1 Introduction

The rapid increase of the carbon dioxide concentration from 280 ppm to 380 ppm within the last 100 years and its suspected impact on the earth's climate has raised significant attention within the last few years. The Stern-report released on 30th October 2006, which tried to calculate the cost of global climate change for the first time was a turning point in the public debate [1]. The basic question is how to achieve a sustainable energy/electricity-supply for the world in the upcoming decades without employing fossil fuels. The rapid economic growth in the emerging markets like China and India and the population growth in many developing countries will increase the yearly energy demand until 2030 by ca. 50 % [2].

Since the main renewable energy source available (besides geothermal and tidal power) is the irradiation of the sun, we will – sooner or later – be compelled to utilize it exclusively. Solar energy can be used indirectly by hydroelectric power plants (through the evaporation of water), wind power plants (due to different warming of the earth's surface) or biomass (by photosynthesis) and directly by photovoltaics or solar power plants.

To get an idea of how much energy is supplied by the sun one can calculate the area that would be needed to supply the whole world with solar electricity. The worldwide annual electricity consumption was ca. 18000 TWh per year in 2004 [2]. The solar irradiation in sunny regions like northern Africa is about 2000 kWh per m² and year. Given the possibility to convert this solar irradiation with an efficiency of 15 %, one would need only a square of about 250 km edge length to supply the whole world. Taking into account a lower solar irradiation of 1000 kWh per m² and year in the same calculus, the area needed for Germany’s annual energy consumption of ca. 600 TWh turns out to be not larger than the Saarland.

Despite the huge potential the fraction of electricity generated by photovoltaics or solar power plants is negligible today. In Germany only 0.17 % of the total electricity demand was provided by photovoltaics and worldwide the fraction is even less (<0.1 %) [3]. Though the annual growth of the PV-industry is impressive especially in Germany (average growth per year 2002-2006: 30 %), a lot more investments for research and start-up companies are needed to significantly increase the fraction of solar electricity. The Erneuerbare Energien Gesetz (EEG), introduced in Germany in 2000, was one important step to boost the PV-industry in Germany, but insufficient public funding for research on alternative solar cell concepts and of state-of-the art Si-solar cells might prove as an impediment for PV-industry in the future.

Today Si-based solar cell produce ca. 98 % of the solar electricity. While mono- and multicrystalline Si-cells make up around 90 % of the market today, α-Si cells/ribbon Si as cheap but less efficient alternatives account for the rest. The Si-shortage in the past 3 years helped other thin film technologies like CIS and CdTe to match with the impressive growth rates of Si-standard cells, but up to know the share in the total PV-market could not be increased. With all the new Si-factories being ramped up these days it is unlikely that these technologies will ever become more than a niche product since they rely on rare noble metals (e.g In, Te) and it is doubtful that they can produce solar electricity on the GW-scale. Therefore, the research on cheap and reliable alternatives to Si-cells, so called "2nd generation solar cells", is considerable.

Among the next generation solar cells, dye sensitized solar cells (DSSC) are the most advanced. With efficiencies of ca. 10 % (1 cm²) they are close to commercialization. In June 2007, the BMBF launched a 300 Mio € program to support – besides organic solar cells – the development of DSSC which raises hope that this cell type will be introduced to the market soon [4]. DSSCs are based on the non-toxic semiconductor TiO_2, which is sensitized with organometallic or organic dye. It is a so-called "kinetic" solar cell, that means no in-built electric field causes the separation of charge carriers, but different rate constants for electrons extraction (via diffusion) and electron recombination. Since only majority charge carriers are transported within the cell, the DSSC is much less sensitive to defects and impurities which allows the application of non-purified starting material. Thus the energy payback time is significantly shorter and the production costs are believed to be much lower compared to Si-cells.

After pioneering work from Tributsch et. al. in the 1970 [5], the introduction of nanoporous electrodes in 1990 [6] improved the light harvesting of the cell and conversion efficiencies of 7 % triggered extensive research activities on this cell concept. However the learning curve flattened in the following years and the predicted progress in terms of stability and upscaling was not made for a long time [7]. Drawbacks like the shut-down of the Institut für angewandte Photovoltaik (INAP), which was founded in 1993 to scale up the technology and to bring DSSC to the market, made investors reluctant and today only very few companies operate in this market (Solaronix, Dyesol). The main problems remain the long term stability of the cell (intrinsic stability) and the sealing of the liquid electrolyte (extrinsic stability). Despite these difficulties the scientific community has even intensified efforts to better understand and improve the device. Although the progress is slower than predicted, a lot of innovative concepts have been developed and are now available for the commercial implementation of the DSSC. If both investors and scientists commit themselves patiently to work on and solve the existing problems of DSSC-technology and are cautious not to raise unrealistic expectations in the public, the DSSC can and will turn out as a low-cost alternative to existing thin film solar cells.