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Untapping flexibility in power systems

Workshop held in Rio de Janeiro discusses means to increase flexibility in power systems, focused on the Brazilian and German cases

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Untapping flexibility in power systems

The German Ministry for Economic Affairs and Energy (Bundesministerium für Wirtschaft und Energie – BMWi), the Brazilian Ministry of Mines and Energy (Ministério de Minas e Energia – MME) and the Brazilian Energy Research Office (Empresa de Pesquisa Energética – EPE), with the support of the German Agency for International Cooperation (Deutsche Gesellschaft für Internationale Zusammenarbeit – GIZ) organized the Workshop "Untapping Flexibility in Power Systems" in Rio de Janeiro, on October 6th 2017. The workshop was held on the premises of EPE under the German-Brazilian Energy Partnership as a first event in the newly-arranged "Working Group on Renewable Energy", with the objective of discussing how to deliver the operating flexibility needed in power systems to cope with growing shares of renewable energy sources (RES) – mostly wind and solar energy – in both countries.

Opening speeches were delivered by Mr. Luiz Augusto Barroso (CEO of EPE), Mr. Carlos Alexandre Pires (Director at the MME) and Mr. Ralf Christmann (Deputy Head of the Renewables Division at BMWi). Attendees included experts from relevant institutions in the Brazilian power sector, such as EPE, CCEE, CEPEL and ONS, from GIZ, international experts and a representative from the German Embassy, Mr. Christian Segnitz. Mr. Thiago Barral (Head of department of power generation projects at EPE) was leading the discussions.

The presentations started with a comprehensive overview of both the Brazilian and German power systems and the main drivers for the growing needs for operating flexibility in face of renewable penetration. A presentation on the innovative concept of "Virtual Power Plant", which makes use of technology to aggregate distributed resources and offer valuable services to the system (including demand-side management), in a competitive environment, closed the morning session. In the afternoon, presentations explored the "Flexibility Tracker", a scoring system that can work as a tool for assessing how certain systems stand regarding to flexibility, and the potential adjustments to market signals and regulatory arrangements. Both morning and afternoon sessions were followed by debates.

The main conclusions and findings of the workshop were

- Renewable energy sources (RES), especially wind and solar PV, are the main drivers for the increasing need for flexibility in power systems;
- There are diverse ways to enable or provide flexibility in an efficient and reliable way, including a more efficient use of existing assets, investment in new flexible generation; and transmission/distribution, aggregation of distributed resources (i.e. storage, demand response, etc.)
- The means to achieve a flexible electricity system require adaptation of market signals and arrangements and regulatory framework;
- With its hydropower plants and reservoirs, Brazil has relevant flexible supply resources that have been useful for enabling the penetration of RES;
- The expansion of transmission has a key role in the provision of flexibility, matching variable supply and demand over larger regions;
- The adoption of economic signals (wholesale market prices) with higher granularity is a prerequisite for efficient dispatch of flexible supply and demand;
- The German speakers provided innovative examples of how regulatory framework adaptation and market arrangements can help provide flexibility, such as Virtual Power Plants, interconnections, shorter trading intervals, negative electricity prices;
- Both countries will have to adopt different strategies towards the flexibility issue, but sharing experiences can be helpful. Planning studies with tools that capture the real needs of system operation, to be integrated with system planning, will be needed.

Below are the highlights and main findings by each of the speakers in the workshop.

1. Overview of situation in Brazilian system

Rafael Ferreira, Advisor to CEO (EPE)

Rafael Ferreira presented the historical evolution of demand and supply of flexibility in Brazil, where hydropower has been the main responsible for electricity supply and ancillary services, delivering the needed flexibility, thanks to the large reservoirs and a transmission system that interconnects most of the country.

More recently, some constraints have or are about to become increasingly relevant for the provision of flexibility:

- Social-environmental constraints to large hydro dams, especially in the last 10 years, changing the role of hydro in system expansion, mostly the penetration of hydro power plants with storage capacity;
- Distributed generation (mostly solar PV), which are expected to increase;
- Climate change adaptation: studies of impacts on supply/demand of electricity are of key importance; hydrology changes might affect flexibility supply; demand profiles might change as well;
- Wind is becoming a relevant energy source (already 8% of the electricity mix).

As a consequence, long-term (seasonal/supra-seasonal) flexibility is still needed, but short-term flexibility is foreseen as a necessary resource for tackling the ongoing transformation of the Brazilian energy system. In fact, demand for short-term flexibility is already a reality in some parts of the network and systemic needs shall rise in medium to long-term. Specific needs are yet to be quantified, but include short-term modulation (ramping), dealing with renewable generation surpluses, accommodation of fast-changing load flows in grid, etc.

Several pathways to untap short-term flexibility in Brazil are possible, encompassing wholesale market design, system operation, regulation and pricing, grid codes, natural gas & electricity sector interactions, amongst other. Regarding wholesale market design and system operation, flexibility could be boosted with finer temporal resolution in prices; establishing day-ahead, intra-day and real-time markets; development of demand response mechanisms; scheduling tools that better represent unit commitment and improvements in RE forecasting, just to mention some of the possibilities.

Finally, some of ongoing efforts in Brazil that are expected to contribute to untap flexibility were mentioned by Mr. Ferreira, including legal changes proposed to commit to the implementation of hourly prices (prices are currently defined on a weekly basis); an industrial demand-response pilot program; ongoing acquisition of new planning software/toolkit to represent the system's characteristics and works to increase the integration of gas and power systems.

2. Flexibility in the German electricity system

Katharina Grave (BMWi)

Katharina Grave explained the status of the German transition to low carbon energy sources, known as Energiewende, as well as the its economic effects, the advantages regarding climate policy and how security of supply has been addressed.

The potential for flexibility lies within supply, demand and storage technologies, and also depends on a good coupling of market and system/grid operation with proper economic signals. Interconnections with other European countries play a major role in the German power system and are also used as providers of system flexibility, especially those with countries that are natural providers of hydro production.

Renewables have become Germany's No. 1 source of electricity, challenging the system in times with low/high demand, but high/low RES production. The table below presents how flexibility can be relevant in the German system:

High RES / low demand	Low RES / high demand
Reduced thermal production	Flexible thermal production
Additional demand	Reduced or shifted demand
Storage (demand)	Storage (production)
Export	Import

The high variability of renewable energy production already requires flexible conventional power plants and other flexibility options to cover fluctuating residual load (energy not covered by renewables). The first conventional energy source to be replaced by renewables in the economic merit order of electricity generation is natural gas, followed by hard coal. Nuclear, lignite, hydro and biomass run steadily and are hardly flexible.

Natural gas contributes to ancillary services and therefore a small share of gas remains in the electricity mix even at days with a high share of renewables. Increasing shares of wind and solar energy in the power system not only reduce the need for conventional generation capacity, but also influence the required structure of the conventional power plant fleet. In a power system with a share of variable renewables of 40%, less conventional base load capacity and more peaking capacity is needed due to increased flexibility requirements.

Germany recently reformed its electricity market system to facilitate flexibility and adopted the following strategies:

- Free price formation in wholesale markets (no price caps);
- Strengthened obligations to uphold demand and supply schedules;
- Shortened trade and balancing periods (to 15 minutes);
- Introduction of negative electricity prices;
- Balancing markets opened to new providers;
- Rules for aggregators;
- Gradual introduction of smart meters;
- Investment combined heat and power production, due to its flexibility.

Also, Germany aims at improving grid connections between North and South to prevent shortages. Large shares of Germany's renewable generation capacities are situated in the North of Germany (where most wind blows), while the centers of (industrial) consumption are situated in the South and West of the country.

3. Which are the (new) technologies and mechanisms that can provide flexibility for the future evolution of the power system and in which time frames?

Xabier Alonso, Senior Analyst and Portfolio Manager (Next Kraftwerke)

Xabier Alonso began his presentation explaining the context in which Next Kraftwerke was created and the market niche their business fit in. The governmental decision to allow and regulate the aggregation of distinct agents (i.e. consumers, producers, prosumers, or a mix of those) to offer flexibility in the market was the trigger in making such business viable.

Next Kraftwerke works as a Virtual Power Plant (VPP), a network of decentralized, medium-scale power generating units such as Combined Heat and Power (CHP) units, wind and solar plants as well as flexible consumers and batteries. The VPP digitally aggregates the capacity of distributed units and smartly controls them, selling those distributed resources to help the grid operation and supply and demand to be met at all times, including trading in wholesale and balancing markets. The control and monitoring systems developed by Next Kraftwerke is fully automated and provide a standardized connection for a large range of different assets.

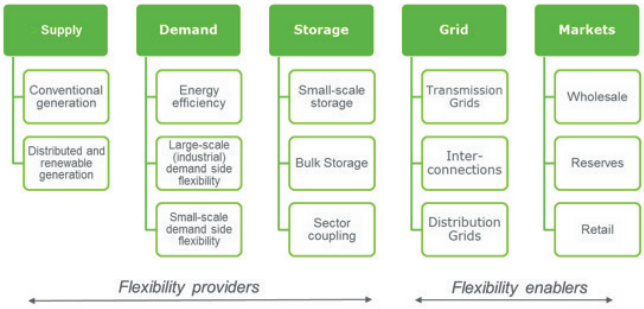
According to Mr. Alonso, demand for flexibility will continue to grow and no one "magical solution" is expected to appear – a mix of solutions will be needed to enable a 100% renewable matrix in a cost-effective way, which includes a portfolio of generation assets.

As for expectations for the future, renewables should continue to penetrate the market and two of the most relevant challenges are improvement of grid reliability and compatibility with high security standards. Additionally, energy markets will continue to develop shorter-term solutions, more trading and better forecasts. The number of players in the electricity market should increase, just like the relevance of digital utilities.

4. Flexibility tracker:

Progress towards high RES systems
Thobias Sach, Consultant for Energy Policies and Strategies (ECOFYS)

Thobias Sach presented a conceptual framework for a flexibility tracker with a top-down KPI (Key Performance Indicator) approach developed by the consultancy ECOFYS. The tracker aims at analyzing the readiness of a power system to renewable penetration in terms of flexibility. It is summarized below:



KPI is presented as a score from 1 to 5, describing lower and higher readiness (to RES). Higher score means: vast potential, substantial application, clear policy incentives,

concerted RD&D efforts, awareness/action and any combination thereof.

The methodology comprises standardized questions, response thresholds and weighting, followed by a refined outcome based on peer review and test applications. Mr. Sach brought examples of the application of the flexibility tracker to Germany, Denmark and Belgium, with a comparative analysis to highlight the main strengthens and weakness regarding flexibility issues in each of those countries.

According to Thobias, potential flexibility topics for Brazil are:

- Supply: Diversification of generation; Assessment and optimization of the intraday flexibility of hydro power plants;
- Demand: Assess the potential of demand side flexibility, e.g. in the industry as well as in load centers (smart meters in big cities);
- Storage: Home storage systems (+ rooftop PV) could be an option;
- Grids: Upgrading of distribution grids to smart (local) grids, supporting and relieving the transmission grid, especially in stressed times;
- Markets: Assess potential to increase liquidity of markets in a system with centralized dispatch; short-term market products.

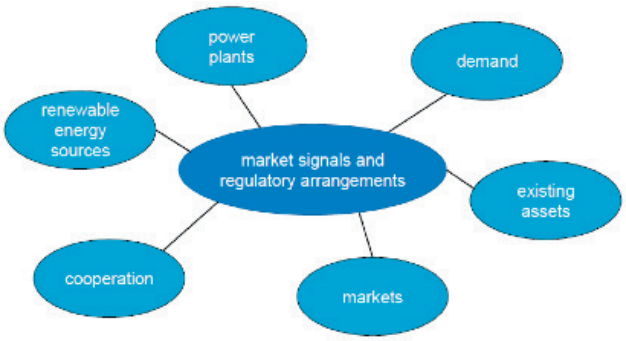
From the analyses shown, it is clear that more flexibility will be needed in the future worldwide. This is not just an operational planning aspect; instead it needs to be thought through to ensure that right incentives exist for market players to deploy flexibility solutions, so that the overall energy system is reliable and cost-effective. It is also clear that many studies address part of the issue (technology or timeframe based), but a holistic approach focusing on system planning is lacking so far. Mr. Sach argued that Flexibility Tracker methodology covers the full scope of flexibility and helps identify which areas (flexibility options) have progressed well and which ones should potentially be left aside. This approach establishes a focus to be pursued by energy planners and policy makers.

Finally, it was stated that not all countries will have the same flexibility approach, as systems differ from one another. However, some solutions could benefit from a coordinated approach and there are lessons to be learnt from distinct countries' experiences.

5. Which market signals and regulatory arrangements can be designed to foster system flexibility?

Tim Bongers, Researcher
(RWTH Aachen University)

In his presentation, Tim Bongers explored six main topics that are fundamental when it comes to market signals and regulatory arrangements to promote and enable flexibility in power systems, which are shown below:



It was highlighted that Germany has experienced a quick increase in renewables under the feed-in tariff regime, but without the necessary market competition. This scenario changed in 2017, with a new regulatory amendment, when an auction-based approach was introduced to foster more competition. This has delivered very competitive prices, both for onshore (wind and solar) and offshore (wind) resources. It was also interesting to notice that factoring transmission constraints in the generation auction was a key factor for success of the auction process.

Another aspect that has been studied is the gradient for future renewable energy supply and demand, taking into account the transformation in the electricity mix. In the analysis presented by Mr. Bongers, near future residual power demand should be covered by existing power plants, but long-term needs mean that flexibility will have to be fostered by regulatory measures.

On the demand side, the starting point is the contribution that all sectors (electricity, services/housing, industrial, traffic, agriculture/other) must give to the reduction in greenhouse gas emissions. Legal framework, as well as market signals and regulatory arrangements are necessary for effective coupling of sectors, in order not to shift problems from one sector into another. Additionally, Mr. Bongers mentioned the potential for demand side management as source of flexibility, especially

industrial and services/housing, each with distinct costs and characteristics.

Managing the existing assets was also mentioned as a field for regulatory and market signals to enable flexibility. A better utilization of assets, avoiding grid expansion, could be achieved with investments in automatic system management, installation of phase shifting transformers and different approaches for capacity calculation of interconnectors, just to mention a few, were described as possible measures that should be considered in the market and regulatory framework.

When talking about electricity market design, Mr. Bongers advocated for markets to be priced closer to the delivery of energy (smaller intervals), as well as the creation of new products to allow participation of new producers and consumers.

Finally, the value of European-scale system adequacy assessment was brought to discussion, explaining how countries could benefit from a regulatory framework that demands cooperation of system adequacy calculation.

Closing Remarks

Ralf Christmann (BWMi) highlighted the importance of experience exchange as a driver for tackling the flexibility provision problem, a challenge for every country facing high shares of fluctuating renewables in the electricity mix. Two topics were suggested for further cooperation: market design and policies, bearing in mind how the solutions presented here could be made possible.

Luiz Barroso (EPE) thanked the participants and highlighted that flexibility will be a very relevant topic to Brazil shortly, as EPE has highlighted in its planning studies for the Ministry of Energy. He also suggested that environmental issues, challenges for the development of transmission expansion (the easiest way to untap flexibility in Brazil) and electricity storage could be additional topics to be developed under the scope of the German-Brazilian Energy Partnership.

This report was prepared jointly by EPE and BMWi.

For comments and suggestions please contact comunicacao@epe.gov.br and giz-brasilien@giz.de