Web consultation – Flexibility Resources: summary of the received feedbacks

Feedback was received from the following experts:

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- Jan Segerstam – Empower
- Maja Božičević Vrhovčak – EIHP
- Emil Hillberg - RISE and ISGAN Annex 6
- Federico Silvestro - University of Genova
- Peter Nemcek – cyberGRID
- Tim Schittekatte - Florence School of Regulation
- Lucy Chatburn - Cleantech Group
- Evangelos Vrettos – Swissgrid
- Abhishek Ranjan - BSES Rajdhani Power Limited, New Delhi, India
- Fernando Morales – Highview Power

Question 1 - Which distributed flexibility resources and which of their characteristics should be considered in TSO/DSO grid planning process for the future?

Summary of received feedbacks:

All available resources should be considered as **flexibility options**:

- Demand Response (DR): in principle commercial and industrial, and in a later stage also residential. Heating/cooling equipment/loads: such as heat pumps and other loads with thermal inertia.
- Energy storage: in various forms, such as Battery Energy Storage Systems (BESS). BESS seems to be the most likely option. In addition, batteries can provide higher independence from the network to face emergencies. It could be grid scale and distributed (in front of or behind the meter).
- Power to X (indirect storage): connected to the use of Renewable Energy Sources (RES), these technologies can provide sector coupling and multimodal flexibility (including, for example, gas, heat and electricity systems).
- E-mobility: Electric Vehicles (EV) linked to smart charging. The potential of vehicle to grid (V2G) strategies should come with an assessment of the infrastructure available to allow vehicles to be connected to the grid for as long as possible (the vehicle per V2G charging point ratio should be close to 1, while today it is 10-15 approx.).
- Distributed Generation (DG): RES (mostly PV), Combined Heat and Power (CHP) and back-up diesel generators. At residential level, the household ability to finance micro-generation investments it is a key point (hard to see now in the post-COVID recession framework). DG plus storage increases the flexibility of the system.
- Grid scale RES: PV, wind... Dispatchable solar energy should increase.

Some of the **characteristics** of flexibility resources that should be considered are the following:

- Power and energy capacity: energy storage plants differ to other conventional assets due to the presence of both power and energy constraints and their dependence on the State of Charge (SOC).
- Availability.
- Ramp-up and ramp-down rates.
- Minimum downtime and uptime.
- Roundtrip efficiency.
- Visibility and controllability of behind the meter (BTM) systems, EV chargers, PV inverters… by the DSO.
    - Active and reactive control capacity of RES plants, e.g. photovoltaics (PV), to support voltage and capacity.
    - Smart charging capacity of EVs.
- Thermal inertia of loads (heating/cooling).
- Long term vs. short term procurement: because their future state at a certain time might be uncertain, some resources can only fully commit a power output near real time. Long term commitment, well ahead the dispatching time, provides advantages in terms of investment and grid security, but it can lead to lower competition levels. By contrast, short-term procurement, short time before dispatching, can allow for more competition but uncertainty.
- Lead time.
- Type of energy generation of storage systems: it could be synchronous, non-synchronous grid following or non-synchronous grid forming.
- From a grid planning perspective, modelling the specific dynamics of these technologies is not relevant.

The above characteristics are better captured for large aggregations of flexible resources rather than for individual devices. One of the responses highlights the importance of the aggregation of several flexibility resources (RES, DR, storage). Aggregation will be less precise in delivery but will always provide a minimum level of energy production (if one resource fails there always be other active). An example of combination of elements is proposed by joining energy production (RES) with industrial loads and storage to create virtual local ecosystems with a higher independence from the grid.

Critical analysis:

All flexibility resources should be considered in planning, including demand (industrial, commercial and residential loads, e-mobility), storage (different technologies and both behind the meter and in front of the meter) and generation (distributed and grid scale RES).
Regarding their characteristics, technical aspects are mainly mentioned. Aggregation is highlighted as important, instead of focusing at individual device level and that for planning to model the dynamics of these technologies is not relevant.
In FlexPlan most of the aspects mentioned have been considered. One issue that has not been specifically considered is the direct control of distributed generation plants by the DSO, even if this could be treated from the demand flexibility perspective.

Question 2 - Which will be the role of flexibility resources in power system operation in 2030/2040/2050? Which will be the main applications where flexible resources can be used in the power system?

Summary of received feedbacks:

Just like today, flexibility resources will be used to match supply and demand but, with increasing variable RES production, the flexibility must increase. The balance will need to be ensured at different levels (distribution and transmission) and the current energy markets will need to evolve to accommodate an increased demand for (and value of) flexibility.

Regarding the **role of flexibility** resources in future power systems, the following have been mentioned in the responses:

- TSO ancillary services (balancing and congestion): preventing overloading of infrastructure, peak shaving for investment deferral (avoiding network investments that are only useful for a few hours a year).
- DSO ancillary services (congestion and voltage): peak shaving for investment deferral. Solving local issues as alternative to fit and forget.
- Frequency stability support because of the decrease in the number of synchronous generators connected to the system (decrease of inertia) and, in general, ensuring system stability and operability: inertia, dynamic voltage control, short circuit level and rotor angle stability.
- Wholesale markets (intraday and Day-ahead market).
- Community or Balance Responsible Party (BRP) electricity supply portfolio optimization.
- Behind the meter optimization/balancing (prosumer use case).
- Adequacy: some storage resources could solve seasonal adequacy issues which will be more frequent in the next decades, contracted load-shedding upon request…
- Black start support.
- Cross sectoral integration: use of storage to integrate different energy vectors.
- Redispatch: to eliminate overloads.
- Meeting climate goals.

Looking at the different time horizons, 2030/2040/2050, some **previsions for the future** are presented:

- 2030: security of supply (through capacity and flexibility markets) and energy sufficiency (maximising consumption of local energy sources); black start services; balancing the hybrid ecosystem of energy; flexibility serving the system that caters for partially flexible end use; transition of the energy system. Not major changes are expected in comparison to 2020.
- 2040: directing resources to optimum end use; transition of end use; energy system flexibility serving the transition.
- 2050: flexibility in full use for end user process needs; the actual need for flexibility; transition of society. Significant changes from today's situation are expected. The black swan would be massive societal change towards flexible processes due to disruptive economic/political/societal events, turning the development drivers upside down and accelerating change significantly while the end scenario would remain. Hard to know how many synchronous generators will be connected to the system, causing a completely different system from the dynamics point of view. Another question is how resilient systems will be with high EV consumption peaks.

In the longer term, an increase in the amount of active customers providing flexibility is expected, due to the significant increase in price fluctuations.
One response expects that balancing market will be coupled between voltage levels and member states, and that the allocation of flexibility will be steered by nodal pricing from 2030 onwards and later also through distribution marginal pricing (DLMP).

Critical analysis:
The role and amount of flexible resources will increase with time. It will be traded in all electricity markets and it will be used by system operators to avoid network contingencies, and by consumers/prosumers to optimize their energy costs.
2030 might not be too different to 2020 but 2050 will involve deep changes in both the electrical system (e.g. lower number of synchronous generators connected directly to the grid) and in the society, which may require more flexible resources to respond to more flexible consumption patterns (led by disruptive economic, political and societal events). From this point of view, it seems significant that no explicit reference to the impact that climate change may cause has been done in the responses.
The allocation of flexibility might be steered by nodal pricing and, later on, by distribution locational marginal prices (DLMP).

Question 3 - How should Demand Response (DR) availability be accounted for in planning? Should DR impact be considered in future demand predictions? how can electricity price and DR programmes' revenues impact on the amount of available flexible power (sensibility of customers)?

Summary of received feedbacks:
DR should be part of the base option for planning. In relation to this, the following main aspects can be considered:

- Real experience of DR programmes or specific loads/load types should be considered to shape theoretical potential of flexibility. Available flexibility should be based on real-life KPIs based on experiences and regular/periodic feedback from market players (e.g. aggregators). Bringing the theoretical potential to the market proves to be much more difficult for various reasons: price/cost, impact to C&I process, weather, comfort, regulatory framework, supplier lock-in, lack of ICT support, etc. For example, at FutureFlow H2020 project, where real-life pilots were deployed, the aggregator started with 730 DR/DG recruitment contacts, got back 600 replies, out of this 200 were positive with 318 MW flexibility potential, but only 33 customers signed up with approx. 50 MW of flexibility. As consequence, uncertainty of availability of DR has significant impact also on the actual operation. The use of different scenarios may help to analyse this uncertainty: not only considering high-load/low-load, but ultimately additional ones depending on the critical resources of the specific system/region. Stochastic methodologies or/and machine learning techniques can be adopted to estimate the real impact of DR and to ensure Security and Quality of Supply Standard (SQSS).

- The market conditions in the planning horizon should allow the deployment of DR utilization. To this respect, flexibility will follow predictable market opportunities that can be made by societally optimal grid planning: grid planning should depart from pure engineering aspects and use similar tools as market scenario predictions use to establish probable and controllable development scenarios.
- Assuming that a large portion of demand is/will be price-responsive and reacts to wholesale or retail time-varying prices, this effect should be considered in future demand predictions. The reason is that varying electricity prices will affect the baseline energy consumption of customers during the day and thus have an impact of the available flexibility upwards and downwards.
- In grid planning problems, DR can be modelled with simplified battery-equivalent models capturing the characteristics listed in Question 1. Ideally, price-driven DR should be captured in an optimization model.
- Planning should take a holistic view.

Additional characteristics of DR to be considered are the following:

- The impact of DR is expected to be higher in demand shifting than in demand reduction, even if there is some evidence that with ''digitalising'' demand also energy efficiency savings are achieved.
- DR revenues will come mainly from flexibility markets and contracts with suppliers/aggregators (explicit DR). The electricity price does not influence much the DR revenues. However, DR could be rewarded also via grid tariff, especially for local DSO ancillary service markets, where low or no liquidity/competition is expected. There is an important role for retailers, they should make attractive electricity tariffs possible rewarding flexibility (implicit DR). Incentives to consumers could be a percentage of total savings by the DSO.
- With an acceptable price DR may represent a significant source of flexibility, but this would need multiple actions at a wider scale, which may require a proper valuation of emission savings thanks to electricity generation from RES plants, which in turn needs flexibility to maximize its contribution.
- Individually or through aggregation DR should access flexibility markets (or later local markets coupled with the wholesale market through DLMPs).
- Explicit DR should be enabled by IoT.
- Not much revenues/savings can be expected for end consumers.

Critical analysis:

It is important to consider the real availability of DR. The theoretical potential of DR should be transformed in available power/energy for the network with data from real experiences.
This availability depends on:

- The incentives/tariffs and market conditions that will impact the revenues that customers will obtain from providing flexibility to the system
- Allowing the aggregation of small resources to participate in flexibility markets.
- Enabling customer participation in DR (e.g. through IoT).

In planning, the effects of DR should be considered in future demand predictions, since it will cause a modification in customers' baselines. In relation to modelling, DR can be considered as a simplified battery, while price-driven DR should be captured in an optimization model.
The impact of DR will be higher in demand shifting than in demand reduction.
DR pricing would require a proper valuation of emission savings thanks to the production of RES, which needs from flexibility to maximise its production.

Question 4 - What kind of new players (aggregators managing thousands of decentralized resources, e.g. battery electric vehicles or heat pumps) or new operational concepts (combination of wind power plants with battery storage, to compensate variable feed-in and forecast errors) will arise till 2050?

Summary of received feedbacks:
Of course, uncertainty is high.

The success of new players and business models will be strongly related to regulation and electricity markets, which should be updated in response to the new operating conditions. New players need stability, long term visibility and enough price incentive to allow new business models to emerge. Small players should be allowed to bid flexibility in markets in small amounts.

With respect to the **players** that may arise until 2050 in the power system, the following have been mentioned:

- Aggregators: we are already seeing the emergence of baseline aggregators such as GridBeyond or NextKraftwerk, or even super-aggregators such as Piclo and Opus One Solutions. These platforms still face some technical obstacles and in particular the financial incentive for small producers is not great. They could evolve into international platforms, global utilities or white-label type services. They may have a strong impact in the short and medium term. They can focus on the aggregation of different resources (e.g. generators, demand, standalone storage, loads with thermal inertia) to provide different services (e.g. balancing, congestion support) with different levels of TSO-DSO coordination (e.g. coordinated access to distributed flexibility resources to maintain a good balance between satisfying local and system-level objectives) and with different objectives (e.g. technical or commercial aggregation).
- Energy Cooperatives/communities: possibly through aggregation and possibly with RES and storage installed.
- Communities of prosumers and consumers.
- RES plus storage producers providing firming, as dispatchable power plants.
- Power to X (gas/hydrogen) producers: in a bidirectional way. Not clear who should own and operate them. The price of electricity can be set at the opportunity cost to produce gas.

In the long term, the following **forecasts** are presented:

- No need for aggregators. Grid management will rely upon an integrated and intelligent system where each single user may be able to interact with the network. All items connected to the grid could be equipped with smart controllers directly procuring and selling the energy based on users' needs.
- AI will be used to optimize the system, to improve forecasts (0% error) for planning... Policy could have a big impact here, for example, if legislation could be introduced to force generators to provide telemetry data to an open repository / platform, this could enable much better planning in the power system.
- Resources will be intrinsically flexible. Energy system resources will interact flexibly to meet the actual societal processes of living, working and developing. The service economy will not be based on the resources but on the target processes of their customers.
- Weather derivatives could re-emerge.
- Storage as a service could be an area that offers a better alternative to co-location of storage with renewables. Location is key to realise the value of storage and economies of scale mean some business cases of storage as a service can emerge. Business models similar to those of LNG regassification terminals could emerge.

Critical analysis:
The importance of aggregators seems to be agreed in the short-medium term, but also that they will not be relevant in the long term due to the evolution of grid management, which will rely on the interaction between the final user and the system.
Other new players might be energy cooperative and consumer/prosumer communities.
RES plants will be "more dispatchable" in combination with storage through firming and forecasts for planning will be improved through AI techniques. Resources might be intrinsically flexible in the future to meet customers patterns. Storage as a service could can emerge in the future.

Question 5 - How can phase shifting transformers (PST) and internal high voltage direct current (HVDC) lines be operated to reduce congestions in the AC grid and thereby reduce the need for grid expansion?

Summary of received feedbacks:
The **applications** of PST and HVDC systems depend on the network, but some of ways in which they may reduce congestions are the following:

- Load Flow management to avoid line overloads.
- As curative measure in the case of an overload after an element tripping in the network. HVDC, PST, and other control solutions, such as System Integrity Protection Schemes (SIPS, SPS, RAS...) can be used to prevent large disturbances after a failure. This makes it possible to go away from the N-1 criterion, but it also builds in dependency on control systems, which may by itself have a negative impact on reliability.
- Coordinated control between several PSTs/HVDC to optimize the grid capacity. US start up New Grid is developing topology optimisation software that can free up 4-12%of latent capacity.
- Redraw power network in order to cope with uncertainty scenarios.
- Phase imbalance removal to increase the effect of available flexibility.

All links should be subject to market based operation and, as such, be driven by the needs of the ecosystems across the linked areas. Link characteristics should be part of the market product design to reflect the technical issues needed to be tackled to use the links in these ways.

Similar to the telecoms, energy will have to be directed where it is needed. On top of PST and HVDC there is a role for:

- Mirrored storage (as Netzboosters concept in Germany able to provide pre-fault services).
- FACTS to help with grid congestion.

Critical analysis:
PST and HVDC are valuable resources to support congestion management in the network.

Question 6 - How much flexibility should be considered in the planning phase and how much is reserved for real-time operations?

Summary of received feedbacks:
According to some of the responses, **no distinction should be made between planning and real-time operation**, all the flexibility considered in the planning phase should be available for real time operation. A distinction is proposed between flexibility needs for normal and abnormal (contingency) situations and, in

this case, abnormal situation needs should be considered for planning. According to another response, in the planning phase, flexibility needs should match the shortfall in ramping capabilities of conventional generators in the portfolio, while, in real time operation, flexibility should be able to compensate for errors in variable RES generation forecasting.

However, the answers show that it is **important to consider operational flexibility** in the grid planning phase, because it might result in avoiding investments in grid reinforcement and/or expansion. Since, the exact operating conditions of the flexibility resources are unknown at the planning stage, various scenarios need to be considered: normal, upside and downside scenarios on short, medium and long time horizons. Flexibility is risky in natural and what can make sense during planning, might turn out completely different in real-time operation. NationalgridESO uses the concept "envelop of uncertainty" to include the different stages of uncertainty varying across time.

Because of the uncertainty, a **simplified representation** of aggregate flexible resources in planning optimization problems would be sufficient, while more detailed models can be reserved for real-time operations.

However, to **account for flexibility needs**, in cases where mutual flexibility (i.e. load and generation side, both) is not prevalent in scenarios, volumes corresponding to most critical network resource failures should be considered in the projected market incentivisation scheme. If there is to be no incentivisation, traditional engineering reserve volume methods can be used as a stopgap.

Critical analysis:

Even if some specific applications are proposed for flexibility in operation and planning, the general opinion is that all flexibility considered in planning should be available for real time operation. The concept "envelop of uncertainty" could be used to refer to the variation of uncertainty across time.
Operational flexibility should be considered in planning through likely scenarios.
In planning, it would be enough to consider the flexible resources in an aggregated way.