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DISTRIBUTED AND CENTRALIZED ENERGY SYSTEMS – SYSTEM ASPECTS OF ELECTRICITY DEMAND-MEETING MANAGEMENT

Abstract: Demand side management is one of the key concepts of intelligent networks (SmartGrids) and covers a very wide range of measures, among which are energy efficiency, lowering of the energy consumption and load management. Load management is particularly important from electric power system point of view. Optimal usage and control of the existing electric power system, which can be achieved with load management, is crucial for reducing investment and operational costs. Measures of demand side management require a synergistic and effective use of knowledge in the areas of technology, regulation, economics and sociology. Article is focused on requirements of specific areas and demand side management programs, which can reduce investment and operational costs of the electric power system.

Key words: *Distributed electricity generation, Smart Grids, Demand Side Management*

INTRODUCTION INTO DEMAND-MEETING MANAGEMENT

Demand-meeting management is one of the key areas of the SmartGrids concept. Basically speaking, demand-meeting management is divided into long-term and short-term demand-meeting management. Long-term demand-meeting management involves persistent long-term changes of consumer habits. The main goal is to assure long-term and permanent reduction of electricity consumption on the consumer side. In most cases, long-term demand-meeting management is regulatorily directed and providing long-term advantages for consumers and the environment as well as cost savings for consumers. Long-term demand-meeting management includes energy-efficiency measures and reduced consumption. The task of short-term demand-meeting management is to stimulate consumers to adapt, for a short period of time, their consumption either with regard to the needs of the electricity supplier or network operator. By all means, this does not necessarily

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mean that the total consumption should be reduced. Stimulation can take the form of alternative tariff systems or an incentive system.

Speaking in terms of the electric power system, besides being important how much power is being consumed, it is even more important at what time it is being consumed. As the entire power system is planned with regard to the peak load, short-term demand-meeting management is even more important as it helps us to assure a higher level of exploitation of the current electric power system, thus minimising the need of having the existing power system expanded and constructing new peak- generation units.

AREAS OF DEMAND-MEETING MANAGEMENT

Since the area of electricity demand-meeting management is very complex, the bodies responsible for implementation of the related programs will, during their practical work, be faced by numerous challenges emerging in the technological, regulatory, economic and sociological area. The figure below shows some of the most important tasks to be accomplished on each of the above areas to enable individual programs of demand- meeting management to be efficiently accomplished. The fact is, that despite being brilliantly technologically supported and being regulatorily or legally well grounded, the program can turn out to be a complete failure in absence of an appropriate communication with consumers or network users. The final result satisfying any of the stake-holders can be assured only through full commitment established on each of the four areas.

The most important task to be accomplished in the technological area is selection of an adequate communication technology and technology enabling result verification. The consumers should be provided with an appropriate equipment enabling either controlling of individual devices at consumers or enabling them to be informed about various tariffs and simultaneously monitoring the actual consumption during individual tariff intervals. Advanced-measurement systems, foreseen by the European Directive to be installed by 2020 at 80% of all the consumers, will provide the basis for introduction of innovative tariff systems stimulating consumers to adapt their consumption. Smart household appliances and installations will help consumers in their effort to find the optimum between the level of the service and the bill to be paid for the consumed electricity. Device controllers enable us to control the devices – intended for this purpose – automatically and remotedly and minimally disturbing the consumer comfort.

The research made at the Milan Vidmar Electric Power Research Institute of Ljubljana shows that the most important advantages of short-term demand-meeting management are on the level of the system costs (investments into expansion and up-rating of the power network and into peak-generation units). Yet, there is quite a number of regulatory problems to be solved in this area in order to allow for a successful implementation of short-term demand-meeting management programs. The role of the stake-holders needs to be defined, precisely who may implement the programs, who may take part in them, what are the relations between the

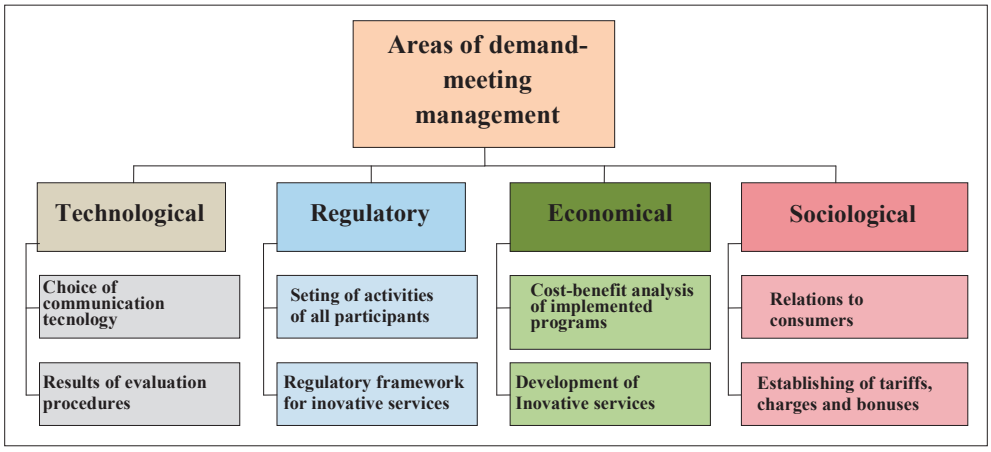

Figure 1. Key areas and tasks of demand meeting management

stake-holders (the programs to be implemented by the system operator will affect the deviation costs of electricity suppliers) and provide the basis for introduction of innovative tariff systems at network fee. In Article 92 of the applicable Slovenian Energy Law it reads that the system operator of the transmission and distribution system can grant to individual consumers from various tariff groups more favourable terms if such consumers, by adapting their consumption, contribute to a more favourable loading of the power system, and that consumers practicing the same type of adaptation are treated equally. A mandatory methodology for laying down tariff systems is to be adopted by the Energy Agency on the basis of a general act and upon governmental consent. Unfortunately, neither the Act on the methodology for assignment of network-fee nor the Ordinance on general terms for electricity supply and consumption determine the procedure according to which specifications of the Energy law would be effected.

In the area of economy, the most important challenges expected to be coped with are associated with development of innovative services. They will be interesting for a very vast circle of consumers and at the time of laying down programs that will, at the lowest possible costs, bring around the highest possible advantages. With this respect it should be noted that – particularly in the beginning phases of program introduction – there will be extra costs contracted specifically by distribution utilities. They are the ones which already now do not dispose of sufficient funds enabling them to implement the adopted network-development plans (see Table 1). Most of the utilities have less than 50% of their own funds available for implementation of investments foreseen by the national long-term development plan; the situation which is particularly critical is that of Ljubljana Distribution Utility.

The sociological area, too, which has in the field of energy in past been often neglected, plays a very important role in demand-meeting management. Commu-

Table 1: Ratio between the needed investment funds foreseen by the national long-term development plan and own funds of individual distribution utilities in thousands €.

Utility	Investments	Own funds	Share
Elektro Celje	35.100	11.442	32,6%
Elektro Gorenjska	26.821	7.285	27,2%
Elektro Ljubljana	75.859	10.766	14,2%
Elektro Maribor	30.500	13.500	44,3%
Elektro Primorska	19.050	8.448	44,3%
TOTAL	187.330	51.441	27,5%

nication with consumers is decisive for program implementation successfulness; it enables consumers to positively accept the programs upon acquainting them with the benefits they can draw from them. From the analysis of the households attitudes to consumption it can be seen that the majority of them is willing to accept various demand-meeting management programs. But there is quite a difference between preferences among individual consumer groups. To sum up, the important conclusion that can be drawn is that it is absolutely impossible to attract all the consumers with one single demand-meeting management program. To allow for an all-round exploitation of benefits from demand-meeting management, the highest possible level of program diversification, adapted to preferences of individual consumer groups, is an imperative.

POSSIBLE PROGRAMS OF SHORT-TERM DEMAND-MEETING MANAGEMENT

From the calculations made at the Milan Vidmar Electric Power Research Institute it can be seen that any one kW lower peak load means – from the system perspective – a saving in the amount of app. 200 € on the annual basis. To stimulate consumers to change their attitude to consumption, there are already today, at the current state-of-the-art, various programs available: programs of direct-consumption monitoring and programs of a critical peak tariff.

Programs of direct-consumption monitoring

By using programs of direct-consumption monitoring, the program performer directly monitors or controls operation of various devices. The most suitable are air- conditioning devices, water heaters, refrigerators and icing devices, as well as heating devices. By interrupting their operation for a relatively short period of time, the consumer comfort practically remains unaffected, i. e. it does not worsen.

The essential advantage of programs allowing for direct consumption monitoring is in the program-performers' ability to monitor the device operation along with a high level of response reliability. The monitoring loads can be joined into groups and each of them can be monitored independently from the others. Moreover, an investment into an advance measurement system is not an unavoidable ne-

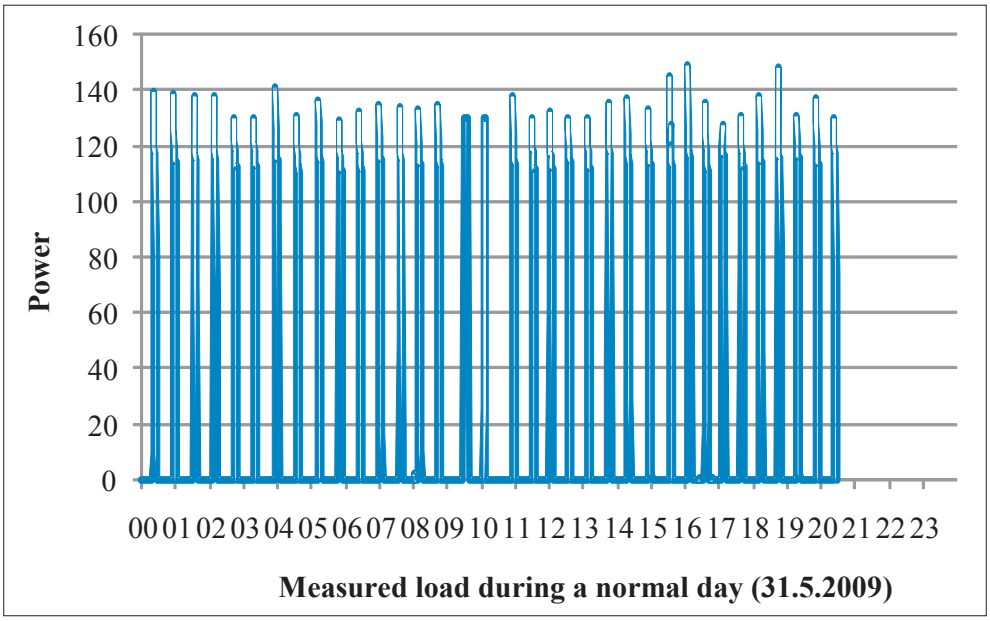

Figure 2. Operation of a typical refrigerator

cessity in these programs. A weakness of these programs is mostly in the fact that bonuses to the consumers are usually fixed, irrespective of either greater or smaller consumption. Also, the share of people willing to allow the program performer to manage their devices is limited, and there are only some of the household appliances, not all of them, that are covered by the program. In Slovenia, the greatest potential are refrigerators. Their most important advantage is their permanent cyclic operation and during their operational time they operate at a constant power. A typical operation diagram of a refrigerator is shown in Figure 2.

Table 2 shows the number of appliances in the Slovenian households that are suitable for remote monitoring, acquired through available data and estimations

Fig. 3 shows our assessment of the total saving potential. If 10% of the Slovenian consumers decide to take part in the program, the annual saving will be of the order of one million €.

Table 2. Estimated number of individual appliances used by the Slovenian consumers and the potential power savings

Household appliances	Number of appliances in Slovenia	Potential saving in MW
Refrigerators	~ 900.000	~ 30
Water heaters	~ 400.000	2–29
Air-condition devices	~ 140.000	10–29
Heat pumps	~ 18.000	9–18
Total	–	51–106

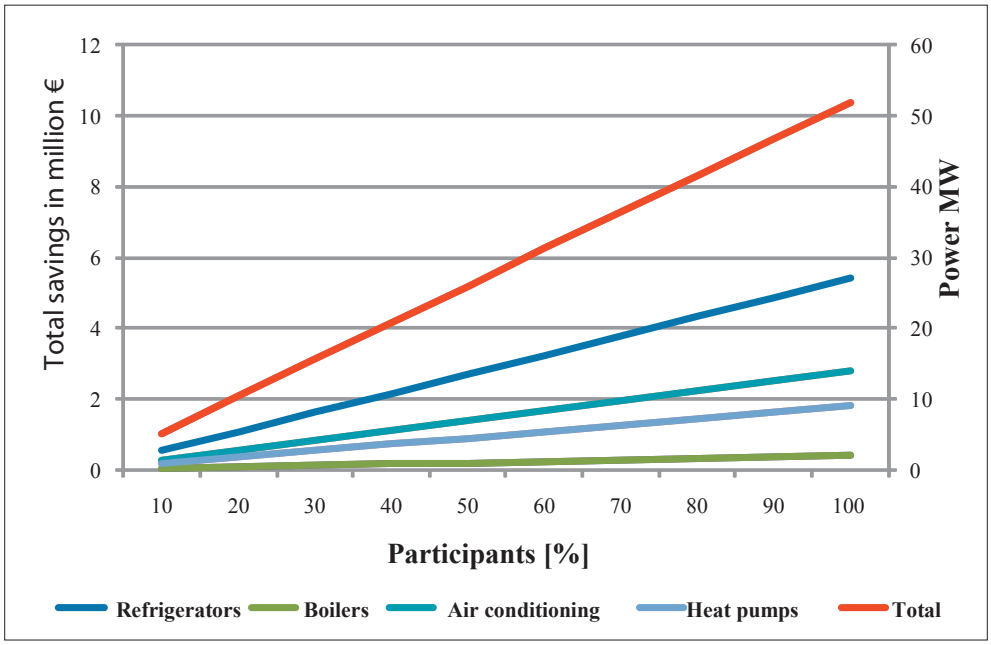

Figure 3. Potential savings in Euros and MW

Programs of the critical peak tariff

In programs of the critical peak tariff or price, the consumers are – at the time when the program performer wishes to lower consumption – given a considerably higher electricity tariff or price. Its compensation can be achieved during "usual hours" when the tariff or price is lowered. The principal idea of setting up a tariff system is that the bill for consumers does not change if they do not change their attitude to power consumption, but, they can reduce it if they adapt their consumption with regard to the needs of the program performer.

The advantage of the program is its implementation which is very simple and imposing no limitation on just few consumer types as is the case with the programs of direct load monitoring. The only precondition are the electricity system counters which measure the actual results of reduced consumption at consumers and which are adequately accounted for. The consumers are offered to buy at their free will load controllers enabling them to simplify their consumption adaptation. They may also choose to combine the two programs, i. e. the load-controlling program and the critical peak-tariff program.

The state-of-the-art communication technologies allow for simple and inexpensive informing the consumers about the critical peak tariff. Mobile telephones are most likely a facility reaching most of the population, thus enabling electricity consumers to be informed through SMS messages about tariff variations. This kind

of communication can be efficiently combined with others, such as e-mail messages, web site information, power displays, etc.

The weakness of the program is mostly in the program performer inability to dispose with reliable information about the potential consumption reduction. This imposes the necessity of testing with pilot projects providing the basis for assessing on their results the potential consumption reduction. Results of some of the pilot projects, mostly those from the USA, indicate an average 20% decrease in the peak consumption through use of such programs. As it is not realistic to expect, that all the consumers will be willing to adapt their peak consumption, we propose to rely on the assessment used in studies by the Milan Vidmar Electric Power Research Institute of Ljubljana about adoption of the advanced electricity-measurement system [2][3] forecasting a 5% decrease in electricity consumption. On the annual basis, this brings along a saving of some 10 million €.

CONCLUSIONS

Advantages of the market-based approach to the proposed adoption of the above demand-meeting management programs is in the fact that there are no regulatory (legal) barriers for their implementation and that their goals are measurable. Unfortunately, their economic analysis shows that the costs of their implementation are, in the current circumstances, higher than their potential advantages. On the other side, the system-based approach to the issue indicates clear economic profits, yet, its implementation will be faced with numerous difficulties associated with problems of short-term consumption assessment, regulatory (legal) barriers and damages caused to electricity suppliers (deviations). Prior to having the approach implemented in practice, the above barriers shall therefore have to be removed.

The economic analysis shows that the total potential annual saving in the system in the area of direct monitoring of individual devices will be of the order of a million € if 10% of the Slovenian consumers adopt the program of direct monitoring. The critical peak-tariff programs would at the foreseen 5% decrease in the peak consumption yield an annual saving of a million €.

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