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LOAD MANAGEMENT VIA AMI AND RISK OF OVERLOADING THE POWER SYSTEM

One advantage of AMI is the ability to Demand Side Management. The ability to control the client devices (Load management) is one of the key function of AMI. Some customers with smart meters and Time-of-Use (TOU) tariffs pay different amounts for their electricity over three (or two) different time periods. They can program their smart appliances. Customer's devices are switched-on when energy is cheaper, and switched-off when it is more expensive. If clients on a massive scale will run their devices at a time when energy is cheaper, then it would affect the bulk electric grid.

1. INTRODUCTION

Currently, the various countries considered issues of implementation of the Advanced Metering Infrastructure (AMI). One advantage of AMI is the ability to Demand Side Management (DSM).

Utilities plan to use Advanced Metering Infrastructure for many purposes including reduction of peak loading, real-time dynamic load modeling, fault detection and reporting and at least four others. Most of these actual uses of AMI are not relevant to the bulk electric grid as they primarily serve the load-serving entity. The one use which could affect the bulk electric grid is reduction of peak loading. This is the primary purpose of AMI as a demand-response system. Clearly, the utilities rolling out AMI expect to achieve a reduction in peak loads and an overall lessening of electric usage during peak periods. This is very similar to previous systems such as Demand Side Management (DSM) or Direct Load Control (DLC) [1].

The cost of electricity with Time-of-Use prices (or Real-time Pricing) varies depending on when it is used. Customers pay different prices at different times of the day. For example, rates can be different depending on the time of the day, day of the week and season of the year (summer and winter). Time-of-Use pricing rewards you

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for using electricity during low-demand periods whenever possible. Time-of-Use prices reflect the fact that the cost to provide electricity changes throughout the day.

2. LOAD MANAGEMENT

Load management LM is the process of balancing the supply of electricity on the network with the electrical load by adjusting or controlling the load rather than the power station output. This can be achieved by direct intervention of the utility in real time, by the use of frequency sensitive relays triggering circuit breakers (ripple control), by time clocks, or by using special tariffs to influence consumer behavior. Load management allows utilities to reduce demand for electricity during peak usage times, which can, in turn, reduce costs by eliminating the need for peaking power plants.

Since electrical energy is a form of energy that cannot be effectively stored in bulk, it must be generated, distributed, and consumed immediately. When the load on a system approaches the maximum generating capacity, network operators must either find additional supplies of energy or find ways to curtail the load, hence load management. If they are unsuccessful, the system will become unstable and blackouts can occur.

Through the implementation of load management, from the market perspective it is aimed that the usually short-term inelastic power demand will be adapted more flexibly to the inelastic power generation capacity [2].

When the decision is made to curtail load, it is done so on the basis of system reliability. The utility in a sense “owns the switch” and sheds loads only when the stability or reliability of the electrical distribution system is threatened. The utility (being in the business of generating, transporting, and delivering electricity) will not disrupt their business process without due cause.

The ability to control the client devices (Load management) is one of the key function of AMI. Customer devices are switched-on when energy is cheaper, and switched-off when it is expensive. Smart meters can control the devices (smart appliances) in different ways:

- smart meter can have a relay which is switched-off or switched-on depending on whether the energy is expensive or cheaper, respectively,
- smart meter can give signals to the controller of home area network (HAN) or Energy Services Delivery Platform,
- smart meter can directly control the smart appliances via technologies such as ZigBee, Power Line Communication (PLC) or other to transmit control signals.

One of the goal of the implementation AMI is that the customers run their devices, which consume large amounts of energy, in off-peak periods load. To be able to talk about the success of the implementation of AMI, many customers must change their habits to use electricity. Thus, in this solution the point is not that a few fans or hob-

byists agree to some minor control devices. In such a case, installation of smart meters for customers that have such capabilities would be unnecessary investment. This capability to controls customers loads should be used on a massive scale.

3. THE PROBLEM WITH RUNNING THE HOUSEHOLD APPLIANCE ON A MASSIVE SCALE

The power system was intended to provide coverage of energy demand, which changes over time in a random way, taking into account periods of greater and lesser demand. Digitally controlled devices can alter the nature of the electrical load. As a result electricity demand that becomes incompatible with a power system that was built to serve an "analog economy".

For example, part of the TOU tariff customers can program their devices to run at a time when the energy will be cheaper. In the case if the control of devices will be used on a massive scale in one time then it can result in significant increase in the power system load at that moment. In addition, it is worth noting that nothing that automatic synchronization of smart meter clock causes the rapid switch-on of a great number of loads at the same instant of time.

If there is no possibility of coordination of switching such devices (e.g. by the power grid operator) then the situation can have an impact on the reliability of power supply, power quality and may cause a voltage drops.

In Poland it is about 14.5 million energy consumers. The following smart appliances could be controlled by an smart meter in household:

- washing machine,
- dishwasher,
- tumble dryer,
- accumulation furnace.

One washing machine at the beginning of the cycle takes the power of 2 kW. One million washing machines that are running simultaneously takes the power of about 2 GW. This would cause the maximum peak load to develop very quickly, which would affect the bulk electric grid.

A sudden increase in demand for energy e.g. at 22:00 would have to be planned to ensure coverage of the planned energy demand for the entire power system. Particularly critical would be the automatic switching of numerous devices. In such case, in a relatively short time (about a few minutes) a substantial increase in the power system load occurs. Balancing this increased demand would not be easy.

The system operator must have a plan to balance such a noticeable growth in demand of power in the entire power system. If the demand for electricity exceeds the currently generated power then plant turbine speed slow down and the frequency drops. In such cases, in the power plants:

- the Primary Control runs by the time of about 20 seconds – as a result of increased demand for power, frequency is reduced. It is important to remember that Primary Control will not return frequency to normal, but only stabilize it.
- then the Secondary Control runs by the time of about 15–20 minutes – Secondary Control maintains the minute-to-minute balance throughout the day and is used to restore frequency to its scheduled value, usually 50 Hz, following a disturbance. Secondary Control is provided by both Spinning and Non-Spinning Reserves. In such case, as a result of decreased frequency, generators increase the level of generated power to increase the frequency to 50 Hz.

Currently, rotating generators in coal fired plants typically operate with power equal to about 60% of rated power. They would have to increase the level of generation. Increased generation of 10% could be overcome in a relatively short time. The increase of the load from 60% to 100% would take about 30 minutes. Significant shortening of the time it is not possible, because the temperature and pressure in the boiler must be kept within certain limits and boundaries can't be exceeded. In the case of biomass co-combustion in the boiler, the additional time would be longer, because the boiler would work with less efficiency.

Poland can import energy via the HVDC cable 600 MW between Sweden and Poland beneath the Baltic Sea. In this way, one can improve the balance in the power system, provided that in Sweden it will not be applied a similar method of control of devices based on TOU or RTP (Real-time Pricing) tariffs.

In this case in the power system frequency decreases. Moreover, in some points of the distribution network a voltage drops below the lower acceptable limit.

4. MASS LOAD MANIPULATION

Researchers in various papers already pointed out the possibility of interfering with the power system by control of mass load on a massive scale. For example, an attacker could use the DSM to send messages turning off all controllable customer equipment. Once a long enough time had elapsed to guarantee most of the equipment would turn on when allowed, the attacker could send the turn-on permission message [1].

5. RECOMMENDATIONS

In order to avoid overloading of the power system by mass, simultaneous and automatic control of customer devices (smart appliances) based on the price signal, the following steps should be taken:

- It should be differentiated TOU tariffs that there will not be automatic, simultaneous launch massive number of receivers at home. Of course, some customers

would express their dissatisfaction with the fact that the neighbors have a cheaper bid price or that their devices do not start immediately when the cheaper energy rates appear, but after some time. Consumers can't accept delays in starting their devices and in such cases they may be set to run such receivers based on the external clock. A full hour schedule changes in demand for power and dispatchers must dispatch power plants, increasing or decreasing their power. In such situations power transient disturbances and in some places minor transient voltage drops may occur. It would be advisable that the automatic increase of load does not take place simultaneously with the routine work of the dispatchers, so that these two power system disturbances do not overlap.

- The grid operator should be able, if necessary, to reduce the rapidly rising demand on the power grid, which results from the automatic switching on the mass number of devices. The system operator should be able to delay the start of some receivers that are automatically run on the basis of TOU or RTP tariffs,
- In Poland, the power system needs for additional international links to the country belonging to a different time zone than Poland.

6. CONCLUSIONS

The danger of an overload of the power system by automatic simultaneously switched-on devices by the public in response to the stimulus / incentives pricing tariffs is real. The adequate steps to prevent it should be taken. Energy regulators should avoid use of promoting a uniform method of control of acceptances from all customers in the country. They should make specific recommendations in this regard in their recommendations for AMI systems. In addition, energy companies should adjust TOU or RTP rates based on which customers will switch on or off automatic control devices in such a way that the switching equipment is not operated full hours of day.

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