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Subject: Adding Gridwise information to Ecogrid Deliverable D1.1

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1. Background

Gridwise is referenced in the Ecogrid Grant Agreement, Annex I - "Description of Work" in the following ways:

- On page 20, Table 1: EcoGrid EU project focus in relation to relevant projects

  GridWise (US) Demonstration of a real-time market that worked like a down-sized power pool, i.e. with each participant submitting bids and offers every 5 minutes.

  Focus on Market design + Market demonstration

- On page 38, Description of work Task 1.1:
  Review of existing markets and future prospects for integration of DER

  Task leader: ELIA. Participants: DTU-CET, IBM ZRL, Tecnalia, ECN
  The participants will bring in knowledge from former and ongoing projects, including .. and GridWise Olympic Peninsula Project (IBM), …

- On page 98, References to earlier projects relevant to the proposal

  IBM background and currently acting as Chairman of DoE's very influential US GridWise Architecture Council 18TUwww.gridwiseac.orgU18T

- On page 110, 31BB 2.3.3 The role and the knowledge of the ICT industry

  The EcoGrid EU project will benefit from the lessons learned in the US GridWise project, in which IBM´s Watson Research laboratory contributed with their so called Internet Scale Control System (iCS), a Web Sphere middleware software that was the foundation of a shadow electricity market system tested in the GridWise project.

- On page 112, 3BB 2.3.5 The role of the Reference Group

  GridWise USA Status confirmed

EcoGrid - EB01 Executive Board initiation - Web meeting, September 20, 2011

EB01-02 Approval of D1.1
The present version of the report primarily focuses on comparative analyses of five European projects. The report does not include IBM's contribution (GridWise) at the moment due to delayed activities at IBM, caused by Consortium Agreement negotiations. Energinet.dk suggested earlier that the scope of the report should be extended beyond these five projects, and probably consider worldwide perspective.
Conclusion: The partners will submit their comments and proposals to SO before the 28 September. Elia proposes thereafter revised content of the report for approval by the WP – leader as soon as possible and finalises the deliverable.

Minutes WP1 meeting 2011-10-03, Jacob Oestergard

The D1.1 will be updated with GridWise experience with IBM, analysis on the Danish System, including experiences from the "Flex Power ", "Danish heat pump projects" and "Danish Energy Forecast", document the real-time imbalance price publication used by Tennet, and create an additional chapter "Gap analysis between the projects models and the Ecogrid model".

Contributions to: Chapter 2. Presentation of the Former and Ongoing Projects

IBM has initiated the process to exchange US PNW-SGDP project information with EcoGridEU project at the recent Department of Energy GridWise Architecture Council meeting in Phoenix. Initial focus could be on the Functional Requirements Specification or other project documents. This process will take some time. For the initial Ecogrid phase, we will therefore focus on the completed project PNW-GWTDP, see following section.

2.7 Pacific Northwest GridWise Testbed Demonstration Projects (PNW-GWTDP)

2.7.1 Projects Description and Objectives

The objectives of the PNW-GWTDP are several. The main objective is to equip the electricity grid in all levels, be it generation, transmission, distribution or consumption, with intelligence in order to prepare for the emerging smart grid. Another objective was to demonstrate concepts of how to integrate highly distributed energy resources in the envisioned smart grid.

The PNW-GWTDP included two projects, the Grid-Friendly Appliances (GFA) project [4] and the Olympic Peninsula (OP) project [3]. The GFA project demonstrated grid frequency controlled appliances in order to shed load in the system. In the OP project the focus was on price-based control of smart appliances and DERs. This project is very similar to the EcoGridEU project in that the entities are controlled by price. Thus, the OP project is of more relevance to EcoGridEU because of this market based approach. This section is therefore mainly focused on the OP project. Furthermore, the time scale used in the OP project is, as in EcoGridEU, 5 minutes. The difference is that the OP project proposed a two-way communication infrastructure that allows the participating entities to place bids into a shadow market.

The price responding devices in the OP project included 40 high pressure water pumps with a total peak load of 150 kW, two distributed diesel generators with a peak power of 175 respectively 600 kW, and 112 homes equipped with a smart home gateway accounting for approximately 75 kW of controllable appliances.

The OP project did not integrate real markets and the demonstration only implemented a shadow-market between DSO and retail customers. The underlying reason was to avoid complex regulatory issues of dealing with existing markets. EcoGridEU is different in this aspect where existing market information is being included in the price generation mechanism. The scalability is an important issue and the follow up project (see section 2.8) has the objective to address this aspect.

2.7.2 Participants

The participants of the Pacific Northwest GridWise Testbed Projects are the U.S. Department of Energy, Bonneville Power Administration, Pacificorp, Portland General Electric, IBM, Whirlpool/Sears, Mason County PUD #3, Clallam County PUD #1, Pacific Northwest National Lab, Invensys, Preston Michie Associates, and Dr. Lynne Kiesling IFREE.

2.7.3 Timeline

The PNW-GWTDP ran over 3 years (2005-2007). The project is therefore finished.

2.7.4 Project Conclusions

The conclusions in the OP project can provide guidance in the design of a real-time market in the EcoGridEU project. One of the major achievements in the OP project was the demonstration that a near real-time market based approach can successfully handle local grid congestion. The OP project considered a virtual feeder and managed to successfully constrain this feeder for an entire year. Thus, the shadow market showed applicability as a tool to manage distributed energy resources. Moreover, the overall peak load could be reduced for the same period. The price responsive entities had automatic bidding/response behavior and this proved to be an important feature in order to show consistent responses. Positive results were shown and the project demonstrated the technical feasibility of a price-based approach to controlling DERs.

Another conclusion was the participation of the customers. The project introduced an account for each customer and filled this account with an amount that each customer could spend each month. If the customer did not participate the balance on the account would be decreased accordingly. However, if the customer participated and actively selected grid friendly comfort levels the balance on the account would be increased. This concept proved to be very good in order to pursue customers to actively participate. EcoGridEU could potentially implement a similar scheme in order to maximize the active participation.

2.8 Pacific Northwest Smart Grid Demonstration Project (PNW-SGDP)

2.8.1 Projects Description and Objectives

The PNW-SGDP is a collaborative, five-year test of new technologies and capabilities that will make the regional power grid smarter. The project is unique in size and scope and it will demonstrate the potential for a safe, scalable and interoperable smart grid for regulated and non-regulated utility environments. The project includes 60’000 metered customers in five US states. The goal is to demonstrate large scale participation of distributed energy resources in the emerging smart grid. The concepts developed in the OP project (see section 2.7) will be further developed and enhanced to accommodate this scale up. Essentially, the aim is to develop standards and communication protocols that can facilitate large integration of wind and other renewable energy sources in the grid. An important topic is to quantify the costs and benefits of the approaches taken.

The publicly available info on the project is still scarce: http://www.pnwsmartgrid.org/ because it is an ongoing project.

2.8.2 Participants

The project is managed by Battelle’s Pacific Northwest Division located in Richland, Washington. Battelle is a $5 billion non-for-profit organization that benefits mankind by helping solve some of the world’s toughest science- and technology-based challenges.

IBM Research in the US is the lead technology partner in the PNW-SGDP. It is building the infrastructure to disseminate the Project’s transactive incentive signal and interlace it with the participants’ responsive assets. IBM will provide hardware and software that will allow the project’s data to flow more effectively, securely and efficiently and support the overall system architecture and interoperability. Lastly, IBM is contributing to the cyber-security, modeling and analytics, social computing and cyber-physical system aspects of the design and development.

The PNW-SGDP also involves the Bonneville Power Administration, five technology partners, 11 utilities across five states, Washington, Oregon, Idaho, Montana and Wyoming, and the University of Washington. An overview of the disperse participation in the project is shown in Figure 1.

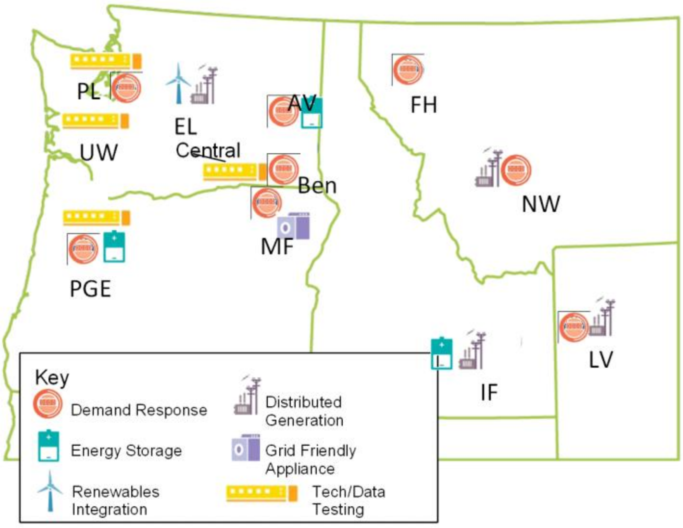

***Figure 1. The geographical overview of the PNW-SGDP with a very disperse set of participants*.**

2.8.3 Timeline

The PNW-SGDP runs over 5 years (2010-2014). The project is therefore executed partially in parallel to EcoGridEU. Sharing information between PNW-SGDP and EcoGridEU is therefore important. However, exchange of consortium information between PNW-SGDP and Ecogrid must get cleared first in due time. Such a request has been initialized at the recent Department of Energy GridWise Architecture Council meeting in Phoenix.

2.8.4 Project Details

The project is ongoing and no conclusions have been made at this time. This section describes the technical details of the project.

The concept developed and tested in the PNW-SGDP is *hierarchical transactive control*. It is important to include multiple objectives in optimizing of the usage of the grid. Hierarchical transactive control provides a flexible method for combining multiple objectives and constraints, such as local congestion, operational objectives, and economic objectives. Hierarchical transactive control is based on a two-way communication that uses two types of signals. For the downstream (toward demand) communication a value signal is used. This signal can be a price signal, but it does not have to be the price that is used for billing purposes. The value signal can instead be an incentive signal. For the upstream (toward generation) communication a demand signal from the demand to the generation is used.

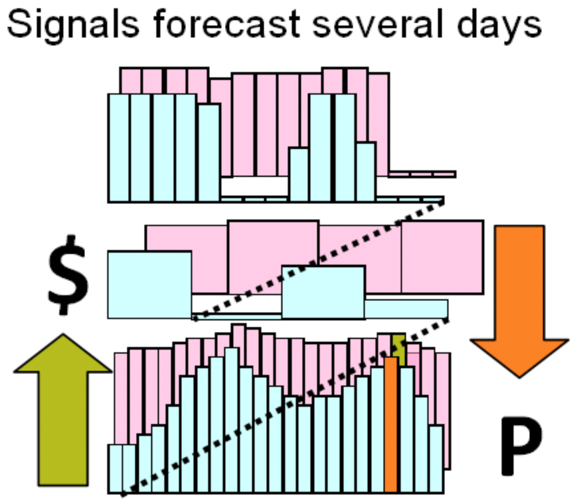

Figure 2. Forecasted value signal and demand signal at a node.

Examples of the value signal and the demand signal are shown in Figure 2. Note that both signals are forecasted. The value forecast allows appliances to plan for the future while the demand forecast allows the grid entities to anticipate problems in the grid.

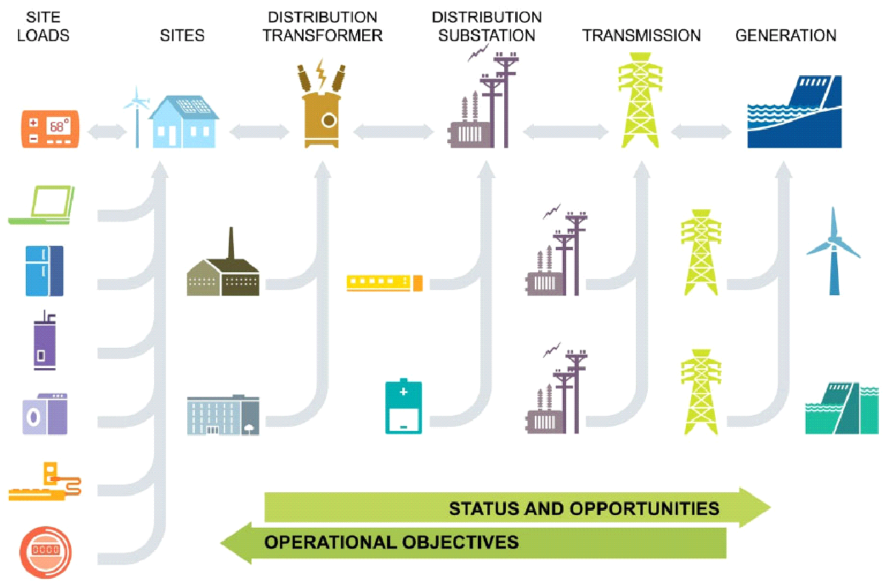

Figure 3. An example of the included grid entities.

Figure 3 shows an example of all the grid entities that can be included in the hierarchical transactive control system. It is important that all entities can influence the value/demand signals according to their local objectives. The hierarchy will thus represent the physical structure in Figure 3. Figure 4 shows this mapping between the physical network and the information network, i.e., the transactive control hierarchy.

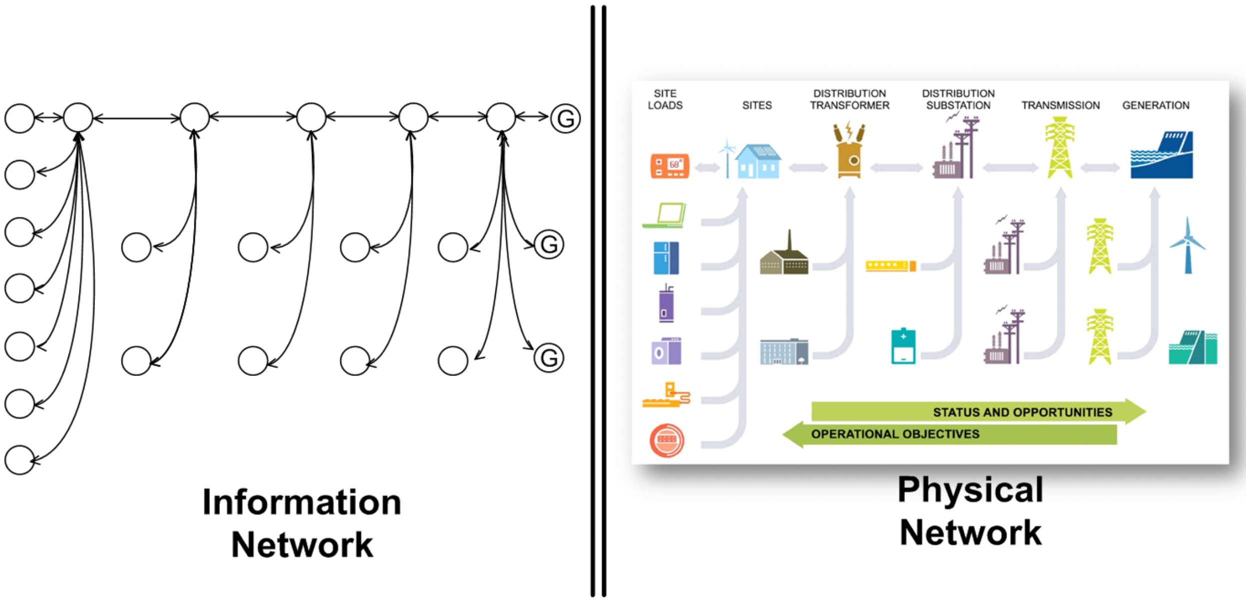

Figure 4. An examplified mapping between the physical network with grid entities and the information network with transactive control nodes.

Contributions to: Chapter 7. Interactions between Market Actors – Visual Representations

7.6 Pacific Northwest GridWise Testbed Demonstration Projects (PNW-GWTDP)

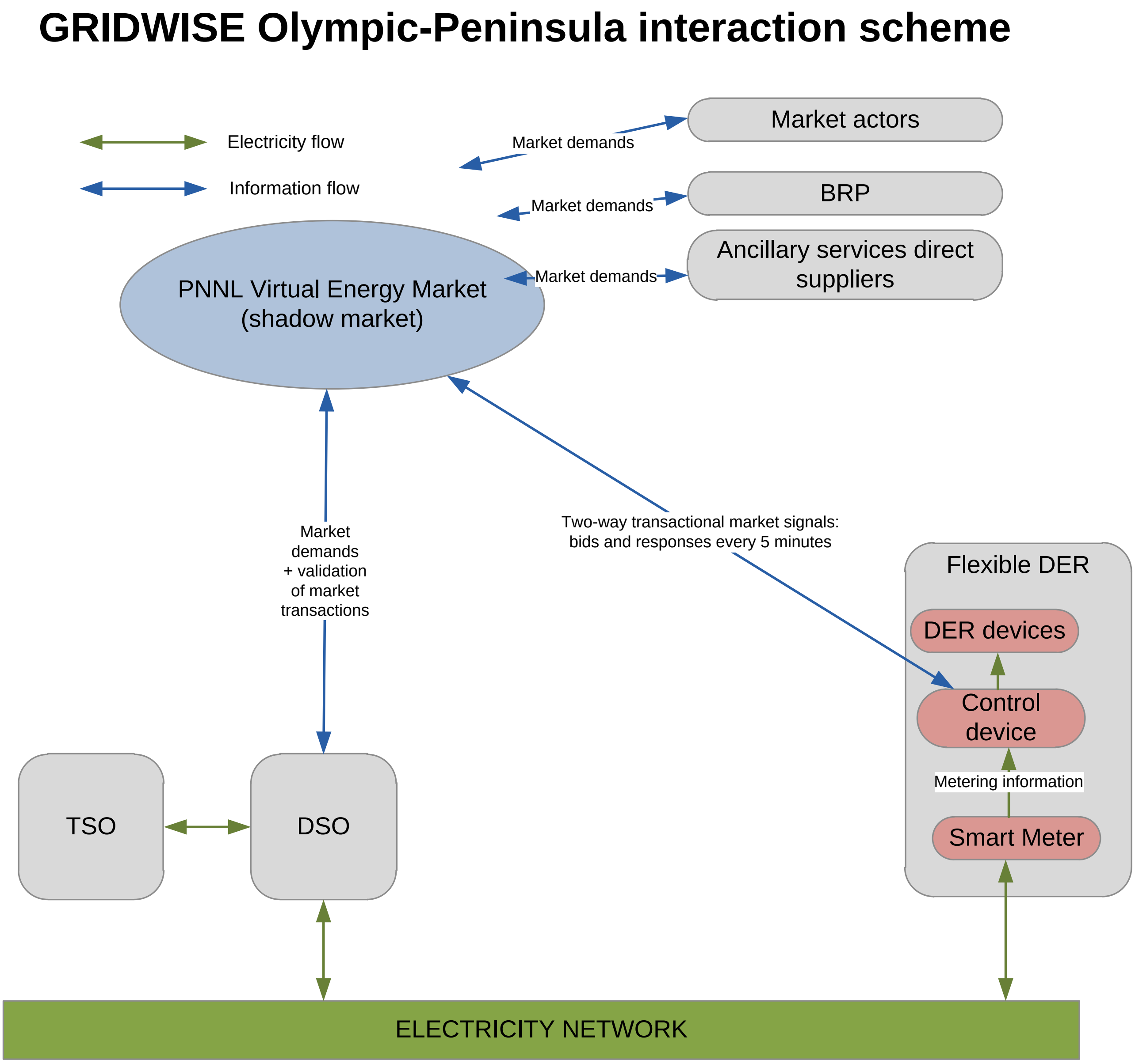

Figure 5. PNW-GWTDP Olympic Peninsula(OP) project – Market interaction scheme.

Contributions to: Chapter 8. Comparison analysis between projects and project's main recommendations VS EcoGrid Model

8.6 Pacific Northwest GridWise Testbed Demonstration Projects (PNW-GWTDP)

8.6.1 Technical R&D

In the projects, two control schemes were used. In the GFA project direct control via frequency based on/off switching was used and in the OP project a 5 minutes price was used to adjust sensitive thermostat set-points or delay pumping. Control device is fully local or local with communications for price signal.

The number of participants was limited to 112 households. Grid stability issues when large populations react to frequency or price were not studied. The scalability was addressed because grid frequency is always available and price broadcasting scales well.

8.6.2 Market Design

The consumer's loads acting as controlled devices, be it on frequency or on price signal. Loads are clothes dryers (frequency). For price driven control, heating systems (via thermostat settings) and pumping applications (via level settings) were controlled. Price saving for price driven control is automatic. For frequency driven control, no immediate monetary benefits to end-customer. The benefits here would go to BRPs and TSOs.

A push approach was used, i.e., a signal is transmitted to the intelligent loads which directly react to signal. Thus, there is no human intervention that could jeopardize the response. However, as set points of thermostats can be overridden and the tolerable liquid levels for pumping systems can be adjusted, which increases the risk of unpredicted response. Also, the system stability is not guaranteed in cases of inflationary price sensitivity.

The signals used in the market are either frequency or price points and the frequency information is continuous while the price signal is sent in 5 minutes intervals. It is unclear what role the communication delays had in the project. Frequency control is used for frequency stability. Price driven thermostat or level settings is used for balancing power control (reduction of imbalance costs). No real market was integrated in the project. Only the pilot shadow-market between DSO and retail customers was used. The underlying reason was to avoid complex regulatory issues of dealing with existing markets.

8.6.3 Technology demonstration

Assuming intelligent loads and reliable, wide-area, near real-time communications, the DERs are controllable. The grid stability was not considered in a large scale because of limited number of participants. However, balancing and congestion clearance in a virtual feeder were achieved. In total, the project included 112 participants. Frequency control was implemented on clothes dryers (typically a few kW). Price signal was used for thermostat setting with electrical heating which was related to the household size, 2-6 kW and the municipal water pumps around 140 kW.

In the project, active consumers, smart appliances, and market signal broadcasting were demonstrated.

8.6.4 Market Demonstration

The customer had the benefit of reduced bills, less taxes due to reduced infrastructure investments. The benefit to the DSO is that it can avoid congestion in the grid by using smart appliances and therefore avoid grid re-enforcement.

The TSO can access more balancing power resources and/or have reduced balancing power needs because the DSO is balancing internally. Also, minor energy savings, thus reduced peak production facilities can be achieved. The scale up of these benefits was not studied.

8.7 Pacific Northwest Smart Grid Demonstration Project (PNW-SGDP)

Note that this project is ongoing (2010-2014) so this section is only a snapshot. Close contact with the PNW-SGDP throughout the EcoGridEU project will enable continuous knowledge sharing.

8.7.1 Technical R&D

Hierarchical transactive control is being demonstrated in large scale. In the hierarchy the grid components are represented by nodes. These nodes can have local objectives and the hierarchy can therefore include both the transmission grid, the distribution grid as well as generation and demand.

The planned number of active participants includes 60'000 customers, 12 utilities, in 5 US states in the Pacific Northwest (OR, WA, NV, ID, WY). This is a technical follow up project of the Olympic Peninsula project in section 8.6. Scalability is therefore an essential part of the technical research and development. The hierarchical transactive control provides the scalability needed.

8.7.2 Market Design

The main actors are smart loads with a price or incentive sensitivity. Price or incentive sensitivity is assumed to be known at diverse hierarchical layers in the power grid. Price or incentive sensitivities are used throughout grid hierarchy but how/if settlements in contractual terms are being used is unclear.

Local objectives can be applied at diverse hierarchical layers of the grid. The risk is that the local price or incentive sensitivity estimation is erroneous and does not properly correlate to the anticipated demand. The signals being sent are a price (or value) signal downstream (from generation to demand), whereas demand signals are sent upstream (from demand to generation). At the various hierarchical layers, aggregation respectively dis-aggregation can occur.

The resolution of the value and the demand signals is unclear. Signals are designed to be sufficiently dynamic to achieve valuable grid objectives (including fast frequency regulation). DERs are assumed to make decisions and prediction of demand, i.e. the demand signal, based on the value signal they receive. The integration with existing markets is still unclear.

8.7.3 Technology demonstration

Similarly as the OP project, intelligent loads are controllable using reliable, wide-area, near real-time communications, and by broadcasting price signals. Grid security and stability issues for hierarchical, price driven control are not yet studied. The communication infrastructure is based on an internet scale control system (iCS). The entities involved are 60'000 customers and the related grid entities for distribution, generation, and transmission. The power ratings presumably range from 1 kW to several MW.

In the project, active consumers, distributors, transmitters, and generators are demonstrated. Also, a grid-wide, hierarchically organized transactive control system is in the core of the demonstration. The hierarchically organized transactive control is based on analytics of consumption and derived price sensitivity at the diverse hierarchy layers.

8.7.4 Market Demonstration

The goal is that the customers experience reduced bills, less taxes due to reduced infrastructure investments. The DSO can avoid grid re-enforcement and achieve a higher utilization of its grid. The TSO could also achieve reduced balancing power needs at possible costs of increased transport capacities.

3. References

[1] P. Huang, J. Kalagnanam, R. Natarajan, M. Sharma, R. Ambrosio, D. Hammerstrom, R. Melton, “Analytics and Transactive Control Design for the Pacific Northwest Smart Grid Demonstration Project”, 2010 First IEEE International Conference on Smart Grid Communications (SmartGridComm), pp 449-454, 4-6 October 2010

[2] D. Hammerstrom, T. Oliver, R. Melton, R. Ambrosio, “Standardization of a Hierarchical Transactive Control System”, In Grid Interop 2009 Conference, November 17-19, 2009, Denver, CO. GridWise Architecture Council, Richland, WA

[3] D. J. Hammerstrom et al., “Pacific Northwest Gridwise Testbed Demonstration Projects: Part 1. Olympic Peninsula Project”, Pacific Northwest National Laboratory, Richland, WA, Tech. Report PNNL-17167, October 2007

[4] D. J. Hammerstrom et al. “Pacific Northwest Gridwise Testbed Demonstration Projects: Part 2. Grid-Friendly Appliances project”, Pacific Northwest National Laboratory, Richland, WA, Technical Report PNNL-17079, October 2007.

	Pacific Northwest GridWise Testbed Demonstration Projects	Pacific Northwest Smart Grid Demonstration Project
Project's description	See chapter 2.8	See chapter 2.9
Technical R&D		
Grid control	2 control schemes: direct via frequency based on/off switching and price sensitive thermostat set-points or delayed pumping. Control device is fully local or local with communications for price signal.	Distributed control devices at different hierarchical levels of the power grid: generation, transmission, distribution, sites, site loads.
Grid security	Limited number of participants (112). Grid stability issues when large populations react to frequency or price were not studied.	60'000 customers, 12 utilities, 5 US states in the Pacific Northwest (OR, WA, NV, ID, WY)
Scalability	yes - frequency always available, price broadcasting scales well.	Mandatory; addressed via hierarchical transactive control
Grid related security		
Market Design		
Who are the main actors in the projects (apart from the classic ones) ?	The consumer's loads acting as controlled devices, be it on frequency or on price signal. Loads are clothes dryers (frequency). For price driven control, heating systems (via thermostat settings) and pumping applications (via level settings) were controlled	Smart loads with price sensitivity are assumed. Price sensitivity is assumed to be known at diverse hierarchical layers in the power grid.
How is the contractual and remuneration relationship between main actors ?	Price saving for price driven control is automatic. For frequency driven control, no immediate monetary benefits to end-customer. The benefits here would go to BRPs and TSOs.	Unclear. Price sensitivities are used throughout grid hierarchy; how this relates to contractual terms is open.
Push/Pull action ?	Push approach: signal is transmitted to intelligent loads which directly react to signal; no human intervention.	Control can be applied at diverse hierarchical layers of the grid.
Risk	Set points of thermostat can be overridden. Tolerable liquid levels for pumping systems can be adjusted. System stability is not guaranteed in cases of inflationary price sensitivity.	Price sensitivity estimation is erroneous and does not properly correlate price level to anticipated demand.
What is the nature of the signal sent to the DER ?	Frequency or price points.	Price (or value) signals are sent downstream (from generation to demand), whereas demand signals go upstream - from demand to generation. At the various hierarchical layers, aggregation respectively dis-aggregation can occur.
Signal price ? sent every X ? minutes	Frequency control is continuous. Price signal (for thermostat setting) sent in 5 minutes intervals. Unclear on signal propagation delays....	Unclear. Signals are to be sufficiently dynamic to achieve valuable grid objectives (including fast frequency regulation!).
DER reaction	Frequency control for frequency stability. Price driven thermostat or level settings for balancing power control (reduction of imbalance costs)	Price elasticity for power consumption: price setting drives load.
Which markets ?	Pilot market-place between DSO and retail customers: fictitious money exchanges in a shadow-market.	Unclear.
Technology Demonstration		
Controllability of DER	Assuming intelligent loads and reliable, wide-area, near real-time communications, DERs are controllable.	Assuming intelligent loads and reliable, wide-area, near real-time communications, DERs are controllable by broadcasting price signals to adjust demand.
Network safety with DER participation	By network we understand the electrical power grid (not the internet). Grid	Stability issues for hierarchical, price driven control is uncharted territory.

	stability not proven to scale to large populations; there could be large swings in demand.	
Communication strategies	Frequency is one-way, price signal is one-way for current cost of energy (i.e. power for the next five minutes).	Internet scale control system as proposed communication infrastructure (iCS).
What devices are/will be demonstrated, how many of them and give their specifications like power?	112 participants. Frequency control on clothes drying (typically a few kW). Price signal used for thermostat setting with electrical heating which is related to the household size - 2-6 kW. Municipal 140 kW water pumps.	60'000 customers and the related grid entities for distribution, generation, and transmission. Powers presumably range from 1 kW to MW.
Which roles are demonstrated?	Active consumers. Market signal broadcasting.	Active consumers, distributors, transmitters, and generators. Grid-wide, hierarchically organized transactive controls.
Which tools are demonstrated?	Smart appliances.	Hierarchically organized transactive control based on analytics of consumption and derived price sensitivity at the diverse hierarchy layers.
Market demonstration		
Technical control/coordination	Unknown.	
What are the benefits for the consumer?	Reduced bills, less taxes due to reduced infrastructure investments.	Reduced bills, less taxes due to reduced infrastructure investments.
What are the benefits for the DSO?	Avoding grid re-enforcement	Avoiding grid re-enforcement
What are the benefits for the Aggregator?	Not applicable	Not applicable
What are the benefits for the TSO/Energy Supplier/Operator?	Reduced balancing power needs.	Reduced balancing power needs at possible costs of increased transport capacities.
What are the benefits for society?	Minor energy savings, thus reduced peak production facilities. Unclear how savings scale to larger populations.	Peace will descend onto mankind, liberte, egalite and fraternite will be let loose.