of EPI differ whether they give ‘principled priority’ to the environment over economic and social priorities or whether they treat them as equally important. The normative understanding of EPI ranks priorities by committing “to minimise contradictions between environmental and sectoral policies by giving priority to the former over the latter” (Lafferty and Hovden, 2003: 9). This means that environmental concerns are most important in order to avoid that they are overridden by economic or social considerations. This far-

reaching understanding would put the environment not only on the same level as the already established core state functions but would turn it into the most important function a state fulfils. While this would significantly improve the prospects of a green transition, it seems unrealistic given the challenge to put the issues on the same level and leads to an “ultimate trade-off ... between existing democratic norms and procedures on the one hand, and the goals and operational necessities of sustainable development on the other” (Lafferty and Hovden, 2003: 10). Hence, the following applies an understanding of EPI in which it is an “important first-order principle to guide the transition to sustainability” since it aims “to systematically connect the seemingly incompatible goals of economic competitiveness, social development and environmental protection“ (Jordan and Lenschow, 2010: 147). This underlines that it brings together the various functions to form a coherent picture.

This means that EPI is a tool to overcome excessive sectoralisation in bureaucracies. This can support a coherent transition management since it enables to detect trade-offs between the various functions. The goal is a fine-tuning of existing policies by taking environmental consequences into account without creating one single policy that deals with all issues at the same time. It “requires commitment, strategic vision and a clear division of responsibilities among institutions” (Sgobbi, 2010: 30). While implementing EPI requires changes to institutions and integrating administrative instruments, the ultimate success depends on active political leadership and long-term commitment as well as an institutional design that facilitates exchange of information. This requires appropriate funding “as EPI activities are likely to impose an additional burden on sectoral and institutional activities“ (Sgobbi, 2010: 31). This for example turns the treasury into an important actor since it controls the funding of the various ministries and required institutional changes. While a variety of instruments exist to implement EPI, they are little used. Jacob et al. (2008: 42) conclude that “most countries seem to prefer to develop policy objectives and frameworks that flag the importance of EPI, without developing operational structures and procedures that significantly alter the distribution of power among the various actors involved or decisively change the prevailing political and administrative routines of policy making”. This falls in line with the observation that most EPI action is targeted at lower levels and top-level decision-makers shy away from it (Jordan and Lenschow, 2010). Hence, most countries have taken soft actions without major impact. This limits the reach of political leaders. The following elaborates which measures would ensure horizontal and vertical EPI, which are two sides of one coin. The case studies will show more detailed, which challenges each case has to overcome in this regard.

3.2.1.1. Horizontal environmental policy integration

Horizontal EPI describes the cross-sectoral integration of environmental policy. It focuses mainly on the interaction of state actors on the highest level (for example the cabinet) but can also include the coordination with external actors (for example business). The main administrative challenge is to overcome the silo structure of government that largely neglects issues that affect all silos but for which none is explicitly responsible. For cross-cutting policy issues, such as protecting the environment, it is not sufficient to do ensure a positive outcome at certain points, but this is a concern that needs to be part of the decision making on a great variety of topics. Hence it is important to deeply integrate the various fields that are effected by the transition process to generate a positive narrative rather than create turf wars between ministries that historically have little in common. Instruments such as liaison officers, task forces and teams can foster collaboration between various bodies (Schout and Jordan, 2008). The problem is often that top-level politicians do not increase awareness in the entire administration but rather “bureaucratize policymaking, while permanent officials resent the meddling of ‘amateurs’ in policy areas about which they generally have little expertise or even experience“ (Pierre and Peters, 2005: 137). However, without technical expertise that enables them to take action, agencies are not capable of including the repercussions on the environment.

In order to strengthen the institutional capacity for strategic action, Meadowcroft (2009a) identifies three paths to represent climate change at cabinet level. This underlines that the cases can take varying trajectories depending on their political culture and existing institutional design. First, an environment ministry or agency; second, a climate change authority; third, linking it to another major ministry, for example energy. While similar options are imaginable to manage the green transition, each option has advantages and disadvantages. The fear is that environment ministries are too weak to truly push the transition agenda forward. For example, Knill et al. (2010) find no clear evidence that an environment ministry increases environmental policy activity. In addition, they conclude that the position of the office holder does not seem to impact the policy output. While this is at first surprising, the low level of relevance of the ministry within government explains it. In response, the ministry should be elevated, for example by linking it closer to the power centre. This again calls for political leaders to impose their will more strongly so that the transmission belts translate it into action. However, instituting new coordinating bodies at the top “can easily overload the apex, given its pre-existing commitments to deliver many other coordinating goals” (Schout and Jordan, 2008: 56). The impact of the body in charge of

environmental affairs in the day-to-day government work crucially depends on the allocated staff, budget and competences (Meadowcroft, 2009a). Key is to equip the body with the necessary resources and ensure that the available policy instruments are applied effectively. Hence, “institutional capacity refers to the availability of institutional resources such as staff, financial resources, professionalism and expertise” (Pierre and Peters, 2005: 7). This is often times overlooked when rearranging institutions so that they are incapable to fulfil their role.

3.2.1.2. Vertical environmental policy integration

Vertical EPI describes sector-specific greening over various layers. Central governments are only one actor besides regional and municipal administrations. How much power they can exert, depends on national circumstances. While this dimension is more important in federal states, it is becoming a growing concern for centralised states as well (Pierre and Peters, 2005). Depending on the circumstances, federalism can be an enabler or disabler of climate policy (Harrison and McIntosh Sundstrom, 2010). The argument for this dual role is that in case of missing federal leadership regional authorities can fill in. However, when the federal government takes the lead, the regional governments can obstruct the efforts to protect their interests and when they actively collaborate, they significantly strengthen the framework which can have lasting impact (Harrison and McIntosh Sundstrom, 2010). An important question is which state level (in particular in federal states) is in charge of enforcing the policies and when decentralisation can help the greening efforts.³⁵

Some scholars argue that federal states have more problems coordinating (Jordan and Lenschow, 2010, Meadowcroft, 2007) because the greater number of involved players increases the likelihood of veto players. Others argue that federal states have better coordination capabilities, probably because they face these coordination challenges in various fields and local bottom-up initiatives can push the agenda forward (Poloni-Staudinger, 2008). This transmission belt is key feedback loop for top-down and bottom-up initiatives. A major advantage of decentralisation is its ability to fill in for lacking leadership from the central government. Furthermore, it can help tailoring regulation to local circumstances (Mazur, 2011). States, for example can be testing grounds for new policies and the gained experiences can be later applied to larger regions (Organisation for Economic Co-operation and Development, 2011d). The arising danger is that regional pressure groups gain political

³⁵ The following will not analyse multi-level governance in the traditional sense by also taking the international level into account. While it is important for environmental policymaking, the focus in this research context is on the national and sub-national level.

influence and distort the level playing field. It is key that central authorities know that and how lower entities ensure enforcement and that non-compliance is similarly punished across the entire jurisdiction (Mazur, 2011). Hence, it depends on the circumstances whether federalism and decentralisation are beneficial for vertical EPI.

3.2.1.3. Operationalisation and current status of the three cases

The institutional design of the three cases differs strongly with China being an authoritarian regime, the United States a presidential democracy and the European Union a supranational body sui generis. The following gives a brief overview over the challenges and chances these designs offer with an emphasis on the coordination within the polities. These form the groundwork for the case studies.

China

China is an authoritarian one party regime with a unitary government in control of political, economic and social decisions that was established in its current form in 1949. Popular elections are not held as the key political actors are chosen by the CPC resulting in a top-heavy regime. Chinese leaders lay out their work programme in FYPs, which guide policymaking. The constant transition that China's economic and social system has been undergoing since the international opening of the country beginning in the 1970s has strained existing institutions (Wang and Chen, 2011). The same can be said for environmental governance which "is both very much in the making and under constant change and transition due to a fluid social environment, both nationally and internationally" (Mol and Carter, 2006: 151). While environmental governance gradually becomes more flexible and pro-active, a strong focus on traditional measures such as central planning and regulation remains and market-based policies only slowly gain traction (Wang and Chen, 2011). Nonetheless, the CPC influences key businesses organised as SOEs.

The 12th FYP stresses environmental governance reforms to close the often diagnosed implementation gap meaning that the government announces many targets but does not implement and enforce actions to reach them (He et al., 2012). This implementation gap is caused by the strong economic growth and the ensuing changes, the predominance of economic over environmental concerns, a central-local gap and a lack of civil society involvement. Chinese institutions currently do not satisfactorily translate political will into policy. One reason is that in China – by definition not a federal state – regional governments are strong actors because of the size of the country and population. Some scholars speak of

“federalism, Chinese style” (Montinola et al., 1995: 52) meaning that the bureaucratic organisation is not linked to political freedom but limited to the power sharing agreement between various political layers. Hence, “the national regulatory framework is vertically implemented through a four-tier management system, i.e., national, provincial, municipal and county levels” (Mol and Carter, 2006: 152) with the lower levels in charge of implementing the necessary measures. While this decentralisation increases flexibility, the centre cannot fully control regional implementation of its orders (Heberer and Senz, 2011). This creates a central-local implementation gap, which the central government aims to overcome by evaluating local cadres based on targets. In the past, economic performance outranked all other concerns in these evaluations, which are crucial for the careers of local cadres. While environmental performance has gained importance in recent years, economical concerns remain the main evaluation criteria (Heberer and Senz, 2011). As a result, the relationship between the central and provincial governments is unstable. Hence, coordination lacks between the private and public sector, the state agencies and between the central and provincial level as well (World Bank, 2012). The case studies shows that also coordination challenges between the actors on the central level endanger progress.

United States

The United States is a federal presidential democracy with a majoritarian electoral system. The president and both chambers of Congress are directly elected.³⁶ A majoritarian system has established a two-party system leaving little chances for independents or third parties.³⁷ The result is the discussed polarised political climate. However, the system requires legislation to pass the Senate and the House of Representative and the president’s signature. Hence, three elected political bodies approve legislation creating a strong system of checks and balances (Harrison, 2010). This limits the political leadership potential of each single body proving the theoretical argument about the high number of veto players in presidential systems. Representation in the House of Representatives is organised by the size of population whereas the Senate represents each state with two senators disregarding the size of their population. Party discipline is lower than in other systems which means that politicians are more dependant on their regional support and try to protect their state’s interest as much as possible (Harrison, 2010). Since 26 states produce coal, they form a majority in the Senate that is likely to protect their domestic coal industry (Skodvin and Andresen, 2009).

³⁶ The president stands for re-election every four years, senators every six years and members of the House of Representatives every two years.

³⁷ A green party exists but it is of little relevance.

The United States is a prime example of a federal state. Significant environmental competencies moved from states to the federal level in 1969 (Goulder and Stavins, 2011). Some states have used these newly-acquired competences to enact stringent environmental legislation (Harrison, 2010). Hence, in absence of federal legislation, some progressive states, such as California, have taken the lead and pushed forward a greening of their respective polity. While the result is a scattered regulatory landscape, federalism and the empowerment of the states in the US context has enabled stronger climate legislation, as would otherwise have been the case. While little progress was taking place on the federal level, those states that want to take the lead can do so. The downside is that the laggards continue with their business as usual. The resulting scattered landscape makes it difficult to assess progress and opportunities in the United States. In addition, state action is dependant on rulings of the Supreme Court and it reduces efficiency due to high transaction costs (Mildner and Richert, 2010). The case study will show that the United States face high coordination challenges because of this scattered landscape in absence of lasting federal leadership.

European Union

The European Union emerged as a supranational entity with the primary goal to ensure peace in Europe after the Second World War. It is often described as an entity *sui generis* because it is more integrated than an international organisation but less than a state. While the currently 28 member states remain sovereign, they have delegated a variety of competences to the European level. The first steps towards European integration took place in 1952 with the founding of the ‘European Coal and Steel Union’ by six countries (France, West Germany, Italy, Belgium, Netherlands and Luxemburg) and the signing of the Treaties of Rome in 1957 (McCormick, 2011).³⁸ Over time, the number of countries has increased and the political and economic integration deepened. First supranational activities on the environment started in the 1970s. The ‘Single European Act’, signed in 1986, transferred environmental competencies to the European level and established EPI as a guiding principle of policymaking (Schreurs and Tiberghien, 2010). The ‘Maastricht Treaty’, ratified in 1992, turned the environment into an explicit policy responsibility and granted the Commission the right to represent the European Union in international rounds (Schreurs and Tiberghien, 2010). The ‘Amsterdam Treaty’, signed in 1997, established sustainable development as a core principle of EU policymaking (Benson and Jordan, 2010). Similarly, treaty changes have increased the role of the European Parliament, which is the only body elected in a popular vote.³⁹ The last significant treaty

³⁸ These are the ‘European Economic Community’ and ‘European Atomic Energy Community’ (Euratom).

³⁹ EU-wide elections take place every five years according to national regulations under a proportional

change was the ‘Lisbon Treaty’, which was put into action in 2009 in an effort to close the governance gap left open by the failed European Constitution. This treaty has replaced the three pillar structure with clearer powers and competences for the EU level (McCormick, 2011).⁴⁰ For the first time the *acquis communitaires* includes an energy chapter, strengthens the role of the supranational level in international climate negotiations and emphasises sustainable development and EPI (Benson and Jordan, 2010). Hence, the current status of climate, energy and environmental integration allows analysing the supranational level as a single case that is similar (but not equal) to a state. Environmental policy and climate change is a driver of further integration as can be witnessed by the growing supranational energy competences. Nonetheless, the member states remain key actors that influence supranational activities. The case study underlines this point.

While the European Union is not a federal state per definition, it looks and behaves similarly. However, the member states are still more powerful than the supranational institutions. Hence, it belongs on the list of “quasi-federations” (Christoff and Eckersley, 2011, McCormick, 2011, Schreurs and Tiberghien, 2010) that show some federal features without explicitly being one. Besides the bureaucratic European Commission that is well-trained in solving transboundary problems, the concerns for energy security and independence, this multi-level design is one reason for the historical EU leadership in climate change mitigation efforts. For example, it allows it to assume a common goal in international negotiations that it breaks down internally according to the capabilities of the member states. Hence, they can share the burden of environmental targets (Schreurs and Tiberghien, 2010). However, it also raises coordination challenges since the member states remain more powerful than the supranational organs resulting in a lack of strategic centre and shifting alliances between the member states. The case study shows that currently the member states opposing a fast green transition are using their veto power to stall progress.

3.2.2. Ensuring a stable governance framework over time

A second key institutional factor that can be changed is ensuring a stable governance framework over time. This is crucial for a successful transition since it lasts between 25 and

representation regime.

⁴⁰ The Lisbon Treaty includes three institutional changes: First, it introduces a new President of the European Council that is elected by the Council members and approved by the European Parliament for a term of 2.5 years (once renewable); second, it implements a High Representative for Foreign Affairs and Security Policy (Foreign minister) is appointed by the European Council for five years; third, the powers of the European Parliament are strengthened and put on an equal footing with the Council of Ministers on almost all issues to overcome the democratic deficit of the European Union.

50 years. Most of the time political leaders change over this time frame. Hence, politicians that want to implement lasting transition governance need to find ways to overcome time inconsistency. If all actors involved know that the transition to a green economy is a credible and reliable long-term goal, they adjust to this goal. It puts vested interest from the fossil fuel era in the defensive position. However, election cycles (four to five years in general) that dictate politicians' actions are contrary to the necessary long-term planning and steering. Hence, several authors see 'short-termism' as a crucial problem for a successful green transition (German Advisory Council on Global Change, 2011, Giddens, 2009, Meadowcroft, 2009a). Two mechanisms increase this problem: First, a time lag exists between action and impact of climate policy, especially since the upfront investments are in general very high. This means that politicians have to implement costly policies without reaping the benefits at a later point in time when they might no longer be in power (Underdal, 2010). Second, public attention might shift to issues with a more direct impact that are easier to communicate (Hovi et al., 2009). This reflects a crucial feedback loop between leadership and time consistency since incentive structures for leaders might oppose investing political capital for long-term problems. However, the case studies show that all three cases have problems ensuring time consistency policymaking.

The three dominant approaches to ensure time consistent policymaking are eliminating alternative options, rational ignorance, and tying hands (Hovi et al., 2009). They share in common that they limit the leeway for future action. Implementing measures that produce results that cannot be reversed is the best way to eliminate alternative options. One example is that when new technologies become financially profitable it is unattractive to revert to older technologies. Rational ignorance describes that "to deliberately refrain from acquiring ever more information about options that are likely to be attractive in the short run, but might lead the decision-maker to deviate from the long-term plan for climate policy" (Hovi et al., 2009: 24-25). In this context Giddens (2009: 93) advocates "an agreement among competing political parties that climate change and energy policy will be sustained in spite of other differences and conflicts that exist". This would ensure that transition governance does not become an issue of political bickering and would significantly strengthen the position of green advocates because potential veto players would lose their political contacts. Without such consensus, newly elected governments can easily reverse transition progress. Hence, dilution of early achievements could severely weaken environmental governance (Hertin and Berkhout, 2003).

Tying the hands of future decision-makers by forcing them to follow already enacted measures can happen in several ways. Giddens (2009) calls for a strong independent body that has the power to change legislation to ensure that once established, strategies and targets remain active over time. This avoids that future political leaders drop ecological concerns from the agenda and turn back legislation. These quasi-independent organs would be for climate policy what central banks are for monetary policy (Atomium Culture and Lund University, 2009). Advantages of such institutions are that “they are protected from everyday political interference by politicians; they are freed from cumbersome government rules over purchasing, hiring and operations; they can move more quickly to adapt to circumstances and exploit opportunities; their mandates and organizational forms can be structured specifically for certain tasks (education or research or supporting firms); they can build their own independent reputations for effectiveness and objective assessments; and they may have more credibility with the public and with stakeholders than politically-linked officials.” (Meadowcroft, 2005b: 15) In addition, they guarantee flexibility in adopting to emerging technologies and react swiftly to external or internal shocks (Organisation for Economic Co-operation and Development, 2011d). While independence from legislative and executive forces is a key prerequisite for such bodies to work effectively, it results in a lack of democratic oversight and legitimacy. One way to solve this problem is by relying on output legitimacy meaning that their performance justifies their existence. Despite their upside, they are rarely in place or have weak enforcement capacities severely limiting their effectiveness because of the aversion by governments to actors that significantly limit their power and criticise their performance. None of the cases analysed has these hard measures put in place.

An alternative to limit the leeway for future decision-maker are policies that have long-term consequences, for example, setting targets and presenting strategies how to reach them (Pralle, 2009).⁴¹ This is the approach taken by China, the European Union and partly by the United States. Credible commitment requires realistic targets enshrined in law to clearly indicate future actions, gain support by the electorate and to allow other actors to plan accordingly (De Serres et al., 2011, Sullivan, 2011). Hence, all stakeholders should develop targets to increase their legitimacy and “incentivise[s] decentralised players, from companies to municipalities, to develop their own visions and strategies within the framework of an

⁴¹ The Kyoto Protocol, the most-important multilateral legally binding treaty to mitigate climate change was based on national GHG emissions reduction targets (Oberthür and Ott, 1999). These targets entailed that industrialised countries spelled out in Annex B of the Protocol reduce their emissions by the set percentage compared to the emissions in the baseline year 1990 during the first commitment period which ran from 2008-2012.

ambitious climate strategy” (Matthes, 2009: 46-47). The formulation should involve “assessments of likely economic, social and environmental costs and benefits, and studies of the potential technological and institutional developments needed to achieve them” (Foxon and Pearson, 2008: S153). Realistic strategies can foster time consistency, become a new guiding document for all layers of government and fulfil a useful purpose as a new government mission that unites bureaucratic silos. Such a strategic framework would bind future decision-makers and at the same time strengthen the social agreement because various actors would base their planning on it.

3.2.2.1. Operationalisation and current status of the three cases

Finding ways to ensure time consistency is key at this early transition stage because a large part of the transition is in the future over which current decision-makers hold little sway. Hence, their goal is to establish a framework that is reliable into the future in order to entrench the trajectory to a green economy. Current decisions makers are more likely to put targets and strategies in place rather than establish independent actors – most likely because this creates less political opposition, as the consequences for future decision makers are weaker.

China

The Chinese FYPs as the strategic policy guidelines have become greener over time. The 11th FYP (2006-2011) has put an emphasis on green technologies that has been significantly strengthened in the 12th FYP (2011-2015), which was drafted by the previous leadership generation. It attempts to reconcile social and environmental well-being with economic growth (Hannon et al., 2011, He et al., 2012). In addition, more nuanced plans lay out the work programme for specific policy areas over longer time frames. Furthermore, China has implemented targets to increase efficiency and renewable energies as well as its planning to pass a climate change law (Hannon et al., 2011). This shows that the green transition is gaining prominence on the Chinese policy agenda. These existing policy documents to some degree bind the new leadership showing that measures to ensure time consistency are in place.

China has adopted several climate change related targets, such as decreasing energy consumption per unit of GDP by 17% and CO₂ emissions per unit of GDP by 16% by 2015 (People's Republic of China, 2011). In addition, it has pledged at the international climate conference in Cancun in 2010 to reduce its carbon dioxide emissions per unit of GDP by 40-45% by 2020 compared to the 2005 level as well as increasing the share of non-fossil fuels in

primary energy consumption to around 15% by 2020 and increase forest coverage by 40 million hectares and forest stock volume by 1.3 billion cubic meters by 2020 from 2005 levels (Höhne et al., 2011). In November 2014 China and the United States for the first time agreed bilaterally on a climate accord. It includes the target for China to reach peak GHG emissions by 2030 and reduce the output afterwards (Landler, 2014). Hence, for the first time it formulates an absolute rather than relative target. In the past, China has mostly adopted relative targets because of the continuous strong economic and population growth. Furthermore, China argues that the industrialised countries are historically responsible for the majority of GHG emissions and it has the right to develop its economy as they have done (Heggelund et al., 2010). The drawback of relative targets is that efficiency increases but overall GHG emissions can continue to rise.

United States

Because of lacking political consensus, the United States has not yet passed binding targets to reduce GHG emissions. Nonetheless, President Obama has made use of the powers the Presidency holds without consulting Congress. With regard to climate change, the first measures were his pledge in Cancun to reduce GHG emissions by 17% by 2020 and by 80% in 2050 compared to 2005 levels (Obama, 2009). In the mentioned agreement with China Barack Obama announced for the United States to emit 26 to 28% less carbon in 2025 than it did in 2005 which “is double the pace of reduction it targeted for the period from 2005 to 2020” (Landler, 2014). However, it remains to be seen whether the necessary measures to achieve these goals can be reached without support from Congress. Furthermore, a future President can override these pledges.

Under the Obama Presidency, environmentally-friendly targets and measures were implemented in various areas directly related to the overall GHG emissions output. For example, Barack Obama made use of an executive order in 2009 to implement an energy efficiency and GHG emissions management strategy for all federal authorities (Townshend et al., 2011). This shows that the president can push the issue forward. However, since it is not supported by a strong political consensus to tackle these issues over time, the measures depend at least partly on the president in power. This contradicts a stable supportive framework for a green transition.

European Union

The European Union has presented a comprehensive climate and energy package in 2009 including long-term targets (20% GHG emissions reduction, 20% energy generation from renewable sources and 20% increase in energy efficiency by 2020) that was included in the broader ‘Europe 2020’ strategy in which ‘sustainable growth’ is one of three priorities (European Commission, 2010c). While green members of the European Parliament have criticised the strategic outlook for putting too much emphasis on GDP growth and a lack of precise measures to reach the environmental targets (EurActiv, 2010a), the climate package was one of the most ambitious roadmaps worldwide.

While the European Union starts from a strong political leadership position compared to the other cases because it had backed up rhetoric with action, its leadership role has recently come into question (Egenhofer, 2010, Parker and Karlsson, 2010). The economic problems threatening the common currency – the Euro – have shifted the political agenda away from environmental issues. This reflects in the agreement on targets for 2030, which were watered down by several member states. The European Commission wanted to implement a binding 30% target for efficiency and renewables, which the European Council reduced to 27% (European Council, 2014). While the proposed GHG emissions reductions target of 40% was passed, a ‘flexibility clause’ was implemented, meaning that the target can be revised in the future (EurActiv, 2014). The package shows that the European Union continues with the targets-based approach that ensures time consistency, these targets have been heavily criticised for a lack of ambition. Hence, this form of time consistency can potentially weaken the green transition framework.

3.3. Adjusting three key functions

The third layer of the analytical framework form three key functions that states need to address through policy interventions in order to support a green transition. These functions are the economic framework, technological innovation and social welfare. They need to be in sync for a successful transition effort. Certainly, further functions will have to change as well but they are not as central as these three. Hence, this analytical model focuses on these three in order to map out a supportive green transition governance framework.

Governments need to set the proper framework for a green transition in these areas by putting in place various policies. The three functions play a crucial but are at the same time closely intertwined and should generate positive trade-offs given the coevolutionary nature of the

transition. Hence, policy interventions in one area will have most likely consequences in other areas. Otherwise they might limit their capacity to support the green transition.

3.3.1. Greening the economic framework

Stern (2006: 25) has labelled climate change “market failure on the greatest scale the world has seen”. According to neoclassical economic analysis, negative externalities and public goods cause this market failure. Externalities, negative or positive, occur “when someone’s action inevitably affects others” (Burda and Wyplosz, 2009: 444). In the case of climate change, negative externalities occur because the output of GHG emissions damaging the atmosphere imposing costs on everyone else and future generations without the polluters facing market consequences for doing so (Stern, 2006). This is the typical problem of a global public good that is non-rivalrous and non-excludable. Hence, everyone can have the benefits for free without paying for the negative consequences such as pollution resulting in excessive use. As a result, capital is misallocated from a green economy perspective. Hence, interventions are needed for the economic framework to steer activities towards more sustainable alternatives.

Since labour and investment form the two main factors of production, the environmental impact of an economy depends on their usage (Burda and Wyplosz, 2009). Currently, they generate too much GHG emissions because the societal costs of pollution are not priced and subsidies distort the playing field in favour of fossil fuels. Government interventions can solve these problems by adjusting the market framework conditions accordingly. However, not only markets can fail, but governments as well. Consensus has emerged that a combination of the two, governments making use of market-based policy instruments, is the preferable solution. Hence, the first-best policy option is an economy-wide carbon price so that the prices properly reflect environmental costs (Baron and Lyon, 2011). This option, which is discussed more closely below, has two side effects: It generates additional state revenue that can be used for other purposes, for example social policy, and it fosters green innovation as it steers investments towards less polluting goods and services. However, this option is often unattainable for political reasons because it involves additional costs for business and consumers. This gives rise to second-best policy options such as subsidies, which are also discussed in more detail below.

Besides adjusting the macroeconomic framework, establishing a green economy needs large investments. Upfront investment costs are higher and operating costs lower (Robins et al.,

2010). Hence, it is crucial to steer the investments in the right direction. In particular in the energy sector they will have a lasting impact on the long-term GHG emissions trajectory due to lock-in effects (Mehling et al., 2010). This underlines that it is a key task for government to incentivise investments in green infrastructure. Various capital investment estimates have been presented (for an in-depth analysis of various investment scenarios see Mehling et al., 2010: 8-15). Robins et al. (2010) estimate that from 2010 to 2020 ten trillion USD (7.6 trillion EUR) need to be invested of which six trillion USD (4.6 trillion EUR) would be debt, two trillion USD (1.5 trillion EUR) fresh equity and two trillion USD (1.5 trillion EUR) equity from internal accruals. McKinsey & Company (2009) predict investments of 530 billion EUR per year in 2020 and 810 billion EUR per year in 2030 in addition to already planned investments. The International Energy Agency (2010a) develops a scenario in which energy-related emissions are halved until 2050 which requires investments of 46 trillion USD (35 trillion EUR). The United Nations Environment Programme (2011) estimates that 2% of global GDP need to be invested in green industries and technologies, which is almost equal to an annual average of 1.35 trillion USD (1 trillion EUR) but will spike up to more than 3.4 trillion USD (2.6 trillion EUR) per year closer to 2050 when global GDP is higher. Stern (2006: 211) assesses “that the annual cost of cutting total GHG to about three quarters of current levels by 2050, consistent with a 550 parts per million CO₂e stabilisation level, will be in the range -1.0 to +3.5% of GDP, with an average estimate of approximately 1%”. While these estimates show considerable differences and investments needs are high, they are achievable. A transition is viable.

Government budgets, which are already stretched, cannot completely cover these costs. The fiscal stimulus applied to many economies after the last financial crisis was a one-time event and cannot be repeated (Robins et al., 2009). Hence, probably more than 80% of the investments needed for the greening of economies must come from the private sector increasing the necessity for governments to create a well-designed market framework (Giddens, 2009, Mehling et al., 2010, United Nations Environment Programme, 2011). The risks for private investors are mostly related to time inconsistency and other time lags demonstrating that these two are closely related. It underlines that the transmission belts do not only work top-down but also can stop bottom-up changes. Investors take into consideration whether governments ensure “that relevant policies exist”, “that the policies are well designed” and “the effectiveness of the institutions charged with implementing these policies” (Sullivan, 2011: 3-4). This underlines the importance that the public sector adopts binding measures to ensure the investors with a reliable long-term perspective. These

“structural changes” (Angelov and Vredin Johansson, 2011: 250) in order to change the investment patterns directly affect the labour market. Before discussing labour market, the carbon price, the role of subsidies in more detail, a short excursus to understand the green growth debate is helpful.

3.3.1.1. Pricing carbon to level the playing field

From a neoclassical point of view, the first-best policy option for government intervention to shape a sustainable economic framework is to get the price signals right by implementing a carbon price that taxes emissions “equal to the marginal social damage created by the sale of each product” (Baron and Lyon, 2011: 124).⁴² This increases the price of goods and services by the social costs of their pollution in order to reduce their demand to a sustainable level. While the European Union has a carbon price in place, the Chinese central government has begun experimenting with this tool and in the United States some states have put it in place. Mehling et al. (2010: 18) argue that the carbon price “is likely to have the largest effect in promoting economically efficient low-carbon growth over the longer term”. The ‘double dividend hypothesis’ states that carbon pricing does not only avoid environmental degradation but at the same time increases economic efficiency by using the revenue to reduce other more distorting taxes, such as income taxes. Since firms that overachieve standards do not earn economic benefits, these economic instruments are more cost-efficient than regulation (Fiorino, 2009). However, state involvement through regulation remains vital as “by its very nature a carbon market demands some form of regulatory control and oversight” (Fitzpatrick, 2011b: 159). This underlines that economic instruments do not end state regulation but rather are a more flexible approach towards regulation.

Government has a variety of options available to create a carbon market, all of which arise political opposition, as most politicians assume that the electorate opposes new taxes (De Serres et al., 2011). Most prominent are carbon taxes and GHG emissions trading systems (ETS).⁴³ While both options allow for various designs, they generally perform equally well when full information is available and monitoring and enforcement are not an issue. However, when this is not the case, the choice becomes significantly more important. The key conceptual difference is that a tax ensures financial security and carbon trading ensures environmental security: Within a given time frame a carbon tax applies the same tax rate on

⁴² An English economist, Arthur C. Pigou (1920), was first to point out that externality problems are best solved by taxing their social costs. For this reason, these taxes are often called ‘Pigovian taxes’.

⁴³ This option is often referred to as cap and trade. However, the following uses the term ETS because the European Union has implemented a system under this name (the EU ETS).

all GHG emissions not knowing how much is emitted whereas an ETS limits the overall GHG emissions output and varies the price. In the tax case, government first sets the tax rate and then polluters decide how much they are willing to emit at this price. Hence, if government sets the rate too low, excessive GHG emissions are set free. In the ETS case, government sets the overall cap of GHG emissions, which are traded among all market participants. Hence, supply and demand set the price for the right to emit GHGs. Common to both schemes is that a stable carbon price is important to channel investments into the green economy and to overcome uncertainty in the marketplace. An innovation-inducing carbon price must be high enough to develop a steering effect and it must be predictable over time to ensure the needed planning security for private actors. Such a carbon price would act as “an incentive for R&D investments leading to the creation of new green technologies, as well as for the adoption by the market of emissions-reducing investments” (Aghion et al., 2009: 6). In addition, additional revenue can be used to reduce other taxes or for other purposes, for example the welfare net.

History has shown that this first-best solution is often times politically not feasible since “a polluting industry often has strong incentives to fight environmental legislation, whereas individual citizens have an incentive to free ride, resulting in little if any political action” (Baron and Lyon, 2011: 125). Free allowances under an ETS and tax breaks under a carbon tax can avoid economic harm at the cost of weakened steering effects. This means that decision-makers are left with “a choice between policy effectiveness and political feasibility” (Organisation for Economic Co-operation and Development, 2011d: 98). Companies often threaten to move abroad in case of excessive costs because of environmental regulation. This can result in two negative effects: a weakened domestic economy resulting in job losses and ‘carbon leakage’ describing that the GHG emissions still occur but only in an unregulated jurisdiction (Reinaud, 2009). While this ‘pollution haven hypothesis’ is disputed, many of the concerned industries can only relocate at high costs decreasing the likelihood of this outcome. Nevertheless, these competitiveness concerns tend to dominate the debate when key trade partners enact less stringent climate policies.

3.3.1.2. Subsiding green instead of brown technologies

The second-best policy option available to decision makers are subsidies. While economic theory assumes that subsidies increase inefficiency because they interfere with market mechanisms, they are a key tool to strengthen certain industrial sectors (Burda and Wyplosz, 2009). Most important in the context of the green economy are energy subsidies that in a

narrow understanding are “a direct cash payment by a government to an energy producer or consumer to stimulate the production or use of a particular fuel or form of energy”, whereas more encompassing definitions, “capture other types of government interventions that affect prices or costs, either directly or indirectly” (United Nations Environment Programme, 2008: 11). The concrete design can differ widely. The rationale for implementing them is mostly to ensure access to energy, avoid social hardship and protect employment opportunities (Mehling et al., 2010). However, subsidies have been proven badly suited to protect the poor which empirically undercuts an argument often used by their advocates (Organisation for Economic Co-operation and Development, 2011d). Furthermore, it hints that the link to the welfare regime does not primarily work through this feedback loop, which is an argument to reduce fossil fuel subsidies. From a green economy perspective, it would be good to reduce subsidies for dirty fossil fuels and increase subsidies for the market introduction of cleaner alternatives, such as renewable energy sources.

The International Energy Agency (2012b) estimates that global fossil fuel subsidies totalled 523 billion USD (399 billion EUR) in 2011, a 30% increase compared to 2010 mostly driven by rising energy prices. Fossil fuel subsidies are mostly concentrated in non-Organisation for Economic Co-operation and Development countries, especially the Middle East. The highest total spending on fossil fuel subsidies takes place in Iran followed by Saudi Arabia, Russia, India and China (International Energy Agency, 2012b). These subsidies increase the demand for fossil fuel based technologies resulting in higher pollution. A survey of six studies finds that overall emissions would be reduced, the degree varies widely, though – from 1.1% by 2010 to 18% in 2050 (Ellis, 2010). The same survey finds that fossil fuel subsidy reform would increase global GDP by 0.1% in 2010 to 0.7% in 2050 of which most would take place in countries not belonging to the Organisation for Economic Co-operation and Development (Ellis, 2010). Besides the economic and environmental consequences, these subsidies hinder the deployment of green technology. Their current distribution further distorts the economic playing field: Fossil fuels have received six times as many subsidies as renewable energies in 2011, which increased by 24% to 88 billion USD (67.2 billion EUR) (International Energy Agency, 2012b). All subsidies spend on renewables only partly offset the support for the dirtier alternatives. Hence, they must significantly grow while fossil fuel subsidies are significantly reduced to introduce green goods to the market.

Momentum towards the reform of energy subsidies has been increasing recently. The G-20 leaders promised in 2009 “to phase out and rationalize over the medium term inefficient fossil

fuel subsidies while providing targeted support for the poorest. Inefficient fossil fuel subsidies encourage wasteful consumption, reduce our energy security, impede investment in clean energy sources and undermine efforts to deal with the threat of climate change” (Group of Twenty, 2009). The Asia-Pacific Economic Cooperation made a similar pledge in 2009 broadening the international support for reducing fossil fuel subsidies (International Energy Agency, 2012b). While this points in the right direction, a report analysing action in response to the pledge finds that G-20 states undervalue their subsidies and have not removed a single subsidy so far. Hence, “[T]angible progress on subsidy elimination remains elusive” (Koplow, 2012: 4). Furthermore, countries spending the most on fossil fuel subsidies have taken the least effort to reduce them.

In this situation, clean alternatives that are needed to ensure a decoupling of economic activity and pollution are at a double disadvantage. They are in general still more expensive because fossil fuels have received a high share of past subsidies and they are still today receiving less subsidies despite being further away from market readiness than their competitors. Hence, they need new subsidies in order to win over market shares that would mark a significant step towards a green economy. Since technologies using renewable resources remain more expensive, these subsidies must overcome higher upfront costs of cleaner alternatives and allow them to compete with established sources. They should be well-targeted, efficient, soundly based, practical, transparent, and time-limited (United Nations Environment Programme, 2008) since it is very difficult to reform a subsidy once implemented because a small minority profits and a diverse majority pays the price. Hence, it is crucial to make smart choices when they are implemented, which in return can achieve lasting behaviour change (Organisation for Economic Co-operation and Development, 2011a). This demonstrates that the subsidy regime is a key intervention point for state action in support of the green economy.

3.3.1.3. Employment effects of a green labour market

A key political argument for the green economy is the job potential arising from this reconfiguration of investment flows. Hence, governments can justify their actions to support the sustainable transition with a growing green labour market. The United Nations Environment Programme and the International Labour Organisation “define green jobs as positions in agriculture, manufacturing, construction, installation, and maintenance, as well as scientific and technical, administrative, and service-related activities, that contribute substantially to preserving or restoring environmental quality” (Renner et al., 2008: 35-36) in

a seminal study.⁴⁴ Little is known about the potential for and the quality of green jobs to date since the transitions are still in their early stages. Theoretically, five effects could take place (Martinez-Fernandez et al., 2010, Renner et al., 2008): First, creation of additional jobs; second, substitution of existing jobs; third, elimination of jobs without direct replacement; fourth, transformation of existing jobs to take new realities into account; fifth, job leakage abroad. In times of globally rising unemployment numbers, new jobs are a strong argument to gather political support. Depending on the concrete effects, the green transition can either help solve employment problems or it can create a shortage of skilled workers. For example, innovation requires highly skilled and specialised technological experts and the government steering requires newly trained bureaucrats that are capable of integrating the rearranged societal preferences in government action.

Analytically, a short-, medium and long-term effect on employment are distinguished: The direct employment effect in the short run will be that “jobs are lost in directly affected sectors and new ones are created in replacement industries” (Fankhauser et al., 2008: 422). This should slightly increase job opportunities since renewable energies are more labour-intense than the fossil fuel industry. In the medium-term, effects will reach earlier stages of the value chain throughout the economy. While early movers should create new jobs, this likely levels out over time as more countries adopt the green economy. In the long run, the biggest increase in the employment opportunities could take place since “innovation and the development of new technologies create opportunities for investment and growth” (Fankhauser et al., 2008: 422).

Various studies have more closely analysed employment potentials. While Renner et al. (2008) state that until 2030 more than 20 million new jobs can be created worldwide, a review paper finds “that job ratios vary widely between technologies, regions, countries and study methodologies” (Lambert and Silva, 2012: 4673). A major uncertainty in all these studies is the differing scope of the green economy definition, which often changes with regard to the included technologies. However, most studies support the claim that renewable energies are more labour intense than conventional energy generation (Lambert and Silva, 2012, Martinez-Fernandez et al., 2010). This means that more work is needed to generate the same amount of energy, which should translate into positive employment effects (Wei et al., 2010). At the same time prices might rise, giving people less money to spend on other goods and reducing overall economic activity resulting in job loss (Lambert and Silva, 2012). For this reason

⁴⁴ For additional definitions see Martinez-Fernandez et al. (2010: 21-22) and Angelov and Vredin Johansson (2011).

Martinez-Fernandez et al. (2010: 13) conclude that the hypothesis that green economies add jobs “seems to lose much of the optimism it gives birth to when analysed closely”. Nonetheless, the employment argument will continue to be a key political argument, in particular because of the positive short-term effects in times of high global unemployment.

While many assume that high-skill jobs will arise, there are also “dirty and dangerous” jobs, for example in sugar cane plantations (Angelov and Vredin Johansson, 2011: 252). In general, green jobs require new skill sets, which are most likely a mix of traditional and new skills that are unique to the green economy. Preparing the labour market for the new realities requires changes to training and education in order to avoid a “skills gap in labour markets” (Martinez-Fernandez et al., 2010: 25). While many existing jobs will undergo a transition, the labour market needs to match workers from vanishing industries with newly emerging sectors. Hence, it is important to reduce structural barriers to this matching. For this reason, “a carefully designed package of labour market, social protection and skills development policies can assure that the labour market is both dynamic – continuously redeploying labour from declining to growing industries and firms – and inclusive” (Organisation for Economic Co-operation and Development, 2011d: 95). Achieving this goal depends on three policy areas: on the supply side, active labour market programmes that prepare job-seekers for newly demanded skill sets; on the demand side, strong competition of products and moderate employment protection; finally, a dynamic labour market requires social flanking to protect workers and their families (Organisation for Economic Co-operation and Development, 2011d). This demonstrates the direct effects of the changing labour market on the required social welfare net.

3.3.1.4. Operationalisation and current status of the three cases

Since the entire economic organisation of a country is a complex system, the following gives a brief overview of the existing status of the cases. It makes use of the ‘Varieties of Capitalism’ typology, initially presented by Hall and Soskice (2001), which is the predominant approach to distinguish developed economies according to their institutional design. This typology helps to identify key characteristics of a national economy and the section will show how different the three cases are in this respect. The more nuanced policy interventions for a green economy discussed above such as carbon pricing, subsidies and the green labour market are elaborated detailed in the case studies.

Varieties of Capitalism distinguishes two ideal types based on differing comparative advantages: A liberal market economy (LME) in which firms “coordinate their activities primarily via hierarchies and competitive market arrangements” and a coordinated market economy (CME) in which “firms depend more heavily on non-market relationships to coordinate their endeavours with other actors and to construct their core competencies” (Hall and Soskice, 2001: 8). LMEs depend solely on functioning markets whereas CMEs are more collaborative reflecting in stronger reliance on institutions “that allow them to coordinate on equilibrium strategies that offer higher returns to all concerned” (Hall and Soskice, 2001: 10) in addition to markets. Table 7 lays out the differences of the two ideal types in more detail. With regard to the topic of this thesis it is expected that more consensus oriented CMEs perform better on environmental and climate indicators than majoritarian LMEs (Dryzek et al., 2011).

Table 7: Differences between liberal and coordinated market economies

	Liberal market economy	Coordinated market economy
Industrial relations	Market-based decision-making on wage levels and hiring decisions	Aggregation of interests of management and workers through collective bargaining
Vocational training and education	General skills that allows for frequent changes of workplace	Workplace focussed training assuming long contract durations
Financial system/ corporate governance	Market-based; disclosing key balance sheet information	Dense networks between banks and companies to evaluate firms
Inter-firm relations	Short-term contracts and high turnover of personnel allow for exchange of ideas	Tight relations between companies to foster technological exchange
Employees	Top-down decision-making empowers managers	Consensual decision-making including the entire firm

Source: Author’s compilation based on Hall and Soskice (2001), Witt (2010).

China

China is not included in the initial set of countries analysed by Hall and Soskice (2001) since it is not a member of the Organisation for Economic Co-operation and Development. Scholars

applying the varieties of capitalism framework on China find that it runs a financial system *sui generis* with strong state interference but differ in their assessment of the other four dimensions. Witt (2010) finds that all other categories lean towards an LME (although they often formally adopt CME characteristics). He concludes that decision-making is top-heavy, worker protection is low, the education system lacks quality and the cooperation between firms is limited. Ahrens and Jünemann (2007) find that the labour system remains inspired by socialist values, while transiting to a more liberal future, innovation efforts continue to depend largely on government support, intra-firm decision-making remains highly hierarchical, and the education system is slowly becoming more complex. Hence, the Chinese economy is best described as a “centrally managed form of capitalism” (Lin, 2011: 64) in which the CPC strictly controls the economy, mostly through its influence on SOEs. This is underlined by the shifting ideological basis that justifies the leadership role of the CPC from Marxism towards improving living standards and social cohesion. This explains the Chinese leadership’s concern with securing considerable economic growth and increasing employment opportunities. While private investments are thriving, SOEs have easier access to funds, credit and other government support. It increases the scope for government intervention, but coordination problems between state layers persist as was discussed above.

United States

Hall and Soskice (2001) present the United States as the prime example of an LME. This means companies are run top-down by very strong managers and without any compulsory workforce representation. Individuals are encouraged to develop a skill-set applicable in various firms as they are likely to work for many different companies. This directly influences education, which puts an emphasis on general skills usable in a variety of industries. Rigid antitrust legislation avoids the collaboration of companies to form oligopolies. Technology transfer between firms is achieved through the mobile workforce that regularly changes jobs. At the same time, market forces decide which inventions reach the marketplace with little government intervention (Mikler, 2009). Assuming that the above mentioned argument on the environmental superiority of CMEs holds true, the United States is in an unfavourable position for a green transition because of its economic structure. While the United States can adjust fast to a changing market environment, the design leaves little room for government actors to influence the marketplace towards rearranged social preferences. The price is the key driver of economic decisions. This means that unregulated areas, green goods and services need to become price competitive with the more polluting alternatives. In this regard many

green industries face a steep task since the social costs of pollution are not included in the pricing mechanism and the new technologies are not yet mature.

European Union

Hall and Soskice (2001) acknowledge that the supranational level has become highly influential on EU member states' economies. However, while authors have adopted a varieties of capitalism perspective to analyse national responses to Europeanization (Fioretos, 2001, Hall, 2008), little has been written about the supranational level. This is most likely because member states remain in control of industrial and economic policy and the European Union holds little influence besides governing the common market. This is a result of national circumstances. Hall and Soskice (2001) put two EU member states in the LME category (United Kingdom and Ireland) whereas seven are put in the CME category (Austria, Belgium, Denmark, Finland, Germany, Netherlands, and Sweden). Another five are left for the more ambiguous Mediterranean type (France, Italy, Spain, Portugal, and Greece). Hence, a majority of EU member states are leaning towards the CME side whereas one of the three largest European economies, Germany, France and United Kingdom, falls into each category.

Despite the strong role of the member states, the supranational level offers reform options. Fioretos (2001) identifies three effects on national economies: First, supranational institutions can adopt facets of national regimes. Second, national governments can adopt multilateral advances. Third, stricter domestic standards might be undercut by laxer multilateral rules. The European Union does not create its own economic framework but it is rather defined by the member states. Nonetheless, Mikler (2009: 80) gives four reasons why the European Union “may be said to be CME-like in setting environmental regulations specifically”: First, the European Union plays the central role in European environmental policymaking. Second, the common market attracts business to coordinate its action with regulators. Third, directives are often based on prior voluntary agreements with business. Fourth, the European Union moves slowly, and, hence, leaves a lot of room for lobbying and external influence. Hence, firms closely cooperate with regulators. This shows that the European Union should be in a favourable position to support the transition to a green economy.

3.3.2. Enhancing sustainable innovation capacity

The second key task that is important for a successful transition to a green economy is a strong innovation capacity. After a discussion of the role of innovation in the transition process, various policy interventions possibilities through the innovation cycle are presented.

State actors can play a crucial role in reshaping the innovation regime of a country, in particular during the early stages of R&D further away from market readiness. Hence, it can support the sustainable transition through fostering eco-innovations.

Technological innovation is a crucial path to reconcile environmental protection with economic growth. Hence, strong innovation capacities are “an essential prerequisite for green growth” (Organisation for Economic Co-operation and Development, 2011c: 16). Sustainable innovation differs from traditional innovation by including the normative goal of reducing the carbon footprint into the research framework. The definition of eco-innovation “as an innovation that improves environmental performance” (Carrillo-Hermosilla et al., 2010: 1075) captures this dimension well. Since the impact of technologies depends on their diffusion, behaviour-changing regulation needs to enrich innovation policy (van den Bergh et al., 2011).

Innovation is a complex process that runs through various steps. The innovation cycle presented by Schumpeter (1942) includes three phases: inventions, which are new ways to carry out existing or new tasks; turning inventions into innovation by introducing them to the market as tradable goods; diffusion, the process of widely distributing the invention to reach maximum market penetration and impact. Since this cycle is not linear and highly complex, it is a long way from the initial idea to a market-ready product. Relevant design features impacting the outcome of innovation policy are stringency (ambition behind the policies), predictability (credibility of the framework), flexibility for sectors and industry size to reach established targets, and strong enforcement mechanisms (Kemp and Pontoglio, 2011, Organisation for Economic Co-operation and Development, 2011b). In theory, government plays a more important role through supply side push policies at the beginning of the cycle whereas private actors and demand-side policies take a central role at later stages (Mowery et al., 2010). At the beginning, public money is key to finance new research fields. Hence, political leaders depend on an objective feedback from the research community as to which technologies are promising and which speed of progress is realistic. Depending on the accuracy of this information it can intervene through subsidies and direct interventions in the innovation cycle. While business is the primary driver of innovation, government plays an important role in steering it. In general, carbon pricing is a key economic instrument to channel investments into the green economy underlining the coevolution of changes to the economic and innovation framework.

Many countries base their environmental policy on fostering innovation (Jänicke and Lindemann, 2010). By following an innovation-based strategy governments aim to become front-runners or so-called lead markets for certain technologies. “Lead markets are countries that first adopt a globally dominant innovation design; they lead the international diffusion of an innovation and set the global standard” (Beise and Rennings, 2005: 7).⁴⁵ However, history shows “that innovation policy is not easy” (Grubb, 2004: 116). This underlines the importance of well-managed innovation systems because policy can have positive as well as negative effects (Kemp and Pontoglio, 2011). Government should follow a technology neutral policy in which the market decides which technology prevails. Hence, public actors invest into a broad variety of technologies or develop tools that do not discriminate between technologies. However, this approach needs to be modified because of the rearrangement of societal preferences in a green economy which eliminates polluting technologies (Organisation for Economic Co-operation and Development, 2011a). In this situation Torvanger and Meadowcroft (2011: 311) recommend a “lumpy investment strategy” which concentrates investments on a modest set of options. This underlines that innovation policy for a green economy needs to focus on goods that have environmental benefits while at the same time nurturing as many technologies as possible.

A key distinction exists between incremental innovations which “are minor modifications of existing processes or products” and radical innovations which “imply a technological discontinuity based on a break with existing competencies and technologies” (Kemp and Pontoglio, 2011: 33).⁴⁶ Existing firms are more likely to generate incremental innovations by continuously improving their products and process whereas radical innovations are more risky and lengthy processes undertaken by small firms or new market entrants (Organisation for Economic Co-operation and Development, 2011a). A problem of incremental innovations is that rebound effects likely offset efficiency gains. Since radical innovations break with existing structures, vested interest of powerful market players often opposes them. Hence, they are more challenging to achieve but are a prerequisite of a green transition. Furthermore, system innovations “which involve technological changes, as well as changes in other

⁴⁵ In order to predict lead markets ex-ante, it has been established that they have various comparative advantages: price (innovations are cheaper than elsewhere), demand (factors that point to higher demand for a given innovation), transfer (demonstrating other markets the usefulness of an innovation), export (foreign desires are included in the domestic innovations) and market structure (high level of market competition) advantage (Beise, 2004).

⁴⁶ Jänicke (2008) distinguishes strong and weak environmental innovation, which is similar to the distinction between weak and strong and ecological modernisation. Others add a third category between the mentioned two: disruptive innovations describing changes in processes and technologies without addressing the underlying system (Organisation for Economic Co-operation and Development, 2011a).

elements that describe technological change” (Geels, 2005: 682) are needed since technological change is only part of the solution. Ideally it triggers behaviour change and reshapes market conditions and other institutions. Public actors should use their interventions to aim for radical innovations such as replacing a dirty fuel with a cleaner alternative.

Corporate behaviour can have a lasting impact on the innovation system. However, even government involvement and positive business engagement can result in unsatisfactory innovation capacity. This stems from under-investment in R&D because firms fear that other actors reap the benefits of their discoveries. Hence, a lack of “knowledge spillovers” (Jaffe et al., 2005: 167) can hamper green innovation efforts. It already seems to be a problem since Aghion et al. (2009) find that private green innovation is weak based on an analysis of patents and other indicators. A two-tier strategy of supporting R&D combined with economic incentives such as a carbon price can help overcome this problem. Furthermore, governments need to ensure the protection of intellectual property rights so that businesses can reap the economic benefits of their discoveries.

3.3.2.1. Invention stage

An invention is the first step in the innovation cycle. Radical inventions are less likely than path-dependent refinements of existing technologies. Hence, this is a key task for interventions to support radical change since carbon lock-in does not necessarily stop radical changes but can delay them for decades (Unruh and Carrillo-Hermosilla, 2006). Given the time pressure that accompanies the green transition, exogenous interventions primarily through government should help overcome this time lag. This means that at the beginning in particular supply side measures need to direct research activities towards resource-efficient inventions.

The carbon price is one key instrument that demonstrates the close link between the economic and the innovation function. Government support for R&D is another link. Most studies show a positive effect of direct R&D support on innovation (Aschhoff and Sofka, 2009). Empirical evidence proves that public support of renewable energy R&D has a small effect on patents: “a 1% increase in targeted public expenditures on R&D results in a 0.05% increase in patent counts” (Haščič et al., 2010: 29). It can be either direct financial R&D support or indirect measures such as tax credits. While indirect measures distort markets less, they also reduce the governmental steering capacity (Organisation for Economic Co-operation and Development, 2011a). Disregarding which option is chosen, public R&D support should be

multifaceted and reliable to create investment security for private actors stressing time consistency.

Transition managers should support radical innovations to advance “the technological frontiers” (Mowery et al., 2010: 1021) even though these efforts have a high risk of failure. Projects that can hardly find private funding because of the high risk involved can make a lasting impact. Government interventions should focus on situations where the value to society is high but private willingness to invest is low. Furthermore, public funding of basic research and technologies far away from market viability is important because private actors cannot afford it (Sandén and Azar, 2005). However, public spending is limited due to budget constraints and, in general, government R&D expenditures on energy and environmental issues are relatively low compared to other areas. This is partly offset by spending on related research areas, for example information and communications technology (ICT). Hence, investing in a broad array of technologies is key to stimulating green innovations (Organisation for Economic Co-operation and Development, 2011a). How much investment is optimal depends on the “the ability of the innovation system to turn such spending into innovation” (Organisation for Economic Co-operation and Development, 2011a: 56). Since public actors must avoid crowding out private R&D efforts, stimulating more private spending is as important as improving the research capacities of the innovation system (Aschhoff and Sofka, 2009).

Besides financial support, positive policy interventions at this stage can improve structural factors. For example, forming effective research networks between academic institutions, businesses and other stakeholders can have a lasting effect (Sandén and Azar, 2005). This is similar to EPI on the state level only that more actors are involved. Furthermore, ideally, such an approach creates niches in which eco-innovations can nurture. In addition, demonstration projects that “may function both as a test that generates knowledge of system performance and user response that can be fed back into development, and as an advertisement that raises the level of awareness of the technology” (Sandén and Azar, 2005: 1563) are an often used policy instrument. They can bring attention to promising new technologies and bridge the development from invention to a marketable good. A promising approach is to combine them with procurement competitions which award contracts to winners of these demonstration projects (Mowery et al., 2010).

3.3.2.2. *Innovation stage*

Only inventions that enter the marketplace have an environmental impact. While this process is costly and time-consuming, it is the radicalness of an eco-innovation and the degree of market penetration that determine its ecological effectiveness (Jänicke and Lindemann, 2010). Hence, the next step is to turn an invention into a good, an innovation. While government should reduce its role and let business and other market actors figure out which goods succeed, it still has several intervention options at its disposal.

Innovation in the energy sector is relatively slow. Possible reasons are the high investment needs, the long time frames associated with it and political risks as well as “very weak market drivers, derived from marginal price differentiation for a homogenous product (electrons), which in turn often sells into a regulated market in which governments may well regulate profits” (Grubb, 2004: 123). In this particular area, which is central to decarbonising the economy, the role of government remains relatively large in order to ensure the necessary technological breakthroughs. A key challenge is the ‘valley of death’ defined as “the gap between discoveries in the lab and the large-scale deployment of commercial products” (Azar and Sandén, 2011: 137). The main problem is often times a lack of funding. The “non-economic investment activity” (Beard et al., 2009: 354) describing that public actors have funded research that creates positive societal effects but is not instantly marketable increases the likelihood to enter this financial valley. In particular, high-risk technologies and radical innovations are endangered by the valley of death because they require large upfront investments (Organisation for Economic Co-operation and Development, 2011a). This is another reason why the public needs to play a funding role at this stage in the innovation cycle.

Governments can help without investing money by increasing awareness for new technologies, creating demand or strictly regulating polluting alternatives. They can, for example, establish niche markets and reduce costs by reducing bureaucratic barriers (Azar and Sandén, 2011). While regulations that ban alternatives can increase green demand, many analysts argue that they do not necessarily foster innovation because it puts the same burden on all actors. While targets and standards can force technology development, it is unclear for regulators how much improvement they can assume (Jaffe et al., 2002). However, if the transmission belts work, decision-makers have more accurate information at hand. Additional measures can include information campaigns or policies that nudge behaviour towards new products (Sandén and Azar, 2005). Furthermore, design and user-friendliness influence

market chances. It is key to link the environmental aspects of a good with “other critical factors of competitive products and services such as style, design, price and performance, to be gauged from the customer and market assessment studies” (Carrillo-Hermosilla et al., 2010: 1081). Hence, when eco-innovations become ‘trendy’, they stand a much higher chance of economic success. However, “[I]f new technologies bring about additional costs without additional benefits for users, regulatory interventions seem to be even indispensable for innovation and diffusion” (Jänicke and Jacob, 2004: 34).

A further demand side instrument to foster green innovations is public procurement meaning “the acquisition of goods and services by government or public sector organizations“ (Uyarra and Flanagan, 2010: 126-127). In the European Union 15 for example, public actors have spent 16.3% of GDP demonstrating that they are a considerable demand source (Edler and Georghiou, 2007). Three rationales exist for public procurement of green innovations: First, it forms reliable local demand that can support local small and medium sized enterprises; second, public procurement can develop an little furnished market which can become the backbone of a green economy; third, this can improve public services and infrastructure (Edler and Georghiou, 2007, United Nations Environment Programme, 2011). Studies confirm that public procurement has a positive effect on innovation, in particular for small companies in structurally weak regions (Aschhoff and Sofka, 2009). However, public procurement based on environmental factors takes rarely place since higher prices of green goods make public buyers vulnerable to the allegation that they waste public money.

3.3.2.3. Diffusion stage

The broad diffusion of innovations is key to maximise their impact. Jänicke and Jacob (2004: 35-36) find that the diffusion rate differs according to “(1) the type of policy innovation (e.g. distributive measures diffuse more easily than redistributive measures), (2) the type and difficulties of the underlying problem, (3) the environmental policy capacity of the potential adopters, and (4) the successful influence of international organization - but also of strategic countries - in support of the diffusion”. This shows that during the final stage public actors hold least sway meaning that they depend on business and consumers.

However, many of the policies discussed in the innovation phase can also foster diffusion, such as “systemic policies, regulation, public procurement and stimulation of private demand” (Edler and Georghiou, 2007: 953) albeit to a lesser degree. These can help to overcome high costs of switching between technologies and information asymmetries. If these pull effects are

well designed, they are more targeted and cheaper than earlier supply-side instruments. In addition, green innovations diffuse more easily when they cater to individual purchasing decisions, which decide about the market penetration of a good. The Organisation for Economic Co-operation and Development (2011a) identifies better information about consumption consequences, raising awareness to environmental degradation, offering alternatives and incentives to switch to a low-carbon lifestyle as suitable strategies to foster green consumption. Table 8 elaborates these dimensions.

Table 8: Four ways of greening household behaviour

Information	Reliable information can guide sustainable consumption. In particular trustworthy certified labels can channel consumers towards green preferences in their buying decisions.
Awareness	Sustainability education raises awareness based on which people can take action. Furthermore, it legitimises those that act.
Alternatives	Green alternatives that replace existing goods without loss of comfort for consumers are a prerequisite for lasting behaviour change.
Incentives	Supporting green goods to achieve comparable prices as other alternatives or including different advantages helps diffusion.

Source: Author's compilation based on Organisation for Economic Co-operation and Development (2011a).

Public actors can play an important role in adjusting framework conditions such as adopting the infrastructure and establishing technical standards (Sandén and Azar, 2005). However, they need to coordinate their efforts with other actors to ensure a coherent framework. While the infrastructure of a green economy is much more decentralised than during the fossil fuel era, technical standards ensure customers that they can use their purchases in a variety of context. While Sandén and Azar (2005) argue that governments play a role in establishing standards, the Organisation for Economic Co-operation and Development (2011a) states that the government role is rather to function as an intermediary that facilitates and coordinates standardization procedures. In particular the timing of standardization is crucial: if introduced too early, it limits the development of new technologies; if implemented too late, the costs to comply can be high. Hence, standards “enable and constrain” (Swann, 2010: 10) innovation at the same time.

3.3.2.4. *Operationalisation and current status of the three cases*

Three different innovation systems are represented by the three case studies. Hence, this brief overview attempts to map out strengths and weaknesses of each of them. Following the discussion of the economic framework, China's innovation system is largely state-controlled, whereas in the United States public actors have less influence and the member states of the European Union are very diverse and the supranational actor must cater to very different needs. It is of particular interest whether the three cases show different ways to stimulate private R&D funding for green innovations. The most common output proxy that measures invention rather than innovation is patents because they are not necessarily commercialized (Arundel and Kemp, 2009). However, several drawbacks exist: Patents rarely capture the quality of a good and international comparisons are difficult because national intellectual property rights and patenting systems vary (Johnstone et al., 2009). Structural factors reflected in national innovation systems can explain a large share of this change. The international distribution of patents shows that the innovation landscape is changing. While for a long-time, the triad of North America, Europe and Japan dominated the innovation landscape, emerging economies, in particular China, are catching up and have almost reached this level (Crescenzi et al., 2012).

China

China's economy system is based on efficient low-cost production processes rather than innovation. While the Chinese innovation system has had little time to develop, it has resulted in an impressive allocation of resources for science and technology policy showing a satisfying performance to date (Organisation for Economic Co-operation and Development, 2008). The fourth 'National Innovation Conference' in 1999 marked the official starting point (Sun and Liu, 2010). The 'National Medium- and Long-Term Programme for Science and Technology Development (2006–2020)' in 2006 (State Council of the People's Republic of China, 2006) elaborated the framework with the aim to turn China into an innovation-based economy by 2020. The guiding principles include an emphasis on domestic innovation and leapfrogging in central industries. Energy and the environment are identified as key areas in which to improve (State Council of the People's Republic of China, 2006). Prior efforts to foster innovation were two public funding programmes: the '973 programme' targeting basic research and the 'high-tech 863 programme' focussing on market introduction.⁴⁷ Chinese innovation is regionally concentrated at the southern coast, which is the industrial heartland of

⁴⁷ Both number combinations stem from the date when they began operation, the 863 programmes in March 1986 and the 973 programmes in March 1997.

the country; most patenting activity happens in Guangdong (46%) followed by Beijing (14%) and Shanghai (13%) (Crescenzi et al., 2012).

In line with the political and economic system, the Chinese innovation system is very state-centric reflecting the dominant role of the CPC (Liu et al., 2011). Public actors set the framework conditions in particular for SOEs. While excessive state involvement partly explains China's innovation problem, the government tries to tackle the shortcomings: Science policy aims to secure more research funding, generate more patents and improve the framework conditions (primarily protection of intellectual property rights) as well as educate more and better scientists and quality management (Kubach, 2011). The current 12th FYP sets the target of spending 2.2% of GDP on R&D expenditure, and to reach 3.3 patents per 10,000 people (People's Republic of China, 2011). Further, the state aims to reduce its involvement and replace it with a business-led framework (Sun and Liu, 2010). While this points in the right direction, it should coincide with a loosening grip of the CPC. Another key challenge is the lack of protection of intellectual property rights that could enhance the innovation capacities of business (Organisation for Economic Co-operation and Development, 2008). Furthermore, the quantity of spending and patenting is as important as the quality, which is not touched upon.

United States

The United States is the international leader in innovative capacity – significantly ahead of the European Union (Crescenzi et al., 2007, Lester and Hart, 2011). Lane (2008) explains this with two arguments: First, the US system integrates public and private innovation efforts very well. Excellent universities and national laboratories have laid the groundwork for a well-functioning national innovation system after the Second World War. This is a framework developed by Vannavar Bush (1945) in his landmark report 'Science – The endless frontier' which has guided US innovation policy for decades and established key institutions. Two important acts of legislation were the 'Stevenson–Wylder Technology Innovation Act' of 1980 "which established technology transfer as a mission of the federal government" and the 'Patent and Trademark Amendments Act', "which created a uniform patent policy among the many federal agencies funding research" (Ratchford and Blanpied, 2008: 215). As a result, academic research is highly intertwined with business. Second, highly competitive US firms have gained their international standing by bringing inventions to the marketplace. In particular the high mobility of capital, labour and knowledge have been a major factor in

driving innovation as they allow for quick reaction to new technologies and goods (Crescenzi et al., 2007).

The US private sector pays for a large share of R&D funding, which reduces the burden on public budgets. Starting in 1965 public spending began to decrease and around 1980 private spending was higher than public spending reaching roughly a ratio of 70% private and 30% public spending today (Lane, 2008). This limits the scope for government steering, which poses a challenge when attempting to turn towards radical green innovations. However, the varieties of capitalism literature argues that LMEs like the United States produce radical innovations because of the flexible labour market (Hall and Soskice, 2001). While this claim is disputed, Crescenzi et al. (2007: 676) argue that the US innovation system is better capable of technological “shifting” rather than “deepening” because it can quickly reconfigure investment patterns. This puts the United States in a good position to make the necessary changes.

European Union

The member states control their domestic innovation policy resulting in a scattered European landscape (Coll-Mayor et al., 2007). Higher patenting rates in Northern Europe prevail over lower rates in Southern Europe. Hence, the European Union lacks a coherent innovation system despite the emphasis on science policy in strategic documents. The ‘Lisbon strategy’ had set the goal for the European Union “to become the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion” (European Council, 2000). However, the results were meagre. The follow-up ‘Europe 2020’ strategy includes ‘smart growth’ as one of three key priorities (besides ‘sustainable’ and ‘inclusive growth’) with the concrete goal to invest 3% of GDP in R&D (European Commission, 2010c).

Some institutional changes have been implemented to increase the capacities of the supranational innovation system. Since 1984, ‘Framework Programmes for Research and Technology Development’ bundle research activities. This is a crucial funding framework since it is enacted through the co-decision procedure reflecting European preferences (International Energy Agency, 2008). The ‘European Research Area’ bundles trans-boundary research. However, existing supranational initiatives are highly bureaucratized and focus on small-scale projects as the member states remain in control (Crescenzi et al., 2007). For example, at the beginning of the decade, the member states carried out 95% of public R&D spending in the European Union and the supranational level only 5% (Banchoff, 2002).

3.3.3. Distributional fairness of costs and rewards

Distributional effects are the final element of the three-layered analytical model on the policy level. Interventions are needed to ensure fairness with regard to the distribution of costs and rewards. The most important argument to pay attention to distributional fairness is that more equal societies do better on a variety of indicators compared to more unequal societies: “The problems in rich countries are not caused by the society not being rich enough (or even by being too rich) but by the scale of material differences between people within each society being too big.” (Wilkinson and Pickett, 2010: 25) Fitzpatrick (2011a) affirms this argument for environmental policy. Hence, the green transition needs to be equitable by addressing the concerns of losers on the one side and winners on the other side in order to be effective and gain public approval. The perception of an unfair transition creates strong veto players. However, it is rarely discussed that the status quo resulting in climate change also has distributional consequences: It affects poor households more directly than richer households that can more easily protect themselves against the developments (Fitzpatrick, 2011a). Hence, policy interventions are needed to ensure a fair transition to a green economy.

Currently, most developed countries have some form of welfare state regime in place to organise social redistribution. However, they are not yet prepared to deal with the consequences of climate change or the green transition. These new problems arise in times of increasing pressure on welfare states as costs are rising and public budgets tightening. According to Gough and Meadowcroft (2011) climate change adds to these problems in at least three ways: First, additional risks and questions of distribution are raised that require an answer. Climate change will cause more floods, droughts, and other extreme weather events that require stronger welfare responses. It is very likely that they continue to hit the poorer households considerably stronger than the well-off who can protect themselves better. Second, environmental and social goals could come in conflict, for example, through rising energy prices. These would affect low-income households more strongly than the rich as well. Third, welfare states have developed during times of expansionary economies. Hence, slowing growth is a challenge in itself even without additional burdens through a major overhaul of the economic basis. Since a green economy leads to less economic growth, it challenges the funding of existing welfare regimes. New mechanisms and funding sources for the welfare state need to be developed. The interaction with economic instruments becomes crucial.

Schumpeter (1942) labelled innovation as “creative destruction”, technological change creates something new but also destroys something old. Since “change disturbs established interests” (Meadowcroft, 2011: 72), the transition process must overcome strong vested interest from the fossil fuel establishment. Since the most powerful groups have generally gained the most from the existing regime (Meadowcroft, 2007), they are likely to oppose radical regime change since this endangers their dominant position. However, it is the stated goal of the green transition to reduce the fossil fuel dependence meaning that by design it will “produce ‘modernisation losers’” (Jänicke and Lindemann, 2010: 135). In this context, it is a problem that government tends to be more concerned with the transition winners since they are producing the positive news that generate public support for the change process (Dolsak, 2001). However, coalitions for change emerge only slowly and at the beginning have few resources at their disposal. Hence, well-organised opposition can reduce public support for transition advocates. Creating “perceptions of fairness make social actors more willing to accept sacrifices, and perceptions of inequity generate social resistance and make the effective implementation of policy more difficult” (Meadowcroft, 2009a: 18). It is crucial to communicate the expected growth dividend as well as the potential costs and find compensation mechanisms (Organisation for Economic Co-operation and Development, 2011d). The following deals with the consequences for households since measures to address a fair-burden sharing between industry sectors have already been discussed.

Since the various transitions to green economies are still in the early stages, little is so far known about their distributive outcomes. However, the literature on climate change mitigation has established that climate policies have regressive outcomes, which likely holds true for the green economy as well (Büchs et al., 2011, De Serres et al., 2011).⁴⁸ This means that poorer households are not only directly affected by the impact of climate change but by the mitigation policies, too. For example, rising energy prices are a particular problem for low-income households that spent a much higher part of their disposable income on energy than high-income households. However, the overall effects of the taxation and welfare system need to be analysed when concluding how regressive the impact is (Organisation for Economic Co-operation and Development, 2011d).

One approach to avoid regressive effects is to delay stern action in favour of less ambitious results. However, this intervention would result in more harm for the less well-off because climate change would take place, which is unjust as well (Fitzpatrick, 2011a). Another

⁴⁸ Transport policies are a notable exception to this rule because they are, in general, progressive.

possibility is to include additional compensation payments in the welfare regime, which could be financed through the revenue stemming from carbon pricing. Social activists have been very timid in taking on climate issues in order not to complicate welfare debates. Nonetheless, the aim is to uphold economic incentives to switch to a low-carbon lifestyle while implementing direct measures that reduce negative impacts (De Serres et al., 2011). The following strategies to use climate policy revenue to achieve distributional goals feature prominently in the debate:

- Lump sum compensation payment schemes have the advantage that they underline the public good character of the atmosphere by rewarding every person with some financial income for its use. Hansen (2009) has proposed a ‘carbon tax and 100% dividend’ scheme. It would redistribute the entire revenue from the carbon tax back to the recipients of the dividend in order to compensate them for the pollution. People could use this money according to their desires. Two alternatives exist to redistribute the revenue of ETS: ‘Cap and Dividend’ and ‘Cap and Share’ (Barnes, 2003, Foundation for the Economics of Sustainability, 2008). Under Cap and Dividend an independent trust administers the climate income and distributes it in equal shares to all citizens. Under Cap and Share each citizen receives an equal share of the available pollution permits, which they can then trade and bank the monetary value if they use less GHG emissions than the average consumer. While most studies conclude that such systems have progressive effects, the exact outcome depends on the design and whether citizens use more or less GHG emissions than the national average (Büchs et al., 2011).
- Income or means-tested compensation does not reward everyone with a financial benefit but only those who have demonstrated their need. The distributional effects depend upon who qualifies for these benefits (Organisation for Economic Co-operation and Development, 2011c).
- Reduction of other taxes, so-called “tax shifting” (Organisation for Economic Co-operation and Development, 2011c: 23), can be revenue neutral. This means that the revenue arising from climate policy is completely used for reductions of other taxes. This is the implementation of the ‘double dividend hypothesis’. Distributional effects depend on which specific measures are taken. Regressive effects can be offset by reducing income taxes on labour or by direct transfers, for example for children (Büchs et al., 2011). However, the problem of reducing income taxes is that many low-income households are dependant on welfare transfers and do not earn an income,

hence, are not affected by changes to income taxes (Organisation for Economic Co-operation and Development, 2011c).

3.3.3.1. Operationalisation and current status of the three cases

Similar to the economic and innovation regime, the welfare regime is complex. The current approach by the three cases to this function differs significantly. While China is still at the beginning of implementing a welfare state, the United States is mostly dependant on private initiatives and has not installed a tight public safety net. European countries, in particular in Scandinavia, have implemented very elaborated welfare regimes. Esping-Andersen (1990) has presented the dominating analytical approach to study welfare state regimes. It focuses on de-commodification, social stratification and the public-private-mix of social service. At the heart of the welfare regime typology stands the concept of de-commodification which describes that “citizens can freely, and without potential loss of job, income, or general welfare, opt out of work when they themselves consider it necessary” (Esping-Andersen, 1990: 23). Social stratification of a society describes how flexible a social order is, meaning how easy it is to move up and down the social ladder. The public-private mix illustrates who assumes which part in the provision of welfare services. On this basis Esping-Andersen (1990) identifies three ideal type welfare regimes in order to describe how countries approach social security:

- Liberal regimes ensure a basic safety net “in which means-tested assistance, modest universal transfers, or modest social-insurance plans predominate” (Esping-Andersen, 1990: 26). Low-income households are the targets of targeted welfare benefits, which often times stigmatize recipients. Overall, the level of benefits is low as liberal welfare regimes provide only a basic level of services. If citizens want further safety nets, they need to buy insurance from private actors. Real type examples are the United States, Canada and Australia.
- Corporatist or conservative regimes aim to preserve “status differentials; rights, therefore, were attached to class and status” (Esping-Andersen, 1990: 27). Redistributing wealth is an afterthought. The church and traditional role clichés for the sexes (male-bread winner model) are important in this understanding. Welfare systems are based on insurance schemes that guarantee benefits in relation to prior payments. Real type examples are many continental European countries, for example Germany.
- Social democratic regimes have expanded “the principles of universalism and de-commodification of social rights” (Esping-Andersen, 1990: 27) to the new middle

classes. They are labelled social democratic regimes because social democratic politicians introduced far-reaching reforms to reach a high degree of equality. Redistribution of wealth to achieve equal opportunities for everyone is the stated goal of this regime type. The Scandinavian countries most closely resemble it as a real type.

Each welfare regime results in a distributional pattern. The most used indicator to describe this pattern in a polity is the Gini coefficient that varies between 0 (perfect equality) and 1 (perfect inequality) (Wilkinson and Pickett, 2010). Hence, the following focuses on the welfare regime structure and on the Gini coefficient to point out how equal the cases are.

China

China's welfare state is still emerging since the primary focus has been laid on economic development. However, rapid economic growth has increased social tensions and inequality. The growing middle class demands a social safety net. While for a long time China has not published official Gini coefficients, it has recently presented them for the last decade. The official data for 2012 is 0.474 after having reached a peak of 0.491 in 2008 but it remains dangerously high; non-official estimates put the number even above 0.6 which would be one of the highest internationally (The Economist, 2013f). Furthermore, poverty remains high with roughly 40% of the population living from less than two USD (1.50 EUR) a day (Peng and Wong, 2010). The numbers show that social inequality is already a major problem in China.

China has not yet been thoroughly analysed from a welfare regime perspective. Peng and Wong (2010), however, have taken a different approach by clustering East Asian countries into inclusive social welfare regimes and individualistic social protection regimes. China falls into the latter category, which is surprising because of the Communist ideology. One explanation is that welfare benefits are skewed towards the urban workforce (Shang, 2006). The suppression of public demand for welfare reforms is identified as a major hindrance for policy reform. In addition, the central government lacks the fiscal strength to implement welfare services. Hence, it has put the burden of providing benefits on the lower administrative levels, which are riddled by corruption. Furthermore, this results in highly varying services depending on the local authorities (Shang, 2006). This categorisation is supported by the finding that China produces a relatively good welfare output with low state expenditure (Abu Sharkh and Gough, 2010). Hence, non-state mechanisms seem to be very important.

United States

The United States has been described as a “welfare state laggard” (Seeleib-Kaiser, 2006: 1464) since first provisions were only established in the 1930s with a second wave of legislation taking place in the 1960s. As a prime real type example of the liberal ideal type, basic public provision and market reliance characterise the welfare regime. Because of the heavy use of means-testing and private insurances, public welfare spending is comparatively low. However, non-monetary benefits such as vouchers and food stamps are common. In this context the taxation system assumes a larger redistributive role (Seeleib-Kaiser, 2006). This rudimentary welfare state regime results in an unequal social distribution in a comparison of industrialised economies. The Gini coefficient in the United States, which has historically increased, reached 0.486 before and 0.378 after taxes and transfers in the late 2000s (Organisation for Economic Co-operation and Development, 2013). Hence, considerable redistribution takes place, but inequality remains high. President Obama introduced universal health care during his first term in office which could reduce social inequality (Lizza, 2010).

European Union

The European Union is a socially diverse area: While the Gini coefficient for all 27 member states was 0.308 in 2011, it varied between 0.238 in Slovenia and 0.354 in Latvia (Eurostat, 2013). This is a trend that is consistent over time. The situation in the European Union is diverse but the member states are largely equal societies, as even the most unequal economies do not reach a Gini coefficient over 0.4. This reflects the diversity of social welfare regimes within EU member states that cover all three ideal types presented by Esping-Andersen (1990): The Scandinavian countries represent the social democratic ideal type, the United Kingdom represents the liberal ideal type and Germany represents the conservative ideal type.

Since member states remain in charge of this crucial policy area, the European Union has few social policy competences (Szyszczak, 2006). Hence, it has not developed a distinct welfare state regime. This limits the impact that the supranational level can have on social equality. However, it has “some features of a welfare state” (Falkner, 2010: 292) stemming from its role in administrating the common market and the free flow of goods and workers. In addition, the European Union funds a ‘European Social Fund’ that aims to help unemployed workers to find a job (Falkner, 2010). It is largely a bottom-up initiative with the European Union assuming a coordination role of sub-level initiatives in order to avoid political and public resistance (Szyszczak, 2006).

3.4. Recapitulation

The transition to a green economy will deeply affect politics, polity and policy and result in the profound overhaul of societies. This chapter has presented a three-layered analytical model that explains the interplay between top-down and bottom-up influences. Political leadership is the key top-down mechanism for the green transition. The political leaders need to adjust societal preferences. This requires (electoral) incentives to remain on the greening path. However, leadership that does not translate into policy action will not change anything. Hence, the institutional design of a polity plays a key role as it describes these transmission belts. In the short-term, vertical and horizontal EPI are key to ensure that all government actors participate in the greening effort. In addition, the polity needs to overcome time inconsistency and send reliable signals to the other actors involved that changing political leaders will not completely reverse course in the future. Otherwise this uncertainty would undermine radical change. The three functions that are of highest importance for transition governance build the third level of the model: the economic framework needs to take into account the negative externalities of fossil fuels and steer investments towards low-carbon goods and services for them to compete on a level playing field; innovation policy needs to foster the development and market penetration of green technologies in order to significantly reduce the economic carbon footprint and make them market competitive; social policy must ensure a fair distribution of costs and rewards of the transition in order to ensure a high degree of acceptance of the transition process. These elements are closely intertwined through a variety of feedback loops. Furthermore, the three cases analysed in this thesis – China, the United States and the European Union – differ strongly in their current status with respect to the six dimensions as can be seen in the following table 9.

Table 9: Meta-overview of the three cases

	China	United States	European Union
Political leadership	Some within the leadership of the CPC understands climate change and environmental degradation as a key challenge	Polarisation of the issue between Republicans and Democrats prohibits continuous political leadership	International leader on climate change with certain doubts about future direction of climate policy

Transmission belts

EPI	Strong coordination problems between the various political layers	Strong checks and balances on the federal level challenge lasting policy initiatives; many competences remain with the states	EPI is enshrined in the supranational system <i>sui generis</i> , but the member states remain the principal actors limiting the impact of the supranational actor
Time consistency	The FYP and other plans ensure a stable framework over time; targets are only relative not absolute	The unsteady political leadership and high level of polarisation has avoided of long term stability and created boom and bust cycles	Stable framework based on targets and strategies; however, targets for 2030 less stringent than 2020 targets
Functions			
Economic framework	Government-controlled form of capitalism in which in many key industries SOEs are in charge, growing role of international joint-ventures; first experiments with carbon pricing	Prime example of a LME that offers little room for government steering; some states have put a carbon price in place	Broad variety of national economies, but mostly CMEs; European-wide carbon price is in place, but with little steering capacity
Technological innovation	Innovation system is immature and highly state-centred, but the capacities are growing; little is known about the quality	Largest innovation capacity worldwide; however, government influence is low limiting public steering potential	Supranational level holds little sway over innovation efforts as they are mostly organised by the member states
Welfare regime	High reliance on non-state actors for welfare provision; highest Gini coefficient of the three	Liberal welfare state regime; middle Gini coefficient of the three cases	Supranational level has little impact on social policy; Gini coefficient of all member states lower than for other cases

Source: Author's compilation.

Preface to the case studies

Sustainable transitions are an uncertain long-term project. The three-layered analytical model has shown that governing and steering them requires a profound overhaul of the governance regime. With many stakeholders involved who need to take care of a variety of tasks, the process is challenging for everyone. At the beginning of the green transitions, the outcome is unknown and the path uncertain. Hence, empirical case studies are a snapshot and should concentrate on parts of the process in order to show a nuanced picture. The following case studies focus on the progress to date for selected policy fields. The snapshot comes with a warning, though: The unsteady dynamic of past transitions indicates that each point in time is likely either positively or negatively skewed. Furthermore, the chosen policy fields are not necessarily representative of overall progress. Nonetheless, this in-depth analysis based on the developed analytical model allows scrutinising whether the three cases escape the carbon lock-in of the fossil fuel era and base their economic activities on a more sustainable foundation.

The starting position of the three cases varies as seen in the previous chapter. Hence, this study applies a most different research design with regard to the polities analysed. They are chosen because they are central to a significant global decarbonisation because of their size. Analysed is always the political level that has the necessary competences to trigger and steer the transition in the given area: the central government of China, the federal government of the United States and the supranational level of the European Union. In China, public actors are deeply intertwined with most political, social and economic decisions. Manufacturing rather than innovation is driving rapid economic development during the last decades. The economic model results in high inequality that together with environmental degradation threatens the legitimacy of CPC rule. Going forward, the authorities aim to combine economic growth with environmental protection and social justice to improve the living conditions of the population. In the United States, the preconditions for a green transition are similarly complicated but very different. The governance system puts private actors into a strong position, as the marketplace is the key coordinating space. This limits the impact of state institutions. Furthermore, the political class is divided whether a green economy is a desirable goal or not. The European Union has historically been an international leader on climate change mitigation efforts. However, compared to the other cases, the power of the supranational level is limited since key competences remain with the member states. The

result is that the European level is limited to coordination and giving recommendations that the member states adopt according to domestic circumstances.

The transition to a green economy will affect all socio-economic areas. Since analysing them all is beyond the scope of this doctoral thesis, the case studies concentrate on one particular topic for each case. Three considerations guided each decision: First, the area must be central to the green economy: either it causes a high share of GHG emissions or it enables other technologies central to the green economy. Second, the areas need to represent a significant chance to significantly reduce GHG emissions. Third, the polities must have shown efforts to achieve a green transition in the analysed area. The three chosen policy fields satisfy these conditions. The Chinese government has put electro mobility high on the agenda, which can potentially reduce GHG emissions from the rapidly growing transport sector. Switching from fossil fuel to renewable electricity generation would considerably reduce the carbon footprint of the US economy. While several states have assumed a front-runner position, the central government can strengthen the transition process. Deploying the smart grid within the European Union would indirectly reduce GHG emissions by allowing other low-carbon technologies to enter the market more easily. While the member states remain crucial stakeholders – in particular in regulating their domestic power mix and shaping European energy policy – the supranational level has gained a prominent role as it is best suited to manage the European grid integration.

4. Electrification of the Chinese transport sector

This case study analyses the Chinese efforts to transition towards an electrified transport sector with the potential to significantly reduce GHG emissions.⁴⁹ While all means of transport – passenger vehicles, buses and municipal vehicles (for example cleaning machines), scooters and bicycles, trains, and airplanes – can be powered by electricity, the following concentrates on road transport since it is the main source of pollution. With the technology, market and regulatory framework for electro mobility still emerging around the globe, this case study offers a snapshot of the current situation in China. Comparing key developments to international competitors makes Chinese characteristics visible. Major technological breakthroughs could alter the situation dramatically. Hence, the future outlook is uncertain.

The transport sector is a major driver of GHG emissions. In China, it is responsible for approximately 8% of total GHG emissions, which is only one-third of the international average (International Energy Agency, 2014).⁵⁰ Because of its large population, Chinese per capita transport GHG emissions are only 12% of those in industrialised countries underlining the potential increase when the Chinese middle class can afford a similar lifestyle (Cai et al., 2012). In 2010, 58 out of 1,000 Chinese owned a car, which is low in an international comparison since the respective numbers for the United States and the European Union are over 700 and between 400 and 550 (Wu et al., 2012). However, projections expect that the ownership rate in China will increase and come considerably closer to European and US levels.⁵¹ While reducing these GHG emissions would be an important step in decarbonising the economy, expectations are that personal transport will grow considerably faster than GDP or population size (PRTM Management Consultants, 2011). Hence, the business as usual scenario of fossil fuel powered (mostly refined crude oil in form of gasoline) transport significantly increases pollution.

⁴⁹ It has benefitted from a research stay at the Institute of Policy and Management of the Chinese Academy of Sciences in Beijing from February to April 2012 upon the invitation of Deputy Director-General Professor Wang Yi.

⁵⁰ The Chinese authorities do not publish official data on GHG emissions in transport. In particular, data on fuel consumption of vehicles is missing. Hence, these numbers by the International Energy Agency (2014) have been questioned. Cai et al. (2012) assume that in 2007 the actual GHG emissions from the transport sector were considerably higher (436 mega tons to 408 mega tons).

⁵¹ A review paper of several market projections expects an average vehicle stock of 230 million by 2020 and 430 million by 2030, which would reflect in car ownership of 120 per 1,000 citizens by 2020 respective 300 by 2030 (Wu et al., 2012).

Strong manufacturing growth has turned China into the world's largest car producer with more than 18 million vehicles in 2011 ahead of the European Union with 17.7 million (International Organization of Motor Vehicle Manufacturers, 2012).⁵² This turns China into the biggest car market worldwide (Huo et al., 2012a). If China continues along this path, it would cause rapid growth of GHG emissions. The International Energy Agency (2010b) predicts that higher fuel efficiency standards and increasing use of bio-fuels can keep transport GHG emissions at today's level but a significant reduction requires new technologies, such as electric vehicles.⁵³ This shift from traditional cars to electric vehicles would mark a considerable technological transition as it entails profound changes to the infrastructure. However, an even deeper transition would shift the Chinese transport sector away from individual transport in which everyone owns a car towards a new design that integrates public transport and sharing models into a more resource-efficient sector.

Data sources include policy documents and statistics as far as available in English as well as press publications, research by mostly international civil society actors and secondary literature. However, finding reliable data in China is a tall task. Steinfeld et al. (2009: 1811) describe the problem well: "As in so many aspects of China's political economy, data, while often available, tend to be inconsistently reported, incomplete, and at times extremely confusing. This is true not just for publicly available data, but also for the internal data upon which policy decisions are made." Hence, this lack of reliable official data hampers academic research as well as policymaking. In order to give an accurate account, the case study presents an array of data when the available reporting is inconclusive. Under these circumstances it is highly important to triangulate the data in order to come to reliable results. The structure is as follows. The first part maps what electro mobility is, and which factors influence its environmental impact. The second part presents the current state of China's transport sector. The third part, the core of the case study, is the application of the analytical model on the Chinese transport sector. A focus is on explaining why to date, despite government interventions, very few electric vehicles are running on Chinese roads. The recapitulation concludes with the key findings.

⁵² This is even more impressive realising that in 1963 a total of 11 cars and in 1990 only 42,000 cars were produced in China (Gallagher, 2006).

⁵³ Chinese fuel economy standards are by now the third strictest worldwide – stricter than in the United States but not as strict as in the European Union and in Japan (Oliver et al., 2009). In addition, it encourages the use of alternative fuels (mainly diesel and bio-fuels) as well as supports research on electro mobility (Cai et al., 2012, Huo et al., 2012b).

4.1. What is electro mobility?

Electro mobility has the potential to significantly alter the transport sector. Replacing gasoline and diesel with electricity generated from renewable sources would mark a significant step towards a green economy. Major upsides are that it concentrates pollution at the site of electricity generation outside of cities as well as reducing noise and it is much more energy-efficient than burning fossil fuels (International Energy Agency, 2011a). While electricity was a potential power source during the introduction of cars in the late 19th century, it has largely disappeared after the internal combustion engine (ICE) became the predominant technology (Unruh, 2000). Since then, the ICE has locked-in and shaped the behaviour as well as infrastructure towards its needs (petrol station etc.), whereas the necessary charging infrastructure for electro mobility is missing. This increases the challenge because it requires an overhaul of the infrastructure. However, in comparison to other industrialised countries, this ICE lock-in is weaker in China because the Chinese car industry had been shut down during the Cultural Revolution when cars were considered luxury goods.⁵⁴

China has coined the term ‘New Energy Vehicles’ (People's Republic of China, 2011, State Council of the People's Republic of China, 2012a) when addressing electro mobility, which is the more common wording internationally.⁵⁵ New energy describes the electricity generation sources. The Chinese wording includes nuclear and large hydro (which are criticised technologies by many environmentalists) as well as renewable energy sources to power a growing electric fleet (Hannon et al., 2011).

4.1.1. Technology development and the Chinese status quo

The transition to electro mobility depends to a high degree on the available technology stressing innovation. However, engineers still need to solve major challenges: high battery cost resulting in higher prices than traditional vehicles, limited driving range because of battery capacity restraints, lack of charging stations and the need to ramp up production to generate economies of scale (International Energy Agency, 2011a). The following discusses engine, battery and charging infrastructure in more detail and elaborates China’s current situation.

⁵⁴ For an historical overview of the Chinese automotive industry Gallagher (2006: 31-45), Kubach (2011: 26-35).

⁵⁵ The following uses the internationally predominant wording electro mobility and electric vehicles rather than the specific Chinese wording.

- Industry has developed various electrified power trains: Pure battery electric vehicles (BEVs) run only on electricity, meaning that they cannot move if not charged. Hybrid electric vehicles (HEVs) combine electricity and traditional ICEs – they can assume various forms, such as plug-in HEVs that are charged through a cable in addition to refilling the tank of the ICE or range extenders that include a small ICE to charge the batteries. An alternative power source applied in fuel cell electric vehicles (FCVs) is hydrogen. While only few BEVs and FCVs are available in the marketplace, HEVs have gained a significant share of several regional markets, for example approximately 3% in the United States in 2009 (International Energy Agency, 2011a).⁵⁶

Chinese carmakers are capable of producing all types of vehicles. However, they lack knowledge on many issues concerning ICE technology limiting their international competitiveness. For this reason, the government concentrates on electro mobility with a more level international playing field in an attempt to ramp up the industry. The definition of NEV of the National Development and Reform Commission includes “HEVs, BEVs (including solar-panel-powered vehicles), FCVs, hydrogen internal-combustion engine vehicles, and other vehicles with new fuels” (cited by Gong et al., 2012: 211). Chinese manufacturers have presented several HEV and BEV models and joint ventures with international car manufacturers have increased the available models (Earley et al., 2011, Liu and Kokko, 2013). Nonetheless, industry insiders suggest that with regard to “energy efficiency, control accuracy and reliability for motors technology in China still lags behind the international advanced level, and further improvements are in need for product development and manufacturing process” (Ou and Zhang, 2012: 2046). Hence, the Chinese car industry is improving but has not yet caught up with international leaders.

- Batteries are the fuel tanks of electric vehicles. A key task for engineers is to improve their capacity while at the same time reducing their price. This is crucial because they explain the high price differentials compared to ICEs and their limited capacity reduces the potential driving range which deters consumers (SupplierBusiness, 2011). While prices are expected to fall with growing production capacities, more research is needed to increase their capacity and reduce their weight. Currently, lithium-ion technology is predominant but most likely new chemical substances will bring the breakthrough to higher energy density (SupplierBusiness, 2011). However, developing

⁵⁶ The most famous to date remains the Toyota Prius developed in Japan in the late 1990s.

better batteries is only part of the solution as battery management systems determine the life time and power of a battery.

China is the world leader in battery production for consumer electronics but not a major innovator in the field (SupplierBusiness, 2011): While it produces over half of all lithium-ion batteries for consumer goods, it holds only 1% of all patent registrations (PRTM Management Consultants, 2011).⁵⁷ This could hamper innovation because of licensing fees (Earley et al., 2011). However, China has cheap access to the required rare earths for lithium-ion batteries giving it a cost advantage.

- Charging electric vehicles takes longer than refilling ICE and needs to take place more often because of limited battery capacities. For electro mobility to gain market shares, charging needs to be easy for consumers (Reichert et al., 2011). Hence, the infrastructure needs to adapt and various models are discussed: First, charging at home through charging cables, which requires new power outlets; second, super-fast charging facilities comparable to existing gas stations that make use of induction technology, which can in the long-run damage the batteries; third, battery swap in which empty batteries are exchanged for charged ones. This is fast but requires standardized batteries, which limits design options for manufacturers.

China has not yet settled on a model leaving analysts to argue that the charging problem hinders the large-scale adoption of electro mobility (McKinsey & Company, 2012b). However, this is a common international problem. A peculiar Chinese challenge is that people in large cities often live in apartment buildings. This means that they lack access to power outlets over night. However, the two major energy utilities, ‘State Grid Corporation of China’ and ‘China Southern Power Grid’ have announced investment plans to begin building the necessary infrastructure until 2015 (Liu, 2012). The major oil companies also start moving into this field by adding electric charging to their gas stations (Li and Ouyang, 2011).

A major advantage of China in the international electro mobility competition is that it is close to a global monopolistic owner of lithium and rare earths required for the batteries and other parts (Kubach, 2011). 30% of rare earths deposits exist in China and it currently produces 95% of worldwide supplies; China is the third biggest world market supplier of lithium (following Chile and Australia) (Earley et al., 2011). Hence, a Chinese analyst states that “China's competitive edge in batteries, electric motors, lithium and rare-earth resources can help the nation to become a leader in the electric-vehicle industry” (Li, 2011). It has put in

⁵⁷ Japan holds 50%, the United States 25%, and Europe and South Korea about 20% of the patents.

place strict export restrictions which has led to price hikes abroad (Stewart et al., 2012). While this does not improve the perception of China abroad, which could hinder the technological cooperation, it gives it a cost advantage (PRTM Management Consultants, 2011, Valentine-Urbschat and Bernhart, 2009). Furthermore, it might stall international R&D of new battery technologies that could diffuse to China.

4.1.2. Greenhouse gas emissions intensity of an electrified transport sector

The environmental impact of electro mobility depends on the electricity generation (Earley et al., 2011, Huo et al., 2012b): GHG emission reductions take place when generation emits less than burning gasoline; GHG emissions increase when the GHG intensity of generation is higher than of ICEs. Hence, the energy mix determines the environmental impact. While China advances renewable sources of electricity generation, it generates almost 80% of its electricity by burning coal for which reason it is responsible for almost half of worldwide coal demand (International Energy Agency, 2012b). In the United States, the second largest coal user, burning coal generates approximately 45% of electricity. Hence, the Chinese energy mix is very GHG emissions-intensive because of the high share of coal burning. This does not bode well for achieving GHG emission reductions through electro mobility.

In a full life-cycle comparison of ICE vehicles and BEVs taking into account the current Chinese energy mix, “the GHG emission changes range from a 23% reduction to a 36% increase over the use of ICE vehicles” (Earley et al., 2011: 22) depending on the regional grid.⁵⁸ These findings are supported by Huo et al. (2012b) who conclude that in a wheel-to-wheel comparison electro mobility will reduce GHG emissions by 12% by 2050 compared to the business as usual scenario.⁵⁹ However, fuel consumption improvements are more effective as they would reduce GHG emissions by 34% during the same time frame. According to Huo et al. (2010), GHG emissions could rise potentially by 7% in an electro mobility scenario – the breakeven point between ICE and electric vehicles emissions is when coal power plants produce 87% of electricity.⁶⁰ Hence, the differing energy mixes of the Chinese regional power grids are an important variable for the GHG emissions from each power train. From an environmental point of view, only the regions with a low level of electricity generated

⁵⁸ Six regional energy grids that are not closely linked serve China. Depending on the grid, between 65% and 98% of generated electricity stem from burning coal (Huo et al., 2010).

⁵⁹ This study assumes that electric vehicles will assume 60% of the market.

⁶⁰ The scenario does not include GHG emissions arising from the creation of the charging infrastructure. The breakeven point also depends on the efficiency of the power plants and which other technologies are included in the energy mix. Currently, in the Northwest, Central and South regions clean energy sources are furthest developed. Hence, they are better suited for electro mobility from an environmental point of view.

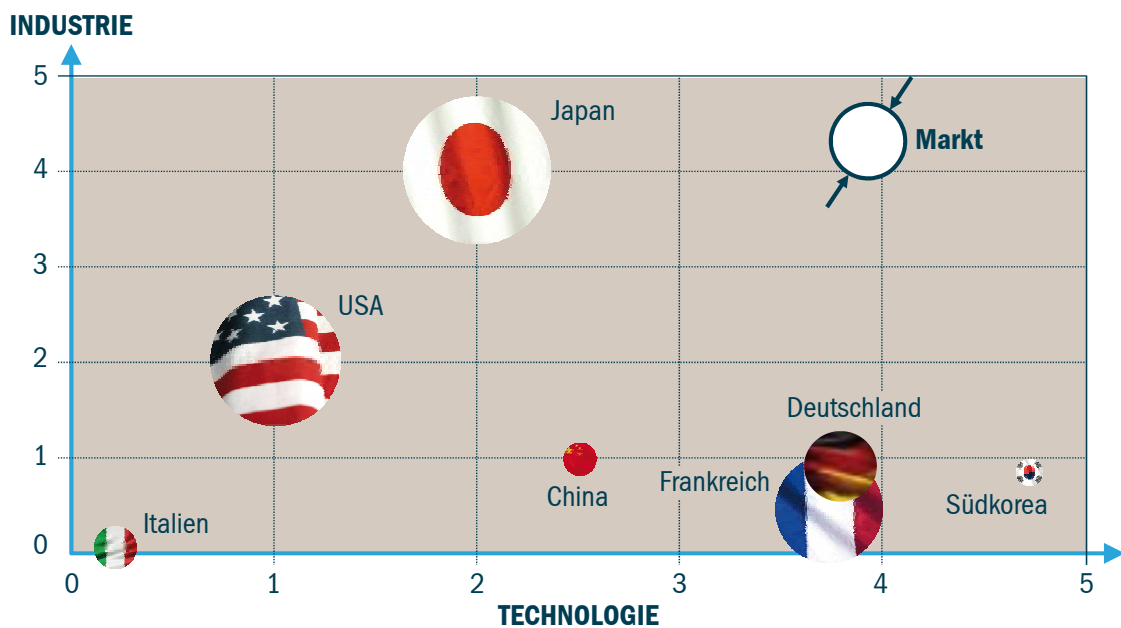
through coal burning should pursue electrified transport. Other parts of the country should change their energy mix first.

4.2. Is China's transport sector transitioning to electro mobility?

China's quest to transition to an electrified transport sector started in the mid 2000s. Key actors have given it a prominent position on the policy agenda for economic and environmental reasons. This was successful in the bike sector that has been mostly electrified: "E-bikes in China are the single largest adoption of alternative fuel vehicles in history, with over 100 million vehicles purchased in the past decade, more than all other countries combined" (Ji et al., 2012: 2018).⁶¹ The transition towards e-bikes was supported by various circumstances: Restrictions on the use of ICE-powered bikes were implemented that served as incentives towards moving to cleaner alternatives and necessary infrastructure changes are small; the batteries can either be taken out of the bike and charged at home or drivers had to stop only briefly at public charging stations because the bikes use little energy. Furthermore, range constraints matter less because bikes are rather used for short-distance commuting than for long journeys. Whether this success story supports the car transition is doubtful.

The numbers for electric vehicles being sold in China and running on the streets are very low. McKinsey & Company (2012b) find that between January 2009 and July 2012, 7,834 electric vehicles were sold; in the first quarter of 2012 only 343 and in the second quarter even less, 235. Official Chinese sources state higher totals with 5,579 BEVs and 2,580 HEVs sold in 2011 (Xinhua, 2012b) and 2,661 BEVs and 3,358 HEVs were sold in the first eight months of 2012 (Xinhua, 2012c). These are underwhelming numbers given the framework in place and they fall considerably short of prior expectations – a fate China shares with many other countries around the globe. Analysts expect that by 2015 150,000 electric vehicles will be produced in China, which would be decisively less than in Germany, the United States and Japan and falls decisively below Chinese targets (Bernhart et al., 2012). Figure 8 taken from an international comparison study underlines the small size of the Chinese electro mobility market. At the same time, it shows that in particular the industry dimension is falling behind whereas the technological development is in the middle of the pack. Furthermore, China is rather a small player in the international quest to electrify road transport.

⁶¹ Earley et al. (2011) state that in 2009 almost 24 million electric bicycles were produced and the overall stock was over 120 million.

Figure 8: International comparison of electro mobility development status

Source: Bernhart et al. (2012: 5).

The ‘Electric Vehicle Index’ presented by McKinsey & Company (2012b) supports this position for BEV. Based on ‘readiness’ (which includes supply and demand of electric vehicles, innovation capacities, activities of domestic car manufacturers and government incentives), China ranks fifth behind Japan, the United States, France and Germany. However, it is slowly losing ground as other markets are progressing faster, mostly because of higher demand. The analysts advocate a strategic shift to reduce the emphasis on BEV and target on technically more advanced options, such as HEVs and range extenders. The following elaborates the Chinese efforts to escape carbon lock-in in the transport sector. The analysis tries to find reasons, why the results are inadequate despite the elaborated framework in place.

4.2.1. Political leadership of the CPC exists

With few chances for bottom-up initiatives in China, the decisions of the top-level are even more important: Political leadership of the CPC is an essential prerequisite to shift the resource base of transport. Other actors have neither the necessary legitimacy, nor the political and financial power to do so. Electro mobility was first mentioned in the 8th FYP, which covered 1991-1995 (Kubach, 2011). The topic reappeared in the 2004 reformulation of the ‘New Automotive Industry Policy’, which named researching energy-efficient and electric cars as a long-term goal (National Development and Reform Commission, 2004). However, at

that time it was not very high on the political agenda. It was in the late 2000s that the topic rapidly gained prominence with key decision-makers (Liu and Kokko, 2013). From 2002 to 2012, during the tenure of President and CPC Secretary General Hu Jintao and Prime Minister Wen Jiabao the push for electrified transport accelerated. The administration formulated the aim to become a global leader in electro mobility. The Chinese Minister for Science and Technology, Wan Gang, as well as an official from the Ministry of Industry and Information Technology articulated that China reaches for world leadership in electro mobility within the next ten years (Li, 2010). This happened when the issue gained international prominence because of the international climate change mitigation efforts and rapidly increasing prices for fossil fuels. It coincided with rapid growth of the Chinese car industry resulting in a positive economic outlook and severely increasing pollution problems.

Given that the CPC relies on output legitimacy to justify its authoritarian rule, this public determination has increased pressure to deliver measurable achievements. Hence, the decision-makers avoid negative publicity at all cost, including censoring the media: After three people died in a car crash involving an electric vehicle, local media was instructed not to report that a BEV was engaged (Voigt, 2012). While other international leaders have also stressed the importance of electro mobility, their governments are in general less involved in economic decision-making. Key companies in the Chinese car industry are in general either joint ventures with international competitors or they are SOEs, so the Chinese government is indirectly in charge (Gallagher, 2006). The companies that need to carry out the government orders, for example car and battery manufacturers, cannot report back negative developments that might endanger the announcements of the government.

The authorities have applied a broad array of policy instruments to gain the international leadership position. They have used the policy window to implement “possibly the world’s most aggressive programme to transition its public and private vehicle fleet to fully electric and electric-gas hybrid vehicles“ (PRTM Management Consultants, 2011: 4). It is managed by various organs of the central government: the Ministry of Science and Technology controls the R&D efforts, the Ministry of Industry and Information Technology, created in 2008, is since then in charge of the development of the car industry, the National Development and Reform Commission (in particular the Energy Bureau) is responsible for strategic policymaking, the Ministry of Finance manages the investments in the industry and several organs establish technological standards (Kokko and Liu, 2012, Liu and Kokko, 2013).

Economic rational outweighs environmental considerations in the push for electro mobility by China's ruling elites. Key is the development of the domestic car industry, which decision-makers understand to be critical for the country's future economic competitiveness (Oliver et al., 2009). As China has not been capable to catch up in the field of ICEs with international competitors who are technologically advanced and more experienced (Valentine-Urbschat and Bernhart, 2009), they decided to focus on electro mobility, a technology that is new to all market participants. In addition, path dependencies towards the ICE is weaker in China because of the comparatively low number of car owners and the short history compared to industrialized countries, in which the infrastructure is built for ICE vehicles. A second key economic consideration is the increasing import dependency because of the rising demand for fuel (Gordon et al., 2010, Kubach, 2011). Relying on electricity that can be generated from domestic coal increases energy security and reduces exposure to the international energy markets. The necessary changes to the energy mix are rarely considered in the debate since economic arguments prevail. Economic considerations outweigh environmental concerns. However, the growing number of cars challenges existing infrastructure and is rapidly becoming a major health and pollution concern (Gallagher, 2006). The continuing urbanization increases the problems (Kubach, 2011). Since electrified transport shifts pollution from city roads to the power plants, this can reduce the problem. The more profound question, whether China can allow the massive expansion of individual transport rather than inventing integrated transport concepts is rarely asked. While at times public transport is the aim of electrification efforts, this is because the government can more easily influence public purchases than the buying decisions of individuals. Overall, Chinese decision-makers are more concerned about ensuring constant economic growth resulting in higher employment and better living standards than environmental degradation. Hence, the discussion in terms of economic potential strengthens its position on the policy agenda. It is doubtful that an environmental approach alone would have received such massive public attention and support given the public preoccupation to generate wealth.

The Chinese government has used demonstration projects (Beijing Olympics 2008 and Shanghai Expo 2010) to introduce the topic to a broader public and gain first experiences. In 2009, the first large-scale experiment was initiated, the '10 Cities – 1,000 Vehicles' project. It was over time stretched out to 25 cities.⁶² This project follows the Chinese tradition to try new

⁶² In early 2009 the first 13 cities were listed as energy saving and new energy vehicle demonstration cities (Beijing, Shanghai, Chongqing, Changchun, Dalian, Hangzhou, Jinan, Wuhan, Shenzhen, Hefei, Changsha, Kunming, and Nanchang). Seven more cities were added in June 2010 (Tianjin, Haikou, Zhengzhou, Xiamen, Suzhou, Tangshan, and Guangzhou). The last addition took place in July 2011 with five more cities

policy initiatives on a small scale to gain first experience and scale them up when successful (Earley et al., 2011). While an official review of the project is not available, Xinhua (2012c) reports that only 11,949 of 52,621 planned vehicles were running on the streets in 2011. Whereas these numbers could not be verified, they point to disappointing results of the pilot project. Nonetheless, electro mobility has received a very prominent position in the 12th FYP as one of seven “strategic emerging industries” (People's Republic of China, 2011: 46).⁶³ The seven industries, which currently contribute 2% of GDP, are expected to generate 8% of GDP by 2015, 15% of GDP by 2020 and China should be the international leader in the respective field by 2030. In order to reach this ambitious goal, the Chinese government has announced spending a total of 100 billion RMB (12.1 billion EUR) on electro mobility by 2015 from the public purse, significantly more than other countries (Hannon et al., 2011).

Following a lack of advancement of the technology and resulting turf-wars within government over strategy and targets, the top-level politicians have started to sound more cautious. They have realised that progress is harder to come by than initially expected as the demonstration projects underperformed and they could not reach the first announced targets: Wen Jiabao was quoted in the CPC's official journal *Qiushi*: “We are no match for developed countries in technology. We've only just begun in electric car development.” (Cited in McDonald, 2012) He added that government guidance was weak and “it remains uncertain whether hybrid and electric cars will be the winners in the end” (cited in *Week in China*, 2011). This is a remarkable turnaround for a political culture in which the political leadership rarely admits failure. It underlines the emphasis the CPC puts on expectation management to protect its output legitimacy. However, whether a policy reversal will coincide with this statement remains unclear (Spiegel Online, 2011). The new Chinese leadership of President Xi Jinping and Prime Minister Li Keqiang, that assumed power in 2013, follows the green agenda of their predecessors because of considerable political and financial investments and the prominent position it assumes in the strategic planning documents. For example, for the first time under their reign China signed a bilateral accord with the United States on climate change in the fall of 2014 (Landler, 2014).

(Shenyang, Chengdu, Nantong, Xiangfan and Hohhot) being included.

⁶³ The seven industries are energy conservation and environmental protection, next generation information technology, biotechnology, high-end equipment manufacturing, new energy, new materials and new-energy vehicles.

4.2.2. Transmission belts between CPC leadership and other actors

Since the political top-level has assumed leadership, institutional constraints are a potential explanation for the lack of change in a system in which governance largely equals government. The authoritarian system limits the scope for public critical voices. The predominant position of the CPC is a two-edged sword: It can trigger change but it also increases the pressure to succeed and limits criticism, which causes problems. Hence, criticism of the Chinese strategy is mostly articulated by international observers, for example McKinsey & Company (2012b). This lack of reflection is a key reason besides technological challenges for the overambitious targets set in the past. However, China shares this fate of not reaching the set targets with many other important car producing countries. Nonetheless, an opener political culture would have discussed much earlier that the targets are unrealistic. This undermines time consistency because unreliable targets endanger the confidence of all stakeholders.

However, the central government is not a unitary actor as is often assumed. Profound differences between key ministries have delayed important documents. Furthermore, precise information is hard to come by under a political culture that in many areas emphasises secrecy. As a result, it is difficult to discern the power structures between the various public actors. This is a troublesome sign since most legislation and directives are published as collaborative efforts (Liu and Kokko, 2013). In the case of electro mobility, lacking clarity on which technologies the Chinese government wants to focus on, with which speed it wants to advance and which support sources are available, hamper innovation efforts. Democratic political reforms that would strengthen the feedback mechanisms seem unlikely in the medium-term. While these would integrate more stakeholders and ensure that a critical media can assess the work of the authorities, the CPC is unlikely to weaken its tight grip anytime soon (The Economist, 2013g).

Supporting electro mobility under the Chinese institutional framework requires solving three integration challenges: First, in China's state-run capitalism, many important car manufacturers are SOEs and receive preferential treatment over private competitors (Liu and Kokko, 2013). While this increases state control, it limits market competitiveness and public authorities overestimate their steering capacity of innovation and production processes. The success of the private company 'Build Your Dream' (BYD), often considered the "poster-

child” (Week in China, 2011) of electro mobility in China challenges this focus.⁶⁴ However, BYD has recently run into economic trouble since “by being a clever private sector fox in a marketplace that rewards wise public sector hedgehogs, BYD has spread itself perilously thin” (Stinson, 2012). This underlines the challenges a private company faces in a strategic economic sector. However, it also challenges the public focus on SOEs as it hampers promising privately owned companies. At the same time, Chinese SOEs so far have not yet been capable of generating the necessary innovations. While this is similar for other car manufacturers, China holds an international leading position in supporting its industry in the quest to develop electric vehicles. Second, electro mobility requires integrated thinking of the energy and transport sector and policy (Kubach, 2011). These generally separated fields need to collaborate for innovative business models to emerge. Energy utilities for example, can enter new markets by selling electricity to car users and developing grid systems that use electric vehicles as storage facilities (Ou et al., 2010). This indicates “shifts in the value chain, the revenue model, and the value proposition“ (Kley et al., 2011: 3394), which significantly alter the market structure for both sectors. The differing opinions between science and industrial policymakers demonstrate the potential for disagreement when making these cross-cutting decisions and turf wars can significantly hamper the development of a coherent framework. However, China shares this challenge with most international markets. Third, the Chinese form of federalism elaborated in more detail below requires coordination between the central government and provincial authorities. Both layers own SOEs which holds additional potential for conflicts between the two administrative layers (Liu and Kokko, 2013). Given China’s quasi-federal organisation, the province level mirrors these central actors. They are in charge of implementing large parts of the central government’s guidelines. Hence, the provinces can severely limit the impact of central planning and assume the role of a veto player.

4.2.2.1. Horizontal environmental policy integration

A response to the deficits of SOEs has been the ‘State-owned Enterprise Electrical Vehicle Industry Alliance’ founded in 2010, which comprises of sub-groups on electric vehicles, batteries and the charging infrastructure (Tagscherer, 2012). The aim is to find a comprehensive approach on various issues of importance to the industry. Companies benefit through investments and information exchange and the government gains influence by

⁶⁴ BYD was founded as a battery producer in 1995 and is, by now, the world leader in battery production and the Chinese electro mobility leader (Kasperk et al., 2010).

strengthening the SOEs (Liu and Kokko, 2013). The integration of strong private companies only happens in regions where they are located leaving regional authorities little chance than fostering their development in order to protect growth and employment potential. While this cooperation – when taken seriously – has the potential to improve the electro mobility capacities to develop, by integrating various sources of knowledge, the impact of these alliances so far is unknown.

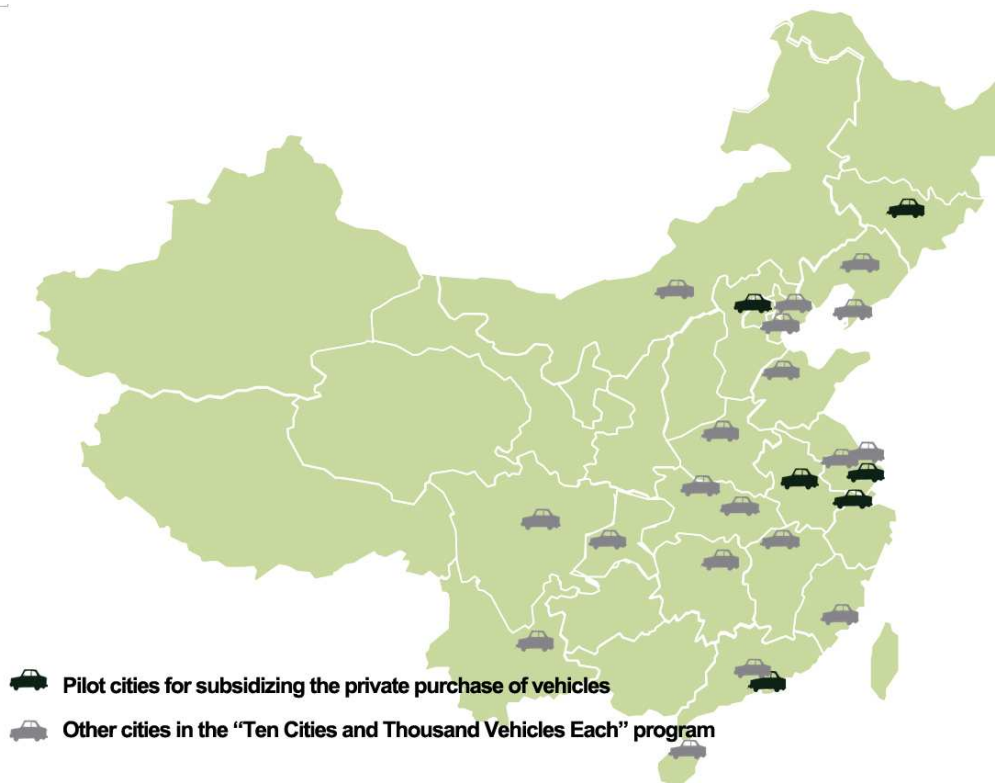
Integrating transport and energy planning is a prerequisite for successful electrification of transport (Kubach, 2011). However, “there is no single policy dedicated to electric mobility in China today” (Tagscherer, 2012: 1) as various public stakeholder aim to achieve their electro mobility goals. The competences are spread out between the Energy Bureau of the National Development and Reform Commission and the Ministry of Industry and Information Technology and Ministry of Science and Technology. Hence, this turf war shows that not even within the central government a common strategy exists. An integrative body does not exist. While it currently looks like the Ministry of Industry and Information Technology has advanced its priorities in the 2012 ‘Energy-saving and New Energy Vehicle Development Plan’ (State Council of the People's Republic of China, 2012a), it is uncertain whether this is a snapshot or a lasting hierarchical order. Given this uncertainty, actors involved in the innovation cycle likely avoid lasting investments. A Ministry of Energy, considered for some time, has not been established even though it could potentially solve the integration challenge (Lan, 2012). This lack of horizontal integration is a weakness of the transmission belts.

4.2.2.2. Vertical environmental policy integration

While China is a central state, it gives the provinces an important role in implementing central government plans as they develop own plans and targets. The province level can also be a futile testing ground for new governance regimes. For example, regional alliances between universities, business and authorities have been established with promising results. However, a key problem of Chinese environmental governance is that “local governments have always placed GDP growth before environmental protection” (Li et al., 2012: 65) because that is the main parameter the regional officials are evaluated upon. Hence, they see electro mobility as a vehicle to bring economic growth and employment opportunities through financial support from the central government to their region. In order to do so, they nurture their regional car manufacturers rather than participate in the national efforts or supporting a concentration of the industry (Gallagher, 2006, Gong et al., 2012, Liu and Kokko, 2013). The ‘10 cities, 1,000 vehicles’ project demonstrates that the support is not concentrated where it would have the

biggest impact but according to regional interests. A World Bank survey of local authorities found that participating cities do so because they aim to foster their local car industry and economy (Zheng et al., 2012).

Figure 9: Cities participating in the '10 cities, 1,000 vehicles' demonstration project



Source: Wang and Su (2009: 12).

Many cities have lobbied to be included as pilot markets without standing a realistic chance to achieving much progress on electro mobility, for example because they lack a strong car industry (Liu and Kokko, 2013). Since GHG emissions in the transport sector are unevenly distributed across China because of differing regional wealth and economic activity (Cai et al., 2012), it would make sense to concentrate electro mobility in areas where pollution is worst, the car industry furthest developed and the electricity mix results in a GHG emissions reduction. However, not only cities with good prepositions for the development of electro mobility were included but cities from which little progress was expected, as well (Gong et al., 2012). Hence, the incentives for regional authorities have harmed the development of electro mobility. In an attempt to solve this problem the central government has included the target of reducing the number of independent car manufacturers and create some strong

players in the ‘2009 Automotive Industry Restructuring and Revitalization Plan’ (State Council of the People's Republic of China, 2009). A concentration of the industry will, if successful, push various companies out of business, while creating various larger ones. This is intended to strengthen the car industry. However, strong opposition from the regions that would lose their car producers must be overcome.

Provinces with local car companies, which they sometimes even own, more actively foster electro mobility. Shenzhen, in Guangdong province (southwest China, close to Hong Kong), “is far and away the leader in all things” (Chambers, 2012) regarding electro mobility. BYD’s headquarter is in Shenzhen which results in a close interaction between industry and regional government. The data on electric vehicles on the roads of Shenzhen vary from more than 3,000 (Chambers, 2012) to 300 electric taxis and 2,000 electric buses (Voigt, 2012), while the city aims to rapidly increase the numbers. It announced the most ambitious targets in the ‘10 cities, 1,000 vehicles’ project with reports ranging from 9,000 (Gong et al., 2012) to 24,000 (Zheng et al., 2012) electric vehicles by the end of 2012. According to Gong et al. (2012), Shenzhen had brought 2,363 electric vehicles on the road by October 2011, which would be the most of any Chinese city but only 26% of the proposed target. Nonetheless, Shenzhen has established a very supportive local policy framework that offers cheaper electricity prices and cost-free installation of charging points for electric vehicle buyer in addition to the federal fiscal incentives.

Shenzhen is not alone with these regional incentives, as several cities and provinces have established their own targets trying to reach them with local financial incentives. The result is a scattered landscape with, for example, varying fiscal incentives, which makes it difficult for consumers to realize what support measures are available. Hence, the complexity of the regional differences and the unsteadiness of the framework might overburden consumers in their buying decisions. In addition, an overemphasis on new energy vehicles is likely to create a surplus of production facilities that will be economically harmful in the future (Wang and Chen, 2011).

4.2.2.3. The Chinese political culture supports time consistency

The discussion of political leadership has shown that decision-makers have slowly lost their enthusiasm. Nonetheless, the role of electro mobility in the FYPs has steadily increased. In addition, more detailed plans specify the framework. While this should ensure stability, past plans have lacked a strategic vision how to achieve overambitious goals. For example, the

Automotive Industry Restructuring and Revitalization Plan, presented in 2009 as an economic stimulus effort after the global financial crisis that began in 2008, aimed that by 2011 5% of all car sales (approximately 500,000 vehicles) in China would be electric vehicles (State Council of the People's Republic of China, 2009). Further ambitions were to stimulate domestic innovation, strengthen the necessary charging infrastructure and achieve a concentration of the car industry. It proclaimed investments in R&D and demonstration projects (the '10 Cities, 1,000 Vehicles' project was a consequence) to achieve these targets. However, the target has proven to be unrealistic because of unreasonable expectations about existing capacities and growth potential. The public authorities had major difficulties to assess the technological capacities of the Chinese car industry despite controlling the SOEs. Hence, the plan did not increase time consistency because it did not create stability but rather questioned the steering capacity of the central government. One possible explanation for this lack to reach the targets in China is that the transmission belts are not working well. However, the Chinese authorities are not the only government that has presented unrealistic targets.⁶⁵ Germany, for example, has announced that by 2020 1,000,000 electric vehicles will run on German streets, but likely only reaches 600,000 without additional financial incentives (Kagermann, 2012).

In an effort to solve the Chinese implementation gap, the 12th FYP has declared the intention for strengthening NEVs but it has not established the future policy framework for the industry. This is the task of the 2012 Energy-saving and New Energy Vehicle Development Plan (2012-2020) (State Council of the People's Republic of China, 2012a) that specifies the future growth path of the transport sector. Based on the negative experience of the 2009 Automotive Industry Restructuring and Revitalization Plan, the draft of this plan has been controversially discussed. As a result, the final version was published in April 2012 instead of summer 2011 as initially planned. Internal divisions within the relevant agencies, in particular between the Ministry of Industry and Information Technology and the Ministry of Science and Technology, have caused this delay.⁶⁶ The major issues between the two ministries were: Which technology should China primarily strive to master and rely on in order to become a world leader in electro mobility and which realistic targets are helpful to reach the long-term goal should it include. On the first question, the Ministry of Industry and Information Technology argued that demand for HEVs will be higher because they are less dependant on new charging infrastructure and they are more readily available, even though other countries,

⁶⁵ See International Energy Agency (2011a: 17-18) for an overview of international targets.

⁶⁶ While the Ministry of Industry and Information Technology is in charge of drafting the plans (Qiang, 2011), Science Minister Wan Gang has been one of the first and fiercest proponents of electro mobility in China.

most notably Japan, are further advanced in the technological development; the Ministry of Science and Technology envisioned that China can become a world leader in BEVs if it develops the technology first (Liu, 2011, Yoshioka, 2011). On the second question, the Ministry of Industry and Information Technology preferred the target of 500,000 NEV and the Ministry of Science and Technology wanted a more ambitious target of one million NEV by 2015 (Hannon et al., 2011). Little is known about the role of business in this process despite its central role. The final version of the plan aims for 500,000 NEV by 2015 and 5,000,000 by 2020 (State Council of the People's Republic of China, 2012a). Even though it is the lower number, the target is very ambitious, in particular given the projections for the market development, which are considerably lower. The reason for these ambitious targets is the political wish to proceed faster than technology allows (Song, 2012). However, constant overshooting can undermine the leadership position of the CPC.

4.2.3. Adjusting three key functions

So far, the two upper layers of the analytical model have shown that political leadership is strong, but the transmission belts face problems translating them to the functional level. In addition, the technology has proven to be more difficult to master than initially assumed. Hence, when looking at the functions in the following it will be key to understand which steering signals they are missing and which policies could help overcome this implementation gap. Furthermore, innovation challenges require special attention. The findings show that Chinese authorities have started adjusting their economic framework in ways that aim to take environmental costs into consideration. Nonetheless, the strong state influence on the industry hampers the degree of innovativeness. While attempts are made to transfer technologies from abroad, further improvements towards a more innovative car industry are needed. So far, the distribution of costs and rewards of the transition towards electro mobility have not played a major role in the Chinese debate.

4.2.3.1. Greening the economic framework

At the moment, electric vehicles are not cost-competitive with ICEs. This is partly due to the macroeconomic framework that does not include the social costs of pollution. However, the more important factor is that expansive batteries result in higher purchasing costs for BEVs and HEVs compared to ICEs. Chinese decision-makers have dedicated half of the pledged 100 billion RMB (12.1 billion EUR) in financial support to demand-side subsidies that help cover this difference (Hannon et al., 2011). In addition, running costs for electric vehicles are

significantly lower since electricity is more efficient than gasoline to reach the same distance with a vehicle (Kley et al., 2011). This underlines that generally green technologies require higher upfront investments but have lower operating costs. Analysts assume that electric vehicles use only a quarter of the energy of an ICE powered vehicle resulting in costs between two and four EUR for driving 100 kilometres (Reichert et al., 2011). In the Chinese context, the fuel economy of a BEV is 300% better than that of an ICE while in a life cycle analysis they use 27% less total primary energy (Ou and Zhang, 2010).

Gasoline and electricity prices are key to the further development of running cost differences. The National Development and Reform Commission is in charge of the fuel price, which it regulates according to a formula that is linked to international crude oil prices. It is comparatively low at approximately 4.90 USD (3.74 EUR) per gallon (3.8 litres) which is position 45 (more expansive than in the United States, but much cheaper than in EU member states) in a comparison of 60 countries (Randall, 2012). The intention is to enable universal access with these subsidies (Lin and Jiang, 2011). However, the “pain at the pump” (Randall, 2012), meaning the average share of household income to buy a gallon of gasoline, is high: A person spends 30% of one day’s income to buy one gallon of gasoline. Increasing gas prices remain a social challenge for low-income households (if they own a car) even though prices are subsidised. A similar story can be told for the electricity price as “China continues to lack a formal, transparent mechanism for linking costs and retail prices in its electricity sector” (Kahrl et al., 2011: 4034). Higher prices for commercial buyers subsidise private consumption. As a result, prices are rather low in an international comparison with the effect that charging stations are not profitable. Li and Ouyang (2011) find that either energy prices need to rise by 25% or the price of batteries needs to fall by 25% in order for this to change.

This discussion of energy prices demonstrates that the Chinese government is not only involved in the marketplace through and directly intervenes in the pricing mechanism. These interventions are triggered by social rather than by environmental considerations. The current design does not internalise externalities. Hence, it actually increases demand for fossil fuels. The World Bank (2012) sees misleading economic incentives as the primary obstacle to green development in China. While the government is unlikely to take fast action to correct these distortions or reduce its interventions because of the potential for social unrest (Hannon et al., 2011), it has realised that slow changes are necessary. The 12th FYP marks a considerable shift in industrial policy towards green technologies, which will receive more investments and other incentives. In addition, experiments with carbon pricing take place. A carbon price

would not only make electrified transport economically more attractive in comparison to gasoline-powered transport but it would incentivise investments into the required infrastructure and research. However, it is unlikely that they offset all the support going to fossil fuels. Since most businesses are SOEs, they are unlikely to desire for change.

4.2.3.1.1. First experiments with a carbon price

As of now, China does not have a nation-wide carbon price in place. Hence, transport does not have to pay for the inherent pollution it creates. This favours ICEs under most circumstances because they emit more GHG emissions than electric vehicles. However, China has started local carbon exchanges and installed low-carbon development pilots in 2010, which were encouraged to experiment with carbon pricing (Han et al., 2012). The 12th FYP mentions the gradual implementation of a carbon market without further specification (People's Republic of China, 2011). The rationale is that in order to reduce pollution, decision-makers have realised that command and control regulation is less efficient than carbon trading (Han et al., 2012). Five cities (Beijing, Tianjin, Shanghai, Chongqing and Shenzhen) and two provinces (Guangdong and Hubei) will serve as test grounds for ETS and during the next FYP, starting in 2016, a national scheme is supposed to be implemented (Xinhua, 2012a). A major problem of these efforts is the lack of reliable GHG emission registers (Guan et al., 2012). Without knowing the exact annual GHG emissions, it is impossible to set and enforce an adequate cap. Here the limited environmental-administrative capacities come into play, as government officials might not grasp the complexity of the issue at hand. Hence, Grubb (2012: 667) correctly concludes that it “seems implausibly fast, but with the pace of Chinese developments, who knows”. While Han et al. (2012) are correct, when they argue that the next five years are crucial because of the currently existing political will to implement carbon trading, this might overburden the administrative system. The first pilot ETS in Shenzhen that went into effect in early 2013 underlines these challenges as not an overall cap is set but emissions intensity targets are used and, in addition, analysts expect an over-allocation of permits (The Economist, 2013b). However, the example of the implementation of the European ETS shows that the design has to adjust to changing circumstances, which requires time. Hence, it is promising that China begins to experiment with this instrument but it will require persistence and time.

4.2.3.1.2. Substituting fossil fuel subsidies with demand-side measures

As a member of the G-20, China has signed the pledge to remove fossil fuel subsidies. However, Koplow (2012) finds that China still has some subsidies in place. To ensure universal access to energy, it subsidises fossil fuel sources to steer the prices. The result is a low gasoline price that reduces costs for consumers but at the same time creates high costs for government and the environment. The International Energy Agency (2012b) reports that in 2011 China subsidised fossil fuels with more than 30 billion USD (22.9 billion EUR) as one of the biggest overall spenders. As a result, the Chinese power generation companies have generated losses, which the government accepts to protect low energy prices (Lin and Jiang, 2011). SOEs are not necessarily geared towards economic prosperity but fulfil political goals, which is a burden on public budgets that limits other investments and endangers the economic viability of electro mobility. However, the taxation system sets incentives to buy energy-efficient cars. The excise tax on vehicles is lower for smaller cars and increases with the size of the car (Zhang, 2010). A new fuel tax put in place in 2009 raised the gasoline consumption tax rate from 0.2 to one RMB (0.02 to 0.12 EUR) per litre and the diesel consumption tax rate from 0.1 to 0.8 RMB (0.01 to 0.10 EUR) per litre. Furthermore, some Chinese NEV models are exempted from the vehicle's tax (Stewart et al., 2012).

The central government has put in place demand-side subsidies to overcome the significant price disparity between ICE and electric vehicles. Several countries have chosen this policy, for example Japan (10,000 EUR), Spain (6,000 EUR), France and United Kingdom (5,000 EUR) as well as Portugal (4,500 EUR) (Reichert et al., 2011). The '10 cities, 1,000 vehicles' project included subsidies for public buyers between 50,000 RMB (6,046 EUR) for HEVs, 60,000 RMB (7,255 EUR) for BEVs and 250,000 RMB (30,230 EUR) for FCEVs (Gong et al., 2012, Kubach, 2011), which puts China in the top regions of the international comparison. In June 2010, the government selected five pilot cities, which are all home to major car manufacturers (Shanghai, Changchun, Shenzhen, Hangzhou, and Hefei; Beijing was later added), that offer subsidies to private consumers of similar size (Earley et al., 2011, PRTM Management Consultants, 2011). Overall, the central government has set aside 30 billion RMB (3.6 billion EUR) to support the market introduction by giving subsidies to consumers and 20 billion RMB (2.4 billion EUR) specifically towards the introduction of HEVs (Tagscherer, 2012). While Liu and Kokko (2013) argue that the differing support for HEVs and BEVs underlines that China favours BEVs over HEVs, the existing price difference is another possible explanation. Otherwise this would be a contradiction to the emphasis that is

put on HEV technology in the Energy-saving and New Energy Vehicle Development Plan.⁶⁷ In general, subsidies are only paid if demand exists. So far, the subsidies have not been sufficient incentives for consumers to shift from ICE to electric vehicles. The same can be said about most other markets that emphasise demand-side policies. One reason might be that the price differential is still not completely offset. McKinsey & Company (2012a) estimates that electric vehicles are up to 150% more expensive than ICE vehicles despite the subsidies.

The government has included a provision that aims to strengthen Chinese manufacturers. Eligible for subsidies are only vehicles that are on the 'Recommendation List of Vehicle Types for the Demonstration programme of Promoting Energy Conservation and Alternative Fuel Vehicles' published by the Ministry of Industry and Information Technology (Zheng et al., 2012). In order to qualify for that list, vehicles must be produced in China to strengthen the domestic industrial base. However, many of the models are not readily available since the technological development of Chinese companies is not fast enough (Gong et al., 2012). Hence, this government requirement, which is supposed to force international companies to enter joint ventures with domestic businesses, harms the transition efforts. The lack of demand for electric vehicles shows that significant financial incentives have not overcome existing opposition to the technology so far.

4.2.3.1.3. Employment effects are largely unknown

The number of employees in the Chinese car industry is not exactly known. Estimates are that in 2009 the green transport sector (including rail and public transport) employed 2.9 million people (Pan et al., 2011). Given the young state of the NEV industry, little data on the employment effects is available. Once again, BYD is the focus of analysis: In 2010, 130,000 people were on the BYD payroll (Kasperk et al., 2010). However, this can have changed by now given the fluidity of the sector and it is unknown how many worked on electro mobility. However, studies stress the employment potential as a political argument. A very optimistic prognosis of 15% of vehicle construction taking place in electrified power trains between 2011 and 2020 would yield 1.2 million jobs annually (Pan et al., 2011). However, this seems unrealistic given the slow market penetration. Nonetheless, the number demonstrates the immense employment potential of electro mobility for the Chinese car industry, which is of interest to the decision-makers because of their need to improve the living conditions of the population.

⁶⁷ It points to the confusion surrounding the policy framework that stems from the lack of openness in the decision-making.

When looking where people are working in the value chain, future problems of Chinese electro mobility efforts arise on the horizon: Currently, workers are needed researching and developing the new technologies, which are required before the low-cost production can scale up. However, a lack of well-trained workers is a problem in China. BYD tackled it through job rotation (Kasperk et al., 2010). While this might work for a single company, it is not a working formula to solve the problem of an entire industrial sector that is supposed to grow. Since the lack of technological solutions partly explains the lack of progress in China, the government needs to find ways to improve the level of training. The car producers must grow into interesting employers that attract high-skilled engineers.

4.2.3.2. Enhancing sustainable innovation capacity

The Chinese decision-makers see electro mobility as a way to move from cheap production to an innovative economy. However, the lack of available models demonstrates that currently Chinese car manufacturers face difficulties to develop electric vehicles. A McKinsey & Company (2012a) study underlines this lack of technological knowledge as 95% of surveyed businesses and institutions claim that Chinese manufacturers are not capable of producing a domestic BEV despite various industrial and R&D policies in place. A Chinese survey of expert interviews, however, claims that China “is at the same starting line as other countries basically” (Ou and Zhang, 2012: 2045). Hence, it is easier for international observers to critically assess the situation than for Chinese scholars.

The government, the central player in innovation policy, has recognised the need to improve the innovation capacity of the car industry. The 12th FYP declares that “[T]he automotive industry needs to strengthen R&D capacity to build whole vehicles; achieve independent mastery of technology for key components; and raise its technological level concerning energy conservation, environmental protection and safety” (People's Republic of China, 2011: 39). Research is focused on ‘Three Transverses and Three Longitudes’, which means that three technologies (BEV, HEV, and FCEV) in the transverses and three technological aspects (drive train, motor, and battery) in the longitudes are researched (Zheng et al., 2012). While this emphasis on R&D is reflected in various other official documents, the government takes concrete actions as it dedicates half of the designated 100 billion RMD (12.1 billion EUR) in support of electro mobility to foster technological innovation (Hannon et al., 2011, Tagscherer, 2012). The lack of a carbon price does not yet channel additional research funding to measures that decarbonise the economy. In addition, “[B]ilateral cooperation is an important driver for China as it seeks new technology, develops markets and ensures the

development of a vehicle market that both meets and sets global standards” (Earley et al., 2011: 10). Chinese authorities have various means at their disposal to force the hand of international car manufacturers.

4.2.3.2.1. Domestic invention is falling behind

The Chinese government has funded R&D efforts to strengthen electro mobility for more than a decade. This reflects the emphasis that the public actors put on the technology as well as “China’s long-term commitment to innovation through sustained programmatic funding rather than an ad hoc approach” (Gordon et al., 2010: 27). The Ministry of Science and Technology has funded the 863 programme since 2001. Overall, 290 million USD (221 million EUR) were spent during the first phase between 2001 and 2005 (Gong et al., 2012). The outcome were 26 national standards and 796 patents as well as first prototypes of NEVs (Gong et al., 2012, Kubach, 2011). Little is known about the quality of these patents, though. In 2006, electro mobility assumed a prominent role in the plans for the transport sector that were laid out in the ‘National Medium- and Long-Term Programme for Science and Technology Development (2006-2020)’ (State Council of the People’s Republic of China, 2006). The result were additional investments of 1.5 billion USD (1.15 billion EUR) during the 11th FYP from 2006 to 2010 (Gong et al., 2012). As seen above, the results were first public experiments with the new technology with an emphasis on public demand. The 2009 Automotive Industry Restructuring and Revitalization Plan invested three billion RMB (0.36 billion EUR) in researching key technologies needed for electro mobility out of an overall investment of ten billion RMB (1.2 billion EUR) into the car industry between 2009 and 2011 (Earley et al., 2011, Zheng et al., 2012). Hence, electro mobility received a considerable share of the overall transport research budget in this period. However, by mid-2011 it was not clear how much money was already spent and on which projects (Kokko and Liu, 2012). Science Minister Wan Gang reports that by March 2011, 57 standards on electro mobility existed and 59 were considered (cited in Tagscherer, 2012). As mentioned, since the publication of the 12th FYP, the Chinese government has announced to spend another 50 billion RMB (6.1 billion EUR) in support of R&D. This makes China the global leader in R&D budgets on electro mobility (roughly 0.17% of GDP) in absolute and relative terms (Bernhart et al., 2012). However, private R&D efforts are negligible.

These efforts do not result in sufficient output. Data presented by the Organisation for Economic Co-operation and Development (2011b) shows that China still lags significantly behind in alternative fuel vehicle patents with less than 1% of the international share. A

similar situation can be witnessed in battery research as China is the world leader in production but continues to lag behind in patent registrations and high-tech production capacities (Earley et al., 2011). One possible explanation is that China spends considerably less money than it announces. An alternative argument is that the structural deficiencies of the Chinese innovation system are causing this poor performance. While the funding is more easily available to SOEs, the discussion of BYD has shown that they seem to have problems generating innovations, which is partly explained by excessive government meddling. The strong state involvement in the innovation process does not allow for research in areas that are promising but rather follows government directions. Furthermore, the decision-makers seem to underestimate the technological complexity of electro mobility which increases the pressure on engineers to develop solutions that, when tested under real-life circumstances, are insufficient. For example, the Toyota Prius took several years to develop. However, under the Chinese authoritarian regime the engineers receive orders from the top and cannot report delays.

Because of weak domestic innovation capacities, China depends on international collaboration and forced technology transfer. It has put in place various international cooperation agreements with key actors in the United States and the European Union (Earley et al., 2011). However, it does largely rely on the model of “import/assimilate/re-innovation” (Gordon et al., 2010: 28). As Chinese companies depend on foreign technology, the government requires foreign car companies that want to sell their cars on the Chinese market to produce them in joint ventures with local companies. In the past, these joint ventures have not necessarily resulted in the expected technology transfer as foreign companies have transferred mostly outdated technologies because pollution requirements were too lax (Gallagher, 2006). Hence, the government has tightened the regulatory framework. Nowadays, foreign car manufacturers have to transfer one key technology for either battery, engine or electronics to a joint venture in order to gain access to the Chinese market (Hannon et al., 2011, Spiegel Online, 2011). Otherwise, they are not included on the list of vehicles that qualify for government subsidies, which reduces their appeal to consumers because of their higher price. A good example of this approach is the ‘Chevrolet Volt’, a BEV (Stewart et al., 2012). The Chinese government did not include it on the mentioned list of models that qualify for state support because it was not produced by a Chinese joint venture and Chevrolet did not transfer a core category. Later, ‘General Motors’, the owner of Chevrolet, entered a joint venture with a Chinese car maker and promised to “transfer battery and other electric car technology to the venture” (Bradsher, 2011). While General Motors argues that the

developments are unrelated, this seems implausible. The Chinese government uses economic incentives to pressure foreign companies to enter cooperation agreements with Chinese companies to overcome its domestic innovation problems. Nonetheless, international managers argue that the transfer requirement stalls the development of electro mobility in China as non-Chinese companies are not willing to comply (Spiegel Online, 2011).

While this forced technology transfer is a clear breach of World Trade Organisation rules according to Stewart et al. (2012), the Chinese car market has become so important internationally that many international car manufacturers comply with Chinese demands to keep market access. Hence, they might be forced to transfer key technologies to China where their intellectual property rights are hardly protected. At the same time, they are still in a good position as long as they hold technological advances that the Chinese industry depends upon. Hence, international car manufacturers prefer to bring development technologies to China rather than the initial research that is more difficult to shield.

4.2.3.2.2. Attempts to bring electro mobility innovations to the market

Electric vehicles are only entering the marketplace in China similar to most other international markets that stand at the beginning of the large-scale introduction. While it was true for some time that the Chinese government neglected the demand side and over focused on the supply side by researching all technical details as argued by Gallagher (2006), this is no longer the case since the implementation of subsidies for private and public consumers. Hence, despite all the criticism of the transmission belts, they have started adapting to their weaknesses. However, the international comparison presented by Bernhart et al. (2012) shows that in particular the Chinese industry is underdeveloped. This shows that the car industry has to continue to catch up.

In an attempt to make use of the strong impact of the state, the ‘10 cities, 1,000 vehicles programme’ focused on public utility vehicles like busses and garbage trucks, which are better capable of taking care of range limitations. In addition, public fleets are easier to survey and monitor and public transport reaches more people (Zheng et al., 2012). Hence, the Chinese decision-makers tried to rely on public procurement. While many lessons were drawn in the process, the project has not reached expectations. A key explanation for the poor performance of the demonstration project is that many of the qualifying vehicles exist in theory only. This means that the cities could not buy the vehicles, even if they wanted to do so

(Gong et al., 2012). Hence, solving this problem requires industry to develop attractive vehicles, which can take some time given the technological difficulty.

Another problem is the lack of coherent standards for electric mobility technology. China has been working on standards since 2007 (Kubach, 2011) but “nationwide standards for important components are not being produced quickly enough” (Earley et al., 2011: 27). Given the regionalisation of production capacities and the high number of market actors, this hampers the development of a coherent technology that creates a single market. For example, within China various charging plugs are used. Hence, the aim is to speed up the standard setting process in order to establish them before the European Union and United States do so (Kasperk et al., 2010). This leadership position would increase pressure on other international market participants to follow the Chinese standards if they want to enter this large market.

McKinsey & Company (2012a) sees the biggest reason for slow sales in the Chinese strategy that overemphasises pure BEVs, which are technically difficult to develop. It argues that China needs to realign its policy framework in order to focus more strongly on various types of HEVs. While BEVs will only become financially competitive in ten years, cars with range extenders could gain significant market shares by 2014 (McKinsey & Company, 2012a). This recommendation runs counter to the initial Chinese strategy to become world market leader in a completely new technology. However, the recent developments seem to indicate that China is slowly moving into this direction that is favoured by the Ministry of Industry and Information Technology. This raises the question whether China will be able to catch up with Japanese producers that are worldwide leaders in HEV technology. Hence, this move towards HEVs could increase market demand but challenge the Chinese electro mobility industry in trying to catch up with advanced technology.

4.2.3.2.3. Little experience with diffusion

Since electric vehicles in China as well as the rest of the world are not yet market ready, large-scale diffusion has not yet started. However, the rapidly expanding Chinese car market underlines the potential. The key argument to explain the current lack of diffusion of electric vehicles in the Chinese transport sector is the lack of vehicles that serve the needs of the consumers at cost-competitive prices. The Development Research Center Enterprise Institute of the State Council of the People's Republic of China (2012b) published a white paper in 2012 that elaborates business models to overcome the demand problems. They focus on

battery swapping as a cheap alternative to increase range and focus on regional car rental networks.

Additional arguments to the slow market penetration have been identified above and are not unique to China but stall the international transition to an electrified transport sector:

- The range of electric vehicles is limited and the necessary charging infrastructure does not yet exist. Hence, it is a promising sign that Chinese grid providers, State Grid and Southern Grid, have announced plans to rollout the necessary charging infrastructure. If they achieve the planned 4,000 charging stations by 2015 and 10,000 by 2020, this will make electric vehicles much more attractive as it reduces range limitations (Hannon et al., 2011). However, this is only possible because both companies are state owned and the government wants them to go ahead even though the economic calculations would oppose such a move.
- People are not used to electric vehicles and are rather interested in luxury imports and sports cars which they know from car salons and mainstream media (Stinson, 2012). Nudging mechanisms can address these decision parameters. For example, electric vehicles have been exempted from the requirement to have a license in order to receive licence plates that are normally difficult to obtain in large Chinese cities (Xinhua, 2011). Some cities in China also think about regulatory initiatives that would ban certain types of ICE vehicles from parts of the cities, which would increase the incentives to drive an electric vehicle. This has been a major driver for electric bikes.

4.2.3.3. Distributional fairness of cost and rewards

The current electro mobility debate in China rarely considers the social dimension. The impact of the industry is too small to have a major impact on the population or industry. As a niche technology it does not (yet) significantly disrupt the status quo. At the moment, it creates new business opportunities, funded by public sources, while it does not negatively affect market players. Furthermore, many of the involved companies are SOEs that do not openly oppose government policy. For consumers, the situation has not changed significantly, either. The only sector in which electro mobility is holding major market shares is e-bikes. Here, it has improved the situation for many households, in particular low-income earners that previously had to rely on bicycles or public transport and that can now rely on more

comfortable e-bikes. However, the current Chinese transport and energy policy has various welfare implications.

The inherent costs of the push to establish a strong domestic car industry through becoming a world leader in electro mobility are rarely discussed as China's authoritarian regime continues to leave little space for civil society actors to express their opinion on government policy (He et al., 2012). Opportunity costs of the strong and expansive governmental push to foster electro mobility exist: The money spent on the fossil fuel and electro mobility subsidies is not available for other purposes, such as strengthening the social safety net. While it is hypothetical to assume for which other purposes it could be used, electro mobility is a technology that is mostly of interest for households that can afford a significantly more expensive car, despite the inherent weaknesses of range limitations and the lack of available models. Hence, electro mobility is a technology that is steered towards high-income households because of the comparatively high prices. While the entire economy can profit from a more innovative and strengthened car industry, the demand-side subsidies only partly offset the price differential. Hence, electric vehicles remain considerably more expensive than ICEs. This results in the assumption that richer parts of the country buy them, which manifests existing inequalities (Wu et al., 2012). Focussing on government fleets and public transport partially resolves this conflict because the societal gains of the public investments are much higher. Nonetheless, the situation of low-income households would improve more by strengthening public transport and developing other low-cost transportation systems.

The current energy subsidy regime does not fairly distribute costs and rewards, either. The "pain at the pump" index (Randall, 2012) demonstrates that the current design of gasoline pricing is expensive for low-income households compared to other countries. China ranks 8th out of 60 countries when comparing the percentage of the daily income someone has to pay for a gallon of fuel, even though it is subsidised. Hence, a reduction of the gasoline subsidies that is needed to make electro mobility economically viable would further increase prices. Low-income households in turn have to spend even a higher share of their income on transportation. In addition, high-income households benefit more strongly from these subsidies than low-income households because they buy more gasoline (Lin and Jiang, 2011). Neither the existing subsidy regime nor the transition to electro mobility is increasing social justice. A chance to do so is the implementation of carbon pricing in order to generate new revenue, which could support welfare benefits. However, so far it is unknown which effects the carbon pricing creates and no statement has been made how the revenue will be used.

4.3. Recapitulation

This case study analysed the Chinese transition towards an electrified transport sector. While under the business as usual scenario, the GHG intensity of Chinese transport significantly grows, electro mobility can be – depending on the energy mix – a key technology to reduce GHG emissions. Chinese decision-makers push the issue because they want to strengthen their domestic car industry. Hence, the Chinese approach to electro mobility is largely based on shifting from ICE technology to electro mobility. Systematic considerations, such as shifting towards new transport concepts and at the same time analysing the GHG emissions impact of transport play an insignificant role. Hence, the transition process could result in a shift of technology that increases GHG emissions because of the coal-dominated energy mix.

While commentators see an “enabling policy environment” (Earley et al., 2011: 2) for electro mobility, the results are poor as very few electric cars are running on the streets. The transition has not yet entered the take-off phase despite large expectations. The case study finds that China’s framework meets many conditions of the analytical model but the key reason to explain the missing progress is that the integration of the various pieces does not work and the innovation efforts have not yet allowed electro mobility to break through. The transmission belts function badly because of the authoritarian one-party rule that marginalises other actors. While the CPC ensures consistent political leadership and has put in place considerable demand-side subsidies for electric vehicle buyers as well as R&D funding, institutional deficiencies limit their impact. EPI throughout all government actors and layers partly fails because turf wars between the various ministries have created uncertainty about the government strategy. Furthermore, guiding documents including targets are in place to ensure time consistency, but they are too ambitious. Hence, the actors that are supposed to fulfil them are incapable of reaching them. Another reason to explain the lack of sold electric vehicles is that technological innovation has not been linked to economic instruments. Nonetheless, first experiments with carbon pricing taking place are a promising sign to offset high subsidies for fossil fuels.

This case study undermines the idea, for example postulated by Friedman (2009b), that the Chinese “one-party autocracy” is more efficient than democratic processes that include a variety of veto players. The continuous power struggle within the CPC and among the various government layers as well as the lack of bottom-up communication create a different set of problems that China has not yet solved. The result is that political actors overestimate the technological capabilities of their industry and limit the scope for innovation because of their

strong involvement through SOEs. International competitors that have much more experience in the automobile sector have needed time as well to establish their knowledge. However, the strong political commitment and financial backing of the industry could achieve a breakthrough resulting in China's transport sector entering the take-off and acceleration phase of the transition in the medium-term. Hence, this case study underlines the importance of the transmission belts within the analytical model.

5. Renewable energy sources in the US electricity sector

This case study analyses the beginning signs of a transition of US electricity generation from fossil fuels to renewable energies.⁶⁸ While renewable energy sources, such as wind, solar and hydro, are primarily used for four purposes – power generation, heating and cooling, powering transport and off-grid energy delivery (Renewable Energy Policy Network for the 21st Century, 2014), this case study focuses on generating electricity without emitting GHGs.⁶⁹ This would be a radical innovation. Renewable energies entered the international policy debates during the energy crises of the 1970s when developed economies were looking for alternative energy sources to reduce their dependence on unreliable energy imports. This marks also the beginning of US renewable energy policy and for this reason, is the analytical starting point of this case study. After some ups and downs over the last decades, global investments in renewable electricity sources stand at 214 billion USD (163 billion EUR) in 2013 and have stabilised at a high level despite being lower than the record-high of 257 billion USD (196 billion EUR) in 2011 (Renewable Energy Policy Network for the 21st Century, 2014). A key reason for this growth is the increased focus on climate change and rising fossil fuel prices since the late 2000s. Hence, the global transition process is in the take-off phase and accelerating. The United States is a key market even though the energy framework has undergone severe changes caused by the financial crisis starting in 2008 and the natural gas boom.

Electricity takes a central role for economic activity as a major input for many production processes. Furthermore, electricity generation is generally the single biggest source of GHG emissions in an economy. Electricity and heat production were responsible for 41% of GHG emissions in the United States in 2012, which is very close to the international average of 42% (International Energy Agency, 2014). A green transition needs to target this critical sector to significantly reduce pollution. However, the GHG emissions intensity of electricity generation in the United States has only slightly decreased over the last twenty years and remains significantly above the average of all Organisation for Economic Co-operation and Development countries (International Energy Agency, 2014). The following shows that missing comprehensive climate and energy legislation and regionalised energy markets are an important reason. While most states have some kind of renewable energy policy in place (see

⁶⁸ It benefits from a research stay at the Stella Group in Washington, DC from October to December 2012. Scott Sklar, a pioneer of renewable energies in the United States, runs this consultancy firm.

⁶⁹ They are not completely clean because of the GHG emissions that arise during the installation and maintenance process.

U.S. Department of Energy, 2012 for a detailed overview), they show highly different approaches to renewable energies. Hence, they are at different points of the transition process – whereas some are currently accelerating the rollout while others are still in the pre-development phase.

Transitioning to renewables challenges established market players and requires an overhaul of the energy infrastructure. This means that it is not a transition from a polluting to a cleaner technology but it is a more profound change process. Fossil fuel-based electricity generation uses large power plants, which are located close to heavy load centres and the necessary fuels are transported to these locations. Alternative generation depends on the availability of renewable sources. This differs according to location and fluctuates over time. As a result, renewable technologies are mostly of smaller scale and need to be transported further. Hence, the transition entails a shift from centralised to decentralised energy generation.

Data sources are official government statements, documents and publications, newspaper reports as well as think-tank studies and secondary literature. Since the case study analyses the development over a longer period, it draws on data at various points in time. This allows putting the development in historical context. The structure is as follows. First, the current status of the US electricity sector and mix is presented. It follows a closer look at renewable energy technologies and their maturity in the United States. Based on the historical development of the US electricity mix, it applies the analytical model on the US electricity sector's transition. The recapitulation presents the most important findings.

5.1. Current situation of the US electricity sector

The United States is the biggest electric utility system worldwide with the most power plants and the largest transmission grid (Sovacool, 2011). Since an abundance of cheap fossil energy sources endow the United States, the exploration has so far left few visible marks. Hence, costs and availability issues have mostly overshadowed environmental concerns. A 2011 comparison shows that electricity prices for commercial users were lowest and for households third lowest in the United States among Organisation for Economic Co-operation and Development countries (International Energy Agency, 2012a). This “convinced many Americans that in the United States they are somehow entitled to consume as much energy as they needed, and promoted the notion that technology could overcome all constraints on resources” (Sovacool, 2009a: 369). The key goal of policy is to ensure that supply of energy

as a public necessity is abundant and cheap (Sovacool, 2011). Hence, US Americans have adopted an energy-intensive lifestyle resulting in high per capita GHG emissions.

5.1.1. Historical development of the US electricity sector

The fossil fuel era has significantly shaped the US electricity sector in a way that is not conducive to renewable energy. Historically, it was understood to handle a natural monopoly, which required government intervention to ensure universal access and regulate the pricing structure. As a result, vertically-integrated utilities – either investor- or public-owned (municipal power companies or rural co-operations) – have assumed central positions. Public utility commissions played a key role in setting the prices and the profit margins of these quasi-monopolists (Lester and Hart, 2011). They rarely considered environmental consequences in their decision-making but based it on the least-cost principle. This limited the choice and influence of consumers since often times only a single provider has been available in a given region. As a result, the 50 states are the primary regulators resulting in strong regional differences, which increases the need for coordination (Carley, 2011).⁷⁰ Over time, the role of the federal government has increased in energy governance without establishing a comprehensive national energy policy (Sovacool, 2011).

This system of highly regulated but protected power utilities had proven to be inefficient (Joskow, 2009). In response, the ‘Public Utility Regulatory Policies Act’ of 1978 put strong emphasis on market liberalisation. The aim was to reduce prices and allow new technologies to enter the market. This was due to a changing understanding of energy that took supply constraints as well as ecological consequences into consideration (Sovacool, 2011). Despite the failure of California’s liberalisation efforts and the collapse of Enron in the 1990s, which was a major setback for energy market opening (Joskow, 2009, Lester and Hart, 2011), several states went ahead and (partly) liberalised their market (Carley, 2011). As a result, today’s market structure differs strongly: vertically-integrated utilities operating in quasi-monopolies serve approximately half of the United States while wholesale markets serve the other half of the country (covering a majority of the population and demand) (Kassakian and Schmalensee, 2011, Lester and Hart, 2011). This means that most consumers can freely choose their electricity provider with direct consequences for renewable energies: While in the past the power utilities unilaterally decided on the energy mix, today “more than half of U.S. customers have the option to purchase green power directly from a retail electricity

⁷⁰ The United States is divided into three largely disconnected electricity grids: the Eastern Interconnection, the Western Interconnection and the Electric Reliability Council of Texas.

provider” (Renewable Energy Policy Network for the 21st Century, 2012: 24) and more than 1.8 million US customers, representing more than 1% of total sales, voluntarily purchased green power in 2010. While this movement is powered by an increasing willingness to pay more for green electricity, it remains limited to a small share of overall demand. Nonetheless, demand for renewables in the US electricity sector is growing.

5.1.2. Renewable energy technologies and their maturity in the United States

Renewable energies make use of natural sources that give power without burning minerals that cannot be replenished (Verbruggen et al., 2010). Hence, they do not run out and emit less GHGs than burning fossil fuels throughout their lifecycle. However, because of their local availability and temporal fluctuations, they require an adjusted grid infrastructure that can transport the electricity from generation to the consumption areas and store it during times of excessive production (Joskow, 2009, Kassakian and Schmalensee, 2011, Schmalensee, 2011). In the United States “the current electric grid simply does not properly accommodate renewable energy sources” (Flick and Morehouse, 2011: 10). The transition to renewable electricity affects generation as well as distribution resulting in a profound overhaul of the electricity sector.

The following focuses on five key generation technologies – hydro, wind, biomass, geothermal and solar –, which have reached different degrees of technological maturity.

- Hydro makes use of flowing waters. A common distinction is made between small and large hydro.⁷¹ The latter provokes strong opposition because of physical, biological and social intrusions (Lizardo de Araujo et al., 2010). Hence, environmentalists pursue small hydropower plants. Hydropower, mostly stemming from large hydro projects, holds by far the biggest share of global renewable energy capacity and generation (Renewable Energy Policy Network for the 21st Century, 2014).
- Wind makes use of air movement. It is commonly divided into onshore (on land), a technology that has reached a high degree of maturity, and offshore (on the sea), a technology which is still emerging. When excluding hydropower from the calculations, wind is responsible for more than half of global renewable energy capacity (Renewable Energy Policy Network for the 21st Century, 2014). A study supported by the U.S. Department of Energy (2008) as well as the wind industry has

⁷¹ The categories of small and large hydro are not clearly defined (Lizardo de Araujo et al., 2010).

assessed that the United States could reach 20% wind energy by 2030 at modest economic cost.

- Biomass is the fourth largest energy source worldwide following oil, coal and natural gas (Renewable Energy Policy Network for the 21st Century, 2012). While it can be used in a variety of ways, it is most important for heating and plays a less important role for electricity generation.⁷² Using biomass to produce energy has been criticised for radically increasing food prices in developing nations as farmers earn more by fielding crops to fuel transport in industrialised nations than feeding low-income households (Arent et al., 2011). For this reason, governments have reduced their support. Nonetheless, the United States remains a key global producer of biofuels (Arent et al., 2011, Renewable Energy Policy Network for the 21st Century, 2014).
- Solar converts (direct and indirect) radiation from the sun to power. While it is only available during the day, it can generate high amounts of electricity. The dominant conversion technologies are photovoltaic and concentrated solar (Denholm et al., 2010). While solar photovoltaic is a relatively expensive technology, production costs have recently collapsed with increasing maturity of the technology. Since the beginning of 2004 the global installed capacity has significantly increased from 2.6 gigawatts to 139 gigawatts at the end of 2013 making it the fastest growing renewable energy technology (Renewable Energy Policy Network for the 21st Century, 2014). Concentrated solar has not yet seen such rapid technological development significantly reducing prices resulting in a negligible international capacity.
- Geothermal uses the heat of the earth to generate electricity with the greatest generation capacities in volcanic areas. A major advantage is its reliability (Williamson, 2010). However, it is mostly used for heating and cooling. A lack of awareness has increased the risk to invest demonstrating a rather low degree of maturity (Renewable Energy Policy Network for the 21st Century, 2014).

5.2. Is US electricity generation transitioning to renewable sources?

GHG emissions reductions are closely linked to the primary energy mix. Since for electricity users the quality of electrons does not differ between fossil fuel and renewable source generation, consumption decisions are mostly based on price signals. The reliance on cheap and abundant fossil fuel reserves reflects in the US energy mix. Currently, power plants that

⁷² This ignores traditional biomass, for example burning wood to heat an oven, because this is associated with high environmental and health-related costs.

burn fossil fuels (mainly coal and natural gas) are the most important generation source, which results in high pollution.

Table 10: Development of the US net electricity mix in %⁷³

	1973	1980	1990	2000	2011
Coal	45.5	50.7	52.5	51.7	42.3
Natural gas	18.3	15.1	12.3	15.8	24.7
Nuclear	4.5	11.0	19.0	19.8	19.3
Renewables	14.9	12.4	11.8	9.4	12.5

Source: Author's calculations based on U.S. Energy Information Administration (2013).

While table 10 demonstrates considerable changes, coal, which is the most polluting fossil fuel, has been the key resource for electricity generation in the United States since 1973. However, since 2000 its usage has decreased by almost 10 percentage points while natural gas has significantly increased its share. This natural gas boom has been a major game changer as new drilling technologies (horizontal drilling and hydraulic fracking) have unlocked previously inaccessible shale gas resulting in an increase of supply and dropping prices (Bradbury, 2012). The International Energy Agency (2012b) predicts that as a result the United States will become the largest oil producer around 2020 and it will be energy self-sufficient (in net terms) around 2035. Hence, natural gas can achieve energy independence and security at low cost while at the same time substituting for coal potentially limiting the scope for more expansive renewable energy (Jenner and Lamadrid, 2013).⁷⁴ However, fracking is environmentally harmful in various ways, such as high water and land usage and contamination through chemicals (Rahm, 2011).

Nuclear power had a first boom in the 1960s and 1970s, when it was expected to assume the key role in electricity generation. However, the power plants that are in operation today, have all been ordered before 1974 since afterwards safety and environmental concerns limited the growth of this industry (Davis, 2012). Nonetheless, it holds a steady share of the electricity

⁷³ The percentage points do not add up to 100 because several technologies that have constantly lost market shares, such as petroleum, are not included.

⁷⁴ In April 2012, the US net electricity generation stemming from coal and natural gas was almost equal (U.S. Energy Information Administration, 2013).

generation mix since 1990. The share of renewable energy sources (including hydropower) has not significantly changed in a positive or negative direction. The energy mix has undergone a transition since the 1970s. The beneficiaries were not renewables but the nuclear industry.⁷⁵ A similar process is currently taking place as the natural gas share grows.

Analysing renewables in more detail shows that the United States' share at 12.5% falls below the international average as 16.4% of global electricity production stemmed from hydro and 5.7% from other renewables in 2013 (Renewable Energy Policy Network for the 21st Century, 2014). Germany, for example, is an international front runner in decarbonising its energy supply (Laird and Stefes, 2009). After officially announcing the shut-down of all nuclear power plants by 2022 and focussing on renewable energies – the so-called 'Energiewende' – its electricity mix included more than 22% of renewable energies in 2012 (Statistisches Bundesamt, 2013). Table 11 breaks down the historical development of renewable energy technologies in the United States.

Table 11: Development of renewable sources in the US net electricity mix in %

	1973	1980	1990	2000	2011
Renewables	14.9	12.4	11.8	9.4	12.5
Hydro	14.8	12.2	9.6	7.2	7.8
Biomass	0.0	0.0	1.5	1.6	1.4
Geothermal	0.1	0.2	0.5	0.4	0.4
Solar	N/A	N/A	0.0	0.0	0.0
Wind	N/A	N/A	0.1	0.1	2.9

Source: Author's calculations based on U.S. Energy Information Administration (2013).

Because of its size, the United States ranked in the top five of installed capacity in 2013 demonstrating its importance for the global renewable electricity transition despite its below average share in the electricity mix. In overall installed capacity, the United States follows China on rank two: without hydro, the United States has installed 93 gigawatts in 2013 only

⁷⁵ It is not considered a safe and clean alternative technology in this doctoral thesis because of the danger of a major catastrophe and the unsolved problem of dealing with the nuclear waste.

behind China with 118 gigawatts (Renewable Energy Policy Network for the 21st Century, 2014).⁷⁶ Large hydro dams are historically the major source of US renewable energy generation. In 1949 they produced approximately one third of the entire electricity. This share has fallen considerably although the hydro capacity has remained mostly stable because growing overall generation capacity (Schmalensee, 2011). In 2011, hydro was the most important source of renewable generation with 7.8% of the electricity mix. However, wind power has been the fastest growing technology underlining that the United States remains “one of the most dynamic markets for wind” (Wiser and Hand, 2010: 246). While solar photovoltaic is growing fast in the last years in the United States – the market almost doubled in 2013 alone –, its overall contribution remains limited. In addition, it is the primary market for concentrated solar but because of the comparatively high cost potential remains unused (Renewable Energy Policy Network for the 21st Century, 2014). The United States is the international leader of biomass and geothermal powered electricity generation but its share of the overall mix remains low at approximately 1.5% respectively 0.5% since 1990. The following scrutinizes why the share of renewable energies remains limited and they have not gained a larger role like nuclear in the 1970s and 1980s and natural gas recently. It follows the historical developments until today and aims to establish the interplay of the various parts of the three-layered analytical model.

5.2.1. Political leadership is unsteady

Climate change and energy policy have become wedge issues in the political debate between Democrats and Republicans. They assume contrary positions in order to activate their electorate resulting in a highly polarised situation: Both claim that their energy policy follows an ‘all of the above’ approach, which means that they aim to foster all domestic energy sources (Coley and Hess, 2012, Littlefield, 2013). However, they emphasise different technologies. While most Democrats favour renewables, Republicans in general oppose them and favour fossil fuels. A key reason is that many Republicans to this date doubt climate science and support climate deniers (McCright and Dunlap, 2011a). The candidates for the presidential election in 2012 demonstrated this polarisation: Barack Obama (Democrat) believes in climate change science and aims to implement measures to mitigate it including various measures for renewable energies, whereas Mitt Romney (Republican) questioned whether climate change is human-made and opposed federal instruments to foster renewable

⁷⁶ The European Union counted as an entity and not as separate member states is ahead of China and the United States with 235 gigawatts installed capacity.

energies (Center for Climate and Energy Solutions, 2012a). Political consensus that mitigating climate change and transitioning towards a green economy are worthwhile currently does not exist. Historically, such a consensus has been the exception – it existed, for example, in the late 1980s, early 1990s (Roberts, 2012). Hence, changing political majorities have often abruptly stopped measures to fight climate change and support clean energy alternatives. In an international context, this diverging position on renewable energy and climate change of key political actors in an industrialised setting is rather unique.

The US political agenda is influenced by a variety of stakeholders and renewable energy is a constant struggle between environmental action groups and fossil fuel industry. While current market leaders have so far closely controlled the public agenda, the natural gas revolution might open up a pathway for renewable energies. Renewable energies entered the US policy arena as an answer to the oil crises in the 1970s (Carley, 2011, Laird and Stefes, 2009, Schmalensee, 2011). Then-president Carter's (Democrat) first major policy initiative after he was elected in 1977 was to pursue comprehensive energy policy. His reply to limited world supplies of fossil fuels, skyrocketing prices and fuel shortages was to focus on domestic energy sources such as renewable energy. A first result was the creation of the Department of Energy, which gave lobby groups a target to support renewable energy (Laird and Stefes, 2009). While strong lobbying by the energy industry prohibited far-reaching changes, renewable energy sources gained a prominent role within this window of opportunity (Hirsh, 1999). This turned the United States into an early international front runner. However, a problem of this top-down approach was that changing political majorities could easily overturn it. Furthermore, by the time renewable energy technologies were not as mature as they are today creating unrealistic expectations about their potential. In particular the lack of a lasting political consensus proved to be a hindrance when Ronald Reagan (Republican) with his anti-interventionist agenda was elected president in 1981. Energy policy became highly politicised.

During his presidency that lasted until 1989 Reagan took the issue off the political agenda and stopped many of the implemented support measures (Laird and Stefes, 2009). This affected R&D funding, staff size at the Department of Energy and fiscal incentives to deploy renewable energy technologies. Hence, this lack of political leadership during the 1980s is a key reason why renewable energies did not assume a bigger role in the US electricity mix following the oil crises. After Reagan's presidency, combined with another external shock, the first Gulf War that triggered fears of another energy crisis, the issue became politically

relevant again (Laird and Stefes, 2009). Under President George Bush (Republican) the ‘Energy Policy Act of 1992’ was passed including time-limited tax credits for wind energy that largely explain the strong growth of this technology. While political consensus pushed forward support policies, it was too weak to ensure lasting political change that could overcome strong carbon lock-in effects (Laird and Stefes, 2009).

Bill Clinton’s election in 1992 coincided with environmental politics and in particular climate change becoming a prominent international policy issue as a result of the 1992 Rio Earth Summit. What at first seemed positive, strengthened the political polarisation as conservative Republicans mobilised against a “threat to the spread of neoliberal economic policies worldwide“ (McCright and Dunlap, 2011b: 158). Nonetheless, international activities gained traction throughout the 1990s supported by the Clinton administration, in particular Vice President Al Gore. However, Congress failed to ratify the Kyoto Protocol after Republicans gained the majority in 1994 as a political consensus opposed US climate action without limiting the scope for GHG emissions from developing nations (in particular China) at the same time (McCright and Dunlap, 2011b). As a result of the Republicans strengthening throughout the late 1990s, George W. Bush, Jr. became president in 2001.

The opposition from the fossil fuel lobby against the green transition is traditionally very strong. With the Bush, Jr. administration it had the ear of the White House since it was closely linked to the fossil fuel industry and climate change deniers (McCright and Dunlap, 2011a). The industry is currently making very high profits, more than 80 billion USD (61 billion EUR) in 2012 by three major companies (Süddeutsche.de, 2013). It is little surprising that they influence the election cycles in order to protect their interests. Together with energy and manufacturing companies they have founded research institutes and other public organs that target the official media and shield Republican opposition to climate change legislation (McCright and Dunlap, 2011a). Hence, climate change denial is not limited to elected politicians, but includes the entire conservative movement, including its media outlets, think tanks and support groups.

The environmental and renewable energy movement has mostly been incapable to overcome this opposition as they depended on external shocks. As a result, the role in the public debate when measured by public hearing and media coverage has declined since the 1970s (Laird and Stefes, 2009). Hence, the incumbents have largely succeeded in controlling the policy agenda by putting energy security and independence high on the agenda. However, renewable energy is not discussed as the predominant solution to these challenges (Bang, 2010). The

fossil fuel lobby has shifted the focus to other clean energy alternatives such as nuclear and clean coal, which would not mark a significant break with the status quo. However, both technologies potentially emit considerably less GHG emissions than existing technologies (Bang, 2010).

Renewable energies re-entered the decision agenda during the 2008 Presidential campaign, which marked the rare exception that candidates of both major parties – Barack Obama for the Democrats and John McCain for the Republicans – were in favour of mitigating climate change and nurturing renewable energies. This created the strongest public support to act on these issues yet (Brulle et al., 2012). As a result, when Obama became president in 2009, he aimed to pass comprehensive climate and energy legislation and cut-off the direct influence of the fossil fuel industry. It shifted its strategies towards weakening planned legislation and reducing the emphasis on climate change denial. This took place during a time of bipartisan agreement, strong support from the civil society and a positive public opinion on the need to mitigate climate and foster renewable energies (Brulle et al., 2012). However, this support could not ensure the passage of the ‘American Clean Energy and Security Act’, which included an ETS as well as a federal renewable portfolio standard (RPS) (Palmer et al., 2011).⁷⁷ Two reasons explain this failure. First, during Obama’s first term, the public perception of green issues changed dramatically as the financial crisis weakened the economy and job situation. As a result of the deteriorating economic situation the legislative efforts failed since climate policy was branded as economically harmful. Furthermore, with the emergence of the right-wing Tea Party inside the Republican party the public debate on climate change underwent “asymmetrical polarization” – supporters of action cannot gain politically because they radicalise the opposition (Roberts, 2012). In this situation, proponents of renewable energy avoid the topic because they would feed their opponents rather than strengthen their own position. Nonetheless, Obama used the fiscal stimulus after the 2008 financial crisis for massive investments in green technologies. As a result, the capacity of renewables (excluding hydropower) has almost doubled – although on a low level – during his first term in office (Sullivan, 2012). The second reasons for many environmentalists that climate legislation failed is that Obama did not invest enough political capital. The New York Times concludes that “Mr. Obama, who originally ran as a champion of solar and wind power, has presided over the nation’s greatest fossil fuel boom since the discovery of

⁷⁷ Such a standard, sometimes referred to as renewable energy standard, requires that a certain amount of the overall electricity production stems from renewable sources. The exact design and definition differs according to the context and legislation language.

Alaska's giant Prudhoe Bay field more than four decades ago" (Krauss, 2012). Lizza (2010) argues that he invested his political capital rather in health care than renewable energy.

This lack of emphasis on the topic reflected during the Presidential debates in 2012 when climate change was not explicitly discussed for the first time since 1988 (Gillis, 2012). At the same time, the natural gas boom shifted the energy discussion from renewable energies to a cheaper domestic alternative. The low-cost, sufficient domestic availability and positive GHG emissions balance compared to coal are key arguments in fostering a perception that natural gas cannot coexist with renewable energies. However, recently, the argument that natural gas in combination with renewable energies can enter the low-carbon energy era has gained popularity. For this scenario to become reality, renewable energies need to become cost-competitive with other conventional fuels in order to compete with coal rather than with natural gas (Channell et al., 2012). Hence, President Obama put the issues back on the agenda with a prominent call for US leadership on renewable energy in his second inauguration address (Obama, 2013a). He wants to achieve progress with measures at his disposal, such as executive orders, that do not require congressional support. For example, he signed for the first time a bilateral accord with China that includes GHG emissions reduction targets (Landler, 2014). The negotiations took place on the highest political level demonstrating the importance that the White House attributed to the issue.

5.2.2. Transmission belts hinder steady federal leadership

The lack of federal leadership stemming from the polarised political culture limits the scope for lasting greening efforts. Several institutional factors help explain this situation. However, the United States gives considerable leeway to the states, which allows for experimenting and leadership from below. This creates coordination challenges.

Constitutional checks and balances limit the power of the president and increase the need for consensus to enact legislation, which protects the status quo against radical change. While the White House, House of Representatives and Senate all have to agree to pass legislation, most of the time, each party controls at least one of the three key organs (Harrison, 2010). Since 1977 one party held all three organs only four times: Democrats held the triple majority from 1977 to 1981 enabling Carter's energy legislation. They did so again from 1993 to 1995 when the international negotiations on the Kyoto Protocol started. However, by the time the United States had to ratify the treaty, this window of opportunity had closed. The Republicans were in control of all three organs from 2001 to 2007 when the fossil fuel industry was strong.

Lastly, Democrats held majorities in all three organs from 2009 to 2011. While President Obama tried to enact the mentioned climate legislation, it could not overcome a filibuster in the Senate, which increased the threshold of yes-votes from 50 to 60 out of 100 requiring Republican support (Lizza, 2010). Hence, most of the time, the system requires compromise between the two parties, which is currently not given. This significantly hinders lasting political change and favours the fossil fuel era status quo.

The electorate reflects the political divide between the parties (McCright and Dunlap, 2011b). Hence, politicians cater to the expectations of their voters by taking a clear position on the issue. In addition, US election campaigns are very costly. Politicians depend on donations, which increases the influence of wealthy donors and interest groups (Repetto, 2011). So far, this has largely benefitted the incumbent energy utilities since the fossil fuel lobby is an economically important player that is capable of influencing elections. For example, in the 2012 presidential election the fossil fuel industry spent more than 153 million USD (117 million EUR) mostly attacking Obama and clean energy whereas only 41 million USD (31 million EUR) were spent to defend renewable energies (Lipton and Krauss, 2012).⁷⁸ Direct campaign contributions show a similar trend: Romney received 13 million USD (10 million EUR) from the fossil fuel lobby whereas Obama collected less than a million USD (760,000 EUR) from this interest group (Lipton and Krauss, 2012). It is a promising strategy for Republicans to represent the interest of the fossil fuel industry and receive their campaign contributions. While commentators argue that the American electorate paved the way for “a new energy future” (Flavin, 2012) by re-electing President Obama, it remains to be seen which consequences this election result really holds; in particular as it has not changed the majority conditions in Congress.

The electoral system emphasises the local background of candidates since local constituencies elect both the House and the Senate. Hence, politicians are “to a large degree expected to defend the economic interest of their local constituents” (Harrison, 2010: 77), which can limit their focus on energy policy towards economic rather than environmental consequences. This is in particular relevant in the Senate to which each state sends two Senators despite large size differences between the states. Since a majority of states is closely attached to the coal industry (either through mining or generation), the votes for climate change and renewable energy that threaten coal are by design in the minority (Roberts, 2012). This means that

⁷⁸ The 2008 election marked a significant exception to this rule as climate change was very high on the international agenda, and both candidates, Barack Obama and John McCain wanted to implement carbon pricing. Hence, spending for green ads outweighed the fossil fuel lobby.

Democrats from traditionally Republican states rather oppose climate and renewable energy legislation (Lizza, 2010). Independent candidates that focus on environmental issues could help overcome this institutional blockade, but the majority voting system has prevented independent candidates from reaching office since they would have to defend candidates from both major parties. Hence, the political system strengthens the legislative status quo on energy issues.

The key role of the states counteracts this federal blockade as they can take charge on progressive energy policy. They have key competences in the field of energy policy because of regionalised energy markets. For example, the Federal Energy Regulatory Commission is the key federal regulatory instance but is only in charge of intra-state trade which limits its reach given the state-wide policy (Schmalensee, 2011). Hence, states can push forward with liberalisation efforts and implement a variety of other policy instruments to strengthen alternative technologies. They can function as niches in which renewable energies develop, reduce their production costs and realise the employment potential. When the federal level blocks their emergence, this is an opportunity for renewable technologies to nurture and experiment within a variety of frameworks. If they prove successful, this increases the chances of successful diffusion of these policy designs. This holds in particular true since the federal politicians largely depend on the economic strength of their home regions. Hence, when renewable energies can assume a key economic role in certain states, this will likely affect the voting behaviour of the states' representatives on the federal level.

5.2.2.1. Horizontal environmental policy integration

While the role of the federal government in promoting renewable energies is limited, a variety of actors carry out initiatives in the field. The U.S. Government Accountability Office (2012) identifies 23 agencies with 130 sub-agencies that have carried out 679 initiatives to foster renewable energy in 2010. While this number is inflated by the stimulus funding in 2009, it demonstrates the importance for a variety of public actors, which is a promising sign. However, with a lack of economic policy instruments in place, they are mostly preoccupied with running particular projects rather than steering a larger transition process. The Department of Energy is most important, other key organs are the Departments of Defense, Agriculture and the Interior that administer programmes with a shifting focus between the various technologies and technological maturity. The Department of Energy focuses mainly on innovation of all technological solutions while the Department of Defense focuses on innovation of solar and biofuels technology in order to reduce the fossil fuel dependence of

the military. The Department of the Interior controls the federal land needed for wind and solar plants and the Environmental Protection Agency is the key regulator. The Department for Agriculture focuses on commercialisation of biomass. Hence, a focus on innovation is obvious.

The diversity shows the necessity for horizontal coordination, in particular since various ministries mirror differing mindsets mostly reflected within the industries that they interact with. A possible source for coordination within the administration would be the climate czar as the head of the Office on Energy and Climate Change Policy in the White House. However, this position has remained open after the failed legislative attempt. As a result the leading person on climate change and renewable energy within the White House has been a rather low-ranking officer (Goodell, 2013). A high-level position that is often called for should be established to fill this void and ensure a coordinated approach from the federal government given the already difficult political situation. In this situation, it is a promising sign that key members of Obama's second term administration are closely involved with climate change and renewable energies (Goode, 2013).

5.2.2.2. Vertical environmental policy integration

Several states have filled the federal leadership void left by George W. Bush with bottom-up initiatives. While the political polarisation has reached the state legislators as well, more Republicans vote in favour of green legislation than at the federal level (Coley and Hess, 2012). For example, California began a strong push for renewable energies under Governor Arnold Schwarzenegger, a Republican albeit the state assembly was Democratic-controlled. The number of states that source more than 10% of their electricity from non-hydro renewable sources has risen from two to nine during the last ten years (Renewable Energy Policy Network for the 21st Century, 2012). The states are key laboratories during times of federal political stalemate albeit with limited scope. Furthermore, while some states implement measures, others do not do anything.

Clean Edge (2012) compares state activities fostering clean energy technologies (including electro mobility for example). It finds that California is the ultimate leader by establishing itself as the "world's preeminent testing ground for clean technology of all kinds" (Clean Edge, 2012: 4). It has earned this position by passing a law in 2006 that requires it to reach 1990 GHG emissions levels by 2020 (Burtraw and Woerman, 2012). The primary tool to achieve this is an ETS. Furthermore, it has established a goal of reaching 33% renewable

energy generation by 2020 (Lester and Hart, 2011). Besides California, the leading states are located at the West Coast followed by the Northeast and Midwest, with the South being the laggard. This is particularly troublesome as in the Southern states costs for increasing energy efficiency and shifting to renewable energy would be very low (Clean Edge, 2012). Hence, the United States leaves the low-hanging fruits on the tree while harvesting the higher hanging fruits, which are more difficult to reach. Besides state action, various local and city governments are also taking action. However, if all municipalities switch to renewable electricity, this would be a strong political signal but would only have a small impact on US GHG emissions (Krause, 2012).

The states experiment with various policy instruments: Some states implement regional ETS but RPSs are the most often applied instrument (Palmer et al., 2011).⁷⁹ As of November 2012, 29 states plus Washington, DC and two territories had binding RPSs and eight states and two territories had non-binding RPSs in place (U.S. Department of Energy, 2012). Since the details of the RPSs differ widely, they have created a scattered regulatory landscape. For investors, it is a major challenge to decipher the framework (Sovacool, 2009b). In addition, RPS favour cheap and more mature technologies (in general wind and biomass) since utilities continue to follow the least-cost principle. This leaves little room for technologies such as solar that remain relatively expensive. In order to stimulate these technologies, several states have included set-asides for certain sources that would otherwise not be competitive (Wiser et al., 2010). Hence, these RPSs include two quotas, one for renewables in general and a sub-quota for more expensive generation sources.

Empirical evidence on the effectiveness of RPSs is mixed. Carley (2009) finds that RPSs do not necessarily result in a higher share of renewable energies. Shrimali and Kniefel (2011) point out negative effects of a RPS when the set target is already achieved without adding additional capacity. While this is not surprising, such window dressing is taking place in some states. On the other hand, Yin and Powers (2010) conclude that RPSs have a positive effect on renewable energy development. Palmer et al. (2011) follow this line by arguing that RPSs are more efficient than tax credits and it is best to combine both measures. When reviewing these studies, Shrimali et al. (2012) find that the contradicting results are due to data inconsistencies and outliers. They conclude that RPSs do not necessarily foster renewable energy but have the potential to do so.

⁷⁹ See '5.2.3.1.1. Regional steps towards a carbon price' for more details.

While it remains unknown whether these state-led bottom-up activities can initiate significant change at the federal level, the emerging landscape creates coordination challenges in case a nationwide system is to be put in place. One example is integrating a potential national RPS with existing state-based RPSs. While Cooper (2008) argues that this would overcome the challenges of the scattered landscape and ensure more security for investors, Goulder and Stavins (2011) state that the reliance on quantity-based rather than price-based policies can create problems when state and federal policies overlap as leakage could occur. Nonetheless, it is a good sign that at the state level initiatives are taking place that can generate support for federal action.

5.2.2.3. Time inconsistency is the dominant characteristic

Because of unpredictable political leadership, time inconsistency is the dominant characteristic of the US renewable energy framework. For example, implemented tax credits have been temporary and expired repeatedly whereas tax credits for other technologies are without temporal limitations. Similar trends have become visible for R&D funding (American Energy Innovation Council, 2011). This results in boom and bust cycles, which have been a major challenge for domestic renewable energy companies. This has challenged investments in innovation because companies were unsure for how long their business model would work. Hence, this lack of market stability has challenged the development of the industry and hampered a reduction of production costs to gain cost competitiveness with other generation sources.

The polarised political climate has also prevented comprehensive legislation, which could stabilise the framework in times of lacking political support. Targets or strategies in the fields of renewable energy and climate change do hardly exist on the federal level. While president Obama (2011) announced in his ‘State of the Union Address’ that by 2035 80% of US electricity should stem from clean energies, this is not legally binding. Furthermore, the term clean energy has not been defined more closely and likely includes other low-carbon technologies such as nuclear and clean coal (carbon capture and storage) besides renewable energies. However, the rhetoric is considerably more ambitious than the ‘Energy Policy Act of 2005’ passed by a Republican majority in support for George W. Bush’s re-election efforts that wanted an RPS of 10% by 2020 that was ultimately dropped from the legislation (Holt and Glover, 2006).

The accord with China signed by Barack Obama in the fall of 2014 includes the goal to reduce US GHG emissions between 26 and 28% by 2025 compared to 2005 (Landler, 2014). This is a significantly stronger target than the only legally binding target from the Copenhagen Climate Conference in 2009. It stated that the United States pledge to reduce GHG emissions “in the range of 17% by 2020” (Obama, 2009) and by 80% in 2050 compared to 2005 levels. Despite the inconsistent policy framework, the United States are currently on a path to reach 16.3% GHG emissions reduction, which is very close to the promised target (Burtraw and Woerman, 2012). The key reasons are the natural gas emergence that is taking away market shares from the dirtier coal electricity generation and the economic recession after the financial crisis. Hence, the United States is capable of ensuring significant GHG emissions reductions under favourable circumstances. However, the future pathway is dependant on the economic recovery, further rulings by the Environmental Protection Agency on GHGs, and regional abatement programmes. The Obama administration assumes that GHG emissions will start rising again showing that progress is not ensured over time (The Economist, 2013d).

President Obama (2013b) has chosen to take administrative measures that do not require approval by Congress to circumvent the lack of legislation. The Environmental Protection Agency, that assumes many roles of a traditional environmental ministry, plays a crucial role in regulating GHG emissions. The basis is the 1970 ‘Clean Air Act’, which was enacted to ensure clean air and now also covers GHG emissions (Burtraw and Woerman, 2012, Goodell, 2013). While the Environmental Protection Agency started by tightening vehicles standards, it currently imposes regulations on new power plants and has proposed tight regulations for existing power plants upon the request of President Obama (Shear, 2013). These standards for new power plants are most important from an environmental perspective and costly for the coal industry from an economic perspective (Burtraw and Woerman, 2012). Hence, the strict standards put forward by President Obama’s serious efforts to follow up his rhetoric with measures that do not require Congressional approval. Furthermore, Obama wants to give more federal land to renewable energy projects and increase federal demand for electricity generated by renewable sources. While these measures are weak in ensuring a stable policy framework over time, they are the current planning basis for power plant developers and can have a lasting impact.

5.2.3. Adjusting the three key functions

The unsteady political framework and the transmission belts that enable bottom-up initiatives have created a slowly evolving patchwork. While in 2011 39% and in 2012 49% of new installed capacity have come from renewables, the lack of a reliable policy framework slows their growth (Pew Charitable Trust, 2013b). The bottom-up initiatives can only partly offset the lack of federal legislation. For example, the lack of a carbon price limits the impact of tax credits because pollution is not included in the pricing mechanism. Furthermore, the unsteadiness has avoided large-scale investments into R&D by private and public entities. Because the transition so far has not been disruptive, the social dimension has not yet been challenged extensively. However, in the long run the transition to renewable energies entails a profound overhaul of the infrastructure, which deeply affects many trenches of society.

5.2.3.1. *Greening the economic framework*

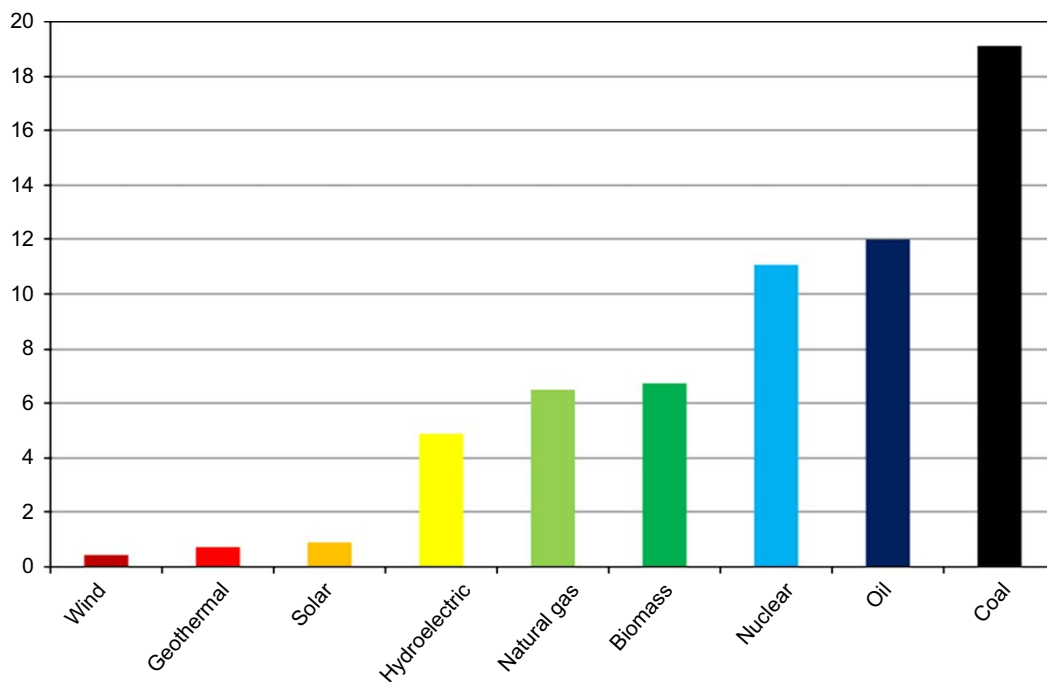
State-led market intervention in favour of a renewable energy transition remains the exception in the United States. Key economic incentives, such as a carbon price or feed-in tariffs, that are implemented by other countries do not exist in the United States on the federal level (Pew Charitable Trust, 2013b). Currently, the framework favours fossil fuels over renewable sources because it does not include the ecological costs of pollution in the pricing mechanisms. In addition, historically, fossil fuels and nuclear have received the majority of energy-related subsidies (Dinan and Webre, 2012, Sovacool, 2011). This is particularly troublesome in an LME such as the United States, in which business is expected to take over an important role in developing new technologies and the public sector largely refrains from interfering. Since renewable energies are currently not cost-competitive with traditional power sources, they require state intervention (Shrimali and Kniefel, 2011). Furthermore, renewable energies require higher upfront investments but their operation costs are low since wind, sun and other natural resources are free and do not continuously burn resources (Heal, 2009). This means that electricity price calculations need to change towards a more comprehensive approach for renewable energies to become more easily competitive.

Despite the unsteady framework, the United States ranks high in global renewable investment comparisons because of its size. However, according to the Renewable Energy Policy Network for the 21st Century (2014) the United States (36 billion USD/ 28 billion EUR) trailed China (56 billion USD/ 43 billion EUR) with investments in renewable energy in

2013.⁸⁰ The investments in the United States have significantly dropped after the record year 2011 because of the expiration of key tax credits for wind and solar projects (which were extended in 2008 as part of the stimulus measures) which had inflated US investments in 2011. Hence, the unstable policy environment hampers higher investments. The key reason is the lack of political consensus and the resulting boom and bust cycles of the industry. At the same time, the natural gas revolution took place mostly because of innovative production technologies and processes. Once electricity generation technologies become market competitive, they can take over market shares without government support.

Including negative externalities in the pricing mechanism through a carbon price would instantly change the economic viability of renewable energies as “coal generation would cost 19.14 cents per kilowatt-hour (b/kWh) more; oil and natural gas generation 12 b/kWh more; nuclear power 11.1 b/kWh more” (Sovacool, 2009b: 4504).

Figure 10: Additional costs when including negative externalities in energy pricing



Source: Sovacool (2009b: 4505).

Including externalities in the pricing regime would incentivise radical low-carbon innovation. The price increases for renewable energies would be very low because of the few GHG emissions they cause. A second factor recently threatening the economic viability of

⁸⁰ The European Union invested 48 billion USD (37 billion EUR) in total.

renewable electricity generation technologies is the natural gas revolution, which has significantly lowered energy prices. While power plants using renewable sources located under favourable circumstances had reached grid parity with the support of tax credits, this has changed drastically in the aftermath of the natural gas boom. This not only affects renewables but also is the key explanation for the decreasing role of coal in the energy mix and the closure of nuclear power plants (Learner, 2012). However, expectations are that the price for natural gas will increase again in the medium-term reducing the price pressure on other technologies (The Economist, 2013a).

5.2.3.1.1. Regional steps towards a carbon price

US economists have developed the concept of pricing emissions through trading emissions allowances. The most famous early programme was the effort to reduce sulfur dioxide emissions that cause acid rain. The politics were surprising: Republican George Bush amended the Clean Air Act in 1990 against opposition from Democrats in Congress (Stavins, 1998). However, it was a great success as it significantly lowered sulfur dioxide emissions. This gave rise to several regional ETS for various pollutants and resulted in the inclusion of emissions trading in the Kyoto Protocol marking the internationalisation of the instrument (Meckling, 2011). However, with the growing political opposition in the United States to mitigating climate change, the perception of ETS changed. The debate no longer centred on the best way to reduce pollution but whether pollution reduction was a valid policy aim or not. Hence, the debate took a step backwards. As a result, the United States has not established a federal carbon price despite various legislative initiatives since 2003 (Meckling, 2011). While Republicans have branded cap and trade as cap and tax, Democrats have been weak in offensively communicating ETS as an efficient policy to protect the environment (Lehmann, 2010). Consensus nowadays is “that the United States would not stomach carbon pricing” (Grubb, 2012: 666).

Filling the federal void, three regional trading schemes have emerged that cooperate in the North America 2050 initiative that is open to all Mexican, US and Canadian states and provinces (Center for Climate and Energy Solutions, 2012b). These schemes demonstrate, despite political challenges with several states backing out after the election of Republican governors, that stringent ETS can be implemented. The ‘Regional Greenhouse Gas Initiative’, in place since 2009, is the oldest mandatory ETS in the United States (Center for Climate and Energy Solutions, 2012b, Kossoy and Guigon, 2012). The aim is to reduce CO₂ emissions from the power sector by 10% by 2018 compared to 2009 levels in initially 10 states. Since

New Jersey left the scheme in 2012, it currently covers Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont (Regional Greenhouse Gas Initiative, 2012). An evaluation of the first three years of operation shows that it had increased regional economic activity, reduced energy bills because of investments in energy efficiency and generated new jobs (Hibbard et al., 2011). However, the cap was set considerably too high resulting in an over-allocation of permits and very low prices resulting in little GHG emission reductions (Kossoy and Guigon, 2012). In response, the scheme has recently announced to significantly reduce the cap size by 45% in order to create more trading activity (Regional Greenhouse Gas Initiative, 2013). California has been the driving force of the 'Western Climate Initiative' launched in 2005, which currently includes California and four Canadian provinces (British Columbia, Manitoba, Ontario and Quebec). California and Quebec are the front runners as they have passed the necessary legislation in 2011 to effectively start their respective ETS in 2012 making it the second biggest ETS worldwide behind the EU ETS. The aim is to reduce regional GHG emission by 15% in 2020 compared to 2005 which is equal to 33% reductions under a business as usual scenario (Center for Climate and Energy Solutions, 2012b, Western Climate Initiative, 2012). The Californian ETS covers 85% of overall GHG emissions and includes a price floor of 10 USD (7.60 EUR) per ton CO₂ (Kossoy and Guigon, 2012). Hence, it is a very ambitious scheme, currently trading at higher prices than the EU ETS. Initially, New Mexico, Arizona, Washington, Oregon, Montana and Utah joined as well but left for political reasons before the trading scheme went into effect (Environmental Leader, 2011). Republicans who were elected governors aimed to avoid the costs associated with the scheme underlining the importance of political leadership. The third initiative, the 'Midwestern Greenhouse Gas Accord' by Illinois, Iowa, Kansas, Michigan, Minnesota, Wisconsin and the Canadian Province Manitoba, has been suspended but not finally abandoned. The future outlook is uncertain (Center for Climate and Energy Solutions, 2012b).

These three examples show that bottom-up leadership is taking place. However, the lack of a political consensus between the two dominating parties hurts regional initiatives as well. Since shifting political majorities have caused several states to drop out, it endangers regional initiatives, as they cannot fully overcome the political polarisation, which significantly limits their impact.

5.2.3.1.2. Slowly subsidising renewables instead of fossil fuels

While the lack of a carbon price indirectly subsidises fossil fuels, they have historically been the recipients of the largest fiscal support. Energy subsidies have been in place since the first coal-powered plants emerged at the end of the 19th century. Payments for these technologies have remained high over time despite significant technological progress. Renewables that only entered the technology mix in the 1970s have received considerably fewer subsidies. This trend continues until recently. Adeyeye et al. (2009) have calculated that during the fiscal years 2002 to 2008 subsidies for fossil fuels were considerably higher (72 billion USD/ 55 billion EUR) than for renewable energies (29 billion USD/ 22 billion EUR).⁸¹ However, stimulus spending reversed this trend: In 2010, over 55% of subsidies related to electricity generation (6.6 billion USD/ five billion EUR) were dedicated to renewable energy with nuclear, coal and gas following in this order (U.S. Energy Information Administration, 2011). Since the programmes fostering renewable energies are time-limited and many fossil fuel and nuclear subsidies are permanent, this is just a temporary development (Adeyeye et al., 2009, Dinan and Webre, 2012). Fossil fuels continue to assume a higher priority than renewable energies.

While the Carter legislation of the 1970s led some states to introduce feed-in tariffs, they ceased to exist in the late 1980s (Mendonça et al., 2009, Schmalensee, 2011). Since then tax credits, which come in two types, are the predominant instrument. The first option is investment tax credits (ITCs) that support large projects with high upfront investment costs. A key problem of ITCs is that they require a tax liability to qualify, which is often times not given, in particular at the beginning of small projects (Mendonça et al., 2009). The second option is production tax credits (PTCs), which are awarded according to the generated electricity making them more attractive for technologies with predictable generation, such as wind power (Goodward et al., 2011). They also favour large-scale projects as investors need large revenue streams to qualify (Mendonça et al., 2009). As a result, renewable projects are mostly financed through large investors for which the tax credits are of use because of their high tax liability (Bolinger et al., 2010, Heal, 2009). Hence, tax credits have led to a very exclusive renewable market in the United States that favours large producers as smaller projects find little financial support. While the PTC was a major source of funding for renewable energies between 2002 and 2008 with more than five billion USD (3.8 billion EUR), the ITC was only little used with 259 million USD (198 million EUR) (Adeyeye et al.,

⁸¹ Nuclear was not included in the analysis.

2009). Wind projects that mainly use the PTC grew faster than solar projects that qualify for the ITC. In general, time-limitations and uncertainty surrounding possible extensions have hurt the development of the industry as another reason for boom and bust cycles. These cycles hinder a sustainable development of companies since they aim to make fast profits while subsidies are in place. Investing in R&D and other future-related expenses is avoided because companies fear that they cannot reap the benefits if the industry collapses.

The historical development of the tax credits demonstrates these boom and bust cycles. The Carter energy legislation implemented for the first time ICTs for solar projects as a temporary measure, which ran out under the Reagan administration that withdrew the necessary funding (Mendonça et al., 2009, Sovacool, 2011). This marked the preliminary end for a fast developing sector with a significant number of companies going bankrupt. ICTs were reintroduced in 2005 for three years and were extended in 2008 as part of the fiscal stimulus package for eight more years until 2016 (Schmalensee, 2011).⁸² Hence, in contrast to PTCs, the ICTs were relatively stable, but little used. The ‘Energy Policy Act of 1992’ introduced PTCs for wind power as a time-limited instrument (Mendonça et al., 2009). Since then, they have run out several times and were later reinstated: The PTC expired at the end of 1999 causing a drop of 93% of annual installed wind capacity the following year; after being reinstated the PTC expired for the second time in 2001 causing a 73% drop of installed wind capacity in 2002; the PTC expired in 2002 for the third time and newly installed wind capacity fell by 77% (American Wind Energy Association, 2011).⁸³ The latest uncertainty surrounding the PTC began in 2008, when it was extended at first for one year and in 2009 for another three years until 2012 for wind and until 2013 for other technologies (Robins et al., 2009). Finally, the PTC for wind projects has been extended at the end of 2012 for another year until the end of 2013 (Galbraith, 2013). The uncertainty surrounding its future caused another scale back in the industry as major investments took place in the years before. As a result, 2011 and 2012 saw strong growth in installed wind capacity while the outlook for 2013 looks very dire: In 2012, 13.3 gigawatts of new wind capacity were added, this is expected to drop to 1.5 gigawatts in 2013 whether or not the tax credit is extended because of uncertainty (Boyle, 2012). The American Wind Energy Association (2012) argues for a long-term strategy that gives more certainty, incentives to reach grid-parity and can include a phase-out

⁸² In their current design, they allow a tax deduction of 30% for solar (without an overall limit), fuel cells and small wind projects and 10% for geothermal projects (U.S. Department of Energy, 2012).

⁸³ Currently, the PTC pays 2.2 cent USD (1.7 cent EUR) per kilowatt-hour of wind, geothermal and closed-loop biomass projects and 1.1 cent USD (0.8 cent EUR) per kilowatt-hour for other applicable technologies (both indexed to inflation) for the first ten years of operation (U.S. Department of Energy, 2012).

of the tax credits. This underlines the importance of the tax credit to the economic development of the industry and the harm that the uncertainty causes. Industry insiders support this claim as they see policy uncertainty as the biggest challenge to the deployment of renewable energies in the United States (Pew Charitable Trust, 2013a).

As another time-limited measure, renewable energies received a considerable share of the spending included in the ‘American Recovery and Reinvestment Act’, which is the major fiscal stimulus following the 2008 financial crisis: 12% or 94 billion USD (72 billion EUR) of the total of 787 billion USD (601 billion EUR) went to green issues; 22.5 billion USD (17.2 billion EUR) were spent on renewable energy (Robins et al., 2009). While between 2002 and 2008 only 44 billion USD (33.6 billion EUR) were spent on clean energy, 150 billion USD (115 billion EUR) are spent between 2009 and 2014 (in direct transfers, tax spending and loan guarantees) (Jenkins et al., 2012).⁸⁴ Besides the extension of the tax credits, the stimulus package allowed developers of renewable energy projects to receive cash grants instead of tax credits for a limited time period (Heal, 2009, Robins et al., 2009). This ‘1603 cash grant programme’ aimed to fill the funding gap that emerged when credit became scarce during the financial crisis. It was hugely popular: in the fiscal year 2009, 1.1 billion USD (0.84 billion EUR) and in the fiscal year 2010 over four billion USD (three billion EUR) went mostly to wind power (U.S. Energy Information Administration, 2011). This installed 12.5 gigawatts renewable capacity in all 50 states (Aldy, 2012). Analysing all projects that applied in 2009, Bolinger et al. (2010) find that an additional 2,400 megawatts of wind power came online because of the cash grants. The second key change was the considerable enlargement of the existing ‘1703 loan guarantee programme’ run by the Department of Energy in order to improve commercialisation (U.S. Department of Energy, 2012). Relabelled as the ‘1705 loan guarantee programme’, it includes technologies that require financial support despite having reached the marketplace. An additional six billion USD (4.6 billion EUR) were allocated to this programme (Aldy, 2012, Robins et al., 2009). The U.S. Energy Information Administration (2011) argues that the considerable loan guarantee size requires profound analysis of each application, which explains long processing times. Nonetheless, it could not avoid that ‘Solyndra’, a solar company that received a 535 million USD (408 million EUR) loan guarantee in 2009, went bankrupt in 2011. While dropping prices because of an international oversupply in the industry caused the bankruptcy, it became a political issue in the United States. Republicans used this example of failed government support to heavily

⁸⁴ This number includes clean coal, nuclear, as well as transport with roughly 50 billion USD (38.2 billion EUR) targeted towards renewable energy.

mobilise against green spending (New York Times, 2012). This led proponents of renewable energy to avoid further calls for additional public money. Hence, the economics and the politics closely interacted. Nonetheless, the stimulus spending had a very positive impact on the industry.

5.2.3.1.3. Employment effects as a political argument

Supportive politicians and industry representatives often make the argument that renewable energies have the potential to create a considerable amount of jobs. Pollin et al. (2008), for example, have argued that investing 100 billion USD (76.3 billion EUR) in renewable energies and energy efficiency would create two million jobs in the United States. Barack Obama campaigned in 2008 with the aim to create five million green jobs by investing 150 billion USD (115 billion EUR) in the green economy over 10 years (Sullivan, 2012). While the exact number of jobs in the renewable industry in the United States is not known, it is certain that these promises have not materialised. Nonetheless, the employment effects are considerable and have increased over time.

The Bureau of Labor Statistics (2013) applies a broad definition as jobs found “in businesses that produce goods and provide services that benefit the environment or conserve natural resources” are green jobs. They find 3.4 million jobs in 2011 equalling 2.6% of overall employment. This is a considerable increase by 300,000 jobs from 2010 to 2011. The majority of these jobs were created in the private sector indicating that companies can make profits with green goods and services and create lasting jobs. Utilities employed 71,129 people in green jobs of which the major share is attributed to nuclear (which is included in the data set). Muro et al. (2011) support these numbers by estimating that the US clean economy employed 2.7 million people, which is more than the fossil fuel industry in 2010 and renewable energy is the fastest growing field of the green economy.⁸⁵

Studies on employment in the renewable energy sector find considerable job creation. The Renewable Energy Policy Network for the 21st Century (2014) estimates that in the United States 625,000 people worked on renewable energies in 2013: 152,000 on biomass, between 236,000 on biofuels (which is not the electricity sector), 35,000 on geothermal, 8,000 on small hydro, 143,000 on solar and 51,000 on wind power. This largely reflects the numbers

⁸⁵ Clean economy is defined in this study as follows: “The clean economy is economic activity – measured in terms of establishments and the jobs associated with them – that produces goods and services with an environmental benefit or adds value to such products using skills or technologies that are uniquely applied to those products.” (Muro et al., 2011: 13-14)

presented by industry organisations. According to the Solar Foundation (2012), the solar industry employed 119,016 people in 2012.⁸⁶ This increase of 13.2% compared to 2011 is expected to continue in future years. While jobs in manufacturing are lost, a strong increase in installation is witnessed. The American Wind Energy Association (2013) states that 75,000 people work in the wind industry. While the effects of the phase out of the stimulus funds is not yet included, the employment numbers are rather low in an international context. The Renewable Energy Policy Network for the 21st Century (2014) estimates that worldwide 6.5 million people work in the field of renewable energy in 2013. The majority works in China with over 2.6 million followed by the European Union with over 1.2 million and Brazil where the jobs are mostly concentrated in the area of biofuels. The United States follows on rank four with 625,000 people working in the renewables sector showing a considerable distance to China and the European Union. However, these numbers are partly explained by the different population in the three cases.

While the international comparison shows that the United States still has room for growth, green employment demonstrates its potential to become a key industry. It is of particular importance that Republicans, in areas that have witnessed considerable green employment growth, support a favourable environment to secure jobs (Cardwell, 2012). Hence, positive employment effects can lead to bottom-up leadership once the impact on the ground is discernible.

5.2.3.2. Enhancing sustainable innovation capacity

The recent technological breakthroughs that triggered the natural gas boom show that innovations can overhaul the energy sector without government intervention within a short time frame. This underlines that innovation resulting in falling production costs is important for renewable energies to increase their share in the electricity mix. However, the need for high capital investments and the lack of quality differences are the rationales for public involvement in energy innovation (American Energy Innovation Council, 2011). Overall, innovation in the US energy sector has been relatively weak despite the high innovation capacities of the entire economy (Lester and Hart, 2011). For example, spending on energy R&D takes a rather small share of 7% of federal R&D efforts (U.S. Energy Information Administration, 2011). Furthermore, it is decreasing, whereas overall innovation investments (in particular in health and defence) are growing. Nonetheless, the federal government is very important in the US energy research as companies play a minor role (Anadón, 2012).

⁸⁶ In order to qualify as a solar industry job, workers have to dedicate at least 50% of their working time to solar.

The historical distribution of public R&D funding between the various technologies mirrors the trend of subsidies. It clearly favours nuclear and fossil fuels while renewable energies have received the lowest share. According to the U.S. Energy Information Administration (2011) public spending for energy R&D has totalled 121 billion USD (92 billion EUR) from 1978 to 2010 of which nuclear received the largest part with 45 billion USD (34 billion EUR) followed by coal as well as end use, delivery and security issues with 26 billion USD (20 billion EUR) respectively; then come renewable energy sources with 20 billion USD (15 billion EUR) while oil and gas have received only four billion USD (three billion EUR). Hence, the latter have gained a strong market position without public funding for innovations.

The U.S. Government Accountability Office (2012) has identified the Department of Energy and the Department of Defense on military issues as the key public actors on electricity innovation. However, the two departments do not carry out research by themselves but coordinate the efforts of many other actors. Several national laboratories are in charge of basic research (Lester and Hart, 2011). Despite the central role of the Department of Energy in steering the energy innovation system, other issues rank higher on its agenda. Hence, Sovacool (2011) argues that the Department of Energy and its subordinate research laboratories have lost their sense of mission on innovation. Three new institutions have been added to the innovation system in order to solve these problems: First, energy frontier research centres are collaborative efforts with universities to solve grand challenges; second, energy innovation hubs are supposed to bridge the gap from basic research to marketable goods; and third, the Advanced Research Projects Agency-Energy funds radical innovation research with large potential and high risks that are not financed by private investors (Lester and Hart, 2011).⁸⁷ All three can be seen as attempts to adjust the innovation system in a way that is more supportive of renewable energy breakthroughs. Despite these institutional alterations, the innovation system is receiving insufficient guidance to steer itself towards improving renewable energies despite the need for them to become cheaper. The lack of time consistent political support as well as the lack of carbon pricing and the ensuing boom and bust cycles have limited innovation efforts.

5.2.3.2.1. Inventions are readily available despite low funding

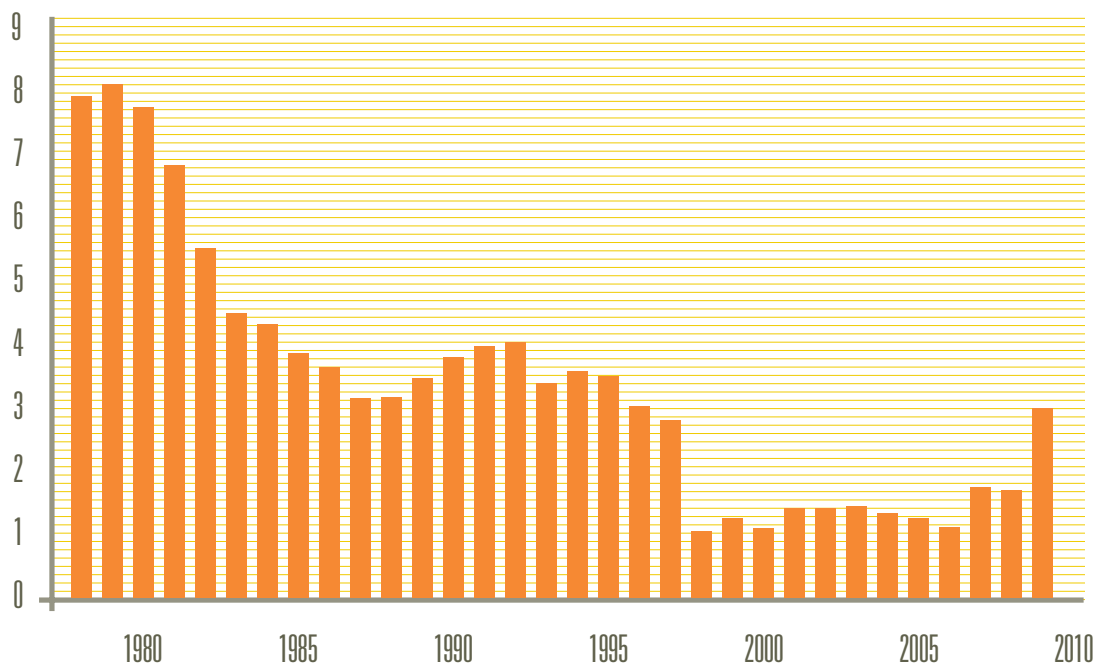
Renewable energies have been researched since the 1970s – the technology has spread from the United States to the entire world. Hence, many crucial inventions have already taken

⁸⁷ The Advanced Research Projects Agency-Energy was put in place in 2007 but did not receive funding until 2009.

place. Recent years have witnessed records of installed capacity despite contracting investments demonstrating that the technology is maturing. However, further innovations are necessary for renewable technologies to reach grid parity because of the low electricity prices in the United States. Despite the need for government support, the lack of a political consensus creates an unsteady innovation policy. In addition, the lack of a countrywide carbon price does not channel investments into green innovation. Hence, funding of renewable energy R&D efforts has largely fluctuated hindering the development of a coherent innovation system.

Around 1980 the United States witnessed the highest spending on renewable energy innovation and it has since declined in real terms (Schmalensee, 2011). The only exception were the stimulus funds that have increased energy R&D funds by almost 100% between 2007 and 2010 (U.S. Energy Information Administration, 2011). Hence, in 2010, renewable energies received the largest share of R&D funding with 32% followed by nuclear and coal (U.S. Energy Information Administration, 2011). Figure 11 demonstrates that this development is in line with overall public energy R&D spending.

Figure 11: Public US energy R&D spending between 1978 and 2009 in billion 2005 USD



Source: American Energy Innovation Council (2011: 9).⁸⁸

Without stimulus funding, US private and public energy R&D funding are both trending in the wrong direction: private funding as a share of sales is only 0.4% and public funding has

⁸⁸ The data for 2009 is preliminary and includes the fiscal year 2009 funding in addition to funds appropriated through the American Recovery and Reinvestment Act.

halved from the late 1970s to 2012 (Pew Charitable Trust, 2013a). A seminal study by Nemet and Kammen (2007: 747) points out that overall energy R&D spending in 2007 has decreased by about one billion USD (0.76 billion EUR) resulting in a “dangerously low” share of 2% of overall R&D investments going to the energy sector. This has resulted in decreasing patenting activity. While the United States trails only Germany and Japan in an international comparison of renewable energy patents (Johnstone et al., 2009), this is mostly due to the size of the economy: when putting overall patenting activity in relationship to GDP, the United States ranks low in an Organisation for Economic Co-operation and Development comparison (Johnstone et al., 2009). Low levels of R&D spending can delay technological progress. Laird and Stefes (2009: 2626) conclude “that these volatile, and rather low, R&D budgets have made it impossible to mount a comprehensive and consistent innovation programme in the United States”.

Historically, private funding has offset this lack of public funding (Nemet and Kammen, 2007). However, a low level of private investment has become the norm limiting the scope to offset lacking public funds. In particular venture capital, which has played a key role in the past, has dried up since the financial crisis. Stimulus spending offered grants to overcome this dry spell. As a result the Advanced Research Projects Agency-Energy could start its activities after receiving research funds for the first time and the peak levels of R&D funding from the 1970s were met again (Goodward et al., 2011). However, the stimulus spending is temporary and in 2011 public and private funds decreased by 18% (Pew Charitable Trust, 2012). However, funding gaps only partly explain the decreasing innovation on renewable energy in the United States. A survey of R&D leaders of 16 companies has found that the main hindrance for them is to find qualified workers (Rissman and Savitz, 2013). This demonstrates that despite the central role of funding, softer aspects are a crucial factor to ensure renewable energy innovation. Furthermore, the lack of carbon pricing has avoided channelling additional funds towards R&D on these technologies. This combination of time inconsistency, a lack of constant demand and few innovation efforts has resulted in the use of basic technologies. This means that incremental innovations of existing technologies outweigh radical innovations (Victor and Yanosek, 2011). However, radical innovations could potentially significantly reduce the price of renewable electricity generation technologies.

5.2.3.2.2. Lack of demand-side measures hinders innovation

A variety of market-proven renewable technologies have won shares of the global energy market. The problem is that they remain more costly than fossil fuel alternatives. Government support such as tax credits has helped renewable electricity generation sources to achieve market competitive prices in the United States. For example, wind power has become cost-competitive since 2000 (Jenkins et al., 2012, Wiser and Hand, 2010). The same holds true for solar in specific locations (primarily California) with good climatic conditions and high energy prices (Denholm et al., 2010). However, in general, solar is still too expensive even with tax credits (Jenkins et al., 2012). Hence, it is promising that the cost curves of renewable energy decreases because of growing international market shares and the technologies maturing resulting in falling prices. The United States has not implemented federal policies to stimulate demand to overcome the valley of death that they might enter because of their higher costs. It is in particular a challenge for smaller projects that do not profit from tax credits. While venture capital plays a key role to bridge the valley, it remains weak as discussed, but the United States usurps 70% of G-20 venture capital spending (Pew Charitable Trust, 2012). Since the required investments are so large, it is difficult for venture capital to completely fill this role, in particular as expected profit margins are small (Lester and Hart, 2011).

Public procurement is another option to strengthen renewable energies so that they gain market competitiveness. Public oversight of market penetration of large-scale projects, however, has failed in the energy sector (not only on renewable energies) because of excessive meddling by Congress and lack of expertise at the Department of Energy (Lester and Hart, 2011). The experience with the 1705 loan guarantee programme proves this point. The politicisation of the Solyndra bankruptcy demonstrates the danger of excessive political meddling in this topic given the predominant polarisation of the issue. The Department of Defense as the largest single demand source for energy worldwide has assumed a key role for public demand. It has laid out ambitious plans to adopt renewable energies: 25% of all energy should be produced from renewable sources and Army, Navy and Air Force should install one gigawatt of renewable capacity each (Gauntlett and Adamson, 2012). According to market research, this can mobilise 1.8 billion USD (1.4 billion EUR) in investments in the next 12 years turning the Department of Defense into a major source for renewable energy demand and helping the technologies to become cost competitive (Gauntlett and Adamson, 2012).

5.2.3.2.3. Diffusion depends on market competitiveness

The diffusion rate of renewable energies in the United States has improved. In the last few years they have become the biggest source of newly added electricity generation capacity reaching almost 50% in 2012 (Pew Charitable Trust, 2013b). Nonetheless, their position in the energy mix must greatly increase to fully decarbonise US electricity generation since their share of the electricity mix has hovered around 10% for some time. While renewables would benefit from rising electricity prices as they could reach grid-parity more easily, the natural gas boom has caused prices to fall. Since gas prices already were low before, this radically increases the price pressure. However, as discussed above, the technologies potentially can coexist, which would strengthen the position of renewable energies. Furthermore, nuclear and coal also have to compete with low natural gas prices. If renewables can gain cost advantages in comparison to these technologies, they can be a good supplement to natural gas.

The U.S. Energy Information Administration (2012) projects that under current circumstances 16% of US electricity generation will stem from renewable sources in 2040. This would mean that no profound transition takes place. The lack of price competitiveness and the absence of tax incentives and a stable policy framework explain this slow diffusion prediction. Hence, in order to achieve a green transition, additional measures besides state-based RPS and time-limited tax credits should be introduced; especially, since the potential to decarbonise electricity generation in the United States exists. Hand et al. (2012) demonstrate that by 2050 80% of the US electricity generation could stem from renewable energies with acceptable price increases. It is a good sign that a majority of US Americans wants to emphasise the development of wind and solar (Jacobe, 2013). This underlines that the public opinion is slowly moving towards greater support for renewables. Similar to the growing employment in the industry, this support could achieve a slow shift towards a political consensus to develop this industry.

5.2.3.3. Distributional fairness of cost and rewards

To date, the transition to renewable energies has created few distributional issues since it has only indirectly affected prices and industrial sectors. Without a carbon price, economic changes have not effected the distribution of capital and investments. The current share of the energy mix largely stems from long existing hydropower plants and recent additions to the overall generation capacities. Public investments have been small in comparison to other available technologies limiting the opportunity costs. Hence, the increasing use of renewable

sources for electricity generation has scarcely affected households and public budgets. Recently, the impact of the natural gas revolution has been more profound as it has lowered electricity prices and has profoundly changed the energy sector. Hence, regions with shale gas reservoirs have profited whereas coal-producing regions have faced a shrinking industry. However, the United States is experiencing an increasing number of extreme weather events that are linked to climate change. These hit low-income households hardest (Weiss et al., 2012). At the same time, the lack of climate policy does not generate additional revenue streams. However, the current fossil fuel dependence has significantly shaped the US infrastructure. For example, it has caused a high reliance on individual transport through cars because cities and their suburbs are far spread out making it difficult to rely on public transport. Hence, large parts of the public infrastructure would need to adjust to a changing resource base.

Transitioning to a renewable energy era would reduce the influence of the strong fossil fuel lobby. This would significantly alter the social, political and economic framework in the United States that has developed throughout the fossil fuel era. While centralised electricity generation characterises it, renewable generation is decentralised and will spread the industry to the regions that have good conditions for renewable sources. Hence, electricity generation would move away from the industrial centres to the areas that are endowed with renewable sources. Hence, the electricity would have to travel calling for a changing grid infrastructure. In addition, it potentially shifts the ownership of electricity from a few major power utilities to the citizens (Mendonça et al., 2009). This would democratise the energy sector and could redistribute the large profits that these companies make. This creates opportunities for previously ignored areas but it remains currently largely unclear how they can capitalise from this (Blair et al., 2011). At the same time, new challenges arise how to govern a more citizen-based and regionalised electricity system. However, these questions will not gain salience before renewable energies gain a larger role and the status quo of the predominant fossil fuel industry breaks.

5.3.Recapitulation

This case study has analysed the transition of the US electricity sector from fossil fuel based generation to renewable sources. This marks a significant break with the current design of the energy sector. While the technological aspects are relatively mature, as most technology exists, the institutional barriers are stronger because the transition would profoundly change the industrial structure of the United States. Currently, renewables hold a steady share of

roughly 10% of the electricity mix. Hence, the transition has taken-off but it is not accelerating. However, during the last decade, the natural gas revolution has taken place by shifting considerable emphasis from coal-fired power plants to natural gas. The US energy sector can transition quickly when new low-cost technologies become available. However, the renewable energy transition has not taken-off because of the higher prices of renewables and the US public does not sufficiently appreciate the resulting environmental benefits. Since the decision for or against a generation source is largely based on market prices, comparatively expensive renewables are in a weak position. While economic rationales prevail, the analytical model offers several explanations for the stalling of the renewable electricity transition.

A key problem in the United States framework is the lack of political consensus to mitigate climate change and transition to renewable energies. Since Democrats and Republicans have diverging views on the issue, time inconsistency meaning that it is unclear for how long certain measures are in place is the most prominent feature that affects all other aspects. With few exceptions, the role of renewables has increased during Democratic presidencies whereas Republicans represent the strong fossil fuel lobby. Hence, historically, times of quick progress and times of stagnation have alternated. These boom and bust cycles are a problem for a long-term transition process because they create a short-term focus. While the transmission belts partly explain the polarisation, they have few chances to strengthen federal political leadership, in particular as targets and legislation are missing. However, they enable bottom-up leadership through the states, which is important. California pursues this most prominently and aggressively. While the unsteady federal supporting net has negatively affected all three functions as it has avoided the implementation of a carbon price and hampered R&D efforts, California has implemented many of these tools. Hence, this bottom-up leadership can at least partially fill the void created by the federal blockade. The social impact – positive and negative – is limited so far since renewable energies in general only compete with other generation sources when they achieve price competitiveness, which they rarely do. However, renewable energies hold opportunities in particular for rural landscapes.

Despite this rather glum outlook, several aspects of the US framework are promising. For example, international technological developments have reduced the costs of renewable electricity sources helping them becoming more cost competitive. Furthermore, President Obama has used the recent fiscal stimulus in response to the financial crisis to substantially foster renewable energies through subsidies and R&D support. While these measures are

time-limited, they have offered the industry an opportunity to grow and create positive impacts on the political agenda. One important feedback loop in this regard is the growing employment in the sector that makes it harder for Republicans to reverse course. Hence, the established facts can potentially overcome some of the political games.

6. Smartening the European electricity grids

The green economy requires a profound overhaul of the grids, which transmit and distribute electricity. The fossil fuel era infrastructure mostly limits itself to transporting electricity from large power plants to consumers. It lacks internal communication capabilities that increase efficiency and flexibility. The green economy needs grids that accommodate intermittent renewable electricity generation, allow the usage of various low-carbon technologies, can store energy and increase the overall stability of the network (International Energy Agency, 2011b). Hence, the call for smart grids that make it possible to “bring reliability, flexibility, efficiency and environmental responsibility to network operations” (Bayliss and Hardy, 2012: 1060) features prominently in the green economy discourse.

Smarter electricity grids are enablers for other green technologies to maximise their impact. Hence, their role is not primarily to directly reduce GHG emissions but to enable such reductions by allowing new technologies to gain market shares such as electro mobility and renewable energies. For example, the European Renewable Energy Council and Greenpeace (2009) have shown that a smart European grid allows for an electricity mix in which 90% stems from renewable sources. Without a modernisation of the grid, this would not be possible since the current infrastructure is ill-suited for intermittent and decentralised electricity generation, which, for example, requires storage capacities. This demonstrates that the smart grid itself does not result in a profound change process (even though it can empower consumers) but it enables technologies that change societal behaviour. Hence, it is part of a deeper transition rather than a simple technological switch.

The European Commission (2011c) estimates that the smart grid can reduce GHG emissions by 9% in the EU energy sector by 2020 because of efficiency gains and lower peak demand. Hence, it does have some direct consequences. In addition, EU economies could save up to 52 billion EUR pointing out a win-win situation from an environmental and economic perspective (EurActiv, 2010b). However, realising these positive spin-offs is a difficult undertaking. Because of its central role for various purposes, the transition to a smart grid requires cooperation of all key stakeholders led by government (International Energy Agency, 2011b).

The European Union is a multi-level organisation dominated by the interplay of member states and supranational institutions mostly located in Brussels. It can only act when the member states have transferred the respective competences to the European level. Since the

European Union lacked competences to act on energy until recently, it has been active based on environmental and common market competences. Through its involvement with energy liberalisation and climate change, Europe has realised that smartening the energy grids is a key task to decarbonise the economy. Hence, the European Commission (2010d) argues that “the development of an EU-regulatory framework for Smart Grids is of crucial importance in order to guarantee that existing barriers to the Smart Grid roll-out (such as data protection rules, lack of standardisation, lack of minimum requirements on functionality and uncertainties in who does what) are addressed at European level as well as that no new barriers to the smart grid deployment are created by unilateral actions of the Member States”. Since the supranational level assigns itself a strong steering role through this statement and has received the necessary competences, the European level can be analysed as a state-like entity comparable to the other two cases in this research context. Nonetheless, the member states remain key players, in particular as the grids are fractured along national boundaries (Coll-Mayor et al., 2007). Since the deployment of the smart grid has started in the mid-2000s, the transition stands at the beginning and has not yet taken off in earnest. This means that the European Union starts from a similar starting point as other major markets such as the United States and China. However, transmission and distribution lines in Europe have the highest need for modernisation because of their age (International Energy Agency, 2011b).

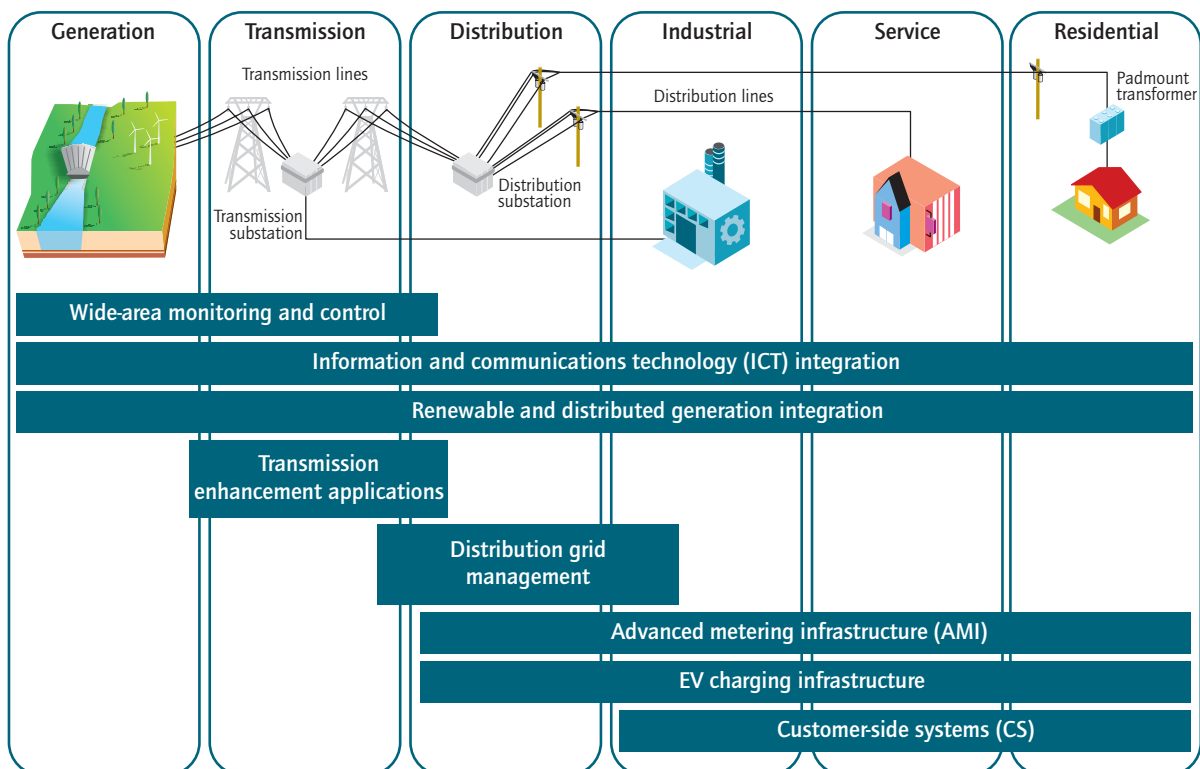
This case study is based on the analysis of primary sources from the European and national levels as well as secondary sources, such as reports from think tanks and market researchers for in-depth analysis. It triangulates the available data to gain a thorough understanding. Since the deployment of the smart grid and meters is still at a beginning phase, few statistics are available. Furthermore, as the focus of the case study is on the supranational level, it emphasises the available EU-wide data. The case study proceeds as follows. The first part elaborates the technical details and inherent challenges of a smart grid. Based on this foundation, it discusses the current situation in the European Union. It follows the application of the analytical model on the EU transition to a smart grid in order to analyse progress and challenges of this process. The recapitulation concludes.

6.1. What is a smart grid?

The European Regulators Group for Electricity and Gas (2010: 18-19) has so far presented the most relevant smart grid definition in the EU context: “Smart Grid is an electricity network that can cost efficiently integrate the behaviour and actions of all users connected to it – generators, consumers and those that do both – in order to ensure economically efficient,

sustainable power system with low losses and high levels of quality and security of supply and safety.” The European Commission (2011c) has adopted this definition in its communication on smart grids. Definitions used by other key international actors include different emphases. The International Energy Agency (2011b) does not include cost-efficiency whereas in the United States, the debate is more focused towards security of the grid (Clastres, 2011). This demonstrates that the smart grid concept is still evolving. However, all definitions share that a smart grid is comprised of a variety of technologies and includes a variety of coordination challenges. Figure 12 underlines the complexity of the technological shift that needs to take place and the broad array of technologies and actors involved throughout the entire electricity system.

Figure 12: Smart grid technology areas



Source: International Energy Agency (2011b: 17).

The smart grid is characterised by the interplay of various technologies throughout all steps of the production process (generation, transmission and distribution) and all types of consumers (industrial, service and residential). While ICT plays a key role in driving the smartening (Pearson, 2011), a variety of new tasks, mechanisms and technologies must be integrated

which challenges the overall system. Since the speed and direction of technological progress remains unknown, the future development trajectory is in doubt. Hence, smartening the grid is an evolutionary process rather than a single radical innovation (International Energy Agency, 2011b). However, it can enable radical eco-innovations. The outcome of the transition is highly uncertain, which challenges decision-makers to find the best trade-offs between the capabilities, dangers and costs of the new technologies.

Various rationales for implementing the smart grid exist: better performance and stability of the grid, new pricing mechanisms that increase efficiency and fostering green technologies that protect the environment. While at first glance, these aspects do not have much in common they all contribute to a green transition. This means that a smartened electricity infrastructure must satisfy these new demands and support various causes (Bayliss and Hardy, 2012, Clastres, 2011, International Energy Agency, 2011b). For example, the changed infrastructure informs consumers through a smart meter in their homes about their electricity usage, which enables various new technologies and purposes. As a result the consumers become active grid participants who can make informed decisions about their energy use patterns. In particular they can react to price signals according to load and demand in the grid – when demand is relatively high, prices go up; when supply is relatively high, prices go down. This would avoid grid peaks in either direction but can become a social problem because of increasing prices. At the same time, two-way communication allows for new business opportunities. For example, utilities can differentiate power quality and pricing as consumers that demand better power delivery security can do so at a higher price. Furthermore, smart grid infrastructure accommodates all kind of electricity generation technologies, in particular small-scale renewables, which are intermittent and decentralised in nature. They challenge the infrastructure in a different way than large, centralised base load power plants that generate constant output. However, the grids need to adapt to the growing role of electricity generated through renewable sources to support their larger deployment, which is crucial to decarbonise the economy. Furthermore, the smart grid allows new appliances to enter the market that can be steered through the grid. Finally, the smart grid can communicate when it requires service or repair in turn reducing maintenance costs while ensuring lasting quality of assets. This increases the resilience of electricity distribution to exogenous shocks and improves the overall stability of this crucial infrastructure.

6.1.1. Technical solutions

From a technical perspective, the potential to shave off load peaks is the key advantage of the smart grid. Since demand for electricity varies greatly, peaks rarely happen but constantly providing emergency capacities is very costly. Hence, they significantly increase the costs albeit being little used since the grid most of the time is underutilised (Bayliss and Hardy, 2012). The answer is active demand response that requires the installation of smart meters at the location of consumption to enable real-time two-way communication within the grid. While this allows for various pricing schemes, it is primarily important to increase the stability of the grid and reduce the overall costs by reducing the need for having peak capacities to stand by. Hence, smart meters are a key component of the advanced metering infrastructure which includes additional technology (Bayliss and Hardy, 2012). The then-available information allows utilities to better profile the demand structure of the supply side and reduces peak loads. While this can cause privacy concerns that need to be taken seriously, these meters are a critical part of demand response management.

Another aspect of the smart grid is energy storage, which requires different technological solutions. It becomes key when intermittent renewable energy sources generate a significant share of the electricity mix. Since their generation does not necessarily meet demand in a timely fashion, storage facilities become important that make the electricity available when it is needed. A key technology in this regard is electro mobility because it can use the batteries of the vehicles as storage capacity but other technological alternatives are discussed as well (Bayliss and Hardy, 2012). Since this integration of large storage capacities into the electricity grids requires new ICT, this industry plays once again an important role in the research and can trigger change (Erlinghagen and Markard, 2012). Since currently relatively few companies are active in the field, new business models must develop that turn the smart grid into an economic success. Hence, government steering needs to take business development into account while at the same time, the increased availability of consumer information, in particular because of two-way communication, results in privacy concerns (McKenna et al., 2012). Fears are that the creation of consumption profiles opens the door to privacy intrusions, for example by insurances or public authorities. Furthermore, the interconnected smart grid is prone to cyber attacks (Pearson, 2011). Malware and viruses gain the potential to attack a critical part of an economy's infrastructure. Hence, ensuring the safety of the smart grid, which is a central backbone of the economy, is essential in order to avoid shutdowns and the ensuing costs.

6.1.2. Current status of European grids

Historically, European electricity grids have developed within national boundaries and not as a common European endeavour: in particular the iron curtain has divided the European continent during a crucial period of electricity grid expansion. The member states affiliate differing targets with the deployment of a smart grid that range from fostering electro mobility to improving reliability and increasing energy efficiency (Clastres, 2011). Hence, developing a common EU framework, despite these varying development statuses of the electricity grid and the different goals associated with the transition, is a major challenge for the supranational actors. However, to meet the European energy targets, a harmonisation of these grids is necessary in order to increase efficiency. The EU level assumes a growing role in steering this transition process because it aims to finalise the common market for energy, which requires an interconnection of the regional markets.

In the late 1990s, the European Commission started the liberalisation of the gas and electricity market. Until then, the domestic energy sectors were predominantly characterised by vertically-integrated utilities that managed natural monopolies and were regulated by the member state authorities (Hierzinger et al., 2012). The European Union aimed to break open these national monopolies in order to foster a common European energy market. It is supposed to increase security of supply and lower prices for consumers. The third and to date last liberalisation attempt has not resulted in mandatory ownership unbundling meaning that “big energy companies would retain ownership of transmission lines, but hand managing control over networks to an entirely separate operator not sharing any stakeholders with the company” (Eikeland, 2011a: 24) as favoured by the European Commission; it rather gives member states various options that “also foresees a parent company retaining ownership of transmission networks but owned by the same set of shareholders” (Eikeland, 2011a: 25). The member states, in particular France and Germany, prevailed after intense negotiations with their goal to protect their national champions, which they assume critical to their economic well-being. Despite the successful push back by key member states against growing EU impact on the energy sector, the negotiation process has shown that the influence of the supranational level is slowly growing (Eikeland, 2011b). For example, the package installs two new EU oversight institutions: on the one hand, the ‘European Network of Transmission System Operators for Electricity’, which brings together all transmissions system operators and is tasked with presenting a non-binding 10-year pan-European transmission expansion plan each two years and on the other hand the ‘Agency for the Cooperation of Energy

Regulators', which bundles all energy regulators (Buijs et al., 2010). It remains to be seen whether these new actors can de facto increase the supranational impact on the energy sector or whether national concerns will continue to prevail. However, they demonstrate the growing role of the European Union in this predominantly domestically controlled policy field.

The result of the historical development of electricity grids along national boundaries and the various liberalisation efforts is that grids are nowadays clustered in at least three regions with differing market structures: First, the United Kingdom is a separate market because of its geographical boundaries as an island. However, it is the most competitive European market because ownership is completely liberalised and not a single major generator and distributor is in charge. Second, the Nordic market, in which the power utilities are mostly state-owned by various administrative layers, has recently implemented complete ownership unbundling between generation and distribution. Third, the liberalisation of the continental European market – the biggest – lags behind. The ownership structure varies between Germany, where some major generators and smaller distributors have divided the market between them and France, which follows the former British version of vertically-integrated utilities. Despite these differences both countries oppose ownership unbundling to protect their vertically-integrated national champions (Eikeland, 2011a, Karan and Kazdagli, 2011). Coll-Mayor et al. (2007) include the Iberian Peninsula as a fourth market. Since the Eastern enlargement of the European Union in 2004, the central European countries play an increasingly prominent role. However, their grids have developed separately during the time of the Iron Curtain. While the transition of the electricity grids lags behind in Eastern Europe because it had to overcome many other challenges since the end of the cold war, many regional efforts are ongoing. There are highly different starting points among the member states that challenge the development of a common European smart grid, in particular since the technical details of the electricity grids as well as the ownership structures vary.

6.2. Is the smart grid evolving in the European Union?

The discussion of the various parts has demonstrated that the smart grid entails a profound change of the current electricity grid systems. A major challenge is that many of the essential technological solutions have not yet been invented and little real-life experience exists. In the European context, two approaches to the grid smartening are present: either smartening and interconnecting the existing domestic grids when necessary or, more ambitiously, creating a common European smart grid that overcomes the national boundaries. However, given the strong position of the member states it is unlikely that the European vision will be realised in

the short- to medium-term. Hence, the current emphasis is on improving the grids within the member states rather than improving transnational connections because of the central position of the member states in energy governance. This includes that they the capability to communicate with each other, which is a tall task given their different historical origins.

A key step currently taking place is the installation of smart meters. While they can widely differ in their capabilities, their rollout is imminently important to achieve two-way communication, demand response and many other smart features within the grid. According to the European Commission (2011c) 10% of all EU households have installed a smart meter to date. Despite this rather low share, it means that 45 million smart meters have been installed in the entire European Union, which is more than in China and the United States (Giordano et al., 2011). However, the situation varies strongly between the member states: Several have begun with the national rollout whereas others largely ignore the issue. The European front runner is Italy where the largest utility ‘Ente Nazionale per l’Energia eLettrica’ has installed approximately 27 million smart meters between 2002 and 2007 and was close to achieving the goal of installing smart meters in all 36 million electricity consuming households by 2011 (Hierzinger et al., 2012). In France, ‘Electricite de France’ has begun installing 35 million smart meters in 2008 (Bayliss and Hardy, 2012). However, other member states have largely neglected the issue to date. Hence, it is difficult to draw conclusions for the European Union as a whole.

6.2.1. Political leadership depends on multilevel interplay

Historically, the European Union has assumed an international leadership role on environmental issues with an emphasis on climate change (Oberthür and Roche Kelly, 2008, Schreurs and Tiberghien, 2010). While environmental degradation entered the EU policy agenda in the 1960s, supranational engagement began in earnest after the 1972 ‘United Nations Conference on the Human Environment’ held in Stockholm and official competences shifted to the EU level with the ‘Single European Act’ signed in 1986 (McCormick, 2011). The transfer of competences coincided with an analysis of the impact of energy on the environment, which highlighted the interlinkages between the two fields (Solorio, 2011). Since then, the position of environmental affairs on the policy agenda has significantly increased. Starting in the 1990s, the then European Community put mitigating climate change and strengthening renewable energies on the international agenda (Oberthür and Roche Kelly, 2008). The results were that the ‘Rio Earth Summit’ discussed the issues and took action with

the Kyoto Protocol. Especially after the United States left the multilateral negotiation process on the Kyoto Protocol, the European Union was the driving force behind the process.

The European Union did not follow up this international leadership with domestic action during the 1990s, creating a “credibility gap” (Oberthür and Pallemmaerts, 2010: 36). This was only closed in the 2000s when the European Union established the EU ETS as the key instrument to achieve the GHG emission reductions that it was obliged to under the Kyoto Protocol. Hence, the European Union took a directional leadership approach of leading by example and through diplomatic efforts (Oberthür and Roche Kelly, 2008). This leadership was supported by the interplay of various actors. Schreurs and Tiberghien (2010: 26) correctly argue that “the actions and commitments of a group of pioneering states and the leadership roles played by the European Parliament and especially the European Commission” enabled this. Germany and the United Kingdom have significantly pushed the issue. Hence, the European level was not solely responsible for the climate change mitigation efforts but depended on continuous member state support. This cooperative effort was strong enough for the European Commission (2007b) to articulate its desire to “take the lead internationally to ensure that global average temperature increases do not exceed pre-industrial levels by more than 2°C”. This statement underlines that climate change has become a central pillar of EU policymaking and the two degrees Celsius target has become a fixture of international mitigation efforts.

The European level as well as the member states quickly realised that reaching the climate change targets of the Kyoto Protocol requires significant changes to the largely national energy policy. Hence, the European Union put into place a progressive climate and energy package in record speed in 2009 (Depledge, 2009, Oberthür and Pallemmaerts, 2010). This included targets for GHG emission reduction, renewable energy use and energy efficiency increases. In addition, the European Commission created the position of a Commissioner for Climate Action in 2010 in order to have a high-ranking coordinator of the effort and underline its seriousness to reach the set goals. This package, widely supported by the member states, is generally considered a strong showing of political leadership (Depledge, 2009, Oberthür and Pallemmaerts, 2010, Robins et al., 2009). The smartening of the electricity grids has become a key issue for integrating renewable energy generation sources, which are predicted to grow in capacity, and achieving necessary energy efficiency gains.

While energy issues were the nucleus of European integration and calls for a common European energy policy have existed for a long time, little action has been carried out at the

supranational level to date. The Single European Act put the common market at the centre of attention with the focus on free movement of people, money, goods and services (McCormick, 2011). Major challenges to this integration were seen in the lacking infrastructure including the grids. Hence, creating a common energy market in the European Union entered the policy agenda with a green paper in 1988 that laid out that free and fair competition generates welfare gains (Eikeland, 2011a). Since then, energy liberalisation underwent three stages: the first energy liberalisation package in the late 1990s, followed by the second attempt in 2003 and the third package that coincided with the climate and energy package (Eikeland, 2011a). Hence, common market objectives dominated the energy debate in the early stages as environmental issues were largely ignored. Given the importance of this infrastructure for the economy and society, the member states and the European Commission have followed a consensual decision-making approach resulting in incremental change. As a result, the European electricity markets remain disintegrated and regionally clustered. Over time, the focus of supranational energy ambitions has shifted from energy market liberalisation to energy market integration and recently environmental and security of supply concerns (Karan and Kazdagli, 2011). Beginning in the early 2000s, energy security gained importance on the European policy agenda because of increasing energy imports and the Russian-Ukrainian gas dispute in 2006 (Eikeland, 2011a). Hence, energy policy in the European Union is now driven by the trias of cost efficiency, energy security, and environmental improvement (European Commission, 2010a). Nowadays, environmental management, in particular mitigating climate change, has developed into a key policy area besides external affairs, economic prosperity and agricultural policy (McCormick, 2011). In this context the smart grid gained political salience because it is indispensable to environmental concerns, renewable energies and the grid interconnection.

The smart grid idea entered the EU policy arena in earnest in the mid 2000s. The Directorate General for Research created the 'European Technology Platform for the Electricity Networks of the Future' better known as the 'Smart Grids Platform' in 2005 (Flick and Morehouse, 2011). This outfit integrates all stakeholders in order to develop a vision for the European networks of 2020 and beyond (European Commission, 2006). The transmission belts are expected to combine a variety of actors that need to implement top-down and bottom-up changes. In 2006, the 'Energy Services Directive' for the first time indirectly referenced smart grids in a key EU document (European Union, 2006). However, the communication by the European Commission (2007b) laying out its intention to be a climate mitigation leader did not explicitly mention the smart grid, demonstrating a rather low salience at the time.

However, the simultaneously developed third energy liberalisation package resulted in an overhaul of the ‘Electricity Directive’, which now includes a target of 80% smart meter roll-out by 2020 (European Union, 2009). A further result of the third energy liberalisation package was that the Commission founded the ‘Smart Grid Task Force’ that at first was mostly concerned with technical standards (Schleicher-Tappeser, 2012). While it has recently increased its scope to include broader considerations, the Commission proposed in 2010 to follow a market-driven approach because major competences remain with the member states. Later, the European Commission (2010d) put forward a working roadmap on smart grid regulation offering four policy options: either to do nothing, present a communication, put forward guidelines and recommendations for the member states or add another annex to the Electricity Directive. The latter would have the strongest effect whereas the first would mostly ignore the issue. Since the Commission did not want to over-regulate the field and wanted to leave sufficient space for other, primarily business actors with its market-driven approach. It likely aims to avoid political fights with the member states (ENDS Europe, 2010). Its communication of 2011 suggests the Commission is applying a rather weak instrument. The communication stresses that “Smart Grids will be the backbone of the future decarbonised power system” (European Commission, 2011c). Hence, the European Union understands that the smart grid is a key enabler for a successful green transition and aims to introduce it for this reason. In addition it “provides an opportunity to boost the future competitiveness and worldwide technological leadership of EU technology providers such as the electrical and electronic engineering industry” (European Commission, 2011c). The Commission is aware of economic opportunities of the smart grid. To realise them, the communication focuses on technical standards, protection of consumer data, establishing a regulatory environment, which is supportive of the smart grid deployment, ensuring a non-discriminatory market that operates in the interest of consumers, and continuous support to foster the necessary innovations. However, it does not pledge funding nor does it take binding measures underlining the soft approach. In addition to the communication, the ‘Energy 2020 strategy’ by the European Commission (2010a) calls for “clear policy and common standards on smart metering and smart grids ... well before 2020 to ensure interoperability across the network”.

A call of the heads of the member states for the Commission to table new initiatives regarding smart grids, reflects the growing importance of the issue. The special European Council (2011) on energy concluded that standards for the smart grid should be presented by the end of 2012. However, the supranational actors have so far largely avoided outright leadership on

the smart grid deployment within the European Union as it could have taken more stringent actions, for example amending the respective directives. It rather limits itself to coordinating the actions of the member states and aims to reduce barriers, as the leadership potential of the supranational level is limited. While it has threatened more legislative action if member states are showing no promising action (European Commission, 2011c), so far, nothing has happened in this regard. However, industry representatives appreciated that the Commission dedicated so many resources to this topic (EurActiv, 2011). It remains to be seen whether the Commission will really take on the member states and enforces stricter rules when the member states do not progress. Past experience with the energy market liberalisation points out that in general the member states prevail.

Recently, energy and climate issues have lost most of the spotlight in the European Union. The economic crisis starting in 2008 and the ensuing sovereign debt crises as well as the ensuing Euro rescue efforts have dominated the agenda ever since. Hence, in particular costly issues such as investing in grid infrastructure have lost political momentum. Furthermore, EU leadership on climate change has recently come into question for a lack of ambition. For example, the target to reduce GHG emissions by 20% by 2020 compared to 1990 is almost achieved (European Environment Agency, 2012). Hence, if the European Union does not move to a more stringent target, for example 30% reduction, it will not have to take any further action until 2020, which would not set an international example (Egenhofer, 2010). The opposition of several member states, most prominently Poland, is the key hindrance to a roadmap that would include stricter targets (EurActiv, 2012). It stems from the domestic dependence on fossil fuels and the fear of increasing costs with more stringent climate action. This internal split undermines the EU position in international negotiations because it can no longer speak with one voice, which is a key prerequisite for effective leadership (Oberthür and Roche Kelly, 2008). This shows that the interplay of member states with the supranational actors, which has for a long time been strength, can turn into a weakness, when some member states obstruct further action. While this could be overcome in the past (Parker and Karlsson, 2010), that this time the internal opposition was stronger. The result is that the energy and climate targets for 2030 were severely watered down through the member states (EurActiv, 2014). Hence, the supranational level could not overcome their resistance, which marks a significant step back for the European leadership on energy and climate issues. The smart grid is not mentioned in the conclusions of the European Council (2014). It questions whether the European Union can uphold its historical front runner position.

6.2.2. Transmission belts need to adjust to multi-level governance

The European Union has identified the environmental policy area as a field to strengthen the supranational actors because of its transboundary nature. This means that in the debate with member states over further integration, the supranational level has good arguments as it can enable collaboration to overcome this common good problem and the ensuing free-rider issue. Furthermore, member states have agreed to transfer competences on environmental issues to the supranational level since they do not consider it as an issue touching their core sovereignty. Nonetheless, the European Union as a whole will only reach its climate and energy goals when the member states support it – the supranational actors are too weak to implement the necessary measures against their opposition. Hence, a broad political consensus is needed and the transmission belts that ensure such a consensus move to the centre of attention.

The predominant role of the member states on energy issues has limited the influence of supranational institutions. Before the European Union gained energy competences for the first time in 2009, it had to base its actions on internal market, competition and environment competences (Benson and Jordan, 2010, Vedder, 2010). Since environmental protection has been a driving force of the European integration process, energy issues are often discussed from a green perspective (Solorio, 2011). The public good character of many environmental problems that transcend national boundaries has strengthened European actors. The result is the current strong position of the European Union on climate change mitigation. For example, the European Union had a single Kyoto target that it distributed to the member states according to their capabilities. However, the lacking energy competence has been a key difference to climate change policy where the European Union could act as the international negotiator representing all member states (Schreurs and Tiberghien, 2010). The historical development concerning energy liberalisation demonstrates that the member states so far have advanced their priorities over the supranational attempts to create a common liberalised European market, which they understand as more important for their economy. While the negotiation process of the third energy market package shows that the clout of the Commission has grown, the member states prevailed (Eikeland, 2011a). This reflects the larger point that with regard to energy the supranational actors have been limited and, hence, timid. Hence, The key integration that took place was the combination of climate and energy policy (Solorio, 2011). These two issues are now closely linked in the regulatory framework and the policy mix caters to the needs of both. Integrating these two key policy fields has

gained the European Union an international leadership position. Without this combination, the supranational actors could not have acted decisively on energy issues.

This means that the supranational actors need more competences on energy to establish a coherent European framework. The ‘Lisbon Treaty’ signed in 2007 includes an explicit energy provision for the first time during the European integration process giving the supranational actors more leeway. Title XXI, Article 194 states that the European Union must “(a) ensure the functioning of the energy market; (b) ensure security of energy supply in the Union; (c) promote energy efficiency and energy saving and the development of new and renewable forms of energy; and (d) promote the interconnection of energy networks” (European Union, 2010). Despite these tasks, the new provision excludes energy generation as well as the energy mix from the supranational competences. It does not refer explicitly to the electricity grid. Commentators are divided whether this provision will increase the scope for a common energy policy or rather mark a manifestation of the status quo. Braun (2011: 8) states that the new provisions “offer little that will move intergovernmental topics into the Union arena”. Hence, it is “a codification of the status quo” (Vedder, 2010: 291). However, others stress that this can be an important step for the incremental development of a common EU energy policy similar to the slow-moving process that took place in other policy areas (Benson and Jordan, 2010, Solorio, 2011). The final outcome will depend on the ability of the European Commission and Parliament to gain influence on energy policy over the member state representation in the European Council. However, this uncertainty results in time inconsistency.

While the deployment of the smart grid in itself is a major coordination challenge because of the large number of actors involved (International Energy Agency, 2011b), the multi-level organisation of the European Union increases the need for integration of various policy areas and political layers for effective energy policy (Solorio, 2011). This means that horizontal and vertical EPI are crucial. The European Union comes from a good starting point since EPI is enshrined in the *acquis communitaires*, its legal basis. The European Community, the predecessor of the European Union, identified EPI as an important principle in the mid-1970s. The Single European Act for the first time enacted a legal obligation, the ‘Maastricht Treaty’ that was ratified in 1992 strengthened the principle and EPI reached the status of a guiding objective with the ‘Treaty of Amsterdam’ signed in 1997 (Lenschow, 2002). At this time, it was the only integration principle in the *acquis communitaires*. This has changed with the Lisbon Treaty, which has introduced further integration principles, such as consumer

protection, which can come in conflict with EPI (Vedder, 2010). Furthermore, the Lisbon Treaty also adds a particular energy integration principle in Article 194 (2) that targets horizontal integration (European Union, 2010). Despite being codified in the EU legal framework for a long time, the implementation of EPI on the EU level remains insufficient (Jordan and Lenschow, 2010). Hence, the following elaborates which steps towards deepening EPI are on their way and which should to be taken.

6.2.2.1. Horizontal environmental policy integration

While the highest political levels have carried out the negotiations of the climate and energy packages, the smart grid has not yet achieved this prominent treatment (Schleicher-Tappeser, 2012). Key political decisions have not yet been taken. The European Council (2011) has called only for standards but has not assumed a strong integrative role. While the Smart Grid Task Force is supposed to assume this role, in the past, its focus on technical issues and the lack of high-level representatives has prevented it from taking on a strong integrative function. However, an updated mandate of the task force presented in 2012 has shifted the focus so “that the development of smart grids and increased distributed generation involve a fundamental rethinking of actor’s roles, the logic of the technical system and market architectures” (Schleicher-Tappeser, 2012: 15). The European Union realises the broader challenges and integration requirements of the smart grid. Nonetheless, establishing this as a cross-cutting issue throughout all policy areas remains difficult, as the smart grid has not yet earned the highest political priority, which limits its cross-cutting importance. Furthermore, the economic crisis dominates the supranational agenda leaving little room to further integrate the environmental area by means of the capital-intensive smartening of the electricity grids.

Despite the current shortcomings, supranational actors have to assume a leadership role in organising the horizontal coordination of guiding the process. At the same time, horizontal EPI on the smart grid topic goes beyond government actors as it points to the importance of many business and civil society actors that are crucial in developing the regulatory and market framework. From a business perspective, not only energy firms are involved but almost to a similar degree ICT which are crucial to develop the necessary technological solutions to enable and use the two-way communication of the grid (Erlinghagen and Markard, 2012). Hence, it is important that the Smart Grid Task Force of the European Commission attempts to integrate all relevant stakeholders in order to establish a common language between these different specialists that in the past had few points of interaction. However, representatives from the renewable energy industry and smaller energy utilities as well as industry in general

and the broader public are not represented in the task force demonstrating that it does not yet cover all stakeholders crucial to the implementation of the smart grid (Schleicher-Tappeser, 2012). However, the European Union has ensured through the Smart Grid Platform and the ‘European Electricity Grid Initiative’ that the innovation efforts are slowly shifting towards smart grids.⁸⁹ While the integration of these European actors has not yet resulted in a coherent vision slowing down further progress, it is an important step to completely integrate the smart grid into the climate and energy framework.

6.2.2.2. Vertical environmental policy integration

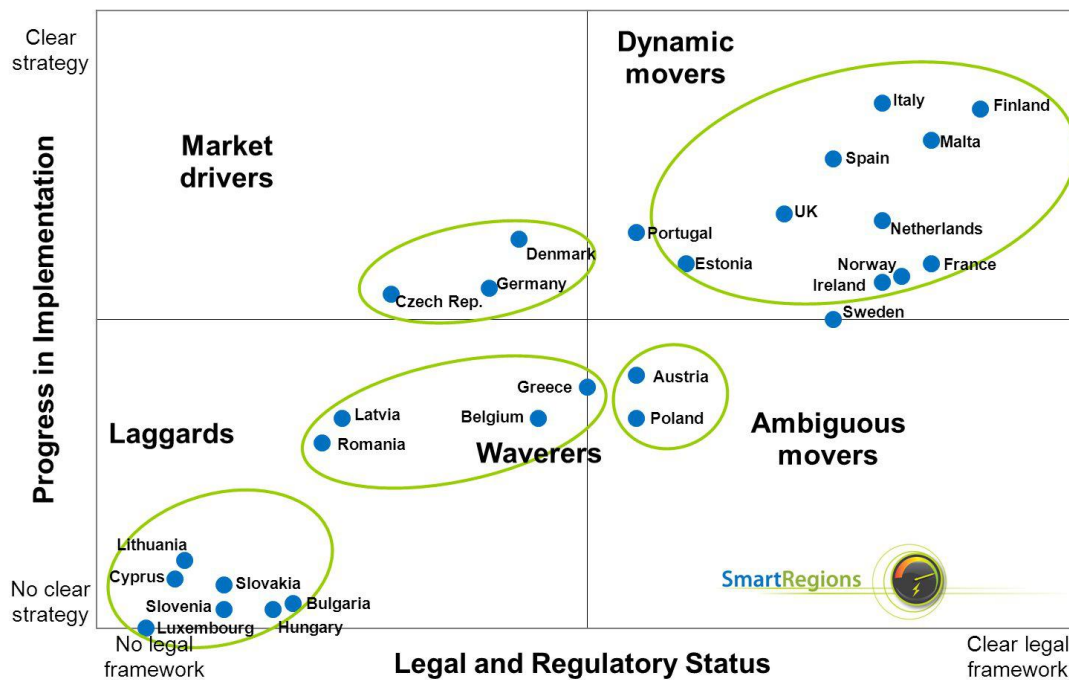
Vertical integration assumes a key role in the multi-level governance set-up of the European Union because of the discussed role of the member states. They have to transfer competences to the supranational level and support the process for it to succeed. Otherwise they have the power to derail the transition process as veto players. If they choose to play a proactive role, they must translate supranational targets into policy action. Hence, they can adopt the targets to their respective market designs, political culture and economic strengths and weaknesses. The history of climate change policy has demonstrated that the interplay of the member states and supranational actors can be very fruitful as various approaches achieve the policy goals. However, commentators fear that during the current economic crisis a renationalisation of climate policy might take place because economical considerations outweigh environmental ones (The Economist, 2013c). This would considerably weaken the EU climate and energy policy.

With regard to the smart meter roll-out – a key component of the smart grid –, the member states have reached differing maturity levels to date so that Giglioli et al. (2010) identify five groups: early adopters (Italy and Scandinavia) that have started large scale roll-out; countries with mandated roll-out, but little deployment so far (France, Spain and United Kingdom); member states that have active pilot projects in place but so far not mandated a roll-out (Germany and the Netherlands); and finally, inactive countries that have so far neglected the issue (Eastern Europe). Hierzinger et al. (2012) have analysed the actions of the member states along the lines of the legal and regulatory status as well as the progress in implementation and come to similar conclusions. Their findings are presented in figure 13. Dynamic movers are countries that have either put in place legislation that requires a rollout of smart meters or have started large-scale experimentation projects in preparation of mandatory measures. Market drivers have started the deployment for business reasons without

⁸⁹ See chapter ‘6.2.3.2. Enhancing sustainable innovation capacity’ for an in-depth discussion.

legislation. Ambiguous movers are currently implementing the regulatory framework. Waverers show interest in smart grids but have not taken any regulatory nor market activity. So far, the laggards do not yet address smart meters at all.

Figure 13: Smart meter deployment in EU member states



Source: Hierzinger et al. (2012: 3).

Member states with the biggest progress have achieved this because of regulatory activity rather than market drivers (Hierzinger et al., 2012). This runs counter to the market-driven approach of the European Union and underlines that most likely tougher measures are required for a successful transition. Interestingly, the groups of laggards and dynamic movers are considerably larger than the medium level. Hence, a majority of countries have either taken strong or no action. This means that the spread between the member states that the European actors need to address is considerable. This does not make the horizontal coordination challenge easier because the interest of the majority of countries is furthest apart. Hence, they expect opposite guidance from the European level.

While so far little progress has been achieved with regard to the goal of bringing smart meters to all households (EurActiv, 2011), the target of the European Union is to reach 80% by 2020 if economically feasible. Hence, the member states still have some time and the outlook is

rather positive. Market researchers predict “that around 212 million smart meters will be deployed in Europe between 2011 and 2020, driven by EU and national mandates as well as utility-driven operational efficiency programs“ (Woods and Strother, 2012) resulting in an overall installed total of more than 237 million smart meters by 2020. 2018 is expected to be the peak with almost 33 million smart meters deployed in one year. Woods and Strother (2012) estimate the overall market size to be 16 billion USD (12.2 billion EUR) from 2011 to 2020 with the highest annual revenue coming as well in 2018 with 2.35 billion USD (1.8 billion EUR). Currently, Germany is the only major Western European country that has not implemented legislation for mandatory deployment. Hence, key member states have taken the necessary regulatory measures to achieve this key step of smartening the grid. The Eastern European member states are expected to take action because of energy theft and economic losses stemming from corruption that can be avoided through better information generated by the smart meters. However, expectations are that by 2020 the Western European market will see 90% penetration of smart meters and the Eastern European market will have only reached 28% and continue to grow (Woods and Strother, 2012). This demonstrates that existing differences pertain and in particular Eastern Europe needs to make extra efforts to push the smart grid. Whether the European level can play a significant role in overcoming this unequal distribution will largely depend upon whether the Western European states are willing to support their fellow member states. So far, no such initiatives are in place.

A key challenge to the national roll-out of smart meters in the member states are privacy concerns (Hierzinger et al., 2012). They can stem from various sources: illegal use can result in electricity theft; commercial users can narrowly target their advertisements and insurances can adjust their coverage and rates to the usage profile; law enforcement agencies can gain additional information about the daily routine of suspects; other parties can use the data in legal battles, for example, regarding child custody or rental agreements; family members or other people living in the same household can control the behaviour of each other (McKenna et al., 2012). The Netherlands has stopped the mandatory roll-out because it could not ensure the safety of consumer data and avoid that utilities create user profiles (McKenna et al., 2012). Article 8 of the ‘European Convention on Human Rights’ states that “e[E]veryone has the right to respect for his private and family life, his home and his correspondence” (Council of Europe, 1950). Based on this article, the European Union has passed a directive that ensures data protection (McKenna et al., 2012). It calls to limit data use to cases in which it is necessary and relevant for a legitimate purpose. This aspect is currently not sufficiently represented in the EU smart grid approach despite being part of the task force mandate. A key

reason is that the competences to regulate this field remain with the member states (Pearson, 2011). Hence, a lack of vertical integration causes this problem. However, it must be addressed since currently used smart meters allow to figure out whether a consumer is at home or not but do not allow to trace which appliances were used. Since the data needs are smaller than often assumed, a solution to this challenge should be discernible when the necessary coordination takes place (McKenna et al., 2012).

6.2.2.3. Strategies and targets to ensure time consistency

Given the limited EU competences on energy and the consensual approach between supranational and member states, the European Union focuses on strategic documents that include medium- and long-term targets to ensure time consistency. Because of their intergovernmental character, the supranational bodies mostly present directives with targets and strategies that the member states adopt according to their national circumstances. The climate and energy package is a prime example of this approach as it set the triple target by 2020 of 20% reduction of GHG emissions compared to 1990, to source 20% of the final energy consumption from renewable energy sources and reduce energy consumption (increase efficiency) by 20% (European Commission, 2008).⁹⁰ As of now, most member states are on track to meet their Kyoto targets (with the exception of Italy) and are forecasted to achieve GHG emission reductions of 19% (instead of 20% which is laid down in the energy and climate package) by 2020 compared to 1990 levels (European Environment Agency, 2012). Hence, in theory, setting these targets and underlining them with strategies how to reach them has proven a suitable approach to significant GHG emission reductions over time. Furthermore, with the EU ETS in place, an instrument was chosen that ensures a relatively stable market framework when working properly that channels investments into green innovation efforts. However, in real-life both measures have drawn criticism for lacking teeth and not having a lasting impact on the economic development in the European Union. Hence, following this path is good, but the European Union needs to ensure that the targets and strategies are ambitious enough to ensure significant greening.

The European Union has chosen a similar but significantly weaker approach for the rollout of smart meters. The amended Electricity Directive states in Article 3 (1) that the member states should aim to introduce “intelligent metering systems or smart grids, where appropriate”

⁹⁰ While the EU target can be increased to 30% if other major economies make comparable commitments, this is unlikely given the current hesitation of some member states and the waning EU leadership position. The electricity sector will have to reach a higher share of renewables (approximately 30-35%) since, for example, the transport sector is unlikely to achieve this share (European Electricity Grid Initiative, 2010).

(European Union, 2009) in order to increase energy efficiency. The annex specifies that when a cost-benefit analysis is positive, 80% of consumers should have a smart meter by 2020. However, the language is unclear with regard to the economic assessment (Hierzinger et al., 2012). While this limits the incentives without further smart grid features available that allow the meters to become cost-efficient, this provision is a crucial driver because the member states have to comply. Nonetheless, industry representatives call for regulatory fine-tuning, for example on the detailed technological requirements of the smart meters (EurActiv, 2010b). Lacking standards can render large rollout projects useless when the smart meters cannot inter-operate in the end. Obviously, the grid does not smarten when the various types of meters ultimately cannot communicate with each other. The communication on smart grids is lacking details on these issues. More stringent action, for example amending the respective directives, would have been helpful. Hence, while the target is a key part of a time consistent framework, the lack of detail might render it useless – either the necessary investments are stalled because of technological uncertainty, or countries go ahead and install smart meters that do not interact in the end.

The future outlook of the European climate and energy policy has recently become less certain with the leadership being questioned despite it being included in various high-profile strategy documents. The climate change and energy targets are one of the five objectives in the ‘Europe 2020 strategy’ (European Commission, 2010c) emphasising their crucial position on the European policy agenda. Since smartening the electricity grids is a key part of reaching the energy targets, they will remain on the political agenda for the considerable future but most likely less salient than during the last years because of the economic crisis. In order to increase the stability of the energy-climate framework, the European Union has settled on a road map approach that sets long-term targets going beyond 2020. As mentioned the European Commission (2010c) followed up the climate and energy package with an energy policy strategy until 2020, which stresses the importance of smart grids. In addition, the European Commission (2011a) has proposed a roadmap how to reach a low-carbon economy by 2050 that includes long-term targets, such as to reduce GHG emissions by 40% in 2030, 60% in 2040 and 80-95% in 2050 compared to 1990 levels respectively in order to follow-up the 2020 targets. Following the path of the energy and climate package, the European Council (2014) has passed further targets to reach until 2030 (the baseline remains 1990): reducing GHG emissions by 40%, increasing the share of renewable and energy efficiency by 27%. These targets are lower than the initial proposals from the European Commission (2014). They have been heavily criticised for being too weak by environmental groups (EurActiv,

2014). A major driver in reducing the ambition was Poland because of its high reliance on dirty coal. Hence, the future strategy and targets have caused a split between the member states that has caused European leadership to come into question. While the goal was to ensure long-term stability, it has created short-term conflicts that have resulted in watered down compromises or delayed action. If a renationalisation of climate policy becomes reality, this will severely endanger the smart grid framework, which is a key technological enabler of achieving the climate targets. This underlines that weakening political leadership can significantly endanger time consistency when it is based on strategies and targets and avoids the creation of independent institutions.

6.2.3. Adjusting the three key functions

European leadership is based on a delicate interplay between the supranational actors and the member states that has created a rather elaborate governance regime. This distribution of power and resources is reflected in the crucial functions identified in the analytical model in which the European level holds few competences because all three deeply affect core state competencies. Hence, the supranational level is often only in the position to adjust the framework conditions but cannot make necessary investments since its budget is relatively small. This means that the supranational level is limited to nudging the member states towards pushing the green transition forward. When they unilaterally decide to continue with the fossil fuel status quo, for example because they fear that it would weaken their economy, this significantly weakens the European approach because it requires support from the member states to be successful. Supranational actors are not in a position to dictate national governments what to do. Hence, strengthening the EU ETS and steering innovation networks towards the green economy are crucial steps.

6.2.3.1. Greening the economic framework

Historically, national governments or regional power authorities have carried out energy grid investments and recovered their costs through the energy pricing system (Buijs et al., 2010). Technological and policy uncertainty can put these investments on hold since it rekindles a free rider problem: all market players wait for others to act first but everyone wants to reap the benefits (Clastres, 2011). This calls for state regulation to ensure that investments take place and the rewards are distributed fairly among all stakeholders. While infrastructure needs are now articulated on the supranational level, the financing has not evolved in the same manner (Buijs et al., 2010). The European Union commands only a small budget of its own

and primarily sets framework conditions. Most importantly, it administers the EU ETS and has altered the national energy sectors through its liberalisation efforts.

The EU ETS aims to channel investments into environmentally friendly purposes. Lawson (2010: 14) has labelled it the “most important instrument for delivering the goal of reducing greenhouse gas emissions” in the European Union. The carbon price channels investments into low-carbon technologies and generates revenue that can be used to offset social disturbances or foster the further greening of the European Union. Incremental energy sector liberalisation has increased competition by slowly creating a common European market. As discussed above, the latest liberalisation package currently allows for two options: the mandated transmission system operators presented as a compromise by the Commission and independent transmission operator model favoured by Germany, France and other member states. This demonstrates that the EU energy sector is still mainly controlled by large utilities that provide all energy services. The International Energy Agency (2011b) argues that vertically integrated utilities are better suited to implement the smart grid because they can share the financial burden more easily and ensure better vertical integration. The argument is that unbundling “makes it difficult to capture both costs and benefits of various technology deployments on a system-wide basis – especially with respect to smart grids” (International Energy Agency, 2011b: 23). While properly regulated vertically-integrated utilities can achieve the efficiency gains of a completely unbundled energy sector, they as well are better suited to find the necessary investments for a smart grid. This position is shared by industry representatives (EurActiv, 2010b). Hence, the European level needs to tread with care when it tries to liberalise the markets and deploy the smart grid at the same time.

The European energy grids require major investments because these have been postponed in the past and new challenges such as the growing share of renewables and the smart grid have not yet been sufficiently answered. The European Commission (2011b) predicts “that cumulative grid investment costs alone could be 1.5 to 2.2 trillion EUR between 2011 and 2050, with the higher range reflecting greater investment in support of renewable energy”. Until 2020, the European energy system needs investments of approximately one billion EUR; the transmission lines require 200 billion EUR of this amount of which the private sector is expected to finance only 100 billion EUR (European Commission, 2010b). Considerable investments are already taking place, mostly for smart meters. According to Bloomberg, investments in smart grid technologies grew by 7% to 13.9 billion USD (10.6 billion EUR) globally in 2012 (Downing, 2013). Spending in Europe reached 1.4 billion USD

(1.07 billion EUR) in 2012. This is considerably less than in China and the United States but investments are expected to grow significantly because of the announced national smart meter rollout programs. Hence, the projection concludes that Asia and Europe are the strongest growing markets as international investments are projected to reach 25.2 billion USD (19.4 billion EUR) in 2018 (Downing, 2013).

According to the European Commission (2011c) 5.5 billion EUR have been invested so far into the European efforts. Only 300 million EUR of this total stem from the EU budget underlining its limited investment capacity. The EU budget is small with a volume of approximately 143 billion EUR equalling 1.2% of EU GDP in 2011 (McCormick, 2011). Since the European Union does not have the right to raise taxes, it is mostly dependent upon member state contributions.⁹¹ Hence, the supranational actors are mostly limited to coordination and ensuring the common internal market. The strong impact of the member states reflects in the way the supranational level is limited in spending the funds: The majority of the budget is assigned to the structural and agriculture funds, which subsidise industries in the member states. In 2011, the EU budget included only nine billion EUR for a variety of policy fields such as external policy, transport, energy and R&D (McCormick, 2011). This demonstrates that it mostly supplements the budgets of the member states and is hardly an independent funding source.

6.2.3.1.1. Real-life challenges of a carbon price

The EU ETS is not only the key instrument of European climate policy but a strong carbon price is a key incentive for smart grid development (ENDS Europe, 2010). The European Union has assumed an international leadership position by implementing this tool. However, the lack of real-life experience with the instrument has caused growing pains and resulted in a near breakdown. Current price signals are too weak to result in lasting changes to production processes and to incentivise investments in green technologies. The weak effects threaten the international front runner position that the European Union has gained in the field of carbon pricing.

After first attempts to implement a carbon trading scheme in 2001, the EU ETS went into action in 2005. As of now it is the largest operating ETS worldwide as it covers 31 countries.⁹² Three arguments explain the quick implementation of an ETS in the European

⁹¹ Contributions by the member states are responsible for 76% of the EU budget, another 12% stem from custom duties on imports and 11% from a EU charge on member states value added tax.

⁹² These are the 28 member states plus Iceland, Lichtenstein and Norway.

Union (Jordan et al., 2011). First, several member states that were climate policy front runners aimed to avoid domestic competitiveness concerns through concerted actions on the European level. Second, attempts to establish a European carbon tax failed in the early 1990s because member states could not unanimously agree as the voting procedures required. Since the member states did not want to introduce a tax, the focus of supranational decision-makers shifted to emissions trading. They could implement this tool based on their environmental policy competences and with qualified majority voting rights. Third, the design features were tilted in a way to buy off political opposition, which ensured its enactment.

Negative long-term consequences have arisen from the politically motivated softening of the EU ETS. The first phase of operation started in 2005 and ran until 2007 as a learning period. This phase covered 12,000 installations that represented 50% of CO₂ emissions and 40% of GHG emissions (Lawson, 2010). It ended with a breakdown of the market because of a lack of demand stemming from an over-allocation of permits and lower than calculated abatement costs (Grubb, 2012). Grandfathering – handing out permits to industry for free in order to avoid excessive costs – proved problematic as businesses inflated the number of required permits. During the second phase, which matched the first commitment period of the Kyoto Protocol (2008 to 2012), the member states had to set their emissions caps in line with their national Kyoto targets (Grubb, 2012). While the reduction targets were achieved, the EU ETS was not the main reason but the financial crisis and the ensuing recession resulting in less economic activity caused GHG emission reductions. As a result, the carbon market broke down once more because of an oversupply of permits. The combination of too many permits in the market and the banking provision that allowed permit holders to transfer them to later periods challenges the currently running third phase because the oversupply continues.

Significant changes took place before the third phase started in 2013. Already in 2012, aviation was included which is now the second biggest sector, so that the scheme covers 45% of GHG emissions during the third phase (European Commission, 2012, Kossoy and Guigon, 2012). While the Commission wanted to achieve full auctioning by 2020, a compromise has been found to exempt industries that are in danger of carbon leakage to avoid their relocation. Hence, approximately 50% of the permits are auctioned off during phase three in comparison to 4% in phase two (Lawson, 2010). Furthermore, an EU-wide cap is established that reduces the allowed overall GHG emissions output annually by 1.74% (European Commission, 2012). Despite this tightening, an over-allocation persists which endangers this period. In addition, a proposed ‘Energy Efficiency Directive’ creates fears that it will reduce GHG emissions

further resulting in even lower prices (Kossoy and Guigon, 2012). Hence, “[W]ithout changes, the future of the EU ETS — and its role in driving emissions reductions — looks bleak” (Grubb, 2012: 666). However, the European actors continue to debate measures to fix the EU ETS, such as withdrawing permits from the market to increase demand and the carbon price. Another option is to establish a price floor, as has been done in California, to avoid the price to fall below a certain threshold. This dire outlook not only spells trouble for European climate and energy policy but could endanger the international diffusion of ETS (The Economist, 2013c).

6.2.3.1.2. Few supranational subsidies

While the EU budget emphasises agriculture and infrastructure spending, energy subsidies play a minor role.⁹³ A review finds that during the last EU budget period (2007 to 2013) annually 2.9 billion EUR of the structural funds were spent on energy with little emphasis on the grids (Usubiaga et al., 2011). So far, the European Union has only funded smaller energy infrastructure projects under the programme ‘Trans-European energy networks’ worth 155 million EUR during the last budget period (Fischer and Geden, 2013) while a larger share went to renewable energies and energy efficiency. Other budget lines target primarily nuclear power. Time-limited measures have also largely avoided energy. The European stimulus package in response to the financial crisis in 2008, the ‘European Economic Recovery Plan’, was worth 200 billion EUR from which 170 billion EUR were spent by the member states and 30 billion EUR came from the EU budget (Robins et al., 2009). Grids have received little of the investments, as only four billion EUR went to energy infrastructure issues (Fischer and Geden, 2013). While this is significantly more than was previously spent, it demonstrates that the European Union has few fiscal capacities to fund smart grid investments since most spending takes place on the member state level. China and the United States invested considerably more with approximately five billion EUR (partly stimulus funding) into the smart grid in 2009 alone (Giordano et al., 2011). In Europe, national budgets and loans by the European Investment Bank were much more important (Usubiaga et al., 2011). In response, the supranational actors aim to influence national spending: the ‘Europe 2020 strategy’ calls for a removal of environmentally harmful subsidies by the member states (European Commission, 2010c).

⁹³ In 2011, 35% of the budget went to the cohesion funds that support the development in poorer regions of the European Union. 31% went to agricultural subsidies (which have been as high as 75% during the 1970s) and another 11% to rural development. The rest was spent on administrative costs (6%) and the other policy fields.

The negotiations on the EU budget from 2014 to 2020 have resulted in a decline of overall spending and energy infrastructure funding. The European Commission (2011d) proposed to fund the ‘Connecting Europe Facility’ that offers grants and loan guarantees in order to stimulate private investment with 50 billion EUR. It sought that 9.1 billion EUR go to trans-European energy infrastructure, 9.2 billion EUR to broadband networks and the rest to the transport sector in order to strengthen these three key infrastructure areas. However, the budget negotiations reduced the funding significantly to approximately 30 billion EUR; in particular the broadband portfolio, which includes smart grids, was cut to one billion EUR and the energy budget was cut to 5.1 billion EUR (van Renssen, 2013). While the budget ring-fences 20% for climate policy, the reduced overall funding will significantly hamper the development of infrastructure projects in the coming years according to EU officials (EurActiv, 2013). Opposition to a larger funding for the Connecting Europe Facility came from the net contributors to the European budget who argue that private investors should assume more responsibility whereas Southern countries see a larger role for EU involvement (Fischer and Geden, 2013). The European Voice (2013) argues that the member states have little trust in the European actors and rather decide how to spend the money domestically. Hence, in the multi-level arrangement they tightly control the supranational actors, for example by keeping their monetary transfers to the budget small.

6.2.3.1.3. Little impact on the labour market to date

Since the impact of the smart grid depends on the interplay of various technologies, it is difficult to assess the precise employment effects. The European Commission (2011c) points out that the “low-carbon energy industry has to date generated 1.4 million jobs in Europe”. This demonstrates the importance of the green sector as a source of job creation in times of high European unemployment. The European Commission (2010b) predicts that the investments of 200 billion EUR into the European grid infrastructure between 2011 and 2020 would create 775,000 jobs and add 19 billion EUR to European GDP. However, the smart grid is only partly responsible for these gains since the investments cover more technologies.

Given its role as an enabler, the creation of smart grids can generate new jobs as well as strengthens other technologies that trigger employment growth. The indirect effects stem from the technologies that the smart grid allows to prosper. The direct employment effects of smartening European grids have not been quantified to date. While during the deployment phase a lot of workers are needed to install smart meters, later the smartened electricity grid might reduce the labour intensity because it fixes many problems by itself with less human

involvement through its improved technological capabilities. In any case, it is likely to alter many existing jobs and require high-skilled workers. The U.S. Department of Energy (2013) analysed the effects of three billion USD (2.3 billion EUR) stimulus funding targeted to the smart grid: The result is that 18,000 jobs were created directly in the smart grid industry and an additional 29,000 jobs in the surrounding industries. Hence, the spending created 47,000 jobs surrounding the smart grid efforts – the enabling capability is more important than the direct effects.

6.2.3.2. Enhancing sustainable innovation capacity

Since the European Union aims for an international leadership role on green technologies such as the smart grid, it fosters innovation in this area (European Commission, 2011c). However, the R&D spending significantly lacks behind international competitors such as China and the United States. Hence, the supranational level focuses on structural issues. It organises its innovation policy through ‘Framework Programmes for Research and Technology Development’ that run for several years. The 7th framework programme spanning the period 2007 to 2013 has included an emphasis on smart energy networks based on the groundwork that was established in the previous two framework programmes (Coll-Mayor et al., 2007). Since this document was presented before the passing of the energy and climate change package, it includes a significantly stronger emphasis on nuclear power than on renewable energy sources and grid improvements. Of the overall more than five billion EUR dedicated to energy research, only a minority of 2.35 billion EUR are spent on non-nuclear research (Lawson, 2010). This means that it does not yet mirror the transition to green technologies. Furthermore, similar to the situation in the United States, spending on energy research is little compared to other areas such as ICT and health (International Energy Agency, 2008).

A further initiative that aims to generate innovations in the field of smart grids is the Smart Grids Platform bringing together key stakeholders. It is an example of the European technology platforms that exist on various topics. They all follow a three step approach: First, they are business-led in order to establish a common vision of key stakeholders; second, they follow this up with a ‘strategic research agenda’; third, they use among other tools the framework programmes to realise their targets (International Energy Agency, 2008). The guiding vision of the Smart Grids Platform stresses that the European energy futures needs to be flexible, accessible, reliable and economic (European Commission, 2006). The internal energy market generating economic growth, securing energy supply and environmental

considerations laid out in the climate and energy package are the driving forces for the European smart grid according to the vision. The goal is to create a grid that is more closely interconnected within Europe in order to overcome the existing compartmentalisation. Hence, the research framework reflects key policy changes but lacking financial support to date has limited its impact.

In response to the changing political agenda with the increasing emphasis on climate change, the European Commission (2007a) presented the ‘European Strategic Energy Technology Plan’ as the innovation piece of the EU climate and energy jigsaw. It calls to “e[E]nable a single, smart European electricity grid able to accommodate the massive integration of renewable and decentralised energy sources” as a key technology challenge for the next ten years (European Commission, 2007a). Furthermore, this plan laid out several initiatives, one of them being the European Electricity Grid Initiative. It is an industry-led effort that has presented a research agenda for the coming nine years worth two billion EUR (European Electricity Grid Initiative, 2010). While it includes market players and academic institutions, the presented budget does not cover the actual rollout of the technology. Funding has been lacking so far, limiting the impact (International Energy Agency, 2008, Lawson, 2010). The result of the budget negotiations and the reduced funding of the Connecting Europe Facility exemplify the challenges to establishing supranational energy innovation. Private investments are unlikely to offset this lack of public spending during the current economic crisis.

With limited supranational smart grid innovation efforts, the member states carry out various R&D projects. A review by Giordano et al. (2011) on behalf of the European Commission finds projects in the member states with a total budget of over five billion EUR. The majority of these projects are concerned with the roll-out of smart meters and lesser emphasis is put on further R&D and demonstration of new technologies. Almost half of the investments took place in Italy, where one major programme, the nationwide rollout of smart meters in all households, cost more than two billion EUR. Hence, the current transition efforts are still in the take-off phase. The majority of projects are located in the European Union 15 (over half in Denmark, Germany, Spain, and United Kingdom) while only around 11% are located in the European Union 12. This reflects the gap between Western European leaders and Eastern European laggards.

6.2.3.2.1. Member states are largely in charge of invention

The European Commission (2011c) argues that it has spent 300 million EUR during the last three framework programmes on smart grid innovation. When taking into account stimulus spending, the total is slightly higher at approximately 500 million EUR (Giordano et al., 2011). As mentioned above, China and the United States have spent considerably more on smart grids with an emphasis on R&D in order to develop the necessary technology. However, this is unsurprising given the significantly weaker role of the supranational level in innovation funding compared to the two nation states. The situation would look differently when taking into account member state spending as well.

The role of the EU institutions is to ensure that the member states include the smart grids in their domestic innovation efforts as well as to coordinate the various efforts. This takes place in the Smart Grids Platform and the European Electricity Grid Initiative. As a result, between 2000 and 2008 the number of smart grid projects grew to more than 80 new projects each year (Erlinghagen and Markard, 2012). The financial crisis and the consequential fiscal stimulus packages, which included spending on the smart grid, have caused a recent spike. As a result, 47% of the projects fall into the R&D category, defined as “creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications“ (Giordano et al., 2011: 21). However, this category is only responsible for 9% of investments as the average budget size is rather small with 4.4 million EUR. A key project category in this regard is system integration underlining that many technologies already exist. Although they require fine-tuning, their integration is the major challenge that smart grid research has to overcome. Hence, it is a systemic issue as well as a technological challenge. This demonstrates a need for large-scale demonstration projects to identify additional challenges and opportunities of the smart grid, which are currently lacking. The Electricity Grid Initiative is the attempt to start these projects but cannot do so without the necessary funds underlining the problems arising through the small EU budget.

6.2.3.2.2. Lack of large-scale experiments hinders innovation

Bridging the valley of death in energy matters is difficult because of low private investments and a lacking incentive structure (International Energy Agency, 2008). Furthermore, the social progress of the smart grid is hard to capture in pricing mechanisms meaning that consumers, for example, need to pay for smart meters without any direct gains. However,

establishing new goods and services as well as business models depends on experience and technological progress. The smart grid proves that it is a major challenge to privatise the gains of the new technology. While the review by Giordano et al. (2011) finds that 46% of all projects are demonstration projects that are responsible for 35% of investments, the average budget size is small with 12 million EUR. Hence, large-scale demonstration projects that are needed to understand the smart grid performance under real-life circumstances rarely take place. Hence, little experience is gathered, which makes it difficult to establish new business models and the social consequences remain largely unknown. Large-scale demonstration projects would integrate many smart meters resulting in active demand response management and new pricing mechanisms. Hence, they would allow for utilities to implement new pricing mechanisms from which they could make profits and which could be beneficial for some consumers. Hence, a lacking business model “is presently among the biggest challenges in Smart Grid implementation” (Giordano et al., 2011: 10). Without these experiments, bringing smart grid inventions to the market depends upon government support since they are not yet attractive to power utilities. The lacking public funds at the EU level currently stop these larger projects from happening. However, France that has carried out large-scale demonstration projects, is a very good example of how such a large project can successfully lay the groundwork for the ensuing nationwide deployment of smart meters (Giordano et al., 2011).

6.2.3.2.3. Smart meters as a first step of smart grid diffusion

The key part of the currently ongoing European innovation efforts moving towards a smart grid is the roll-out of smart meters: 7% of deployment projects are responsible for 60% of investments (Giordano et al., 2011). Hence, few but very large projects are taking place in the member states. While these projects are limited to only a few countries with Italy being the biggest market, they can function as large-scale experimentation projects that are needed to gain practical experience with the challenges of a smarter electricity grid. However, the diffusion is taking place because the regulatory framework requires their implementation and not because of market mechanisms. Hence, regulation is the key driver to deploy smart meters (Hierzinger et al., 2012). This underlines that the smart grid innovation efforts are dependant upon government incentives and frameworks even during the latter stages of the innovation cycles. Hence, the supranational actors should assume stronger measures in order to foster innovation

A major challenge to the European wide rollout of the smart grid is the technological uncertainty arising through the different national market designs. Hence, it is a step in the right direction that the European Council (2011) and the European Commission (2011c) put standardisation at the centre of attention and it has become a central task of the Smart Grid Task Force. However, actual progress still lags behind (Ab Iago, 2011). Hence, further progress is necessary on this issue to increase two-way communication within European electricity grids. A further problem, that even the European Commission (2011c) admits, is that in an international comparison, European governments have done little to foster the deployment of the smart grid. The combination of lacking capacities of the supranational level and the lacking interest of many member states limit the smart grid deployment to front runner states and widens already existing gaps between member states. Hence, this is another argument that supranational actors must play a more assertive role to reach a common level.

6.2.3.3. Distributional fairness of costs and rewards

Deploying the smart grid requires social acceptance by consumers. Their cooperation is essential to achieve the necessary efficiency gains as they can undermine any efforts by the state or utilities with their behaviour. If the consumers do not adapt to the changing infrastructure in which they become an active participant through two-way communication, the utilities have a hard time to realise the potential of the smart grid. Hence, it is important to explain to consumers' challenges and opportunities of the smart grid so that their behaviour is based on information rather than myth.

Research on the United States shows that people have too high expectations concerning smart meters, which will likely result in disappointment (Krishnamurti et al., 2012). While a significant group has privacy concerns that can be addressed, other consumers expect decreasing prices. However, the smart meters cannot solve all problems of the electricity grids and prices might initially rise because of the necessary investments. While a significant monetary savings potential of approximately 10% exists in the long-run, when the smart grid is operational, the high costs of installing the necessary infrastructure need to be recovered at first (Bayliss and Hardy, 2012). Faruqui et al. (2010) estimate the cost of an European smart meter roll-out to be 51 billion EUR and the benefits to be worth between 26 and 41 billion EUR leaving a considerable gap that needs to be paid for by someone. This means that those, who pay this bill, are likely opposing the transition to a smart grid because they do not have any new benefits, especially at the beginning.

Dynamic pricing mechanisms can help fill the void, meaning that consumers will bear the majority of the burden, as they have to pay the price of higher electricity rates to recover the investments. The real-time communication within the grid allows introducing more precise pricing mechanisms. Hence, consumers can influence their electricity bills according to current prices, which depend on the load in the grid in an attempt to avoid peaks. The current pricing regime includes various cross-subsidies as everyone pays the same price all the time, while the costs of generation differ sharply according to the load. This changes with dynamic pricing. Hence, in theory consumers that use an above-average share of peak electricity will see an increase of their bill and the below-average peak users will see a decrease (Faruqui, 2012). At night, when less electricity is used, but for example wind power continues to produce power, the prices are likely lower than during high peaks hours during day-time.

A study on the United States finds that prices for consumers will increase between 8.4 and 12.8% (Haddad et al., 2010). Similar estimates for the European Union are not available. The social acceptance of the smart grid and new pricing mechanisms are likely dependant on the distribution of these costs. The European Commission (2011c: 2) argues that the smart grid “opens up unprecedented possibilities for consumers to directly control and manage their individual consumption patterns, providing, in turn, strong incentives for efficient energy use if combined with time-dependent electricity prices”. However, it does not mention equity concerns in the communication and does not envision to compensate the transition losers despite that equity consequences are manifold as discussed. The most important reason to deal with the equity concerns arising through the smart grid and meter are the compulsory nature of their roll-out as included in the mandatory targets set by the European Commission (Felder, 2012). Hence, nobody can escape them.

The social impact of introducing dynamic pricing is currently unknown because of the discussed lack of large-scale demonstration projects. However, it is a well-known fact that energy costs are regressive and low-income households pay a considerably higher share of their income on energy than high-income households (Büchs et al., 2011). Hence, they are more strongly affected by changing energy prices. However, differing positions continue to exist: Darby (2012) argues that fuel poor households could benefit from dynamic pricing because of better information and the potential for social energy pricing. Faruqui (2012) makes the case that in particular low-income households that spend considerable time at home, such as the unemployed, seniors, and families with small children, have to pay higher prices because they cannot avoid peak load usage. Real life experiments need to increase

knowledge and lay out how households and industry can adapt to changing pricing structures. The European Union can assume a crucial role in pointing out these social challenges to the smart grid deployment and help member states overcome opposition from consumers by sharing best practices and keeping the issue high on the agenda. Furthermore, it can ensure that the revenue stemming from the EU ETS is at least partly channelled to compensate transition losers. Otherwise the social benefits of the smart grids will not materialise.

6.3.Recapitulation

This case study has analysed the beginning transition to smart electricity grids in the European Union. The smart grid is a key enabler for many low-carbon technologies that are needed to reach Europe's climate and energy goals. The deployment of a smart grid in the European Union has the potential to redefine the interplay of electricity consumers and producers in significant ways and allows for new technological advances as well as pricing models. Currently, the transition is in an early stage with some member states assuming a lead position while the European level is the framework setter that brings together key stakeholders. So far, it could not avoid that the national developments are very disparate. The supranational level is rather weak and depends on broad support by the member states to take the lead.

The complex interplay of various actors of the European multi-level governance regime explains its historical international leadership position on climate change and energy issues. While the smart grid is a key technology to reach these goals, it has not yet achieved a similarly prominent position. At the same time, vertical integration is a challenge because the divergence between the member states is significant. As a result, for example the installation of smart meters is spread unevenly across Europe. Furthermore, these varying sources of leadership challenge the transmission belts. While the European Union aims to establish the green transition as a cross-cutting policy priority, it has few resources at its disposal to ensure the implementation. The 2009 Lisbon Treaty included for the first time an energy provision in the supranational treaties but the consequences are rather limited. Hence, it largely depends on the member states to carry out major initiatives, which they do to varying degrees. While the European Union presented a communication on smart grids, which is the middle way of its instruments at its disposal, it could have taken other measures to increase the pressure to act. While strategies and targets are supposed to ensure time consistency, the concrete initiatives on the smart grid are rather weak because the European Union does not want to overburden the member states. Some of them are currently rebelling against the EU emphasis on climate

change and energy and endanger the existing regulatory framework. Hence, the top-level is too weak to overcome opposition that is brewing from below.

Since the European Union has few fiscal resources at hand, it is mostly limited to ensure a supportive framework. The most important instrument in this regard is the EU ETS that is supposed to reduce GHG emissions and channel investments into green goods and services. However, it is currently undergoing a difficult period because of an oversupply of permits that have resulted in a low trading price. However, green employment is materialising. However, the low carbon price has little impact on the innovation system, which is largely controlled by the member states because they are in charge of the funding. It is problematic that large-scale demonstration projects are lacking which would foster knowledge development as well as teach lessons about the social consequences, which currently plays a negligible role in the European debate. However, the smart grid can have crucial impact on the distribution of costs and rewards because of new pricing mechanisms and the high investment needs that do not directly translate into better services for consumers.

7. Conclusion

This doctoral thesis has analysed whether China, the United States and the European Union are taking significant actions to transition to green economies in key technologies. The selection of these countries as case studies was based on their importance for a significant global GHG reduction, as they are the three leading economies and polluters. The aim was to answer two sets of research questions: *a) Which capacities to transition to a green economy do China, the United States, and the European Union have? How do they govern their respective transition processes? b) Are China, the United States, and the European Union advancing in their quest to decarbonise their economies?* After reviewing the literature and developing an analytical model of transition governance, the study carried out in-depth case studies of the Chinese transport sector, US electricity generation, and EU energy infrastructure. Hence, the research applied a most different research design with regard to the political entities under question. The respective technologies analysed in the three different cases were similar with regard to their importance for a significant decarbonisation of economic activity, that the political entities have tried to put in place a supportive policy framework and that they are international key actors in these areas. The case studies enabled learning about the capacities for a green transition in the respective cases. Data triangulation allowed for a thorough analysis because it combined various available data sources such as primary government documents and statistics, studies from think tanks and market analysts, press reports as well as academic literature.

This dissertation finds that the three cases are slowly transitioning to a green economy but so far the changes have not largely altered the respective status quo. A significant decoupling between economic activity and pollution is not taking place in the analysed areas. Hence, with green goods and services remaining a niche market, the transition efforts have so far not fundamentally affected any of the three economies. When answering the research questions, it is important to note that the three cases begin from very different starting points in the studied areas – electrifying the Chinese transport sector, shifting to renewable electricity generation in the United States and deploying the smart grid in the European Union. This results in an important disclaimer: they can advance the transition in other areas faster or slower meaning that it does not reflect the overall progress towards the green economy, which consists of GHG reductions in a variety of economic subsectors. In addition, the transition is not a linear process but rather very unsteady meaning that it is unknown when the change process will increase or decline in speed.

The cases base their transition trajectories on significantly different governance frameworks stemming from their different political cultures. Key differences that have been identified are the primary actors and the predominant logic of decision-making. Furthermore, the rationales for the transition efforts as well as the scope differ since some efforts aim at exchanging one dirty technology with a cleaner alternative while in others more profound social changes are taking place.

- China is a quickly industrialising economy governed by an autocratic all encompassing one-party regime. Improving the living conditions and generating economic growth is key to the CPC in order to justify its rule. Hence, China's primary motivation to become an international leader in electro mobility is to establish a strong domestic automotive industry based on a technology in which other industrialised economies do not yet have significantly more knowledge, skill and experience. Positive environmental and health effects strengthen this economic rationale. Public actors largely control the decision-making of a transition that is between the predevelopment and take-off stage. However, the lack of electric vehicles on the roads proves that it has not yet taken off despite strong public support. The Chinese transition approach is largely technology-focused with an emphasis on shifting from traditional ICE technology to cleaner alternatives. Systematic considerations, such as strengthening public mass transport play an insignificant role. Hence, the transition process could result in a shift of technology that increases GHG emissions because of the coal-dominated energy mix. The transition capacities largely depend on the will of the CPC.
- The United States is a federal democracy in which the two-party system has created a toxic political atmosphere. This negatively affects the green transition since it has become a highly polarised wedge issue. Since many US Americans want to continue their high-emissions life style, cheap energy prices for domestic industry and consumers are generally more important than decarbonising electricity generation. This coupled with lacking political support limits the scope for renewable electricity generation. Hence, market mechanisms mostly outweigh political considerations. Renewables are in the take-off stage for some time but will only accelerate under the current framework when renewable electricity becomes price competitive. The US efforts to transition from fossil fuel powered electricity generation to renewable resources mark a significant break with the current economic framework because they require considerable changes to the infrastructure. While the technological aspects are

easier to master, the institutional barriers are stronger since the transition entails a more profound overhaul of the way things are done. Hence, the transition capacities of the United States are based on the market rather than political involvement.

- The European Union is a multi-level governance regime sui generis. While the role of the supranational actors is slowly increasing, the member states continue to dominate decision-making processes, in particular as they largely control the key functions. While the member states hold important energy competences and try to ensure their national sovereignty, some of them have taken the lead to deploy the smart grid whereas others ignore the technology. Supranational authorities act as framework setters dependent on member state support in this governance regime. The European smart grid is entering the take-off stage (with strong differences between the member states). Its deployment has the potential to redefine the interplay of electricity consumers and producers in significant ways and enable low-carbon technological advances. However, it can also prolong the current arrangements when it is only used to change the pricing models. Hence, the transitional effects are least known of the three cases. In the European Union the interplay of the various layers puts heavy emphasis on bureaucrats finding ways to make the multilevel governance regime work.

The case studies underline that none of the three is currently doing enough to achieve a smooth green transition. These findings mirror the evaluation of *The Economist* (2013e) that stated in the summer of 2013: “the world’s three biggest polluters unveiled carbon-reducing measures. In China and America these are more ambitious than previous policies. But they fall far short of what is needed to rein in the relentless rise in global carbon emissions.” While domestic action is taken in all three cases, it is not sufficient to solve the climate challenge. Each case’s transition approach has different strengths and weaknesses that are deeply engrained in the institutional design and largely determined by historical developments. The introduced analytical framework helps to learn which capacities are supportive of a green transition and which not. The model emphasises the three layers of politics, polity and policy. It focuses on top-down mechanisms by putting the state in the spotlight of analysis. Hence, political leadership is a key area. This needs to be translated into policy action through the institutions of the polity, which can be described as transmission belts. Finally, three functions need to be altered in order to allow a swift transition from the current fossil fuel based regime to a green economy: the economic framework, the innovation cycle and the distribution of costs and rewards through the social welfare regime.

As introduced, political leadership describes whether a consensus between key political players that they want a green economy exists or not. Active leadership can result in a variety of positive feedback loops that ensure that the transition becomes reality, for example by strengthening other actors, shaping public opinion or through passing crucial legislation. In the European Union and China the political class has established a consensus that a green economy is a political goal and backs this often times up with action. However, differences pertain between these two cases and the stability of this consensus is unknown. First, the European Union has a much longer history on green leadership than China, which has only recently shifted in this direction. Second, the motivation differs: China primarily aims to foster industrial development in tomorrow's markets and to reduce pollution whereas for the European Union environmental and economic reasoning as well as the interplay of various political layers explains the push for green technologies. In the US context sustained political leadership is missing. This is a significant weakness. In a politically divided society, political leadership on climate change and clean energy depends largely on the party in power. This clearly favours the status quo of carbon lock-in since the majority to repeatedly overcome path dependency has been lacking. Barack Obama aims to overcome this polarisation with his presidential powers showing that a president that takes the lead on this issue can make a difference.

Translating political leadership into effective policy implementation is the main task of the transmission belts that are manifested in the polity and its institutional design. These belts enable two-way communication from top-down to bottom-up actors and vice versa. Two dimensions were analysed in more detail. First, whether a country makes the green transition a cross-cutting priority among all key bureaucratic actors on all administrative layers. This should ensure that the environmental considerations are implemented throughout all silos and levels of government – the key terms in this context are vertical and horizontal EPI. Second, whether this consensus is consistent over the long-term, for example through implementing targets and strategies. For all three cases this capacity is a challenge – albeit for very different reasons.

In China, the absolute power of the CPC and the secrecy surrounding decision-making hinders the integration of key stakeholders. The case study has underlined the problems associated with authoritarian rule and the lack of a participatory leadership at various points. Instead of creating an efficient monolithic block, the Chinese approach to electro mobility is characterised by turf wars between various ministries that hinder horizontal policy integration.

Furthermore, the federal and provincial levels often times do not cooperate but rather obstruct each other's initiatives. Hence, the transmission belts hinder the information flow between the various actors. This case study does not support the myth that Chinese one-party authoritarianism results in efficient policymaking (Friedman, 2009b). Many factors that hinder political leadership in the United States are direct results of its institutional design. For example, climate change and the green economy have become electoral wedge issues that the parties use to fire up their electorate. Furthermore, strong veto players support the status quo and establish high barriers to change development trajectories. While the federal structure allows for bottom-up initiatives by the states, time consistency is largely lacking from the US renewable energy transition. Most support measures are time-limited and lasting legislation is not in place. In the European Union, EPI is enshrined in the *acquis communitaires*. However, the leeway of the supranational level is limited because it only recently gained competences in the field of energy and the member states continue to play a strong role. While the climate change and energy package has laid out a time consistent approach for the member states based on goals and strategies of how to reach them, these have been criticised for lacking ambition. While the member states have approved this package, they have also watered it down. Hence, the supranational actors could not overrule their position showing the dependence on their support, which is for example dependant on national elections and economic development.

The discussion of leadership and transmission belts has shown that China, the United States and the European Union can improve on the politics and polity level. The case studies find that at this point in time they are a key explanation for the lacking progress in all three transitions. Political leadership either absent or only insufficiently translated is an important explanation why the functions have only partly been adjusted to support a green transition. This dissertation has analysed three functions in particular: the economic framework, innovation and the distribution of costs and rewards. The model assumes that they offer opportunities for non-public actors such as industry or civil society to influence the transition trajectory. Hence, when they are not changed top-down, rising bottom-up pressure can result in change that changes the incentives for political decision makers.

Ingredients of a green economic framework are a strong carbon price and channelling subsidies towards green goods and services. This can generate green job potential as it shifts economic activity towards cleaner alternatives. Currently, Chinese energy prices are distorted resulting in an environmentally harmful over usage of fossil fuel-based goods and services.

While the CPC fears that reducing these price differentials would endanger domestic political stability, China has begun experimenting with carbon pricing and has put costly demand-subsidies for electro mobility in place. Hence, efforts are visible to reduce the preferential treatment for fossil fuels. However, in the Chinese government-controlled capitalism political steering remains more important than free market transactions. The United States has repeatedly failed to enact federal carbon pricing and it seems unlikely to do so in the foreseeable future. While regional trading schemes have emerged (most prominently in California), they can only partly offset the lack of a nationwide system. Subsidies, which have historically benefitted fossil fuels more strongly, have under Democratic president Barack Obama shifted to funding renewables. However, these fiscal support measures are time-limited creating boom and bust cycles. Bottom-up initiatives initiated by for example California establish a precedent that can support federal action. The supranational EU budget is small compared to the budgets of the other two cases since most revenue remains with the member states. For this reason the macroeconomic framework setting competence of the European Union is key in order to set financial incentives for a green transition. Some measures are in place. For example, the European Union runs the world's largest ETS. However, it has come under pressure from the market and the member states since it does not send strong price signals, as the permit price is very low because of design faults. These have so far not been fixed. This once more underlines the importance of top-down political leadership to change the functions.

A green transition partly depends on new and improved technologies and goods that help decarbonise the economy. This requires focus on radical green innovations throughout the innovation cycle. The state is assumed to play a significant role in particular at the beginning to create protected niches for radical innovations to take place. The case study finds that the Chinese economy lacks innovation capacity, which is mostly explained by its low maturity status. Despite heavy investments and special innovation programs, China continues to have problems to domestically produce electric vehicles – a key reason for the slow development of the technology. Nonetheless, China has announced high spending on electro mobility R&D to bridge this gap and develop the necessary technology. So far these efforts have had little measurable success. While the United States is the most innovative economy worldwide, energy innovation is weak and public as well as private spending on it low. The case study shows that the United States has played a crucial role in developing renewable electricity sources in the past, but it is unlikely to significantly increase investments in green energy innovation soon. The recent surge in funding for renewables stems from time-limited stimulus

funding leaving the future development uncertain. Hence, this is most likely a spike rather than a long-term trend that is needed since green innovations are capital- and time intensive. The European Union plays only a limited role in European innovation policy. For example, it has a very small supranational R&D budget and most innovation policy is carried out at the member state level. While the supranational actors align their priorities with the green agenda and assume a coordination role that includes a variety of stakeholders, it can hardly impact this crucial dimension. This is a significant weakness of the European greening efforts.

Ensuring the fair distribution of cost and rewards of this profound transition process is the third analysed function. The aim is to avoid excessive opposition by ensuring that transition losers are at least partly compensated and ensuring that the rewards of the transition are shared justly. In all three cases, this dimension is currently of lesser importance since they stand at the beginning of the change process. The changes so far have not yet significantly altered the social situation through disruptive alterations of the status quo. The assumption is, that this will change when the transitions progress. New – economic and social – players will arise and others that have grown strong in times of the carbon lock-in will have to adjust to changing realities. However, in all three cases already at this point in time some social implications arise and first clues about the handling by the authorities can be drawn. In the Chinese case, opportunity costs of investing in electro mobility exist. Public funding flows towards a cause that predominantly favours the well-off because only they are capable of buying expensive electric vehicles. However, the current effects are few and this dimension is hardly discussed in China. Alternatives that would more strongly favour poorer households, such as strengthening public transport, have not the same urgency as electro mobility. In the United States, renewable energies will according to the findings of the case study only prevail as the primary energy source under the current framework when they reach the same price as other sources of electricity generation. Under these circumstances a green transition is unlikely to result in rising energy prices, which could increase energy poverty. Furthermore, little public revenue is spent to support this transition reducing the potential for opportunity costs. Hence, the current greening has a weak effect on the distribution of costs and rewards. This would significantly change when the United States proactively support the transition as is most likely needed in other technological areas that are further away from reaching market price competitiveness. The European Union has not yet addressed social consequences of the smart grid deployment. However, consumers will have to pay for the smart meters and their installation and for some consumers prices will raise and for others they will drop. Hence, mixed consequences are likely but so far few large-scale experiments are in place from which

experiences can be drawn. However, since the effects are not yet strong, it is unknown how the European Union will address this issue. It is a warning signal though, that so far public documents have not addressed this dimension.

The case studies demonstrate that all three major polluters and economies must strengthen their transition efforts because they show weaknesses in several areas. They also show that the transition trajectories of the cases are clearly affected by the existing design of the polity and that they will follow different paths towards the same goal.

Answering the second research question whether the cases are advancing in their transition efforts seems easier at first glance. This doctoral thesis concludes that none of the three largest economies analysed here is thoroughly decarbonising its economy in the chosen field. So far they remain niche markets. The transition stages and S-curve (following Rotmans et al., 2001) suggest that after a long build-up transitions can accelerate and move very fast to a new equilibrium. Currently, the cases are all at the beginning but in slightly different stages: electro mobility in China is between the predevelopment and take-off stage, renewable energies in the United States has been in the take-off stage for some time and deployment of the smart meters in the member states of the European Union is very diverse with the most advanced entering the take-off stage, while a European smart grid remains in the predevelopment phase. The current progress by the three cases largely depends on leadership achieved through investing political capital. While this has not always been successful, very little has happened without the engagement of top-level politicians who can otherwise block important decisions. Hence, finding an answer to the question how to generate more change agents and win larger support for the turbulent transition process is more acute than ever. Further research is needed on how incentives can be put in play that encourage political decision makers to trigger the green transition by taking first decisive steps. As of now, none of the analysed sectors and political entities seems to be at the point of speeding up. It remains unclear whether they will take-off eventually. It is currently not ensured that the green economy will become a global reality.

This thesis finds that the three cases share a further characteristic: the transmission belts are a key indicator whether progress can be achieved or not. In China, a key reason why the leadership of the authoritarian regime achieves some progress but so far has not reached the high goals it has set for itself is because the transmission belts do not work properly. While the lack of private business hampers the technological development and the lack of consumer acceptance lessens demand, changes towards more democracy are unlikely to take place soon.

The findings show that translating political leadership to changing functions is a tall task. In the United States, constant green political leadership is largely missing, which creates boom and bust cycles that harm a steady change process. The lack of steady federal political support hampers the emergence of a new industry and reflects deep splits of the civil society on the issue. While the supportive political leadership of President Barack Obama has created a positive atmosphere for the renewable energy industry, the transmission belts and institutions hinder avoid that this becomes a long-term process. However, the federal structure of the United States allows for bottom-up leadership from key states. It remains to be seen in how far this can change nationwide policymaking. In the European Union, the supranational decision-making depends on the support of the member states showing that feedback mechanisms are particularly difficult to establish. Furthermore, the supranational level has only little power over the functions, which remain largely under control of the member states. They can differ widely between the member states, which hampers overall progress. Here the supranational level needs to assume a stronger steering role. However, it can hardly assume this role without support from the member states. This points out an institutional challenge that can result in change when all levels proactively interact whereas when the opposite is the case for any reason this supports the status quo. Further research addressing other technologies must be undertaken to see whether these empirical findings also hold true in other policy areas.

Some broader lessons that contribute to the literature can be drawn from these empirical results. First, the findings support the claim of the literature (Meadowcroft, 2009a) that political leadership is the single most important factor determining progress of a green transition. They demonstrate that in particular at this early stage of the transition political leadership is needed to implement transition goals and preferences to break with the fossil fuel status quo. In all three cases public actors have played a key role to push the transition forward. Looking at the analysed areas, governments took the initial moves towards a green economy. When continuous leadership is lacking, like in the United States, the green transition is having a very hard time gaining traction. While certain states have assumed an important front-runner position in the absence of federal leadership, they can only partly fill this void. However, this comes with a limitation: The transmission belts should to enable working two-way communication for political leadership to achieve impact. Otherwise, political leadership can hardly affect the key functions to become an effective driver of a green transition.

The importance of political leadership will likely diminish over the course of the transition and the feedback loops will increase the green transition lock-in. While this dissertation has laid some existing feedback loops between the various facets, further research is needed to establish how positive coevolutionary feedback loops can be strengthened. Most likely at later stages in the transition, when the economy undergoes rapid change, the role of political leadership could decrease. The analytical model developed and applied in this thesis cannot sufficiently answer this point because of an inherent top-down bias stemming from the focus on the state, political leadership and public actors. Nonetheless, the findings of this doctoral thesis underline the need to establish ways in which bottom-up initiatives can change the governance framework and become a reliable force of change. Since the case studies show the currently central role of the state as framework setter and coordinator when top-level politicians take the lead, a refinement of the analytical model should elaborate how other actors can foster change within the state itself. While pressure for change from popular opinion is one possibility, this needs to be upheld for longer time periods. However, during times of economic hardship it is easy to follow the argument that environmental policy harms economic growth.

At later stages of the transition other players are assumed to play a larger role once the rearranged societal preferences have begun to overhaul state institutions. This can put more emphasis on changing the functions once the polity has adapted to changing governance priorities. This would imply that a green transition cannot work only top-down but needs the interplay of bottom-up and top-down measures to succeed. Hence, the state is not only a subject of the transition but also an object that needs to change. Whereas in the case of the United States the top-down influence is rather weak so far, the bottom-up developments ensure progress. When they come together under a progressive president such as Barack Obama, the transition can speed up. In China and the European Union progress is largely dependant on the political level and state actors. When they change their objectives to other areas and the green transition ranks lower on the agenda – as is currently the case in the European Union because of the economic turmoil – the transition is entering rough times. Hence, a green transition is the interplay of many factors underlining that it is a highly complex coevolutionary endeavour.

Political leaders continue to base their arguments on economic as well as environmental rationales. Hence, the economic state function dominates thinking. This dimension will most likely gain a more prominent role once the green technologies move into the centre of the

economy. Hence, the countries are competing for market shares if the green economy becomes a more major part of economic dealings. However, finding out which entity can strengthen its position depends on which country will first accelerate its transition. It is difficult to establish an order at this point in time due to the complexity of the transition process and its governance. However, it becomes obvious that the acceleration would challenge the core of the state because of the consequences for the established fossil fuels era institutions.

Currently, the focus on the economic effects of the green economy underlines that many of the current advances do not put the state into an object role. Hence, public actors often times ensure greening to a certain degree but do not initiate the necessary changes to significantly decouple economic activity from pollution, which would call their own structures into question. This reflects in the problems of the transmission belts since changing them would include severe changes to the core of the polity. Currently, it only acts as a subject that continues to follow the economic rationale primarily with lesser emphasis on ecological concerns. Hence, the state's priorities have not shifted since it has rarely attempted to change its institutions to a framework in which ecological protection as well as economic growth is protected with the same rigour. This must not necessarily remain this way. Most likely, if the green economy becomes a global reality, the state that assumes this challenge of adopting its institutions first, will be the front-runner. This would in turn question the status quo of the laggards to adjust accordingly if they want to follow the path to the green economy. Currently, China intends to become an environmental state but it is unlikely to make the necessary changes towards a plural democratic society anytime soon. The US government is not in a position to steadily overhaul itself because of the strong veto power of the checks and balances and the diverging political understandings of the necessity to do so. The European Union is closest to changing its core by trying to implement instruments such as the EU ETS that would significantly alter the market place. Further research is needed whether these trends are stable and will continue into the future. Furthermore, the exact design of an environmental state requires further specifications.

Institutions change only slowly. This is a key reason why the transmission belts have not yet significantly adopted to the greening of the economy when prescribed by the political elite. However, it is this dimension in which the object role of the transition process of the state manifests itself. Since states are unlikely to change themselves without strong external pressure, as the powers of the fossil fuel era do not look for radical change, it likely requires

strong demand from the civil society and progressive business actors. While in all three cases lobbying for the green transition has increased and the public opinion has become aware of the challenge, it has not yet reached a point in which a significant share of crucial stakeholders pressure public actors to take the lead in the green transition efforts. Hence, more grass-roots efforts are needed to strengthen the change agents and turn them into a strong political force. These actors face the task of finding measures how to increase their political and social clout. Furthermore, the question remains how to deal with governments that are unwilling to transition to a green economy, for example when a Republican majority governs the United States. Here, models that allow for bottom-up leadership – with or without toppling the government – must be developed. However, future research when the transition is more advanced is required in order to establish the changing weight of the parts of the analytical model and which capacities gain or lose importance.

More research is needed how to handle the arising confrontations between keepers of the status quo and transition advocates. Currently, the least important aspect in the model is the social disturbance that the transition causes because the relatively early transition stage has caused little turmoil. The German transition to renewable energies tells a different story: Since the German energy mix depends more than 20% on renewable energy sources, prices have soared. While various reasons explain this spike, it begins to undermine public acceptance for the energy transition because people fear that they can no longer afford energy. This underlines that at later transition stages the social dimension becomes a key question that China, the United States and the European Union need to address by giving convincing and just answers.

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