German Institute
for Economic Research

No. 24/2009
Volume 5
September 17, 2009

DIW BERLIN

Weekly Report

Power from the Deserts: Not a Mirage

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Energy policy is confronted by two major challenges. First, fossil fuels will become ever more scarce and expensive in coming years, a trend which will intensify conflicts for the control of natural resources. Second, the burning of fossil fuels—particularly coal—is leading to an increase in harmful greenhouse gas emissions. To address these challenges, the share of renewable energy in total energy consumption must be considerably increased. In sharp contrast to fossil fuels, which are becoming ever more depleted, renewable energy sources are essentially inexhaustible. Furthermore, renewable energy produces hardly any greenhouse gases.

The large-scale exploitation of solar energy for power generation offers enormous potential. In theory, solar-thermal collectors installed in North Africa over an area roughly the size of New Jersey could meet all of Europe's electricity needs. The construction of high-voltage direct current (HVDC) lines would be necessary to import power from the Mediterranean region without excessive transmission losses. An expansion of European electricity networks could also yield supplementary benefits, including enhanced integration of domestic renewable energy (such as wind power), and improved competition in electricity markets.

The vast majority of the world's energy needs are met by fossil fuels. Fossil fuels account for over 80% of primary energy consumption worldwide, according to IEA estimates.[1] In Europe, this percentage is nearly as high, and imports cover approximately half of Europe's fossil fuel demand.[2] The greater part of Europe's oil and natural gas imports comes from Russia. In 2006, renewable energy represented approximately 7% of primary energy consumption and some 15% of electricity demand in the EU. In its recently adopted energy and climate package, the EU has set a target of expanding renewable energy as a share of total final energy consumption to 20% by 2020.[3] Many European countries, however, are already having difficulties meeting the targets set for 2010 (see Figure 1).

1 International Energy Agency: Key World Energy Statistics, 2008.

2 EU energy data, http://ec.europa.eu/dgs/energy_transport/figures/pocketbook/2006_en.htm

3 Resolution of the European Parliament of December 17, 2008, on a Directive for the promotion of the use of energy from renewable sources.

JEL Classification:
Q40, L94, Q42, P28

Keywords:
Electricity trade, Solar energy, DESERTEC

In order to make Europe's energy policy goals a reality—particularly in the area of climate protection—the deployment of renewable energy must be considerably expanded (see Box). In this regard, the electricity sector must play a vanguard role, as the transition to renewables is more difficult in other sectors (such as transportation and heating). Over the long term, Europe's electricity supplies should primarily come from renewable sources. To this end, it will be essential to harness large-scale natural resources—not only offshore wind energy in the North Sea and Atlantic, but also the immense and cheap solar resources in the Mediterranean region and North Africa.

Affordable Electricity from the Desert

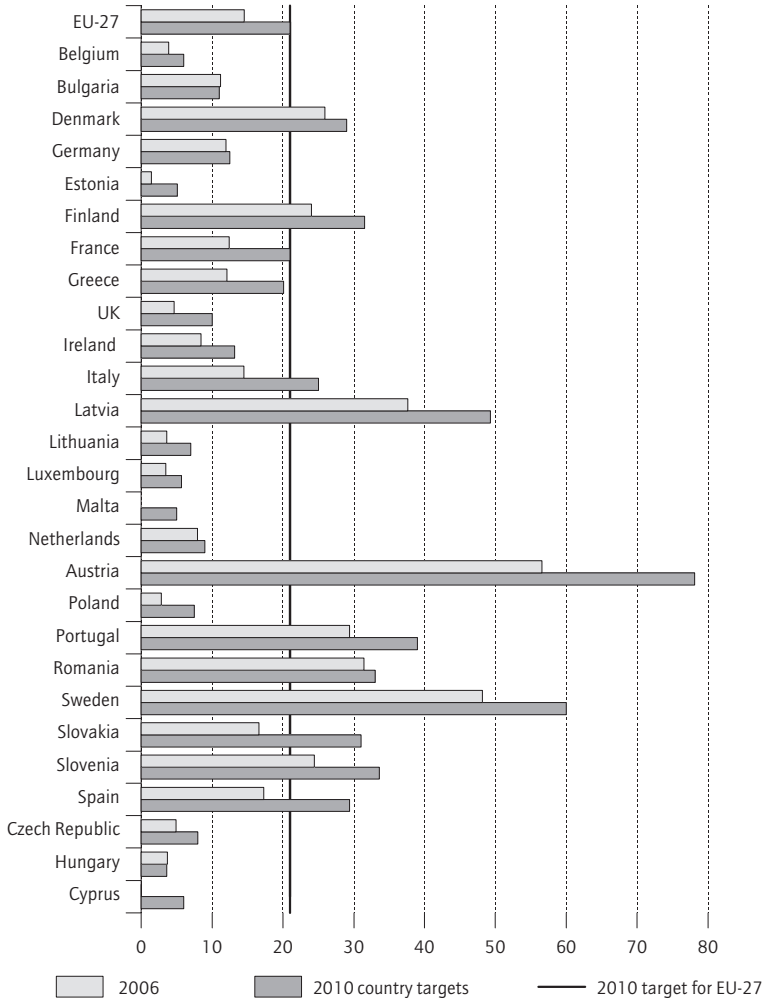
The DESERTEC concept, which was proposed some time ago by the German Association of the Club of Rome, is currently the subject of intense media discussion. A consortium of firms under the leadership of the insurance company Munich Re recently announced an initiative to implement the concept. The initiative represents a partial realization of a European energy scenario that was developed in 2006 in a study carried out by the German Aerospace Center on behalf of the Federal Ministry for the Environment.[4] In the study, a European energy scenario was envisioned in which solar power generated in a series of Middle Eastern and North African (MENA) countries would be imported to Europe via HVDC lines.[5] The study also foresaw the establishment of an overly HVDC super grid so that renewables in Europe such as wind, water, and biomass could be better exploited and integrated into European electricity markets. The study anticipated that renewable energy as a share of total electricity generation could be expanded from 20% in 2000 to approximately 80% in 2050 (see Figure 2). According to the study, electricity from MENA countries would first reach Europe in 2020, and account for approximately 17% of European electricity consumption by 2050. At this point in time, however, the domestic generation of power from renewable resources would make up a much larger percentage of total electricity consumption: over 60%.

In order to facilitate the transmission of solar energy to Europe on this scale by 2050, the German Aerospace Center has estimated that investments of 45 billion euros in HVDC lines will be necessary.[6] On top of this figure, 350 billion euros will be re-

Figure 1

Electricity from Renewable Sources in the EU

Percentage of total power consumption



Source: EU energy data. **DIW** Berlin 2009

4 German Aerospace Center, Trans-Mediterranean Interconnection for Concentrating Solar Power (TRANS-CSP), 2006. Two additional German Aerospace Center studies—MED-CSP and AQUA-CSP—analyze the use of solar thermal power to meet the energy and drinking water needs of North African countries.

5 There are two technological approaches for generating electricity from solar energy: First, photovoltaic (PV) can be used, which converts solar radiation directly into electricity by use of semiconductor technology. Another option is solar-thermal electricity generation. In this approach, collectors focus solar radiation on a receiver, where it heats an energy carrier. As with a conventional thermal power plants, the resulting steam drives a turbine and generator, which in turn produces electricity. In contrast to photovoltaic panels, concentrating solar thermal plants can compensate for fluctuations in the amount of available sunlight by storing energy in heat storage facilities. This enables the generation of a steady volume of electricity. In principle, when a solar thermal facility is equipped with heat storage tanks of sufficient size, round the clock operation is possible. The volume of natural solar energy available in Germany is nevertheless not sufficient for the economic operation of concentrating solar thermal power plants.

6 This is equivalent to a line capacity of approximately 100 gigawatts, which is required for annual transmission of about 700 terawatt hours of CSP electricity.

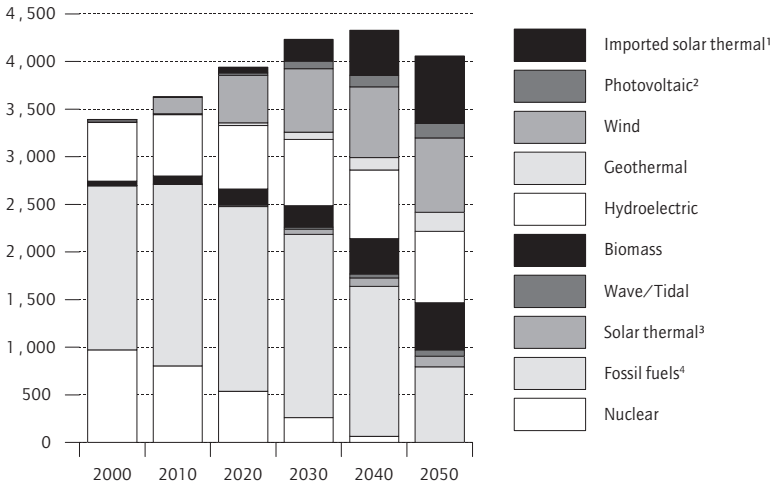
quired to construct concentrating solar power (CSP) plants in MENA countries. Similar figures have been cited by the DESERTEC initiative. The size of these investments makes the project perhaps the largest private-sector undertaking of all time in the area of renewable energy. It is important to take into account, however, that the preservation of Europe's conventional energy supply structure would also require considerable investments: between 2007 and 2030, some 1.5 trillion dollars (1.07 trillion euros at current exchange rates) in new, predominantly fossil-fuel power plants and an additional 750 billion dollars (some 540 billion euros) in transmission and distribution networks.[7]

It must also be noted that the German Aerospace Center study is based on a number of very optimistic assumptions. The study supposes, for example, that electricity demand in 30 European countries will decline from 2040 onward, and that total demand in 2050 will only be slightly higher than it is today. In the event of higher demand growth, only a much smaller percentage of electricity consumption could be covered by solar energy, despite the considerable investments described above. With regard to power generation, as well, the study describes a trend scenario that is theoretically possible, but which, for the most part, cannot be realized unless a number of ancillary conditions are fulfilled.

Figure 2

European Electricity Production and Solar Power Imports until 2050

In terawatt hours/year; according to Trans-CSP scenario



1 Solar thermal power generated in MENA countries (Middle East and North Africa).
2 Photovoltaic power generated in Europe; it is assumed that this generating capacity is distributed among many countries.
3 Power generated within Europe using solar thermal power plants, mainly in Spain, Portugal, and Turkey.
4 Coal, natural gas, and oil.

Source: German Aerospace Center, Trans-Mediterranean Interconnection for Concentrating Solar Power (TRANS-CSP), 2006. **DIW** Berlin 2009

Combination with Further-Reaching Concepts Possible

Other proposals for the construction of a pan-European electricity network beyond the scope of the DESERTEC project are also being discussed at present in the media. Various strategies envision a massive expansion of Europe's electricity networks that would enable 100% of the EU's power needs to be covered by renewable energy in a cost-effective manner.[8] One network expansion concept currently under consideration foresees the combination of a long-range European "Super Grid" with a flexible, decentralized "Smart Grid." The resulting "Super Smart Grid" would be able to tap large-scale natural potentials of renewables, such as offshore wind power and North African solar power, while also integrating decentralized, flexible renewable plants and demand-side measures. With an optimal combination of these approaches, up to 100% of total power needs could be covered by renewable energy by 2050.[9]

Eliminating Obstacles

Ambitious network expansion plans such as the DESERTEC project are confronted by a number of financial, political, and institutional challenges.[10] First, most of these projects entail considerable investments. Government loans and purchase guarantees could help the DESERTEC project to get off the ground. There are also large unknowns concerning the future shape of European energy and climate policy. Clear, long-term and binding targets in the area of renewable energy and climate

7 International Energy Agency: World Energy Outlook 2008.

8 Gregor Czisch, for example, has presented a concept based predominantly on wind power with which Europe's complete power needs could be met by renewable energy. Hydroelectric and biomass plants would serve as a backup, while solar thermal plants would play a limited role .Photovoltaic is hardly used at all. Considerable power transmission capacities would be necessary to balance out spatial and temporal fluctuations in the volume of power generated. The concept would require massive annual investments of nearly 80 billion euros for new generation capacities and network expansion. The centralized approach and high import dependencies of individual countries are two aspects of the plan subjected to criticism. In Germany, for example, over 80% of power demand would be met by imports. See Czisch, G.: Szenarien zur zukünftigen Stromversorgung. 2005 University of Kassel dissertation.

9 Battaglini et al.: Development of SuperSmart Grids for a More Efficient Utilisation of Electricity from Renewable Sources. Journal of Cleaner Production 10, 2009, 911–919.

10 These challenges are currently being investigated within the scope of a project financed by the Federal Ministry of Education and Research called "Mainstreaming of climate risks and opportunities in the financial sector." An expert workshop on this project took place at DIW Berlin in March 2009.

Box

Challenges in Energy and Climate Policy

European energy policy pursues three interrelated goals: cost-effectiveness, environmental sustainability, and security of supply (the so-called "energy policy triangle"). Considerable challenges are faced in all three of these areas. Fossil fuel resources such as oil, natural gas, and coal are finite and are becoming increasingly depleted. Europe's strategic reliance on energy imports—particularly Russian natural gas and oil—is rising. Furthermore, while a common European market for electricity was created by a 2003 EU Directive, competition is still imperfect. Lastly, the global climate is endangered by extensive burning of fossil fuels. Approximately 75% of greenhouse gas emissions are produced by industrialized countries. The present concentration of atmospheric greenhouse gases is already close to a level which will irreversible harm the world's climate according to the Intergovernmental Panel on Climate Change.

The establishment of global climate protection targets is becoming ever more likely. In 2005 Europe introduced an emissions trading system in order to achieve the emission abatement targets set by the Kyoto Protocol. The US Congress recently ratified a bill that would introduce a cap-and-trade plan for greenhouse gases. The bill calls for a 17% reduction in emissions from their 2005 levels by 2020, as well as an 80% reduction by 2050.

At the December 2009 UN Climate Change Conference in Copenhagen, it is hoped that a successor agreement to the Kyoto Protocol will be signed. Although the passage of an agreement with ambitious targets is unlikely in light of the global economic crisis, climate protection will remain a key issue internationally. In order to address the challenges posed by global warming, governments must furnish reliable and stable frameworks for action. Long-term planning reliability must be assured for stakeholders who invest in new energy solutions.

Attaining the goals set forth by the European energy policy triangle as well as realizing more far-reaching climate protection targets will only be possible if industrialized countries are successful in replacing fossil fuels with renewable energy on a large scale. The rising global demand for fossil fuels is already partially reflected by higher prices, particularly for oil and natural gas. The macroeconomic costs of transitioning to low carbon technologies will be much lower if efforts are initiated now rather than at some point in the future, when a much more rapid transition will be necessary.

protection would help to minimize investment risk. Lastly, it would be an error to underestimate the local resistance that often arises to network expansion plans.

Exploiting Export Opportunities

The potential for expansion in the area of renewable energy is considerable. Depending on the growth of global demand, enormous export opportunities could arise. Should an increasing number of countries accelerate the development of renewable energy, German companies are well positioned. For example, large-scale solar power projects in the MENA region could produce sizable contracts for German firms in the solar technology, plant engineering, and power network sectors.[11] For this reason, several industry representatives have expressed a keen interest in the DESERTEC initiative.[12]

Strengthening Competition and Supply Security

The expansion of European electricity networks would strengthen competition in European electricity markets. The elimination of cross-border capacity bottlenecks would help to limit market power as well as better unify the European domestic electricity market.[13] Supply security would also not necessarily worsen with the integration of electricity imported from the MENA region. On the contrary: with the diversification of energy imports, strategic import dependencies could even be reduced, such as the European dependency on Russian natural gas. However, there is still a considerable need for research in order to quantify supply risks associated with solar electricity imports.

11 A recent study by the Wuppertal Institute estimated the extent to which German solar companies might benefit from the increasing global adoption of solar technology. According to the study's findings, German firms produce numerous key technologies, particularly components such as receivers, mirrors, and turbines. Wuppertal Institute: Economic Opportunities for the German Industry Resulting from a Global Deployment of CSP (Concentrated Solar Power) Technologies, June 2009.

12 WirtschaftsWoche, online version, June 23, 2009.

13 See Kemfert, C., Traber, Th.: Strommarkt: Engpässe im Netz behindern den Wettbewerb. DIW Berlin Weekly Report 15/2008.

Conclusion

Solar electricity imports could represent an important stepping stone on the path to a secure, climate friendly, and affordable energy future. A requisite step, however, would be a considerable expansion of Europe's power network infrastructure. The much-discussed DESERTEC project currently being spearheaded by Munich Re is a promising beginning. Yet if the project is to move forward, efforts must also be made to secure North Africa's own energy supplies, so that a basis for long-term prosperity in the region's countries can be created.

While promoting the implementation of solar projects in MENA countries, the expansion of domestic renewable energy should not be neglected. Even if the DESERTEC project were to be realized in its planned scope (with investments in the range of 400 billion euros), imported solar electricity will only comprise 17% of total consumption by 2050, according to the German Aerospace Center. From the present perspective, the realization of an even larger import share would present an extreme challenge. Consequently, a large percentage of energy needs must also be met in the future with domestic renewable sources. In any event, the expansion of electricity networks will be necessary in order to balance out spatial and temporal fluctuations of renewable electricity. In this connection, the long-range "Super Grid" and decentralized, flexible "Smart Grid" approaches could superbly complement one another. It should also not be forgotten that energy efficiency must be considerably improved. Otherwise, there is a danger that the contribution made by imported solar energy will represent a drop in the proverbial bucket.

On a technical level, the realization of the DESERTEC project appears quite feasible, although some research is still required concerning the expansion of European power networks. For the project to move forward, efforts must also be made to ensure the right preconditions are in place. In order to increase public acceptance for the expansion of electricity networks, it will be necessary to clearly communicate the advantages of long-distance transmission of green power as well as the disadvantages associated with alternatives—particularly a continued dependency on power generated from fossil fuels. At the European level, public institutions must facilitate clear, stable, and advantageous conditions for the project, and thus provide sufficient investment incentives. Only then it will be possible that "power from the deserts" moves from a mirage to reality.

(First published as "Strom aus der Wüste – keine Fata Morgana", in: Wochenbericht des DIW Berlin Nr. 29/2009)

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ISSN 1860-3343
Price: Euro 10.–
www.diw.de/english/produkte/publikationen/weeklyreport
Translated from the German.