Rethinking the Future of Energy:
"What will future electricity grids look like, and is 100% renewable energy possible and affordable?"

Prof. Dr. Günther Bachmann, German Council for Sustainable Development

Rethinking the Future of Energy Conference
hosted by the World Bank Energy Sector Management Assistance Program, ESMAP
March 4, 2014, Washington D.C.

I thank the World Bank ESMAP for the kind invitation. Addressing this particular global audience on the issue of rethinking energy on the basis of the German *Energiewende* is a privilege. Sustainable and secure energy is a key issue for all economies and societies, whether mature, emerging or developing. The quest for which the world's post-2015 agenda thus must strive is "sustainable energy for all." However, shared issues need differentiated solutions. A plurality of approaches and ideas will be needed to cover the diversity and needs in the countries of the world. The German *Energiewende*, or energy transition, involves a profound and robust makeover of the German energy system[1]. To accomplish the Energiewende objectives a more efficient use of energy and resources clearly has the greatest immediate leverage. Together with renewables energies those leverage challenge all kind of engineering and manufacturing skills in a big time experiment[2]. It is against this background that I will try to answer the three questions that you have posed in the announcement of this talk:

1) What will future power grids look like? Future grids will differ significantly from what we have now. Their functionality and role will have to change. Imagining the future of grids requires a broader perspective: it is about green/sustainable infrastructure.
2) Is 100% renewable energy possible? Yes, it is in reach, at least as far as electricity is concerned. But what does 100% mean precisely?
3) Is 100% renewable energy affordable? Yes, and it is an economically rational option for Germany. But the real challenge is "beyond affordability"!

Points 1 through 3 are not about technology or money alone. To a substantial extent it is also about culture, governance and leadership. Framing our energy future as a part of an overall trajectory towards sustainable development is essential.

[1] The *Energiewende* is a branding of a highly complex cultural process. Politics and policies, innovation, economic, and social aspects are intertwined. The German public energy debate is a story of protest rooted in the 1970s. Up until 2011, German society was deeply divided over the issue of nuclear power. In 2011, a broad consensus in Parliament and the public put the *Energiewende* on the agenda, with a commitment to phasing out nuclear power generation by 2022 while remaining on track towards achieving the very ambitious 2050 climate objectives, keeping German industry competitive and avoiding energy-bound deindustrialization effects, and keeping social transfers reasonable.

[2] Bachmann, Günther and Lutz Engelke (ed.) (2013) future lab germany. innovations for tomorrow's world, Berlin: Murmann, 288 p.. http://www.murmann-verlag.de/buch/future-lab-germany-0

The grid

It is fair to say that Germany maintains one of the most reliable grids in Europe, and probably in the world. A high-quality grid is essential for any industrialized economy, all the more so considering that some 25% of Germany's jobs are either in or associated with industrial manufacturing. High-quality electricity is key to transitioning growth patterns into sustainable development.

The grid will have to change profoundly, physically in terms of lines and new technology, and also in terms of modalities and governance. This process has already been initiated and is ongoing.

Advancing grid modalities and infrastructure is expected to provide new options for green business cases. Decentralized off-grid energy generation is an option here and there in mature economies, and even more so in developing and growing economies. However, there is reason to doubt that there is a strong dichotomy between decentralized and centralized structures. It is more probable that both elements actually complement and reinforces one another. A grid that handles a major share of renewables in energy production requires more flexibility in terms of backup capacities instead of simply pursuing the baseload/peak pathway. The first option combines intermittent electricity with smart redispatch and demand-side peak management, and storage with a set of fossil-fueled reserve generation capacities. The latter option provides constant capacity in accordance with the "energy-only market" and merit order calculation that have been part of the dominant mode of electricity generation based on fossil/nuclear fuels. The new and upcoming grid characteristics are: flexible, small, digital. That means flexibility in matching supply and demand; small scale metering (and steering) rather than large scale homogeneous services; security through comprehensive integration of decentralist solutions. This is an observation of today's trends. But clearly, further r&d and innovative investments are needed.

The future of the grid will probably also mean a change in modality. It will increase its role in industrialization processes, in particular if industrialization follows pathways that implement sustainability solutions. With smart grid appliances, the grid itself will foster business options connected to load (peak) management, energy security, and provision of storage capacities. It will play a role in manufacturing processes rather than just being a functional service provider. Of course, this raises all kinds of big-data issues.

The power grid of the future will not be about electricity alone. There might be an integrated electricity and gas grid infrastructure. This will open new options for storage and smart grid appliances. Already on the horizon are new techniques such as power-to-gas (using surplus wind energy to generate hydrogen and store it in the natural gas grid) or even power-to-liquid (adding methane-generating processes). As of today these techniques are expensive and not competitive. But scaling and industrializing these innovations might bring costs down.

There might be more stand-alone off-grid solutions. In Germany, we see enterprises and local communities increasingly establishing off-grid solutions. They are made possible by renewable energies. Those technologies have been brought to maturity and industrialized by means of the subsidies paid by German electricity consumers in accordance with the German feed-in tariff scheme. As a result, electricity users see off-grid solutions as a kind of windfall profit that can be harvested from the successful investments of the past.

In Germany, we are seeing a renaissance in governance issues for grids. The German *Energiewende* has already added legal and administrative responsibilities to the work of the federal grid agency. Planning and siting as well as public participation in permitting procedures have been gaining more and more attention, and rightly so. Adding to this, there are examples in Germany where local communities are trying to regain control of the grid by buying (parts of) it back from private companies. This is might be considered a type of reverse innovation.

In the future, collective infrastructure systems will play an increasingly important role. The idea cannot be ruled out that we need to develop our sustainable infrastructure into a collective or common good. Then, grid access might mean a flat rate for its use and integrating it into a systemic infrastructure for sustainable patterns of production and consumption. This would offer ample room for new approaches to efficiency and redefining the notion of wellbeing.

100% is in reach

In the 1970s and -80s when people started engineering renewable energies, everything was small, and we said that small is beautiful. Innovation was driven by inventors and small-scale startups. Moral persuasion was key. In Germany, the feed-in tariff scheme advanced these solutions to the point that they not only successfully established a niche in the overall market, but eventually moved on to leave the niche behind.

In the present, innovation comes in different forms. Now, the industrialization process rolled the technical solutions out. This type may be addressed as "distributed innovation" and characterises any country's overall competitiveness. Germany's "made in Germany" is particularly bound to use those processes. Today we can say that 100% is beautiful.

First-generation wind turbines and photovoltaic appliances as well as concentrated solar power (CSP) are constantly being redesigned. And new technological appliances are being added, along with the trend toward electrifying devices of all kinds and increasing energy productivity. The sustainable building sector – for instance Germany's green building certificate "DGNB" – is opening new options for renewables and energy efficiency. Photovoltaics (PV) integrated into the façades of buildings and turning a building into a power plant are no longer the stuff of science fiction. Nor are other technologies along these lines.

Quantity matters. Due to the intermittent availability of wind and solar energy, installed capacity does not equate to full-time working capacity. Experts estimate that some 300 gigawatts of renewables must be installed by 2050 (installed capacity) in order to meet the 620 terawatt hours of electricity (working capacity) that we have available and are secured by a peak supply of some 80 GW today. One hundred percent fossil energy is different from 100% renewables if measured in installed capacity. Clearly, the elephant in the room is energy efficiency. More efficient demand may drastically save energy, provided this potential can be released. But nevertheless, industrializing (developing and scaling up) of storage facilities, smart grid architectures, and backup fossil residual power capacities must be put on the balance sheet. Nevertheless, the interrelation of supply and demand is a key question. Precisely, the question of how quantity of supply relates to nature of demand (consumption-

wise, market-wise, efficiency-wise, and investment-wise) - and vice versa - is one of the most exciting questions.

Turning costs into earnings

The real answer to whether 100% renewables are "affordable" lies "beyond affordability," which means beyond what we call affordability today. More often than not, energy markets are regulated markets, and these regulations are designed to ensure their functionality. The "rethinking the future of energies" is not only about technology or supply and demand, but also about the rethinking of markets and cost-benefit relationships.

Communicating (large) figures about the assumed costs of the German *Energiewende* is one-sided communication that produces misunderstandings. In the past, no major energy system was "affordable" in the sense of the economic standards that renewables are held to today. No major energy system could have initially been introduced exclusively as a business case. And no energy system has relied (and will rely in the future) exclusively on subsidies. That much is obvious. To assess the competitiveness of renewables, it is important to reconsider some basic trends:

- Compared to fossils and nuclear, the renewables are different, economy-wise. They do not produce running costs, at least not to any significant degree. The "energy-only" market with its merit order calculation scheme seems artificial. How the energy market functions when it is dominated by renewables with no running costs? How additional costs for residual fossils are being realized? Both are still open issues.
- The past liberalization of the European internal market has resulted in a general underinvestment in energy infrastructure that is still a burden today.
- The German taxpayer has subsidized the success of renewables in Germany, and to a significant extent globally as well. This has brought PV costs down from more than 50 €Ct/Kwh in the early 1980s to (possibly) less than 10 €Ct today. This mechanism alone is a unique example of how a forerunner can industrialize an innovation – in order to facilitate access to modern technologies for all. The federal stock exchange is offering electricity futures for 2015 for around 4 €Ct.
- The renewables surcharge is rising. In 2014, a four-person household can expect a bill of € 371 on average. This raises social concerns about equity, a just balance of burdens, and growing energy poverty.
- Certain businesses are exempted from paying the full feed-in tariff, mainly energy intensive and globalized enterprises. This has fueled public debate and concerns in Germany about copycat misuse, and the EU Commission has voiced concerns about excess subsidies. But the exemption has a point. The transition of a highly industrialized country such as Germany needs to maintain high standards of industrialization. All companies in Germany are on an equal footing. They can (and do) either pass on extra costs to their customers in Germany or apply for exemption if this is not possible. We must nonetheless concede that distorting effects and annoying examples of corporate misuse should be avoided.
- The feed-in tariff mechanism has appropriately established the renewables industries. However, we now need adjusted approaches. Adjustment means to allow for systemic links that can take into account what the electricity is used for and when. It is mandatory for the future to allow for renewables generation capacities to provide

system-integrated power accounting also for the shrinking, but still needed residual fossil quantum of electricity.

The overall question is what kind of market design matches the requirements of a mature renewables sector. The (old) merit order system does probably not. It even shows distorting effects. These days, it even drives modern low-carbon fossil power generation (and co-generation of heat and electricity) out of the market. Utilities are forced to keep old (and therefore cheaply producing "cash-cow"-type but carbon intensive) fossil power plants running 24/7.

"Affordability" is a moving target. The task at hand is to change the market framework in a way that the renewables can fully mimic the benefits of disruptive technologies. Low-carbon options and high-efficiency power plants should be strengthened for generating the residual load.

Broadening the perspective: Culture

Transitioning is a political and cultural challenge, rather than a technical and economic one. Technological alternatives are mandatory to allow for political choices. That is why research strategies, innovation and innovative rollouts are key. But when it comes to the stage where things have to be put in action and action has to change gear the cultural character becomes obvious. It is built into the politics of change, the notion of technological feasibility or engineering excellence as well as the approaches to costs and benefits.

The *Energiewende* in Germany involves a process of a forced phasing out of nuclear power while still meeting climate policy goals, maintaining the competitiveness of German industry, and balancing the social factor. This is a complex challenge. Aside from often debated technical and economic components other elements also add to this complexity. These have a background in culture / political culture such as consensus building, nexus to lifestyle for sustainability, local communities, participation in decision making processes and access to markets.

Experience is being gained first hand and involves opportunities and related risks. We have to learn while making mistakes. There is a rich German debate on the transition trajectories. It is equally important that this debate take views from the international arena into consideration. Peer expertise is key in this respect, and that is why, on invitation of the German Chancellery, eminent experts prepared the peer review report titled "Sustainability – Made in Germany," which was released in September 2013[3].

So far, the *Energiewende* has been successful. The share of renewable energies is rising, the grid is stable, and Germany does not rely on imported nuclear or fossil electricity. Of course, there are some unintended side effects and some substantial issues. The *Energiewende* is not a bank. "Too big to fail" is not an option, nor is failure.

But the domestic agenda is challenging. The dynamics of pricing needs to be tackled. Everyone must be able to benefit from low stock exchange prices. Temporarily increased

[3] http://www.nachhaltigkeitsrat.de/uploads/media/RNE_Peer_Review_Report_November_2009_03.pdf

carbon emissions must be reduced by addressing the constraints of the old market design. The success of renewables and their further increase require adjustments of the market design. Conflicts of interest regarding land use and biodiversity have to be dealt with more effectively. We also have to rethink the payment scheme for renewables. The payment scheme as it exists now with the core element being the renewables surcharge charged on the individual electricity bill cannot be continued all times, or be even expanded to cover additional costs. For the purpose of phasing-in renewables the feed-in tariff is a successful tool. Now the tool itself has to be phased into a new modality in order to match the requirements of a matured significance and to move on onto an energy mix with dominant renewables.

The purpose of industrializing innovation should better be served by public funds. This would replace parts of the renewables surcharge on the individual bill. Those payments are an advance provision of a future infrastructure. The change in payment modalities would foster intergenerational justice and underline the character of the *Energiewende* as a collective endeavor for the benefit of all. It would not only rearrange the coverage of costs that would otherwise be left unchanged. It would make a difference in terms of overall costs, the subsidy debate, the consensus, and the cost-benefit ratio. This political innovation might be a part in the disparately needed package formed by a reform of the feed-in tariff, the market design including subsidiary capacity mechanisms, and the climate mitigation instruments.

Attitudes of leadership are also important. It seems fair to say that the “David-style” fight of the supporters of renewables against what is often perceived as fossil-nuclear “Goliath-style” utilities still holds true in a large number of cases. With the growing significance of renewables, however, we have to overcome confrontational interaction and develop cooperative skills.

I thank you for your attention.

Prof. Dr. Günther Bachmann
Secretary General of the German Council for Sustainable Development
www.nachhaltigkeitsrat.de
guenther.bachmann@nachhaltigkeitsrat.de

This is the full version of a speech given on March 4, 2014 at the ESMAP meeting. It was edited by SocioTrans, Stephan Elkins.