# Innovations in the Power Sector -

# Disruptive Change and Evolution of Institutional Arrangements in Mature Systems

**Discussion paper**, Draft version 2, April 10, 2016

*Objective and Structure of the paper: This document is meant to initiate and inform the discussion on the implications of current and upcoming profound power sector changes for developing economies and the role of International cooperation. It points out the various innovations, the profound changes and transformations of the power sector en course in some first mover countries with mature power sectors, systemizing the different drivers and responses as well the compound impact and institutional adaptations and changes . On this basis it offers a framework and some ideas for the discussion on institutional arrangements and dynamics in the power sectors in developing countries, given their priorities and in response to the technical, business and regulatory innovations. In order to make the case for a wider scope and involvement of the international cooperation*

Mandate, Authors and Acknowledgements: This discussion paper was commissioned by and further developed in the framework of the Energy Sector Program 'Technology Cooperation', which is financed by the German Federal Ministry of Economic Cooperation and Development (BMZ) and implemented by Deutsche Gesellschaft für Technische Zusammenarbeit und Entwicklung (GIZ) GmbH. This version is based on various earlier versions drafted by retired GIZ-staff Paul H. Suding, accompanied over the year by Klas Heising, Frank Seidel and Thomas Elmar Schuppe, Wolfgang Frohberg and Jens Burgtorf of the Technology-Cooperation program commissioned to GIZ. It has profited from contributions and debates by GIZ colleagues and partners in various conferences and workshops, and in particular from comments by GIZ colleagues including Michael Franz, Christopher Gross and Michael Koeberlein, as well as experts Ole Langniss (Dr. Langniss E&A), Kilian Reiche (iiDevelopment) and Hans Helmut Forsbach (ETA-Energie) .

**Introduction and Overview**

Since a couple of years, new actors and new modes of operation, driven by technology and business innovations and policies are increasingly entering the power sector, pivoting in industrialized countries. These innovations challenge the customary hierarchies, reverting energy flows and imposing new operational modes and provoke new business models. This has profound consequences for the institutional arrangements. The diagnosis of the sector characteristics on which the current institutional paradigm was based and introduced over the last 30 years may not be valid any more. In some countries, where changes are already profound, regulators and policy makers react with modifying regulatory rules and power market design, enhancing or reforming the reform.

While these changes widen and encompass more countries, the institutional reform based on the paradigms of the 1990s is still pursued in many countries. In view of the current revisions of regulations and organizations in some first mover countries, it seems high time, that ongoing reform of sector concepts and plans are revisited and possibly modified.

In consequence, international cooperation, in particular German Development Assistance is well advised to assess the consequences of the ongoing changes in the power sector for its energy sector strategies which are closely related to environment and climate matters.

The work is divided in two parts. The present first paper is supposed to inform and provide a glance over

- Drivers and impacts of various innovations with disruptive potential leading to profound changes <u>in mature power sectors of industrialized countries, and</u>
- Institutional rearrangements in these countries in response to profound changes.
- Occurrence and strength of the drivers and indications of change in <u>developing countries' power sectors .</u>
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In the upcoming second paper the drivers and strength of the various innovations and related issues and the challenges are discussed, including a rapid assessment of countries likely to be concerned. In order to reduce complexity, the status, the discussion is separated and addressing three parts of the power systems: the bulk power stage, the distribution/customer (retail) stage of integrated grids as well as the on-grid and off-grid electricity access area. Being a first attempt the paper is meant to setting a possible framework for further discussion on the matter rather than giving answers to the many issues involved in the wide variance of developing countries' systems. It is, however also supposed to be an appraisal of the relevance of the matter and to give orientation for future development cooperation in the energy sector.

1. **Innovations and change in mature power sectors: drivers and implications, impacts, consequences and responses**

In recent years various technological and related innovations[1] have occurred and proven disruptive for the customary ways of operations and business in the electricity sector. Acute changes are observed particularly in some industrialized countries, which are first movers in particular with the policy drivers.

For the purpose of differentiated diagnosis, the innovations can be categorized in three groups: (i) variable Renewable Energy (vRE) power, (ii) distributed generation and (iii) Information and Communication Technologies – ICT, although in many places (i) and (ii) widely overlap. One could consider a forth category for storage technologies, which have not had a comparable impact yet, but may have it in the future.

The innovations are fueled by business opportunities in new technologies and services, and promoted by various policies responding to challenges related to climate change mitigation and energy security and other objectives. This signifies very strong coalition of underlying interest in policy and new businesses driving the changes, against a weakened resistance from incumbents.

The cumulated implications of these changes lead to a whole new concept of the power sector's operation in countries, where the innovations are advanced. In several countries and States, the traditional dispatching an one-directional flow from a limited number of central generators to consumers covering a predictable load has become the electricity sector's operation mode of the past. There, the task becomes managing a multidirectional flow of electricity and matching demand and supply from a vast number of large and small, dispachable and non-dispatchable sources which are distributed all over the system. In addition, consumers begin to see benefits in actively being involved in demand-side-management and self-generation, which renders load even more fluctuating.

The cumulative implications of these changes imply economic opportunities for new business models and by consequence fundamental changes (disruptions) in traditional centrally focused utility business models. As is already witnessed in some places, institutional adjustments are required and will come on the agenda in many more countries..

Even if the innovations are technically universal, not all of the changes , however, happen cumulatively in the same way and at the same time in different countries. Some countries such as Germany and other EU countries, Australia, some States in the USA , are the first ones to be confronted with the implications.

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[1] In order to embrace all the interrelated recent development which lead to the profound power sector transformation, we agree with the notion, that the term 'innovation' in this respect " is not limited to merely technology, but applies widely across market design, planning, operation, institutional coordination, finance, business models, and stakeholder engagement." A recent Status Report on Power System Transformation by A 21st Century Power Partnership lists 11 innovation domains: see: Miller Mackay et al. Status Report on Power System Transformation, Technical Report, NREL/TP-6A20-63366, May 2015, https://cleanenergysolutions.org/resources/status-report-power-system-transformation

### 1.1 A closer look to individual changes and responses

With the intention to draw lessons from these cases for other countries, where only some of such changes or specific combinations occur yet, it may be more instructive to first look at individual innovations and changes, which require more specific responses in the particular framework, and then look at the consequences for the overall institutional change. Thus, instead of conceiving the changes as one huge complex revolution[2] of the power sector, we try as far as possible to distinguish the groups and individual traits of innovations even if they interrelate and in some power systems happen at the same time.

#### 1.1.1 The **rise of variable renewable energy (vRE) in generation** (i)

The fast growth of vRE (wind and solar power as well as run-of-river hydro power) imposes challenges with regard to the system integration and transformation of the electricity system:

- Increasing vRE capacities' operations force successive adjustments in the operation of all other generating units in an interconnected system. Once significant ( say at 10% wind or 20% solar) and further growing vRE shares being available and obtaining assured dispatch, whether privileged by law or based on short term cost competitiveness in the electricity market, the customary base-load operation is losing more and more space and relevance. Between varying demand load and vRE generation ever less residual load remains to be covered by conventional power stations. Also, the residual load is widely fluctuating, which makes secure and stable supply a much more sophisticated task. In the short to medium run unfitting (i.e. inflexible) existing plants may still be operated but yield too little income to recover their capital cost because of lower load factor and prices due to oversupply and low operating cost of competing RE power.

  Short to medium term responses in competitively organized power generation systems include further differentiation of products in the wholesale markets (e.g. day-ahead and intraday markets down to hours or quarters in power exchange), modifications in the ancillary services', regulations or markets including operating reserve and reactive power, price differentiation according to wholesale market situations also in the retail markets, and other measures to manage demand, as well as the increase of cross-border power exchange etc.

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[2] Strong terms including 'revolution' are frequently used to characterize the profoundness and disruption , in particular by consulting companies, which tend to promote the disruptiveness of the combined changes and the newness of the challenges in particular for the business models of the incumbent large power corporations. See McKinsey for EU und US utilities http://www.mckinsey.com/client_service/electric_power_and_natural_gas/latest_thinking; Ernst & Young worldwide http://www.ey.com/Publication/vwLUAssets/EY-utilities-unbundled-issue-20/$FILE/EY-utilities-unbundled-issue-20.pdf. PWC , The road ahead - Gaining momentum from energy transformation, and other publications http://www.pwc.com/gx/en/industries/energy-utilities-mining/power-utilities.html and Accenture, How Digitally-Enabled-Grid-Utilities-Survive-Energy-Demand-Disruption.pdf https://www.accenture.com/t20150523T024232__w__/nl-en/_acnmedia/Accenture/Conversion-Assets/DotCom/Documents/Global/PDF/Dualpub_14/Accenture-Digitally-Enabled-Grid-Utilities-Survive-Energy-Demand-Disruption.pdf

In the long run, a much more flexible system in order to balance supply and demand incl. storage, new smart electricity applications etc. is required to match the increasingly volatile residual load, which may at times of high vRE generation fall to zero or even become negative.

- In addition to the abovementioned modifications, responses in industrialized countries include paid capacity reserve regulations (in Germany ) or capacity markets in some European countries and some U.S. states). However, these regulatory provisions to ensure adequate capacity are only partly evoked by the rise of vRE.
- New regional concentration of renewable energy generation capacities due to different geospatial availability of RE-resources was not anticipated in existing grid configuration and requires significant restructuring and/or extension of the transmission and distribution grid and operations. Once a substantial RE generation capacity is erected in a specific high resource area (e.g. of wind power in the US Midwest or in the North Sea area in Europe) not only the evacuation to the grid (in case of wind often medium voltage part of distribution) but also the high voltage transmission to consumption centers is often impeded by missing or overload network capacities. Congestion occurs and the RE generation assets cannot be used to full benefit. Apart from constructive additions to the transmission grid and coupling to adjacent systems and the allocation of charges, institutional response may include zoning and incentivize prioritization of new (less productive) generation closer to consumption centers or to optimize given transmission capacity.

### 1.1.2 **Decentralized or distributed generation on consumer level** (ii)

Generation on consumer level in addition to utility size generation has grown very rapidly in some places not only on the basis of variable renewables like solar but also on the basis of combined heat and power (CHP), and attracted more attention to the downstream distribution sector and consumer side of the electricity systems.

- In electricity systems where a rise of decentralized generation is based on privileged **feed-in rights and tariffs (FiT),** many commercial and residential consumers have become producers and suppliers to the grid while remaining at the same time consumers, metered and remunerated under separate contracts. The FIT typically encourages the small investor to install as much capacity as possible whose operations temporarily invert the electricity flow in the distribution network. In some cases partial curtailments of distributed generation may technically not be avoidable or economically preferable, even when financial compensation is provided. This motivates or even requires technical changes towards a more flexible grid, but also rules to optimize distribution operations.
- Where **self-consumption promotion is implemented** instead of feed-in to increase decentralized generation, often with some kind of **net-metering** as measure of choice, the consequences for the grids and supply are more complex. Net-metering has allowed the 'rise of the **prosumer**', i.e. the metamorphosis of the mere electricity consumer to an actor commanding various options of drawing power from or feeding power into the grid. In terms of electron flow in the distribution grid, this may not be much different from the feed-in in principle as described in the previous paragraph. But the incentives

for the prosumer are different and the investment and operation decisions will be different accordingly. This will confront the distribution system operator (DSO) with a different demand load curve and some unusual distributed net feed-in patterns. In case of high penetration in particular of solar PV the distribution operator is faced with lower demand during sunshine hours and a steep load increase at twilight towards the evening peak (e.g. the much publicized Californian duck curve). Obviously the value of this kind of PV generated power falls with increasing capacity. This may call for modification of the net-metering rules and specification (of periods and amounts) of credits for feed-in of excessive energy. In addition, the unified metering given a consumption-based remuneration of grid-services causes the distributor losing income, which may require an increase of network service tariff, which in turn will hurt consumers who do not have the option of self-generation. The loss of revenue (for the utility) issue may be taken care of by introducing flat or capacity network rates or adequate Time-of-Use tariffs. However, intermittent load variation and defection spreading from a local to a widespread issue calls for new technical solutions including storage and new electricity applications as well as demand side management. Many countries currently revise their RE self-consumption policies and grid fees in order to better tune the impact with an optimal grid and load management, provide incentives for storage and other flexibility options, and better balance of grid services and their remuneration to avoid bringing (often already cash-strapped) DSOs into dire financial straits.

- With **rapidly falling cost of solar energy**, however, similar issues are expected to also occur increasingly where neither net-metering nor feed-in tariffs are offered. Where **electricity end user tariffs are high**, consumers also turn to self-generation in a way that they physically use less energy from the grid and furthermore provide security against load shedding or supply instabilities. Similarly, small prosumers may prefer self-consumption even when feed-in tariffs are offered, when end-user tariffs are substantially higher than feed-in tariffs.
- Prosumers may also start to use the <u>electricity for other purposes</u> including charging car batteries or for heating requirements. This causes similar issues for the distribution system and poses the question of how an economical distribution system should look like and which institutional framework including pricing it should have.
- <u>New groups of agents</u> have entered the system in the downstream part seizing new business opportunities.
    - New **suppliers** have sales access to competitive <u>retail markets</u> in order to stimulate competition to the utilities and use their purchase access to the wholesale market.
    - There are now **aggregators** of small generating capacity which participate in the wholesale market and <u>offer energy</u> at the power exchange where applicable as well as ancillary services to DSOs.
    - Similar to municipal utilities , which <u>offer supply flexibility</u> from Combined Heat and Power (CHP) facilities, flexibility is also offered as a service by aggregators of small CHP and storage.
    - Small producers and flexible consumers are getting organized by aggregators to <u>virtual power stations</u> selling flexibility to distribution system operators or via IT platforms, provided that prices are sufficient.

- Communities of consumers and self-generators form micro- and mini-grids, small local networks based on third party distributed generation or mutual exchange of energy, and even further interconnected to cellular grids.
- Further numerous smaller service businesses have been created independently or within existing utilities or DSO's, including the renting of PV installations, brokering in distributed generations.

### 1.1.3 Digitalization (iii)

**The application of Information and Communication Technologies (ICT) or** in the electricity sector, known principally under term 'smart energy' or 'smart grid' should be distinguished from the above-mentioned changes. It is, however, also a facilitator and base of these changes and will be part of the responses to the challenges. The ICT industry is very much involved in the following changes:

- There is a strong movement to apply ICT thoroughly in the electricity sector, labeled smart grid, independently of renewables and distributed generation, since it allows more rapid and efficient actions on all levels of operations, their coordination within a propriety system of one actor (TSO, DSO or other) as well as better interaction between the sector actors (trading or other) and levels as well as interaction with consumers (in particular prosumers). Thus, the smart grid development by itself requires already regulation in form of ICT standards , so the stakeholders may communicate on the basis of a common standard on each level, but also interoperability of the different levels of the system.
- There are specific applications of ICT in the operations of the electricity consumers, which among others allow automatization of processes, remote control etc.. The terms **smart home, smart services, and 'industry 4.0'** refers to this digitalization, which also modifies electricity services and consumption. These developments are rather subjects of other regulations than in the power sector, although utilities are increasingly participating in view of the impact this may have on demand profiles and management.
- A key innovation is the ICT application in the communication between electricity consumers and suppliers (**smart meter**). This may be much more than a metering device for billing, when it collects and transmits much more data, when it provides price or other scarcity signals, and when it even allows for remote control (by supplier or aggregator or DSO) of consumer appliances, heating and cooling equipment, generation equipment of prosumers etc. This technology might act as catalyst for the optimization processes of the whole energy system incl. grid and ancillary service operation and as such the enabler for the widespread use of distributed generation with numerous prosumers acting as consumer, producer and stabilizer at the same time, which requires smart regulation and (market based) incentive schemes as well. This part of digitalization requires not only technical standards to assure a wide market of interchangeable equipment, but also norms to avoid restraint of competition between power suppliers as to assure access in the new local power markets. Protection of personal data must be strictly assured against use of data management and analysis,

since the meter may be able to establish a profile of the client which is highly valuable for marketing purposes or even for government surveillance.

- Another important ICT application is the short and medium term forecasting based on big data by generators, suppliers and grid operators. With more and more computing power and big data availability, consumption, production, weather and other data sets are being analyzed to prepare decisions on daily business operations, marketing as well as future (grid etc.) investments. Respective modeling and scenario forecasting becomes a product that utilities use, and a respective service business is evolving fast.

In this incomplete *tour d'horizon* of current multiple changes, we have already seen many specific responses to individual issues.[3] And further innovations are still coming. **Storage technology, jointly with increased cross-sectorial integration with thermal and transportation sectors** may become **a forth category of change.** Jointly, they will continue to modify the competitive positions of generation, grid and consumption technologies. The interaction of these changes, however, not only provokes specific adjustments, but leads to a profound transformation of the power sector, which is already forcing incumbent utilities down or to reinvent their business model drastically. It also requires and has already triggered reviews of the institutional arrangements.

## 1.2 **Institutional change in electricity sectors in response to profound transformation**

The changes delineated above happen to occur most pronouncedly in high income countries with seemingly 'mature' electricity sectors, namely Germany and other European countries, Australia and the US, where some States and Interconnected Systems are more concerned than others. In these systems, which before seemed to be 'settled', the interaction of innovations has disrupted the status and are pushing transformations.

### 1.2.1 Status of mature systems which are experiencing the change

'Maturity' is understood in various ways. In terms of market volume, electricity consumption was in tehse mature systems, not growing substantially, and demand for energy services in industry, commerce, services and households which principally and customarily are provided by applying electricity was stagnating, i.e. disregarding the new applications such as e-mobility. This customary demand was covered to a high degree of sufficiency and in good quality. The cost of the electricity supply was largely covered by receipts from sales, i.e. by pricing and enforcing payment. This apparent equilibrium does not mean, that no subsidies to supply or demand existed in these systems, nor that all social cost was internalized. Cross-subsidies in pricing to different consumer groups were common. However, there were little subsidies to support a deficit in operations.

[3] For an overview of the landscape of changes and a different way to present them, see Miller, M., Martinot, E. et al., Status Report on Power System Transformation A 21st Century Power Partnership Report, Technical Report, NREL/TP-6A20-63366, May 2015, http://www.nrel.gov/docs/fy15osti/63366.pdf

In terms of institutional arrangements[4], the concerned power sectors seemed 'settled', after a period of restructuring and reform, during which a market oriented paradigm was implemented which had emerged in the 1980s as an alternative to the prevalent regulated private owned monopolies or state owned enterprises, with the "objective to increase efficiency, reduce costs, and improve quality of service". [5] To different degree and form, they had put into practice what was considered the 'textbook model'[6]:

- Vertical separation of competitive (generation, marketing and retail supply) and regulated monopoly distribution, transmission, system operation) segments.
- Horizontal restructuring to create an adequate number of competing generators and suppliers.
- Horizontal integration of transmission and network operations to create an independent system operator (ISO) to maintain network stability and facilitate competition.
- Creation of voluntary markets and trading arrangements for wholesale energy as well as ancillary services, including balancing of the system.
- Application of regulatory rules to assure access to the transmission network and incentivize efficient location and interconnection of new generation facilities.
- Unbundling of retail tariffs and rules to enable access to the distribution networks in order to promote competition at the retail level.
- Arrangement for supplying retail customers including benchmarks for charges for power derived from wholesale markets also when power is generated by local suppliers.
- Creation of independent regulatory agencies with duties to implement incentive regulation and promote competition.
- Privatization to enhance performance and reduce the ability of the state to use the enterprises to pursue political agendas.

Some of these electricity sectors had also some other recently created rules to follow which also constitute part of the institutional arrangements.

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[4] In this paper, the term 'institution' is used basically in the sense of rules, which constitute the regulatory framework, following the meaning coined by Douglas North: "Institutions are the rules, organizations are the players", which allows to better distinguish institutions and organizations, see: North, D. C. , Institutions, Institutional Change and Economic Performance. Cambridge University Press, Cambridge 1990. This concept is further developed in the New Institutional Economics and is somewhat narrower than the sociologists' sense of institutions as 'structures or mechanisms of social order which they govern the behavior of a set of individuals in a community'.

[5] For an inventory of power sector reforms before the new disruptive developments, see Sioshansi, F.P., Pfaffenberger, W., Electricity Market Reform - An International Perspective, Elsevier Global Energy Policy and Economics Series, 2006, http://www.sciencedirect.com/science/book/9780080450308; and for an updated account see Sioshansi, F.P., Evolution of Global Electricity Markets, New paradigms, new challenges, new approaches, 1st Edition, Academic Press2013, http://store.elsevier.com/Evolution-of-Global-Electricity-Markets/Fereidoon-Sioshansi/isbn-9780123979063/ The quote is from the Foreword: The Market versus Regulation, by St.Littlechild, in this book.

[6] This 'textbook model' is enumerated by Littelchild, S. The Market versus Regulation, as well as Joskow, P.L., Introduction to Electricity Sector Liberalization,: Lessons learned from Cross-Country Studies, both in Sioshansi, F.P, Paffenberger, W. op.cit.

- The organization of a carbon market triggered by emission allowances also for power generation and the organization of trading the defined units of allowances (cap-and-trade system) is an important element of the institutional set-up in the EU.
- Some of the RE promotion policies, which are among the most forceful drivers of the changes, do have non-temporary character. Clearly, Feed-In Laws and RE-obligations like Renewable Portfolio Standards (RPS) with or without certificates (and certificate markets), competitive bidding or auctioning rules of the RE generation are part of the institutional framework. Similarly, specific rules for decentralized self-generation like net-metering are part of the institutional set-up. So are fiscal incentives like production tax credits.
- With respect to the ICT, the existing standards are part of the institutions.

#### 1.2.2 Revisions of institutional framework in response

With the above mentioned innovations, these recently reformed 'mature' power markets and regulations faced new challenges to ensure effectiveness as well as efficiency of the power supply, grid efficiency, supply security and reliability and sustainability, besides other objectives depending on the political priorities against the backdrop of longer-termed political perspectives such as mitigation of climate change. In order to make the changes work in an overall productive way, the new operation type and the rise of the *prosumer* and the establishment of local sub-grids require a revision of the institutional framework including eventually new organizations, in particular of the market design and regulation regarding the downstream part.

These revisions are pushed by various stake-holders who would gain from changes – this includes Information and Communication Technology (ICT) companies or prosumer organizations - or would cut losses, which applies for power utilities. Some important new players, including private capital and hedge fund financed companies are expected to enter the system in several and forceful ways with new business models, trying to take market volume from incumbent power corporations and cooperate or compete with small newcomers.

Currently, there are several industrialized countries which are considering and implementing institutional change as a response and consequence to some or all of the developments mentioned above. The institutional responses are somewhat different following the difference of approaches in vRE, decentralization and power market design. , with Germany, and :

- In the States of the US with net-metering, Renewable Portfolio Standards, Production Tax Credits and independent power system operators , California, some North-Western[7]

[7] In response to the challenge to manage the growing multiple and fast response options from smart homes, distributed generation and energy storage the concept of aggregating response was implemented in a pilot project in Pacific North West. The Bonneville Power Administration (BPA), a regional North-Western Federal power marketing agency and balancing authority has solicited for aggregated Demand Response resources as a pilot project. The proposal of Energy Northwest, a public power joint operating agency, was adopted and has started to operate in early 2015. It involves demand voltage reduction by distributers, fast industry demand reduction and a electricity storage facility and is governed by a so-called Demand Response Aggregated Control System (DRACS), which is hosted at the Pacific Northwest National Lab (PNNL), which is one of the key technical advisors in the new grid operation systems. See a recent presentation http://www.nwcouncil.org/media/7148937/2_en-dr-jas-2015_0225-pndrp.pdf

and some North-Eastern States, in particular New York[8], are at the forefront of discussing and piloting reforms. Also National Organizations have developed generic concepts, including the **transactive energy** concept.[9] In numerous US-States, the net-metering option for prosumers worked like an accelerant in disrupting the business model of utilities and the effective operation of the institutional framework. Jointly with other factors, the reduction of quantities of kWh accounted in the net-metered electricity bills has eroded distribution receipts of utilities without reducing distribution cost or even raising add cost. Utilities and regulators have modified the net metering rules and limited the credits for surplus fed back into the grid. But it has become obvious, that the challenges are multiple and more general and require fundamental institutional changes beyond mere tariff tweaking.

- Germanys power sector, protagonist for the feed-in approach and commercialization via power exchange, faces several issues ges:[10]
    - **'Flexibility'** is a mjor challenge: Variable RE sources have attained a high share in power supply and are set to grow further, based on the increasing cost competitiveness and ongoing political support. The creation and activation of flexibility options including demand side or load management, storage, and new power applications like e-mobility and so on require redressing the rules, removing obstacles and disincentives for actors, providing incentives and possibly create new submarkets of accessory flexibility services. This signifies a further functional unbundling.
    - Also in Germany, power companies are confronted with the loss of the viability of their business model based on central nuclear and fossil power generation, and are already struggling for survival and trying to save the day by **profound corporate restructuring** by now (namely by E.ON and RWE). However, their losses occur more in generation and marketing rather than on distribution level.
    - Due to the feed-in rules, distribution companies in particular in the rural and suburban areas absorb increasing quantities of distributed generation associated

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[8] New York State Department of Public Service, 14-M-0101: Reforming the Energy Vision (REV), About the Initiative http://www3.dps.ny.gov/W/PSCWeb.nsf/All/26BE8A93967E604785257CC40066B91A?OpenDocumenthttp://www3.dps.ny.gov/W/PSCWeb.nsf/a8333dcc1f8dfec0852579bf005600b1/26be8a93967e604785257cc40066b91a/$FILE/REV%20factsheet%208%2020%2014%20%282%29.pdf

[9] The *transactive energy* concept was developed by an Expert Group convened by US DoE; a key feature is the idea to make the value count in energy and accessory services transactions; the concept is presented in detail in GridWise Transactive Energy Framework Version 1.0 Prepared by The GridWise Architecture Council, January 2015 http://www.gridwiseac.org/pdfs/te_framework_report_pnnl-22946.pdf,
See also a critical analysis of applicability by the California Public Utilities Commission, Atamturk, N., Zafar, M., Transactive Energy: A Surreal Vision or a Necessary and Feasible Solution to Grid Problems? California Public Utilities Commission, Policy & Planning Division, October 2014; http://www.cpuc.ca.gov/NR/rdonlyres/F67634A7-4613-4CB0-BB00-C668CED4CEC1/0/PPDTransactiveEnergy_30Oct14.pdf;
Electric Power Research Institute (EPRI) , the research organization of the US utilities, has pronounced the ideas in "charting the course for the future power system" http://integratedgrid.epri.com/#sthash.EocRHeeR.dpufe

[10] The Green Paper of the Federal Ministry of Economic Affairs and Energy exposes the issues for the German power system which is integrating huge shares of variable renewable energy sources, much of which on the low voltage level, and proposes to create and exploit multiple flexibility options, as solution. Federal Ministry for Economic Affairs and Energy (BMWi), An Electricity Market for Germany's Energy Transition, Berlin October 2014; https://www.bmwi.de/BMWi/Redaktion/PDF/G/gruenbuch-gesamt-englisch,property=pdf,bereich=bmwi2012,sprache=de,rwb=true.pdf Weissbuch vom Juli 2015 http://www.bmwi.de/BMWi/Redaktion/PDF/Publikationen/weissbuch,property=pdf,bereich=bmwi2012,sprache=de,rwb=true.pdf

with increasing grid integration costs and load management. As long as the duality of feed-in of distributed generation and supply of consumed energy is maintained, they are not confronted with losses in income since consumers pay a distribution charge according to their level of consumption. Only recently, since new solar PV and other distributed generation cost have fallen below grid parity, the self-consumption from proprietary generation or micro-grid becomes competitive to feed-in conditions and the distributors as well as retailer's loose income. The struggle about participation of self-consumers in regulated grid fees is ongoing.
    - When the additional cost or premium from the Feed-In remuneration are apportioned to electricity consumers and become very significant like in case of Germany, these may become obstacles in the incentive structure and favor inefficient responses. Thus, such apportionment may need revision.

- Other places of discussion include the UK and Australia. In the UK, the regulation for the distribution function was already modified and a **performance based regulation** has replaced the cost-of-service based regulation.[11]
- With respect to long term supply security and uncertainty whether an energy only market (EOM) would ensure sufficient reserve, in particular with high vRE and variable residual load these and other OECD-countries are introducing **capacity markets or regulated capacity requirements.** Different from UK and France, Germany has recently opted against a large-scale capacity mechanism of any kind but adopted a regulated capacity reserve. The slow demand growth and the rapid increase of renewable energy capacities has provided some countries with an overcapacity, which makes the capacity issue less urgent, and rather poses the problem of stranded investment.

One principle idea for institutional power sector reform in these industrialized countries is that new types of transactions (of energy and ancillary services) should be guided by value of the service instead of cost. Thus, value-based pricing is discussed to replace the traditional cost-based optimization and regulation. This implies much more price-differentiation for consumption and feed-back to the grid, even corresponding to the market situation, and involving prosumers in the provision of ancillary services and flexibility. The practical proposals also include modifications in the existing markets for energy, in particular the spot market. The more significant proposals include creating new regional market places for energy and ancillary services, in which distribution companies may act as buyer of services from *prosumers* and other actors.[12] Another proposal implemented already in UK is the performance-based re-regulation of the grid services. All this is enabled by ICT applications (smart metering, intelligent grids) for which standards are required.

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[11] The Office of Gas and Electricity Markets (OFGEM) developed RIIO (Revenue=Incentives+ Innovation+Outputs), a performance based model for setting the network companies' price controls; for more details see ofgem, Price controls explained, Factsheet 117, March 2013; https://www.ofgem.gov.uk/network-regulation-%E2%80%93-riio-model

[12] Bundesverband Neue Energieanbieter proposes regional flexibility markets – bne: Decentralized Flexibility Market, Berlin 2015; http://www.bne-online.de/en/system/files/files/attachment/20150122_bne_De-Flex-Market.pdf; similarly, but restricted to ancillary (??) services (in German) Energietechnischen Gesellschaft im VDE (ETG); Regionale Flexibilitätsmärkte, VDE Frankfurt September 2014; (kostenpflichtige Studie)

As seen, the industrial countries or states most concerned with and responding to the profound changes are jurisdictions, where the power sector is largely liberalized.[13] The solutions discussed are either more unbundling of the unbundled systems, creating specific markets (for ancillary services e.g.) with market access and competition, or rather a revision of the regulation. The existing systems are not abandoned but rather built upon and adjusted, even splitting off more separate partial and local markets and distinguishing even more products.

Nonetheless, there are also considerations of revision of the underlying paradigm. The fragmentation may make it more difficult to coordinate scarcity signals from generation and grid into appropriate price signals to end-users or even to individual equipment[14] If the underlying market system gets over-challenged and ineffective due to rising complexity, which is difficult to manage even with advanced ITC systems, it may cause system instability when a swarm of actors reacts immediately to signals, invert the scarcity situation in part of the system which then reacts and sends out opposite signals.[15] Such complexity and the changing energy flow directions and operation mode on distribution level lead some experts to suggest re-integration and unified control of the distribution and transmission operations.[16] The decentralized generation, from consumer size and also from community or utility size wind- or solar parks fact, feeds mostly into the distribution grid which that way assumes a transmission function.

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[13] Actually, the matter has been picked up by several large consulting firms, who seem to believe, that the power companies will need a lot of advice in order to successfully face the new challenges. In Germany, E.ON has already made a profound change in corporate strategy, because of the and the disruption of the conventional business model based on central power stations and the opportunities she sees in the new power system. See E.ON: Empowering customers. Shaping markets., Pressekonferenz , 1. Dezember 2014, Präsentation. http://www.eon.com/content/dam/eon-com/Presse/141201_Strategy_Charts_PK_DE-final.pdf . RWE will follow soon.

[14] A disagreeing comment is notified from an IEA working group on smart grids doubts whether systems with increasing number of participants are appropriate to manage smart grid, see International Energy Agency, Technology Roadmap Smart Grids, OECD/IEA 2011, pp 17. www.iea.org/publications/freepublications/publication/smartgrids_roadmap.pdf

[15] See the abovementioned critical analysis by the California Public Utilities Commission, Atamturk, N., et al..

[16] E.g. Mark O'Malley, The Energy System of the Future, What does it look like ?, Presentation at the EWI/FAZ Energietagung 2015: Dezentrale Erzeugung, Cologne 03.11.2015, http://www.inform-you.de/Referentenbeitrag.aspx?search=&sv=&ab=&bis=&code=P9100127&id=704707