

# Promises and Pitfalls of Polycentric Federalism: The Case of Solar Power in India

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## Abstract

Recognizing that no central authority can combat climate change, scholars have pointed to the potential of polycentric governance in tackling climate change. Yet, empirical evidence for such a claim is scarce, particularly in the Global South. This study analyzes the characteristics, promises, and pitfalls of polycentric governance to promote climate mitigation efforts in three Indian states. Our contribution is twofold: (1) conceptually, we propose a framework to investigate the promises and pitfalls of polycentric climate governance in a federalist system with a particular focus on aspects of scaling and institutionalization, and (2) empirically, we compare solar power development across three Indian states with favorable conditions for solar power but varying performance. Based on a qualitative analysis of interviews and documents, we show how state governments with different party backgrounds have been vital in implementing policy changes and overcoming political barriers. Still, very few bottom-up initiatives exist and were successfully institutionalized.

**Keywords:** energy transition, federalism, institutionalization, Global South, polycentric governance

Collaborative efforts, joint commitments, and collective action are often considered crucial to addressing climate change. Scholars have recognized the potential of “polycentric” governance to initiate innovative experiments and local political interventions that—ideally—contribute collectively to solving common-good problems (Jordan et al. 2018). Polycentricity thereby refers to an adaptive governance arrangement with competing decision-making centers at multiple levels that tackle interdependent policy problems based on a joint set of norms and principles. In what follows, we make two contributions to the lively debate about the promises and pitfalls of polycentric governance: conceptually, we discuss the potentials and limitations of polycentric governance as an

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analytical framework; empirically, we confront polycentric governance with Indian federalism to explore the effects on promoting solar power in the world's largest democracy and the third largest greenhouse gas (GHG) emitter. These insights are also valuable for climate mitigation efforts in other federalist countries like Brazil, Mexico, Spain, and the United States (for an excellent overview on climate governance and federalism, see Fenna et al. 2023).

Emerging economies like India face increased pressure to reduce GHG emissions while responding to development needs (Dubash 2019). The International Energy Agency (2021) estimates that India's GHG emissions will rise by 50 percent by 2040, while its current per capita emissions are still below the global average. India launched its National Solar Mission in 2010 to promote sustainable energy supply. Today, India is one of the most influential countries in international energy and climate politics, leading in contexts like the G-20. In 2021, India announced its commitment to decarbonize by 2070, yet it appears insufficient to achieve the Paris Agreement's 1.5°C target (Vaidyanathan 2021).

One aspect that potentially shapes India's ambitions is its federalist constitution. The twenty-eight constitutive states (and eight union territories) vary markedly in implementing solar policies and projects. Energy represents a policy subject with shared responsibilities between the national and state-level governments. This leads to a complex system in which several governmental levels with different power resources set and implement activities (Morrison et al. 2017). Since federal states formulate and enforce energy policies in India, we ask, how do promises and pitfalls of polycentric governance materialize for the case of solar power development in India? Polycentrism has been widely used to study climate adaptation in India (e.g., implementing the National Adaptation Fund for Climate Change) but less so for the country's emissions reduction efforts (as an exception, Busby and Shidore [2021] investigate climate mitigation). Therefore, we apply a polycentric federalist perspective to analyze solar power development in the states of Gujarat, Kerala, and Himachal Pradesh. We highlight scalability and institutionalization as crucial challenges for polycentric governance.

At first sight, polycentric governance and institutionalization seem somewhat different shoes. Polycentricity stresses nonhierarchical forms of governance beyond classical regulation and governing by the state and markets (e.g., Ostrom 2010). Such a setting creates multiple and often overlapping decision-making centers in formal and informal arrangements (Petrovics et al. 2022), similar to multilevel governance (Heinen et al. 2022). In contrast, institutionalization scholars ask how new rules and practices go beyond individual projects and shape entire sectors and societies (Bernstein and Hoffmann 2018; Pasquini and Shearing 2014). While polycentric governance can foster experiments and innovations, going beyond these initial efforts is crucial for institutionalization. Hence polycentric governance can be perceived as a first step toward institutionalization, and we will demonstrate how the concept works for the Indian case with potential validity for other federalist contexts, such as

Canada, Germany, or Australia. To do so, we develop a conceptual framework to investigate the promises and pitfalls of polycentric governance, introduce Indian politics and climate governance, explain our methodology, and analyze solar power development in three Indian states before concluding with future research needs.

## Conceptualizing Polycentric Federalism

Scholars often describe polycentric governance as more suitable than centralized, top-down arrangements to tackle climate change (Morrison et al. 2017). Although not perfect, “polycentric systems have considerable advantages given their mechanisms for mutual monitoring, learning, and adaptation of better strategies over time” (Ostrom 2010, 552). Yet, empirical evidence is scarce to support these hopeful assumptions. Especially upscaling, replicating, and institutionalizing innovative projects face severe political challenges in complex governance arrangements like federalism (Schoenefeld 2023). Overall, only a few studies focus on the actual performance of polycentric governance in energy or climate politics (Jordan et al. 2015; Sovacool and Van de Graaf 2018), and hardly any shed light on how this plays out in the Global South (Sovacool 2011).

### *Polycentric Governance Characteristics*

The notion of polycentric governance goes back to the 1960s, when scholars like Ostrom et al. (1961) described the emergence of order through various decision-making centers for US municipalities. Polycentric governance was an attempt to move beyond the classical dichotomy of “markets” and “states” to reflect the institutional diversity and division of labor when common-pool resources are provided not only by hierarchies or markets but by multiple independent governing authorities (Ostrom 2010; Wagner 2005).

Four aspects characterize polycentric governance. First, polycentricity recognizes that some political issues are *interdependent policy problems* a single actor cannot solve (Heinen et al. 2022, 60). This has resonated particularly well with environmental governance research (Heikkila et al. 2018, 208). Second, polycentric governance refers to a setting of *multiple decision-making centers* with “at least some formal or informal autonomy” (Stephan et al. 2019, 29). No single decision-making authority has the power to dominate the emerging system, and there is also no rule on how many centers must exist or how autonomous they must be (Stephan et al. 2019, 31). They are usually located across different scales and levels, including state and nonstate entities. Third, to solve this fragmentation, actors within such a system interact using *nonhierarchical coordination* (Schoenefeld 2023). This can happen through “competition, contracts, partnerships, alliances, collaboratives, joint decision-making councils, the formation of higher-level authorities, and other forms of coordination” (Stephan et al. 2019,

34). Fourth, an *overlapping set of—formal or informal—principles, norms, and rules* is a prerequisite for polycentric governance (Petrovics et al. 2022, 440).

### *Promises and Pitfalls*

Polycentricity offers a variety of advantages when governing complex issues like climate change. First, polycentric governance is more responsive and tailored to (local) needs due to the engagement of numerous (local) stakeholders (Jordan et al. 2015, 301). Multiple governors offer diverse perspectives and higher reflexivity (Morrison et al. 2017; Sovacool 2011, 3833), which enhances *input legitimacy* and trustworthiness (Ostrom 2010). Second, soft vertical and horizontal coordination characterizes polycentric systems. Experiments might flourish, as well as *innovation, flexibility, and learning* (Heinen et al. 2022, 56; Morrison et al. 2017; Ostrom 2010). Third, dispersed decision-making authority can make it less prone to corruption due to independent and less centralized centers of power that ideally check each other to increase *accountability*. This is particularly important in areas of limited statehood where states struggle to provide transparent and accountable governance services (Draude et al. 2018). Fourth, polycentric governance is open to *spontaneous ordering* elements (Stephan et al. 2019, 36) but does not rely purely on these random interactions. Fifth, the resulting governance networks should be more *resilient* than simple organizations due to the complex and often redundant ties between different actors (Sovacool and Van de Graaf 2018, 318–319). Finally, combining all of the preceding factors, common-pool resources are expected to be governed more *effectively* under polycentric governance.

Governing through multiple decision-making centers also creates pitfalls (Rauhut 2017). First, polycentric governance is *more complicated*, as several different interests have to be aligned. This triggers a “joint-decision trap” (Scharpf 1988) when transaction costs of regulation are high and decision-making centers cancel each other out in turf wars. Second, complexity and fragmentation can result in a *lack of public authority*, through an unwanted empowerment of nonstate actors. Polycentric governance can then reinforce a retreat of the state and constitute neoliberalism in disguise (Beckman 2023). Third, actors within polycentric governance settings are often *poorly coordinated* (Sovacool 2011, 3833). They struggle to deliver authoritative decisions to solve distributive or value-driven conflicts, which leads to inefficient silo solutions instead of diffusing best practices (Morrison et al. 2017). Fourth, polycentric governance systems are hard to steer or control. They *lack capacities and financial means* and are ineffective in sustaining political change (Stehle et al. 2022). Finally, it remains an open question whether polycentric governance can foster *upscaling* and systematic change (Petrovics et al. 2022, 438). Even if potentially common-pool resources are better provided locally, it is unclear if and how these arrangements thereby change broader societal institutions. Table 1 summarizes the characteristics, promises, and pitfalls.

**Table 1**  
Analyzing Polycentric Governance

<i>Characteristics</i>	<i>Promises</i>	<i>Pitfalls</i>
Interdependent policy problems (across levels)	Input legitimacy	Complication and fragmentation
Multiple decision-making centers can substitute each other	Innovation and flexibility	Lack of authority
Forms of nonhierarchical coordination between decision-making centers	Accountability	Lack of coordination
A joint set of principles, norms, and rules	Spontaneous order	Lack of capacities and finance
	Resilience	Limited scalability
	Effectiveness	

### *Polycentric Federalism*

If polycentric governance initiatives remain limited in scale, how can they trigger large-scale transformations? Moving toward carbon-neutral societies, we argue, largely depends on solid institutionalization within established state structures. In all federalist systems, public governors and administrators act within a complex multilevel governance arrangement. Described as “the most prominent example of polycentricity” (Stephan et al. 2019, 24), federalism represents “a philosophy of polycentric governance based on the recognition that complex and variegated systems ... may not be necessarily and optimally governed from a single centre” (Hubbard and Paquet 2010, 3).

While *polycentric governance* refers to practices, *federalism* describes the constitutional and legal structure in which these practices occur. For example, the legal framework may specify the powers delegated to each level of government and the procedures for resolving disputes between these. Nevertheless, like polycentric governance, federalism is a system of governance in which power is divided between units, allowing for a degree of autonomy where multiple knots of decision-making authority exist (Ostrom 2010). Federalism should not be taken to be synonymous with administrative decentralization, as it is not the division of labor that is characteristic but rather the collaboration between different levels of government, the bureaucratic apparatus, and nonstate actors in an arena “for human interaction within the public square” (Wagner 2005, 183).

Polycentric governance and federalism emphasize the decentralization of authority, but both stress the coordination of decision-making centers, potentially resulting in subsidiarity benefits (Lenaerts 2017). While polycentric governance approaches often obscure state and substate authority, it is central to federal systems. Such a system can either deliver policies more effectively

through healthy competition (“competitive federalism”) or enable collusion among governments (“cartel federalism”), particularly when parties are involved (Wagner and Yokoyama 2013). To function properly, federalism thus “requires a polycentric arrangement among competitors” (Eusepi and Wagner 2010, 330). As these relations are generally “under-specified in existing polycentric governance thinking” (Schoenefeld 2023, 207), we explore these for the case of India.

## Indian Politics, Energy, and Climate Governance

India can be considered a polycentric system in which various units of government and nonstate actors interact (Arora et al. 2013; Jha 2019; Tillin 2019). India’s federal political system involves comprehensive political and fiscal powers for the central government. States are responsible for implementing national policies but possess significant powers in several fields like agriculture or public health. Sectors like forestry and electricity are listed under the constitution’s concurrent list: the central government and the states both engage in policymaking and provide funding (Pillai and Dubash 2021; Tillin 2019). However, states differ concerning available financial resources, making them more or less dependent on financial support from central government funding.

Cooperation between the central government and state governments partly depends on the political parties in power, often leading to center–state conflicts when rival parties govern those tiers and higher coordination when the same party is in power in both tiers. Historically, federalism in India has thus been “centre-heavy” (Tillin 2019, 40). However, since 1991, the country witnessed a wave of decentralization following the economic liberalization (Sharma and Swenden 2018, 53). Since the 1990s, the political scenario has also witnessed growing importance of regional political parties in forming a central government under the leadership of the Indian National Congress (INC) or the Bharatiya Janata Party (BJP). This marked a change in power structure of the federal state. Yet, since the election of the BJP-led National Democratic Alliance (NDA) to form the central government with an absolute majority in the parliament in 2014, scholars like Tillin (2019) have noted an increasing political and administrative centralization, which has not impacted the ongoing processes of financial decentralization (Sharma and Swenden 2018, 54). This points to the critical role of centrally sponsored schemes and sufficient state-controlled financial resources for steering policies and implementation in Indian states. Notably, smaller states still strongly depend on fiscal transfer from the central government, particularly in the policy fields of renewable energy (e.g., Busby and Shidore 2021).

Federalism significantly shapes Indian politics (Tillin 2019). In particular, states play a pivotal role when implementing (and in many sectors also formulating) policies. While over the last seventy-five years, the country has become less centralized, tendencies toward “quasi-federalism” have been discussed

particularly under the BJP-led NDA government (for recent developments, see Chakrabarty and Pandey 2023; Jha and Choubey 2023). Yet, state governments and nonstate actors play an important role when developing pilot projects and experimenting with innovative technologies. State governments have sufficient leeway to engage in their own rule setting and funding due to the continuing process of financial decentralization and adequate powers in the energy sector.

Although energy policymaking has long been dominated by the national government, not only have states become important implementors but their role has “shifted from pure implementation ... to more independent policy-making” (Jørgensen et al. 2015, 279–280). Policymakers thereby face a continuous tension between the country’s potential to move toward low-carbon energy infrastructure and expanding fossil-based energy generation (Bandyopadhyay et al. 2019), which raises concerns over a just energy transition, particularly in coal-mining states (Ordonez et al. 2023). Climate policymaking has gained ground with the National Action Plan on Climate Change (NAPCC) of 2008 (Höhne 2022). State governments were requested to develop respective State Action Plans, but these hardly impacted state policies (Pillai and Dubash 2021). Based on the NAPCC’s ambition to implement one gigawatt of solar energy in India, the central government adopted the National Solar Mission in 2010, under which the INC-led United Progressive Alliance government set the target to twenty gigawatts by 2022. In 2014, the following BJP-led NDA government increased the target to 100 gigawatts by 2022 and announced a non-fossil energy capacity target of 500 gigawatts by 2030 (Busby and Shidore 2021). While this made India a major player in solar energy, the Solar Mission is also criticized for paying little attention to marginalized communities (Upadhyay and Singh 2021) and local panel manufacturers (Behuria 2020).

## Methodology

To analyze solar power development from a polycentric governance perspective, we follow a qualitative approach based on differently performing subnational cases (for different types of cases, see Seawright and Gerring 2008). All twenty-eight states and eight union territories are encouraged to contribute to India’s National Solar Mission, from which we compare three states with varying levels of target fulfillment: Gujarat (more than 100% achieved), Kerala (37%), and Himachal Pradesh (11%) (Center for Strategic and International Studies 2021).<sup>1</sup> These three polities represent relatively advanced Indian states with above-average human development indicators, functioning economies, and minimum administrative capacities but with different kinds of success in solar power development. We thus investigate three cases in which progress can be expected but is happening at quite different speeds.

1. Each state has a specific target assigned by the central government to achieve the national target. Targets are determined by factors like land area, days of sun per year, and individual solar potential.

We base our study on twenty-nine interviews with national and state-level experts, including government representatives, researchers, consultants, and nongovernmental organization representatives (see Appendix). We conducted the interviews between 2018 (Gujarat) and 2023 (Kerala and Himachal Pradesh). Additionally, we consulted media sources and government documents related to the three states' solar energy development. Selected solar power interventions promoted by the state (e.g., solar parks), cities (e.g., solar thermal), and nonstate actors (e.g., solar irrigation) illustrate polycentric action.

We coded the material according to the aforementioned aspects related to the "characteristics," "promises," and "pitfalls" of polycentric governance. To close gaps in the empirical material, we enriched our qualitative analysis with existing literature and official documents about energy politics in the three states.

## Practicing Polycentric Federalism? Promoting Solar Power in India

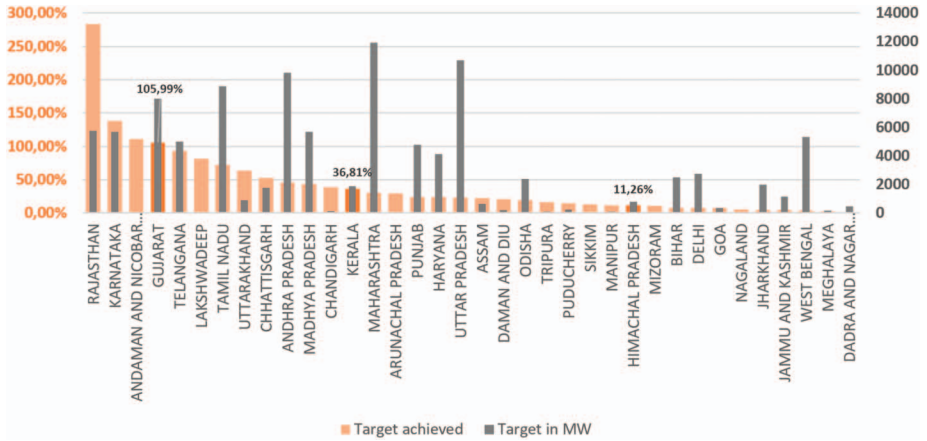
In December 2021, India pledged to achieve carbon neutrality by 2070, aiming to avoid carbon lock-ins while rapidly developing (Bond et al. 2021). India's vision includes increasing the share of renewable energy sources to 50 percent by 2030 (Vaidyanathan 2021). Under the National Solar Mission, the central government uses financial incentives, guaranteeing demand and buffering to support state governments' implementation efforts (Jolly 2017). Furthermore, central planning and consultancies are brought in (Pillai and Dubash 2021, 8–9). Yet, state governments can also use their resources to promote solar energy. Comparing the achievements of all states on their assigned targets under the Solar Mission reveals significant differences in performance and goal achievement (Figure 1).

In the following sections, we examine three advanced states with high solar power potential but different levels of solar power expansion. We introduce each state's political context, summarize polycentric governance characteristics, and discuss promises and pitfalls.

### Gujarat

Gujarat, in West India, covers substantial desert areas with high solar radiation. Its economy shows a high level of industrialization alongside continuous agricultural production. Gujarat has been ruled by the BJP over the last twenty-five years, among others, under then chief minister Narendra Modi (2001–2014). It was India's first state to adopt a State Solar Policy (2009) with financial incentives for solar parks. Gujarat's installed solar capacity increased from almost nothing (2009) to 8.8 gigawatts (2023), making Gujarat one of India's leading solar states (*DeshGujarat* 2023). Public programs promoting decentralized solutions like rooftop photovoltaics were less successful than solar parks (*Times of India* 2015a). Nevertheless, some municipalities like Rajkot became front-





**Figure 1**  
State-Level Contributions to India’s Solar Mission

Based on Center for Strategic and International Studies (2021).

runners in household-level solar thermal installations, which was subsequently scaled up to all municipalities in Gujarat (Interviews 01, 10, 11). Also, nonstate initiatives have been scaled up, including solar irrigation projects by farmers’ cooperatives (Fernandes 2020).

### *Gujarat’s Polycentric Governance Characteristics*

Four aspects characterize Gujarat’s solar energy landscape. First, solar energy provision is an *interdependent policy problem* that *multiple decision-making centers* address. The state and central government adopt policies and programs that private project developers implement. These can install solar systems independently but often require public land and finance. Second, the most relevant actors in Gujarat are state agents (Interview 07): Gujarat’s Energy and Petrochemical Department formulates policies with financial incentives, Gujarat’s Energy Development Agency defines eligibility criteria for solar projects, Gujarat’s Electricity Regulatory Commission sets the tariffs for solar parks, and the state utility companies enforce these tariffs by signing power purchase agreements with private developers (Thakkar 2010; Yenneti 2016). Third, national and state governors can substitute for each other in solar park promotion, while local nonstate or municipal initiatives are much more nested within upper-level governance settings. A *joint set of norms* drives these initiatives: they collectively aim to solve development needs (i.e., energy security and access) and occur within growth-oriented markets (Interviews 04, 06, 07, 08). Finally, multiple decision-making centers *coordinate*. On the one hand, state governments throughout India compete to attract project developers (Interviews 02, 03; *Times of India*

2015b). From 2009 until 2014, the BJP-led state government of Gujarat even competed on solar energy against the Congress-led national government's National Solar Mission by which Gujarat's then chief minister Narendra Modi intended to showcase leadership (Interviews 05, 07, 08). On the other hand, partnerships emerged when nonstate or city initiatives were scaled up. For large solar parks, the state government provided land, power evacuation, and road infrastructure to private developers (Pandit 2012). Similar partnerships were established for canal-top solar projects, such as in Narmada (Interview 02; Goswami 2016).

### *Promises of Polycentric Governance in Gujarat*

Concerning promises, we observe mixed results on *reflexivity* and *input legitimacy*. On one hand, non-state-driven solar irrigation projects were tailored to farmers' needs (Climate and Development Knowledge Network 2020) and quickly replicated with government funding (Fernandes 2020). Similar developments happened for Rajkot's solar thermal project (Interview 10). The state government's solar park funding was adjusted in response to changing developer demands (Interview 07; Kaushik 2020). On the other hand, scholars found a lack of procedural and distributional justice in establishing solar parks. For example, state officials did not consider local community knowledge when selecting Charanka Solar Park's location, resulting in negative consequences for the livelihoods of pastoralists, agriculturalists, and animals. Due to local resistance, the solar park's capacity was reduced to 216 megawatts instead of the planned 500 megawatts (Yenneti and Day 2015).

The polycentric setup also favored *innovation* and *flexibility*: the state government experimented with solar park and canal-top solar models to identify the most appropriate option for upscaling. When solar energy costs were uncompetitively high, Gujarat's government provided sufficient incentives with feed-in tariffs and several facilitative measures to innovate the solar power sector. Motivated political actors and bureaucrats seemed vital to introducing these policy changes (Jolly 2017). Competition among state governments was an additional driver for Gujarat's solar energy adoption (Busby and Shidore 2021): when solar power projects experienced difficulties in Gujarat due to rising competition among states, the state government adjusted its solar policy in 2015 and 2021 to remain in a top position (Kaushik 2020). However, small-scale solar rooftop solutions struggled to grow due to restrictive state regulations that protect the financial health of Gujarat's utility companies (Sareen 2018, 24). Gujarat's polycentric setup shows *spontaneous order* across jurisdictional levels. The state government initially acted independently from the national government, and only from 2014–2015 onward did its policies become more aligned. Nonstate or municipal pilots (e.g., solar irrigation, solar thermal) served as experiments that Gujarat later scaled up through public funding (Interview 10; Fernandes 2020). At the same time, the establishment of solar parks benefited from public–private partnerships between state governments,

private project developers, and financial institutions and the facilitative role of Gujarat's Solar Association (Jolly 2017; Yenneti 2016).

The polycentric setup was also *effective*, as Gujarat's government and competition with other states provided sufficient incentives and investments (Interviews 02, 03; Kaushik 2020; *Times of India* 2015b). Solar power costs decreased from Rs 17 per unit to Rs 2.5 per unit (Interviews 12, 13), making it cheaper than thermal power since 2017 (Lopez 2018). Yet, scholars noted negative consequences for the livelihoods of parts of local communities residing next to solar parks (Stock 2022; Yenneti and Day 2015) and relatively high consumer prices (Jolly 2017), casting a shadow on solar power development in Gujarat.

### *Pitfalls of Polycentric Governance in Gujarat*

High levels of *complication* or *fragmentation* have not emerged as essential barriers in Gujarat. Notably, the state's provision of project-ready land with infrastructure to solar park developers reduced complications (Lopez 2018). Public bodies either drive or scale up promising initiatives, indicating no *lack of authority* and the importance of public bodies in providing attractive conditions for developing solar energy. Yet, the *lack of coordination* between the national and Gujarat's governments was evident between 2009 and 2014, when projects with national finance were exempted from state-level incentives. This had no significant impact, as project developers opted for the more attractive financial support from the state (Interview 07). However, this led to higher feed-in tariffs and prices (Jolly 2017; Yenneti 2016). After 2014, coordination improved, facilitating the implementation of national projects and collaboration to meet national targets, for example, through adopting a hybrid solar and wind energy policy in 2018 (Koshy 2022).

Gujarat's government had sufficient *financial resources and capacities* to establish itself as a front-runner solar state (Interview 07; Yenneti 2016) and benefited from national funding from 2014–2015 onward (Interview 04). In contrast, municipalities lack capacity and resources (Interview 10; Stehle et al. 2022). Utility companies' protectionist stance on their available financial resources also reduced the speed of solar power capacity expansion, as they stopped buying solar power when they had met their mandatory renewable purchase obligations, supposedly to prevent them from becoming unprofitable (Interview 07; Jolly 2017). They successfully lobbied for a limited amount of allowed self-consumption from solar rooftop energy in Gujarat's Solar Policy (2015) to remain financially healthy (Interviews 09, 10; Roy 2019).

Limited *scalability* and a lack of broader institutionalization were no constraints in Gujarat. While the 2009 Solar Policy initiated the experimentation with solar parks, subsequent policies targeted upscaling these solutions (Kaushik 2020). Gujarat's solar park and canal-top solar projects were scaled up in Gujarat (Interview 07) and replicated in other states, such as Rajasthan and Maharashtra (Botekar 2016). Since 2014, India's government has promoted

Gujarat's solar park model through a particular scheme (Solar Energy Corporation of India 2023). Activities in cities like Rajkot and nonstate actors' solar irrigation initiatives were upscaled (Interview 10; Fernandes 2020), but high feed-in tariffs under the 2009 Solar Policy constrained Gujarat's solar energy expansion (Busby and Shidore 2021; Sareen 2018).

## Kerala

Socialist policies, social reforms, and an active labor movement have long shaped Kerala's state politics. The state features a democratic multiparty system dominated by two major coalitions, the Left Democratic Front and the United Democratic Front. Prabhu (2021) evaluated Kerala's administration as transparent, accountable, and responsive to public needs. Furthermore, decentralization and local participation are increasingly important (for an overview, see Rajesh 2020).

Solar power is considered a viable source for enhancing energy independence in Kerala, where the electricity sector relies mostly on hydropower, followed by thermal power and imports from other states. However, land is scarce, and potential land for solar parks directly competes with agricultural production in one of India's most densely populated states. In 2013, Kerala introduced a comprehensive solar power policy to install 500 megawatts of solar capacity by 2017 and 2,500 megawatts by 2030. As of July 2023, the state had reached 840 megawatts, with a relatively moderate target to cover 10 percent of its electricity supply with solar power (Ministry of New and Renewable Energy 2023).

### *Kerala's Polycentric Governance Characteristics*

Compared to Gujarat, polycentric governance characteristics are less developed in Kerala regarding solar power development. Promoting solar power is an *interdependent policy problem* that affects local livelihoods and farmers primarily due to land scarcity. To avoid political tensions and conflicts with farmers, the government only carefully experiments with solar power (Interviews 15, 18). The state features relatively few independent *decision-making centers* given Kerala's centralized governance system, in which the national government plays a vital role. Yet Kerala's 2013 Solar Energy Policy (Government of Kerala 2013) emphasizes the role of local self-governments in power production, which is a rare reference to representative government entities. Various initiatives, such as Cochin's solar-powered international airport or *Aditya*, a 100 percent solar-powered ferry in the Alappuzha district (Navalt 2022), demonstrate the potential to promote innovative solar power projects. Still, *nonhierarchical coordination* is flawed in Kerala, and projects often fail to expand or get replicated, creating "frustration" (Interviews 19, 21) among stakeholders. As an exception, Kerala's first floating solar power plant on the Banasura Sagar reservoir (Manoj 2021)

led to similar projects across India. Left-wing and communist *norms and principles* represent stable common principles that shape solar activities. For example, Kerala's solar rooftop program includes a social component to provide higher subsidies for solar PV in lower-income households.

### *Promises of Polycentric Governance in Kerala*

Various solar power initiatives have flourished as independent projects and joint ventures in close collaboration with the state government. Kerala supported innovative solar power research and technologies early on and promoted their development. Since land availability issues prevent large-scale solar power parks in the state, locally adopted small-scale innovations (e.g., a solar ferry) and decentralized solutions, such as rooftop installations, determine Kerala's solar power sector. The floating solar power plant and the solar ferry represent innovative first-mover projects realized with public funding. Kerala promotes applied research to diversify the electricity system, but researchers criticize the slow progress beyond individual demonstration projects (Interviews 19, 22, 24). Thus the promises of *innovation* and *flexibility* remain limited in Kerala. At the same time, *accountability* is relatively high, given the central role of the state government (Interview 23).

A slow and complicated installation process long characterized the state-wide subsidy scheme for rooftop solar power (Soura). The situation changed in 2021 when a centralized Solar Rooftop Portal was implemented as a one-stop shop to facilitate the administrative process when connecting installations to the grid (Interview 21). While such a regulatory invention has improved the system's overall output, high *effectiveness* and *resilience* cannot be observed in Kerala. However, solar power implementation has recently accelerated, and interviewees expressed much hope, particularly for rooftop installations (Interview 25). *Input legitimacy* in Kerala's advanced administrative system is generally high. However, chances for random interactions between stakeholders that would lead to a *spontaneous order* are relatively low due to Kerala's top-down regulatory system. Researchers and business representatives emphasize the success of innovative experiments in Kerala but also a lack of statewide support schemes (Interviews 19, 21).

### *Pitfalls of Polycentric Governance in Kerala*

While a *lack of capacity and finance* was not considered a significant barrier to solar power development due to Kerala's relatively high financial resources, interviewees raised concerns regarding a *lack of coordination* and a high level of *complication* regarding solar power development (Interviews 17, 19, 24). Coordination between the central and state governments is challenging due to the ideological differences between the ruling parties in Kerala (mainly the Communist Party of India and the INC) and at the national level (particularly since

the BJP took office in 2014). Nevertheless, the national government cofunds innovative approaches like the solar ferry or the Soura scheme, the latter of which national government officials praised for its “impressive progress” (Interview 24). Still, interviewees raised the concern that initiatives to promote solar power at the national level and in Kerala rarely reinforce each other (Interviews 17, 20).

Given the state government’s central role, *fragmentation* and a *lack of authority* are not considered crucial issues—particularly regarding rooftop installations. The state government implemented a system to coordinate multiple stakeholders, strengthen distribution utilities, and promote private involvement in solar power planning (Interview 21). However, once land acquisition gets involved, the state Ministry of Agriculture becomes a powerful veto player. Even Kerala’s Solar Energy Policy 2013 empowers landowner rights and protects the rights of communities (Government of Kerala 2013). Finally, issues of *scalability and replicability* were described as main concerns (Interviews 18, 19). Innovations like floating solar were first implemented in Kerala but struggled to escape their pilot project status, while other Indian states, such as Gujarat, rolled out similar projects more quickly.

For over a decade, Kerala has actively promoted solar power initiatives. It fosters technological innovations and further develops its political incentives, for example, by reforming its Soura scheme into a “Kerala model” to make solar power more affordable to poorer households (Pillai 2021). These commitments rarely lead to policy reforms or a significant reallocation of resources.

## Himachal Pradesh

Located in the Western Indian Himalayan Region, Himachal Pradesh features a two-party system with the INC and the BJP. While the INC finds favor predominantly in the upper areas of the state, the BJP has its base in the lower regions of Himachal Pradesh, with agriculture as the primary source of livelihood. Despite changing INC and BJP governments, state authorities have remained progressive and development oriented (Sharma 2015).

Solar potential is promising, with 280–300 days of sunshine annually. Still, the state’s hilly terrain and restricted land availability constrain suitable sites for solar power generation. Responding to India’s National Solar Mission, Himachal Pradesh formulated its inaugural solar policy in 2014, subsequently amended in 2016 (Government of Himachal Pradesh 2016). The policy was an initiative to set up grid-connected solar rooftop PV systems in the state—particularly in private households and government buildings. Support was later expanded to ground-mounted solar systems by introducing independent power producers (IPPs) in response to stakeholder concerns, such as statutory clearances and administrative burdens (Interviews 28, 29). These initiatives to enhance the capacity of solar power should contribute to the state’s aim to become the country’s first “green state” in 2026. With limited industrial

activity, the state experiences a power surplus for eight to nine months annually. Given the state's topography, decentralized solar power generation is most suitable (Government of Himachal Pradesh 2016).

### *Himachal Pradesh's Polycentric Governance Characteristics*

Promoting solar power presents an *interdependent policy problem* with interconnected challenges like agricultural production, limited land availability, and advanced hydropower. Initiatives from state and nonstate entities point to *multiple decision-making centers* with varying degrees of control and power. More recently, Himachal Pradesh decided to involve "Gram Panchayats" (a system of governance at the village level) to promote solar power. Two Gram Panchayats were established as "Green Panchayats" in each of the twelve districts (*Economic Times* 2023a). However, Himachal Pradesh struggles with *nonhierarchical coordination* to effectively develop the solar power sector. Himachal Pradesh's Energy Development Agency, Himurja, serves as the coordinating agency for renewable energy projects. It was designed to register solar projects, coordinate with state and central government agencies, and facilitate administrative processes for granting permits and approvals (Interview 28). At the same time, the Himachal Pradesh Power Corporation Limited developed decentralized activities like the five-megawatt Berra Dol solar power plant in Bilaspur (*Tribune* 2019) and the thirty-four kilowatt rooftop solar installation in Shimla (*Himachal Watcher* 2018).

The government supports private developers and incentivizes them through different schemes and subsidies. For example, in 2022, Himurja increased the subsidy on domestic installations from Rs 4,000 per kilowatt to Rs 6,000 per kilowatt (Yadav 2022). Another scheme (Rajiv Gandhi Swarojgar Yojana) provides a subsidy to encourage IPPs to set up solar power projects in the state (Saur 2023). Youth are also encouraged to develop solar power plants through a 40 percent subsidy scheme for solar projects between 250 kilowatts and two megawatts (*Economic Times* 2023a). Himachal Pradesh's "green state" vision represents an overarching set of *joint norms and principles*.

### *Promises of Polycentric Governance in Himachal Pradesh*

Polycentric governance characteristics are limited in Himachal Pradesh and thus restrict the extent of reflexivity and *input legitimacy* (Interview 27). However, the amended solar policy (2016) and attempts to use solar power in response to the peculiar demands of the state show forms of *innovation and flexibility*. Himachal Pradesh explores various opportunities for innovative solar power (Government of Himachal Pradesh 2016), including solar-powered water heating in households and hotels, solar driers to increase the shelf life of agricultural products, and floating solar power systems in line with the region's topography, tourism demands, and agricultural needs. More recently,

power producers outside the state have been allowed to establish solar power plants, demonstrating an increasing openness to innovation from outside Himachal Pradesh. Private-sector participation in solar energy projects has been seen since early 2003. The first private solar power developer initiated a project in 2003 that is still functional, along with participation from other private developers.

Overall, we find innovative decentralized solutions like mountain solar heating systems and solar driers for fruits, vegetables, and medicinal plants. However, these solutions are sparse, face funding issues, and have limited avenues for upscaling. This also indicates a lack of *input legitimacy* since local stakeholders have limited influence on the political decision-making process. Although private developers have been growing all over the state, there is limited *spontaneous order* due to the mentioned restrictions (Interviews 28, 29). With the top-down approach, the state follows the central government's directives and implements national rules and regulations with limited self-initiative (Interview 27). Although the state initiated several solar power projects, encouraging participation from village-level governance structures and providing incentives to private-sector developers, we do not see a *resilient* and *effective* polycentric governance system, and the promises rarely materialize for solar power development in Himachal Pradesh.

### *Pitfalls of Polycentric Governance in Himachal Pradesh*

A lack of *capacity and finance* (Sharma 2015) seems not to hamper solar power development in Himachal Pradesh. The state government not only avails its own resources but also receives funding from the central government (Ministry of New and Renewable Energy 2023) and outside agencies, such as the World Bank (*Economic Times* 2023b). While there is also no considerable *lack of authority* in Himachal Pradesh, solar power projects face a *lack of coordination*. Solar power developers have to deal with two agencies (Himurja and the Himachal Pradesh State Electricity Board) to clear their projects, which can significantly delay them, according to project developers (Interview 27). They face challenges in obtaining statutory clearances in a time-bound manner. This also reflects practical *complications* due to a *fragmented regulatory landscape*. The state promotes niche development for solar power, such as mountain solar water-heating systems and solar driers to reduce postharvest losses. Despite some early and successful attempts to innovate solar water-heating systems, financial support for installing new systems and sustaining existing ones is inadequate. This strongly inhibits *scalability* beyond the innovative niche.

Finally, independent nonstate initiatives are rare, and projects remain small even when implemented top-down by the government. The sustainability of solar projects in Himachal Pradesh could face even more challenges without effective interstate electricity trade. While the state is fully electrified, there is no sign of a surge in industrial electricity demand, given that the state's primary



focus is agriculture. Therefore mandated solar projects will benefit only if mechanisms are established that enable interstate electricity trade (Interview 26).

## **Polycentric Governance Across Indian States**

The three states illustrate different *polycentric governance characteristics*. Although multiple decision-making centers exist in all three, especially Gujarat's state government encourages private-sector involvement, Himachal Pradesh relies more strongly on national financial and regulatory incentives, and Kerala's state-level centralized system prioritizes top-down regulation. While Kerala shows little signs of nonhierarchical coordination, elements of partnerships can be found in Gujarat and Himachal Pradesh. Due to Gujarat's sufficient financial resources, the state even provides incentives independently from the National Solar Mission. Hence a joint set of norms takes different forms across states and is independent of which party is in power. While energy security in a market-driven approach is central to Gujarat, socialist values, social justice concerns, and clean energy ambitions prevail in Kerala and Himachal Pradesh, respectively.

We observe the *promises* of polycentric governance differently in all three states, except for resilience. For input legitimacy, even the most promising case, Gujarat, whose government tailored its approach to the needs of stakeholders like private households or small businesses, often neglects the livelihoods of local communities residing next to solar parks. Innovative experiments, particularly in Gujarat and Kerala, show different levels of spontaneous order with and without state government involvement. They include strong backing by public-private partnerships, especially for solar parks in Gujarat. Kerala's emphasis on decentralized solutions should increase accountability of the polycentric setup. Lastly, effectiveness varies: while Gujarat's polycentric landscape was effective through partnerships (yet partly at the cost of local communities and high prices), experiments remained marginal in Kerala and Himachal Pradesh.

Also, *pitfalls* of polycentric governance show great variety. Fragmentation between agencies is crucial in Himachal Pradesh, while Gujarat shows promising signs of policy integration. At the same time, Gujarat, Kerala, and Himachal Pradesh do not indicate a lack of authority due to the central role of public actors in their solar initiatives. Still, Kerala and Himachal Pradesh face significant hurdles from limited coordination. None of the states seems to face limited capacity. Most importantly, Gujarat indicates that polycentric governance initiatives can be upscaled, while Kerala and Himachal Pradesh are examples of limited scalability. Institutionalization remains a key challenge in all three settings.

## **Conclusions: Institutionalizing Polycentric Governance**

Developing solar power in a federalist country is a complex challenge. For the case of India, we witness that although the central government has set a national

policy framework, formulated targets, and provided substantial financial means for states, great variety in how these incentives are employed within the respective state has emerged (see also Busby and Shidore 2021, 10). State governments have been vital in implementing policies and overcoming political barriers. Still, very few bottom-up initiatives were sustained or even scaled up.

However, a closer look supports a more positive reading: Gujarat successfully institutionalized its solar power ambitions in a polycentric manner. The state adjusted its solar policies and subsidized initial experiments such as solar parks and solar canals. Initiatives like Rajkot's solar thermal project were institutionalized statewide. Kerala offers favorable conditions for experimentation but struggles to mainstream experiences beyond initial experiments. The *Aditya* solar ferry and Cochin International Airport are prestigious demonstration projects with high-level political support, although they have not (yet) disrupted established fossil fuel-based systems. Himachal Pradesh adopted the State Solar Power Policy in 2014 and implemented it relatively late compared to other states. These different levels of political support led to varying outputs of solar power capacity, ranging from Gujarat's 8.8 gigawatts to slightly more than 800 megawatts in Kerala and much less in Himachal Pradesh. Thus a strong involvement of public actors, sufficient capacity and coordination, input legitimacy, and little fragmentation are central to scaling up polycentric experiments.

The main takeaway from our analysis is that polycentric federalism needs to be understood as a continuous political process with multiple equilibria. Whereas Himachal Pradesh is still experimenting and takes a wait-and-see strategy for solar power, Kerala has taken firmer steps but struggles to leave the experimentation phase. Large-scale solar parks in Gujarat seem entrenched, and the interplay between the central and subnational levels is firmest. However, notably independent and decentralized forms of solar power face significant challenges in all three states. Thus linear institutionalization is not guaranteed. At the national level, solar power strengthens the ambitions of the BJP-led NDA government to centralize development and create a "more unitary imaginary of Indian identity" (Tillin 2019, 128). Yet, collusion or "cartel federalism" seems less significant for solar energy. Instead, we see a competitive setting that is less politicized than other areas in India.

Establishing links between polycentric governance and institutionalization will be crucial for future research (Yenneti and Day 2015), as transformational changes beyond initial experiments are required to tackle climate change (Marquardt et al. 2023). This implies a more political understanding of how institutions create sustainable structures (e.g., Paterson et al. 2022), and we need more research on how multilevel governance arrangements and particular federalist systems can incorporate stimuli from polycentric governance (e.g., Benz and Broschek 2021). All federalist systems in the Global South and North must find new equilibria that accommodate the promises and pitfalls of polycentric governance in rapidly changing energy landscapes.

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**Appendix: List of Interviews**

<i>Date</i>	<i>State</i>	<i>Actor Group</i>	<i>Reference</i>
7 Dec 2016	Gujarat	Consultancy	Interview 01
9 Feb 2018	Gujarat	Civil society	Interview 02
13 Feb 2018	Gujarat	Consultancy	Interview 03
5 Mar 2018	Gujarat	State government	Interview 04
5 Mar 2018	Gujarat	Research	Interview 05
5 Mar 2018	Gujarat	Research	Interview 06
6 Mar 2018	Gujarat	State government	Interview 07
7 Mar 2018	Gujarat	Civil society	Interview 08
8 Mar 2018	Gujarat	Consultancy	Interview 09
8 Mar 2018	Gujarat	Municipal government	Interview 10
9 Mar 2018	Gujarat	Municipal government	Interview 11
4 Apr 2018	Gujarat	Consultancy	Interview 12
20 Apr 2018	Gujarat	State government	Interview 13
27 Apr 2018	Gujarat	Research	Interview 14
24 Jan 2023	Kerala	International organization	Interview 15
24 Jan 2023	Kerala	International organization	Interview 16
25 Jan 2023	Kerala	Consultancy	Interview 17
25 Jan 2023	Kerala	Civil society	Interview 18
30 Jan 2023	Kerala	Research	Interview 19
1 Feb 2023	Kerala	Research	Interview 20
1 Feb 2023	Kerala	Business	Interview 21
2 Feb 2023	Kerala	State government	Interview 22
2 Feb 2023	Kerala	State government	Interview 23
3 Feb 2023	Kerala	Research	Interview 24
6 Feb 2023	Kerala	Research	Interview 25
28 Jul 2023	Himachal Pradesh	Civil society	Interview 26
1 Sep 2023	Himachal Pradesh	Research	Interview 27
2 Sep 2023	Himachal Pradesh	Business	Interview 28
2 Sep 2023	Himachal Pradesh	Business	Interview 29