DSM Platform for Optimal Energy Management Strategies Development

Dr.sc.ing., Artjoms Obushevs

Institute of Physical Energetics
Smart Grid Research Centre
INSTITUTE OF PHYSICAL ENERGETICS

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European Liaison on Electricity Committed Towards long-term Research Activity Integrated Research Programme

“Demand side management and monitoring solutions”
(IPE Nr.2015/07-01)
Significant amounts of variable renewable capacity have been installed already and a lot more will be deployed by 2020 and beyond. The increase in numbers causes significant changes in power system operation manner.

Power system generation will shift from classical dispatchable units to more intermittent renewables, and as consequence of this, generation and provided services will shift from central transmission to decentralized distribution system.
The different type of flexibility resources connected at the different power grid levels, and their characteristics can affect PS operation and market mechanisms implementation.

The interactions between the different stakeholders become more complex in an increasingly flexible power system.

Therefore it is necessary to understand the impact of control actions across operator boundaries

- DSO-DSO
- TSO-DSO role in the network operation/ market facilitation
- TSO-TSO
ASSESSMENT OF THE RESOURCES FLEXIBILITY

✓ In new conditions local **distribution grids** will be used more dynamically resulting in more voltage issues.

✓ **Prosumer** participation at the demand side will be expected for voltage and frequency control in the future.

✓ Today, there are already a number of ways through which consumers can contribute (direct or indirect) to grid stability:

  • Frequency reserves
  • Electricity markets
  • Strategic reserves
  • Local balancing solutions
  • Grid support
Today, various market participants operate at different market levels within various sub-markets and trade different products.

- The combination of different electricity sub-markets and direct control mechanisms, the **frequency and voltage** control services must be obtained to ensure the security of supply in all power system operational levels.

- Day-ahead and intra-day markets are performed based on separated forecasts of energy needs, system congestions, and system contingencies, among others.

A better approach would be to perform all these forecasts in an **integrated and unified manner by web-of-cell concept**. This methodology would allow network/cell operators to achieve an optimal reliability and decision-making under uncertain dynamic conditions.
Electricity market design with web-of-cell concept
Important structural components of electricity market design are future requirements and responsibilities of TSOs and DSOs, taking into account power system and technology development can be mentioned:

- Multi criteria **forecasting algorithms** for prediction
- Scheduling algorithms for **scheduling of reserves**
- **Databases** for storing and retrieving historical data
- **Communication infrastructure** for information exchange with Market Operators, other TSOs, DSOs, resource owners, etc.
- Ensure **the long-term** ability of the system to meet reasonable demands for the distribution of electricity, for operating, maintaining and developing under economic conditions
- Provide system users with the information they need for efficient access to the system
- Covering energy losses and maintaining reserve electricity capacity
- Ensuring transparency with respect to system users
Due to the major changes mentioned before, the essential feature of electricity market design will be focused on the System Services, provided by TSOs and Ancillary Services, in their turn – provided to the system operator by generators and consumers.

- In practice ancillary services fundamentals are defined by the relevant TSO.

- This choice should correspond to system characteristics, including needs of the synchronous area/ protection plan and also the capability of the generating technology.
## Characteristics of the Markets for Frequency Control Ancillary Services

<table>
<thead>
<tr>
<th>Country</th>
<th>Frequency Containment Reserve</th>
<th>Frequency Restoration Reserve</th>
<th>Replacement Reserve</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Procurement Scheme</td>
<td>Remuneration</td>
<td>Procurement Scheme</td>
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<tr>
<td>Finland</td>
<td>Voluntary market</td>
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<td>Market based</td>
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<tr>
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<td>Mandatory provision</td>
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<tr>
<td>Poland</td>
<td>Mandatory/Contract</td>
<td>Yes</td>
<td>Mandatory/Contract/Market based</td>
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<tr>
<td>Portugal</td>
<td>Mandatory provision</td>
<td>No</td>
<td>Mandatory/contract</td>
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<td>No</td>
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<tr>
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<td>Market Based</td>
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<tr>
<td>France</td>
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<td>Contract</td>
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</tr>
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<td>Market based</td>
</tr>
<tr>
<td>Sweden</td>
<td>Mandatory provision</td>
<td>Yes</td>
<td>Market based</td>
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</table>
Ancillary services structure with power system needs for operational flexibility, taking into account the new functional requirements’ definitions, can be depicted as follows:
Future Market Design for ancillary services structure can be based on following:

- Defining the need of users
- Choosing the entity responsible for AS procurement & procurement method
- Matching demand and supply
- Defining the structure of bids and payments
- Organizing market clearing procedure
- Avoiding price caps & providing efficient incentives.

Potential changes to the existing ancillary services markets are likely to occur due to the changing requirements of those ancillary services which should be carefully considered to eliminate any unintended consequences.
2030+ POWER SYSTEM REPRESENTATION

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The trend to strengthen consumers’ flexibility in E-market environment is conditioned by the wider expansion of Smart Grid Technologies including Intelligent Metering Systems.

Prospectively, bulk installations of Smart Meters alongside with development of more flexible appliances should lead to the widespread public acceptance and deployment of price responsive demand.

Demand side management (DSM) aim either at reducing consumption or shifting consumption.

One option in DSM is direct load control, where, based on an agreement between the utility and the customers, the utility remotely controls the operation of certain appliances in a household.

Smart pricing is an alternative where elaborately designed pricing rules are adopted to encourage users to individually and voluntarily manage their loads in order to reduce their own energy cost.
HOME AREA NETWORK MONITORING & CONTROL

Most of the current load control decisions in existing DSM systems are made manually, which makes it difficult for the participants to monitor the real-time prices and to use other advanced pricing methods.

In fact, lack of knowledge among end users about how to respond to time-varying prices is currently a main barrier for fully utilizing the benefits of real-time pricing methods and DSM in general.

This problem can be resolved by equipping users with home automation systems and by implementing automated energy consumption scheduling units that can draw on pricing information to schedule the operation of various residential appliances on behalf of customers.
HOME AREA NETWORK MONITORING & CONTROL

Smart Grid Research Centre research facility Demand Side Management-Smart Home Lab is equipped with developed monitoring & control socket hardware for DSM platform elaboration with features:

• Send data at periodic intervals to a web-connected base-station;
• Real-Time monitoring of active, reactive, apparent powers, currents, voltage and extra sensors (temperature, humidity, etc.);
• Remote control possibility (switch off/on socket devices);
• Easily customized for a variety of applications.
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HOME AREA NETWORK MONITORING & CONTROL
Home area network facility with real-time monitoring & control

- Monitored (P, Q, I, V, Temp) load
- Air conditioning 3500W
- Refrigerator 200W
- Heating System 4000W
- Controllable and monitored (P, Q, I, V, Temp) load
- Room LED lighting 81W
- Monitoring and Control Server 5W
- UPS, Server 500W
- Total Active Power
- Total Active Power - Real Time
- Voltage level
- Water heating 1500W
Current solution makes it possible to monitor aspects of building performance without costly investments in wiring and makes it easier to identify where improvements in energy efficiency can be done (using different demand side management strategies, new equipment, distributed generation sources, storage technologies etc.) and then see and analyze the effects of implementation.
Energy management strategy is based on the Load Management systems and allows switching on/off appliances when particular circumstances occur, in order to maintain the net power exchange with the LV network within a desired range. The list of appliances and their priority list, their criticality levels and their maximum interruption time, load profiles of different appliances and the possibility to change it in response to price and system signals are presented.

Load classification with possible interruption time
Load profile could be changed by Load Management system according to three functional conditions:

- **Comfort**: avoid automatically e-meter disconnection when power exceeds contractual limit. The user specifies a priority for each appliance.

- **Emergency**: shedding of loads according to their priority as a result of an emergency signal received from the distributor (Critical Peak Price or by Voltage and Frequency setpoints).

- **Savings**: customers may set Load Management systems parameters for shedding loads when energy price exceeds a fixed threshold. The customer may choose load shedding priority.
DSM Platform was launched in May 2015 in monitoring and control state. Currently control is managed manually, however created platform allow implementation of different energy management strategies (particle swarm optimization, genetic algorithm, linear optimization techniques, Monte Carlo simulations, Markov decision process, dynamic programming, Multiagent control).

Laboratory tests have shown that the printed circuit board is not exposed to electromagnetic fields crosstalk between power and adjustable steering part. In the future, for more compact design authors plan to develop this version of printed circuit board with surface mounting devices components.
Total HAN consumption distribution in July with 10 second scale
Total HAN consumption distribution in August with 10 second scale.
Different consumption type behavior for one week
Proposed results and future monitoring allow as a next step analyze behavior of each appliance for possible load shifting by implemented technology.

As a future steps could be mentioned implementation of distributed generation with storage possibility.

In such way lab will represent behavior of passive/active consumer/prosumer and could provide wider results and experiments related to optimal DSM strategies.
CONCLUSIONS

- In the future power system scheme, TSOs will be able to control significantly lower part of the generation compared to the traditional centralized configuration.
- Large power imbalance could be faced with accurate day-ahead predictions of decentralized generation and electricity demand of load centres.
- Increased electricity loads and sources such as EVs and residential PV systems, will influence the balance between day-ahead production and consumption schedule and will leave energy markets with higher and less predictable need for balancing power.
- The new role of the system operators and of the new actors is to guarantee the quality and security of supply at minimal costs within the market framework in force.
- Presented research is dedicated to experimental rational use of energy with aim to demonstrate and simulate the potential of smart meters and home area network automation implementation and their interoperability with energy management strategies.
CONCLUSIONS

✓ One of the main challenges associated with smart grid operation is optimal energy management strategy of residential building with respect to multiple objectives. With new energy management solution, the wasteful use of energy for householder and business owners would be decreased, and further utilization of RES will be provided.

✓ By developed EMS, two-way digital communication between DSO and common household devices could be enabled smart energy system and advanced smart grids component management, giving the prosumers instrument, to improve their energy efficiency and to actively participate in electricity market for lowering their costs of energy consumption.

✓ The important outcomes of this research is dedicated to a demonstration of research facility Demand Side Management-Smart Home Lab and prosumer possibilities actively participate in electricity market, with the aim to achieve the rational use of energy.
Smart Grid Latvia

Founded in: 2014
Number of members: All Smart Grids stakeholders in Latvia
Target audience: All stakeholders in Latvia

Top 3 Priorities

- Demand Response
- Market Integration
- Integration of Renewables

Main Focus: Facilitating the transition towards Smart Grids
- to collaborate with research institutions;
- to facilitate national smart meter roll-out programs through knowledge transfer and support in the SGT smart appliances and end-use device operational management to obtain and automatically respond to real-time price signals to serve the consumer needs best;
- to promote the SGT to electricity consumers to enable them to choose services that meet their needs.
Thank You for attention!

Artjoms Obushevs: A.Obusev@gmail.com

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