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Conference Paper

Towards a global electricity market

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The Global Environment

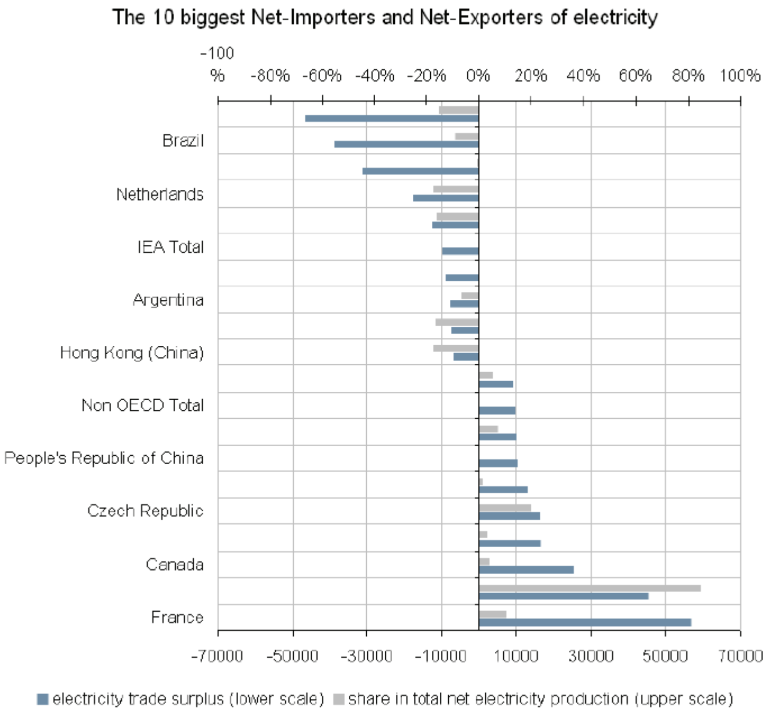
Towards a Global Electricity Market

The Challenges

In principle, solar and wind are more than enough to deliver any amount of energy mankind might want to demand. However, these sources are usually best exploitable in areas that are far from demand centers: It is technologically challenging to transport electricity over large distances and even more to store it; as a consequence electricity markets have developed as regional markets.

To change this, proposals have been made recently to generate electricity, e.g., by large-scale solar thermal power plants in North Africa and transport it through high voltage direct current power lines to the demand centres in Europe. Projections claim that by 2050, 700 TWh electricity per year—this matches a rough quarter of the European electricity demand in 2006—can be transmitted, raising yearly revenues of €35bn.

In addition, other world regions aim for an integration of regional power grids and sources: In January 2010, several European governments littoral to the North Sea announced to connect their production of wind energy.



Yet, projections show that in the midterm the future energy mix for electricity generation will still contain fossil energy and nuclear power. The share of the fossil energy in the future energy mix strongly depends on the implementation of low-carbon technologies like carbon capture and storage (CCS) and the ability to substitute low-carbon for high-carbon energy sources. Nuclear power will also constitute an important option due to its provision of emission free power. However, since there are unsolved major caveats of nuclear power, an expansion of the nuclear power share is not the complete answer to the energy puzzle:

What are the options and their potential contributions to the future energy mix for electricity generation? What proportion of our energy needs will still have to be covered by fossil energy like gas, coal and nuclear power? How can the supply in regions that lack those energy sources be secured? What is the appropriate time frame for implementation in order to avert serious consequences of climate change? What is the politically feasible mix? What are the business challenges for energy companies in this changing environment? Are large scale projects for electricity generation a sensible strategy for large international energy companies

to prepare for a carbon-free future? Or is the installation of decentralized small-scale systems the more efficient solution? Will it be possible to combine the two approaches? Or are they conflicting? How could a secure functioning of a global electricity market be guaranteed—especially if potentially instable states are involved? Will importing countries be willing to pay the price of a security loss for carbon free energy?

Proposed Solutions

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- Opening up markets to foreign competition
- Smart grids across borders
- Optimization in generation and distribution at least on a regional basis

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Increase power grid capacity and interconnect national power grids

A vigorous effort to increase power grid capacity and interlink national power grids would lead to larger electricity markets. Overall volatility in the provision of renewable electricity would be reduced, increasing renewable base load capacity. Power suppliers might at the same time be able to reduce overall reserve capacity, thus cutting costs for power from all sources, including fossil fuels.

Establish renewable large-scale projects

Interconnected grids would not only allow for increased base load use of existing renewables, which are often of a small scale compared to fossil fuel plants. They would also set the stage for a spatial decoupling of electricity generation and consumption, including the option of large scale projects to generate electricity from renewable sources. These large scale projects include, e.g., Concentrated Solar Power (CSP) plants in deserts or off-shore wind parks and could provide a significant contribution to the extension of renewable capacity.

Development of electricity storage capacity

Electricity storage presents a natural solution to eliminate the central obstacles to the large scale use of renewable electricity sources, which is the problem of high volatility. However, despite significant research effort, cheap and efficient solutions are still not available on a sufficient scale—so far, pumped hydro facilities are the only option that is actually used on a large scale. Corresponding private and public research programs should be fostered, focusing on new approaches like the use of hydrogen as well as on intelligent application of existing technology. Programs for the promotion of E-Mobility play an important role in developing

storage solutions as well, since batteries of electric cars may be used to cheaply store electricity in high supply-low demand periods.

Decentralization of electricity generation

The strategy of decentralizing electricity generation by means of small-scale installations is discussed as well. These installations could, e.g., be gas-fired and, once installed, are available on short notice. They could serve as reserve capacity and satisfy the demand for balancing energy, which will rise if renewable capacity is expanded–especially as long as regional interconnection between renewables is underdeveloped.

Making grids smart

Current electricity grids lack digital communication channels between their interconnected elements. Generators only know how much electricity is demanded by all consumers but not by whom exactly and for what purpose. Making grids smart means to establish those communication channels, thus allowing for optimizing the operations of the interconnected elements. Possible benefits could include a reduction of peak load capacity and the optimal utilization of energy storage capacity.

Establish institutions to handle interconnected electricity markets

Another side effect of larger interconnected grids may be an increase in competition in electricity markets. While this is probably beneficial for consumers, established power producers might be deterred from building up the necessary infrastructure. National grid regulation authorities are obliged to arrange for the necessary incentives and sanctions. The necessity of international cooperation between national authorities is obvious, preferably within existing frameworks, either on a regional (e.g., existing FTAs) or global (e.g., IEA, WTO) level. The European Union is already moving in that direction by building a supra-national Agency for the Cooperation of Energy Regulators (ACER), as well as a number of additional regulator co-operations.

Edward Kahn

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Global electricity market

In the long run, the most sustainable forms of power generation, solar and wind, will drive the electricity system. Achieving a system based on these resources will require an integrated network that delivers energy over transmission infrastructure from sources that are often far from demand centers. In broad scope, the technological requirements for such a system are readily identifiable. These include storage, improved transmission and increasing energy conversion efficiency. The system design challenges are not minor, however, and will engage the engineering community significantly.

I will focus my remarks on the institutional challenges. In one way or another, electricity has always been a regulated industry. While market forces have also played a major role in the development of the electricity industry, governments have had a strong hand in stabilizing and organizing investment and controlling prices. As the geographic scope and technological basis of electricity markets have grown, regulatory institutions have adapted to these changes and evolved. In the industry’s infancy, the municipality was the focus of electricity development. In recent years, national authorities have emerged to play the leading regulatory role, although more local factors are still a consideration to varying degrees. A global electricity market will require major institutional innovations.

There is already international commercial activity in electricity. The market for electric generating equipment of all kinds is global in scope. The largest vendors of all technology types operate internationally. There are also multinational companies with ownership interests in electricity assets in multiple countries. Transnational electricity trade, however, is still comparatively modest in scope.

I focus attention on two institutional issues that require attention to facilitate transnational electricity trade. First, building the transmission infrastructure necessary to enable global electricity trade will require cost-sharing arrangements. Many of the lines that will be built will rely on DC technology because it is most efficient for long distances. There are significant scale economies with DC technology. Therefore projects will most likely require multiple participants. Allocating the costs of large projects must be done before such projects are built. The second important institutional issue is dispute resolution. Although this issue addresses problems that will arise after infrastructure is built, resolving the framework for dispute resolution ex ante will encourage project development because it will reduce uncertainties about commercial operation. Finally, I address the question of how much global integration of markets is optimal.

Cost allocation

Construction of new international transmission facilities will require a cost-sharing plan to facilitate investment. Relevant projects will often be too large for single buyers and single sellers alone. Diversifying the risks of large projects also argues for multiple owners. There are likely to be many parties who would benefit from large transmission projects, but some may seek to avoid or minimize their share of the costs. Such “free-riding” is a common problem in economics. Regulatory institutions must try to avoid this outcome. Even if there is agreement in principle for cost-sharing, there are many different ways in which this can be accomplished. Methods must be developed that allocate costs to beneficiaries in some roughly proportionate manner. It is more important that these allocations be robust rather than overly precise, since imprecision in estimation is inevitable.

One simple allocation rule that has worked well on the buyer side is the load share principle. Customers pay in proportion to their share of contracted capacity. In the case of wind energy, with its substantial and often random availability, there can be complications arising from how and when shares are measured. Despite such complications, load share cost allocation can be robust enough to facilitate commercial arrangements.

Additionally there are often “network externalities,” in which new projects require network upgrades in other parts of the system. This topic can be opaque because it involves network reliability issues are often not treated in a standard fashion. Therefore the opportunity for disagreement is correspondingly large. Here also, regulatory institutions have a role to play in defining which parties should be responsible for which costs.

Dispute resolution

It is inevitable that under a regime of international electricity trade, commercial disputes will arise from one circumstance or another. Parties will disagree about the interpretation of events, unexpected circumstances will arise, disruptions of one kind or another will occur. It is essential, therefore, that dispute resolution mechanisms be established that will allow for the settlement of commercial disagreements in a mutually acceptable manner. There are already a variety of institutions that address commercial dispute resolution in the international context. These institutions are likely to need further development in the context of a global electricity market.

Regulatory institutions play a prominent role in the dispute resolution process in electricity, even if regulators are not the adjudicators involved. This is because regulatory standards help define the benchmarks for establishing a reasonable allocation of costs and benefits in a commercial context. Disputes in electricity commerce often reference regulatory rules, standards, decisions or common practices. Where regulatory standards differ, the resulting ambiguities and conflicts can impede rather than facilitate dispute resolution. Therefore, even if a commercial conflict does not directly involve regulatory authority, it is important for global electricity trade that regulatory standards and practices to be harmonized as much as possible.

The current regime for the arbitration of international commercial disputes has uneven global participation. Countries that are most likely to be electricity exporters in a global electricity market, many of which are now oil and gas exporters, have historically participated less in these procedures than countries that are likely to be importers. Cultural differences appear to be at the bottom of this difference in participation. Legal traditions are quite diverse, and this impedes a finding common ground for arbitration. For arbitration to be successful, the parties must agree on procedures to be used, standards of evidence, and enforceability of decisions among other factors.

In a global economy, trading partners need to have a common understanding of commercial contingencies. Cultural differences have historically deterred this to a certain degree. Energy officials from prospective electricity exporting and importing countries should include dispute resolution procedures in their negotiations over commercial arrangements to broaden the scope of electricity markets.

How much global integration of electricity markets makes sense?

Economists typically see trade as a process that benefits all parties. Because electricity plays a somewhat special role in economies, however, there are potential concerns about security of supply that need consideration. Electricity is an essential infrastructure industry. Modern society depends upon a reliable electricity supply for the most mundane and most sophisticated tasks. The disruption of electricity service imposes disproportionate costs on society. There is some risk that a global electricity market could result in greater fragility, a less secure system of supply, at least under some conditions.

There are some technology solutions that could ameliorate the security risks of global electricity trade. The chief among these is large scale storage. Inventories buffer supply interruptions in all industries. Storage provides the inventory function. Electricity storage, however, has not been economic except for hydrologic reservoirs. These are too limited at present to provide much of a buffer on any large scale. Back-up thermal generation, based on existing technology, is a widely available alternative for hedging against supply interruptions. Regulators will have to decide how much back-up plant to support as a security of supply hedge.

It is likely that natural limits on global electricity trade will appear. The cost advantages of remote resources may not turn out to be so uniformly great to overcome the substantial costs of transmission, at least on a consistent basis. When security of supply costs is factored in as well, the cost advantages of trade will be further reduced. The current dependence of European countries on imported natural gas, for example, is likely to exceed the degree of integration of electricity markets.

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Towards efficient, clean, and innovative electricity markets

1. By 2050, electricity should provide a much greater share of our energy needs and should be produced entirely by renewable energy sources. Electricity is the most efficient energy carrier, and can be produced by renewable sources, so a sustainable energy future requires increased electrification—of car and train transportation, for example, and buildings. It requires sophisticated efforts to reduce and manage demand. It also requires a massive effort to drive renewable energy into the system, from large-scale solar, wind and geothermal projects and from decentralized production.

2. Success will require development of super-smart integrated grids in key regions. There is no need for a fully integrated global electricity market, connecting Latin America to Europe, for example. But a shift to renewable energy sources will require fully integrated grids in key regions such as North America, Europe, and China. Those grids must be super-efficient, to connect markets to often distant large-scale renewable energy sources. Europe, for example, needs a grid that can connect its markets to solar concentrated power in North Africa and offshore wind in the North Sea. Southeast Asia needs a grid that can help it tap the geothermal resources of the "Ring of Fire." The grids must also be "smart," able to manage the variable production of renewable sources, to tap decentralized sources such as residential solar panels, and to manage loads.

3. A shift to renewable energy requires investment in research on storage. The nature of wind and solar energy, in particular, is very different from other energy sources. They are variable. Although we know from research that wind power and solar are negatively correlated—if the wind stops blowing there is often sunshine and vice versa—substantial investments into energy storage and planning are necessary. Renewable sources such as biomass, geothermal, hydro pump storage and solar concentrated power (with molten salt storage technology) need to deliver back-up. In later years, hydrogen production from excess renewable electricity can certainly add to the storage potentials.

4. Regional grids are only possible if we can break through current political barriers. Construction of super-smart regional grids will require policies and regulation that facilitate the needed planning and investments. So far, national electricity regulators and often even regional regulators determine the fate of these investments based on their narrow national or regional mandate. Grid companies are often hampered by utilities on one side seeking to defend their incumbent (often unsustainable) energy production and fearing stranded investments, and regulators on the other side whose interest is to "keep the lights on" but only in their specific areas. Effective management of cross-regional and even cross-border trade in particular of variable renewable power is falling through the grid—literally!

5. We also must meet the needs of 1.5 billion people who have little or no access to electricity. There are perhaps 1.5 billion poor people, often in remote areas of developing countries, who have no or only erratic access to electricity. Providing them with basic reliable and affordable energy services is a moral obligation. This may often best be done through decentralized, off-grid solutions.

Klaus Rave

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Sustainable energy transmission—Challenges and visions

Pathetic as it may sound, we should realize that our entire civilization depends on energy services, especially electricity. In a recent edition, The Economist has published the following statement from America's National Academy of Engineering: Neither the car nor the computer have been the biggest engineering accomplishments of the 20th century, but the large distribution of electricity via national grids (*The Economist*, 10.10.2009, p. 69). Now, we are living in another century and **this leads to me my 1st thesis: Today we are facing a fundamental change in the way grids are designed, built and managed.**

The configuration of our electricity grid originates from the era of industrialization, and is therefore over 100 years old. We now have to think about a grid for the 21st century. However, first of all let us have a look at the "old world," which still represents the status quo here in Germany.

Traditionally, the German system falls back upon so-called base-load, medium-load and peak-load electricity generation plants. Electricity flows from the power station to the consumer along a one-way street. That is the supply side. But what about demand?

If we want to face up to the challenges of the future, this one-way street must not become a dead-end-street. The electricity high way of the future will optimize the balance between supply and demand and thereby overcome traditional barriers. Renewables are unsteady and stochastic. An intelligent grid will stabilize them and optimize their economic value.

My 2nd thesis is: We need more intelligence within the grid. Let us merge the IT-world with the ET-world.

The grid can be called intelligent or "smart" for the first time, when these former one-way streets have been transformed into an intelligent communication network. In this grid, variable usage tariffs would be valid, car batteries would be used as storage capacity, electric appliances which are not needed would be automatically switched on and off and "virtual power plants" would come into being. The Energy Agency NRW has estimated the percentage of energy which could be saved to be between 20 and 25% per household (Earn money with Smart Metering, in *energiespektrum* 10.2009, pg. 39). According to other calculations, demand peaks could be reduced by up to 30% (*The Economist*, 10.10.2009, p. 70)

Admittedly the route to a Smart Grid is not easy. As one expert said: "In the Smart Grid, we have to conduct a large, multi-faceted orchestra, which has a lot of individuality" (ABB, from wind to HVD via CHP). Polyphony instead of monotony. Sounds good to me.

A real problem is that in the electricity market "... there are 360 different communication standards or protocols" (Dr. Christian Feißt, Cisco Industry Lead Utilities Internet Business Solutions Group). These are the hidden barriers and it is well-known that they are difficult to overcome.

My 3rd thesis: New international routes for electricity transport open up new perspectives for renewables.

A further type of technology is essential for modernizing electricity distribution in Europe. the high-voltage direct current (HVDC) electric power transmission, which enables the transfer of energy over long distances with little loss of power. This technology has been a reality for a long time—especially in China and India where several projects have been implemented over the past few years. For example, electricity from the Three Gorges Dam is transported over hundreds of kilometres using the HVDC electric power transmission system. Currently, the

most powerful HVDC long-distance transmission systems are in China (Wikipedia's list of HVDC plants). In Europe the "North Sea Super Grid" is a promising project.

On an inter-regional, even a transcontinental level, the potential of HVDC is enormous. Desertec should be able to demonstrate this: Large companies such as Münchner Rück, Siemens, Deutsche Bank and RWE consider new grid infrastructures and energy generation to be feasible. Moreover, if the Desertec project is connected to a European Super Grid, solar power from the Sahara desert could be combined with off-shore wind power from the North Sea: Desert power plus coastal power. Hydropower from the Alps and Scandinavia can serve as storage capacity: There we have the batteries in the form of hydro-power our systems needs.

Not only does the north-south axis open up opportunities here. In the east-west direction, considerable energy resources are lying within the grids: Subsequently, "if we were to combine the European and Russian electricity grids, […] an exchange of power across ten time zones would be possible."

If the technology is available and the potential is enormous, why are these things not yet large scale reality?

We are currently in a difficult situation because the word infrastructure comprises it already: There are established "structures," not only in a physical form. We advocate change and naturally there is opposition towards this: Too much money is made by too few power players.

The electricity grid is a natural monopoly. The strict separation of transportation and production of energy goods, the so-called "unbundling," is an essential prerequisite for more competition and an open and transparent market. The transportation of electricity is a different business from the generation and sale of electricity.

However, the opportunities linked to the further development of the "Single European Market" are encouraging. Crucial—according to EWEA and EURELECTRIC—to the large scale deployment of renewable energy in this regard is a European approach to grid planning and the integration of wholesale markets.

A promising aspect in this regard is the proposal for an Energy Infrastructure Package that the Commission intends to present by the end of 2010. It will form the basis for future strategies to develop infrastructure and interconnections at the European level (Stock taking document—towards a new Energy Strategy for Europe 2011–2020). From my point of view, the objective for the European level should be an intelligent, European electricity grid, in the form of a holding company that would effectively promote competition, security and climate protection.

We need a truly European approach and solution.

There is a multitude of political arenas that we have to take into account. Look for example at the declaration to be found in the Federal Grid Agency's policy document:

"Grid planning must therefore incorporate:

- technological basic conditions for the grid;
- technological developments and advancements in the field of energy transportation across long distances;
- specifications and objectives related to regional planning policy;
- environmental and nature protection targets and
- economical criteria in terms of efficient, considerate and timely infrastructure investments, which are tailored to suit the market's needs and balance fairly the interests involved" (citing Riese/Wilms: Overall idea for the planning of transmission grids and grid connections, p. 108).

As a banker, I know that structural changes in particular require capital flows—in particular in times of financial crisis. This capital does not need to come from economic stimulus packages nor from development banks alone. The private sector has already discovered the renewable energy field. In 2008, private investments in renewable energy sources worldwide were, for the first time, larger than private investments in fossil fuels (Amory Lovins (RMI): Interview “It’s easy being green,“ in *The American Interest*, p. 47). In Europe in 2009, wind power was the number one source for newly installed power plants, followed by gas; photovoltaic (solar power) was third.

So why not thinking of initiating a new, attractive investment opportunity? After all, everyone is an electricity customer! What would it be like with a “citizen’s grid?” Due to a legally fixed rate per kwh, the Renewable Energy Law was and is the driving force behind investments in wind, solar and biomass power plants in Germany. Citizen’s wind farms have offered an excellent investment opportunity and are not only extremely popular but a much admired model for the world. What you own you cherish and do not object to.

Grids are natural monopolies, they are reliable and beyond that, long-term profitable assets in a regulated market with definitive return: That is—especially in these days—much better than a savings account! And local resistance to grid extensions or new grids can be overcome by ownership involvement. Let us talk “community grids.”

My 4th and last thesis is: New ownership, new technologies, new dimensions constitute a powerful challenge and an opportunity that must not be missed.

Thomas Straubhaar

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Recommended approaches towards a greener economy in Turkey and Brazil

Green energy developments are a question of private technological innovation rather than a matter of political decisions!

Green energy developments should be stimulated by basic research incentives rather than by a paternalistic support of specific technologies!

Therefore it is essential to:

- Provide a particularly attractive and stable political and macroeconomic framework to attract as much direct investments as possible and as needed to develop “green.”
- Invest in Research and Development rather than spending public money for specific green technologies.
- Search for potential second-mover advantages in order to leapfrog to the most advanced technologies.