Making the Power System Intelligent

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***Abstract* – The increasing power demand requires better exploitation of the existing system. A possible method is the decrease of the peak/valley ratio of the daily load curve. The intelligent applications help the control on the power system level. We dig in depth, how the intelligence of lower levels could be raised. The traditional ripple control can not be extended on a lot of programmable household appliances, as the washing machine, refrigerator, tumble drier, etc. We investigated typical households and found a great voluntary control potential. The paper presents the measurement results and gives a structure to take these loads into a "smooth" DSM.**

***Keywords* – DSM, Intelligent Energy delivery system, Modelling of the power system, Household Loads, Smart Grid**

I. OBJECTIVES

Nowadays we face the incredible increase of the energy demand all over the world. The unconditional satisfaction of the hardly schedulable load demand led us close to the limits of resources, economical viability and environmental sustainability. The EU encourages searching solutions in the frame Intelligent Energy Europe program.

There is a great capacity reserve at generation and transmission part of the load is more balanced, if the peak/valley ratio approaches the 1. Without Demand Side Management (DSM) this ratio is close to value 2. Although there are many DSM techniques (tariff control, campaigns, scheduling techniques) practically the ripple control is spread over. We work on the exploitation of more DSM capabilities and looking for new control structures.

To overcome these problems the power system must be made more active, the generation and the load must co-operate, there is a need for i*ntelligence in power systems.*

II. THE INTELLIGENCE IN POWER SYSTEM

A. Power system level

The age of power system technology is close to a hundred years and the traditional control tool palette was extended in the last thirty years by different Artificial Intelligence based applications in the control centres [1]:

- Alarm filtering and processing
- Fault analysis and equipment diagnosis on the network
- Remedial actions, system restoration
- Security assessment (static and dynamic stability)
- Load- and generation forecast [3]
- Planning and scheduling the load and production
- Electricity market operation
- Training simulators
- Different optimisations (loss, security, generation, network configuration [2])
- Unit commitment,
- Maintenance scheduling
- Decision support, etc.

Operations in the deregulated market:

- Strategic bidding
- Price forecasting
- Congestion management
- Portfolio management
- Market forecasting, etc.

Realizing these functions different intelligent techniques are used:

- Artificial Neural Networks (ANN)
- Fuzzy sets
- Expert systems
- Multi agent systems
- Constraint programming
- Pattern matching, etc.

All the functions are realised (wide area) SCADA systems.

B. Local or regional customer level

The Intelligent Energy and Smart Grid topic covers some lower level aggregation of small loads and resources (typically DG REN sources, as microturbines, micro-hydros, small wind turbines and photovoltaics and intelligent loads as self controllable air conditioners, dryers, washing machines and electric bread baking machine) that are scheduled and controlled on low level. These partial grids (semi microgrids or virtual microgrids [4]) can be counted as an intelligent part or an intelligent load of the network.

At the demand side the ripple control has been widely used for decades. This is a rough, unintelligent, time based remote switching technique.

There are two groups of load that can be made “intelligent”:

- Medium size, concentrated customers, as malls, office buildings (towers) and compact residential areas. Each one represent 0,5-3 MW load.
- Small scale customers are typically the households, with 3-20 kW peak load. One household does not disturb the power system, but thousands represent hundreds of MW-s. That is why it worth to deal with them.

III. Measuring of the consumer habit

We concentrate on the second group. The households may contain three groups of electrical appliances:

- Non reschedulable, spontaneous loads, as the hair drier, TV set, radio, telecommunication devices, modems, lighting, iron, microwave oven, coffee machine, computers, cooking plate, etc.
- The water heating boilers and the electric heating is remotely controlled by ripple control for decades
- We concentrate on the third group that represent a great load potential, but the usage attitude makes possible the voluntary reschedule of the normal usage schedule. These are the washing machine, tumble drier, refrigerator, cooler, air conditioners, electric bread backing machine and the heat pump.

These loads can be theoretically delayed or rescheduled from peak time to valley.

We performed measurements on different households. We used analytical and statistical methods, too. *(Details should be described in the full length paper.)* We found that the present ripple control did not alleviate the peak problems (see Fig. 1.) That is why we recommend to use better the present DSM tool (see Fig. 2.).

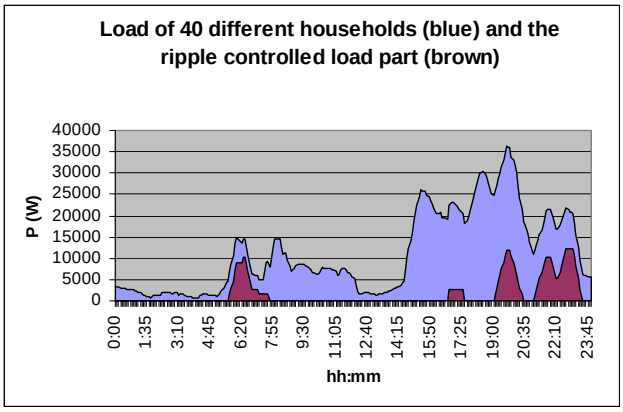

Fig. 1.: Original DSM

After deeper analysis we found that the reschedule potential is over 50 % in an average household. After rescheduling half of the potential, the peak decreased more than 30 %.

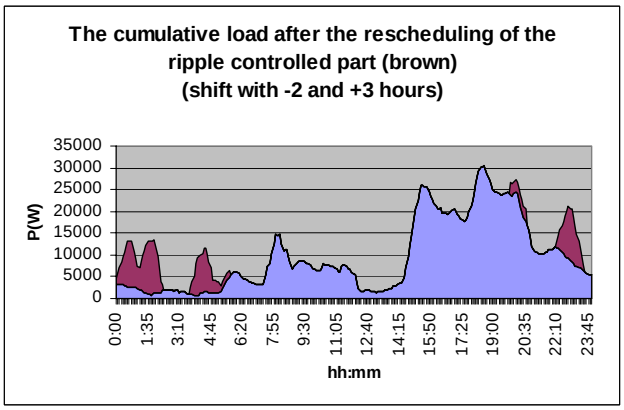

Fig. 2.: Rescheduled ripple control

IV. Realisation of the rescheduling principles

The loads and the reschedule possibilities can be monitored by special additive hardware units. These provide information to the local control machine (e.g. 1 unit / flat) and these can activate the commands of the remote control.

In the full paper discussed the details of the control system, the communication, the control strategy and the legislative side too.

V. Conclusion

The unlimited growths of the power demands require the technically intelligent cooperation between the electricity producers and users. We investigated the Demand Side Management capability in the small households and we found a huge technical potential.
We provided a control strategy and a hardware realisation scheme. We are convinced that this type of solution makes the network smart, we contribute to the sustainable electricity supply.

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VI. References

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