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Situation Management Over the Smart Grid

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Abstract

The article encloses a systematization of energy monitoring and management methods for increasing the efficiency of the Smart Grid on basis of the situation management. The Situation Management is determined as a binding process between strategic and tactical administrations of the energy consumption. Also Situation Management may be considered as an integration of two technologies of energy savings: one of one's is based on the systems of energy management and another technology is a SmartGrid. The work was performed as part of the Russian Federation grant MK-5279.2014.8 "Synthesis of efficient technologies for remote monitoring and managing of intellectual power system with active-adaptive network."

Keywords: situation management; smart grid; energy management system; energy saving; energy efficiency; smart metering.

Introduction

Energy saving and energy efficiency (ESEE) is one of the key targets of modern regions's economic development, [1]. In the context of ESEE a special importance attaches to monitor energy performance and operational management of energy saving from technical, organizational and economic position. A breadth and a complexity of the task require a development of range of effective tactical and strategic tools. The most promising of such tools are the development of the Smart Grid (SG) [2, 3] and the concept of energy management systems (EnMS) [4], which allows development a united management-information system for the rational usage of energy sources for the individual components and for the ESEE system as a whole.

An important feature nowadays is that the energy management of the Smart Grid or MicroGrid, as an administration of large territorial and administrative portioned object, does not allow to use the tactical and the strategic approaches together in Russia. Chiefly this is caused by a difference between placed targets and the high spending for the concrete management decisions, as well as absence of a mechanism of integration of a global and a local management within the framework of energy systems. The above defines the task of the development of the principles and tools of complex ESEE processes, adapted to the stated specifics.

Materials and methods

1. Modern Standards and Technologies in an Area of the Large ESEE Systems. Let mark out key areas applicable to the object of research. Smart Metering (SM) are systems of hardware and of

software which are based on the latest international scientific and technological achievements, providing a new level of reliability:

–fast and accurate measurement of physical magnitudes, which are present quantitative characteristics of the energy resources;

–monitoring and management of the supply, transportation and consumption;

–automatic transfer, processing and presentation of information on the resources consumption ;

–creation of situational databases about energy consumption with elements of infotainment of management tasks.

Thus, SM based on an intelligent accounting is an automated system that provides monitoring and control of energy consumption according to the criteria of energy efficiency optimization. This information is needed as for consumers and for the energy providers as well. Such measuring methods are called "smart tools" for energy monitoring [5].

The Concept of the Smart Grid (SG) implies the joining of consumers and producers of electric power in united automatic system, which allows checking a performance of each component of the network at the real-time mode. Smart Grid gives a chance of realization of self-tuning of dispensed energy system, which will allow the effective distributing of electric power across the network according to a complex of the conditions [6].

Integrated into a unified platform, the existing automated information systems (an industrial control, a process management, a data collection and a transmission of information, etc.) will provide a new of power grids structure with the object of the improvement of networks performance [3]. A perspective smart electric grid will able to produce automatic reconfiguration to achieve a minimum energy costs without sacrificing reliability. It should be noted that the control into the Smart Grid networks has a purely tactical nature.

An approach of the Energy Management Systems (EnMS) is using to solve the tasks of strategic energy management [7]. EnMS is a system of management which ensures efficient usage of energy resources. Such systems are based on the standard technological metrology and exams of power quality, analysis of energy consumption and implementation of energy saving activities. According to international standards, for example as ISO50001, DIN EN16001 or GOST R 50001-2012, these systems not only provide the automation accounting of energy but also affords an opportunity of further identification and elimination of wasteful energy consumption.

2. The Situational Management over the SmartGrid as an Instrument of ESEE Technologies Integration

The Notion of the Situation management (Situation Management - SMn), as one of the modern forms of realization of decision support system, founded on a technology of modeling and situation analysis, allows to use its functional for integration of existing approaches and technologies of municipality activities in area of energy savings to account of the concentrated presentation of information and integral control. The SMn technologies occupy the intermediate branch of hierarchy of management ESEE between level of tactical management, based on the Smart Grid conception, and strategic control placed on basis of EnMS (Figure. 1). A time of reactions of levels of management (T) is straight pro rata of responsibility of make a decision and is most important on top of the hierarchy.

Let's consider the hierarchy of energy management.

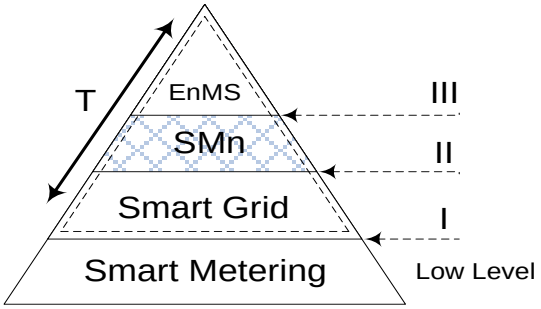

Figure 1. The hierarchy of management levels in ESEE

The Lowest (I) level formed on basis of technologies of Smart Metering with possibility of the remote data collection does not is the level of management as a fact but it is the base for shaping of following decisions for next levels. The System of the intellectual accounting allows organizing the relationship with measurement instrumentation and providing the accuracy and reliability of the metrology on qualitative level.

The integration of Lower level and level Smart Grid will allow getting over of centralized supplying of energy to distributed ones via organization of bidirectional relationship with instrumentation. The realization of control mechanism at the SG rate provides possibility of the remote connection/unhooking parts of municipality electric networks and restrict of powers consumption, changing of the tariff and monitoring the emergencies and similar.

The Top-level (III) is presented by organizing-economic instrument of management and is realized on basis of the EnMS system. This allows to get formed the strategy of the improvement of municipality energy savings.

The Situation management realizes intermediate level (II) of management and it is the binding process between strategic and tactical management of energy consumption. This level of management unites the energy savings technologies based on the energy control systems (EnMS) and Smart Grid and use thereby all technical abilities and organizing mechanisms ESEE of Smart Grid.

3. The Formalization of the Process Support of the Smart Grid Energy Savings

The relations between components of hierarchy of the levels of management in ESEE may be presented from position of theory of sets as a graphic scheme brought on Figure 2.

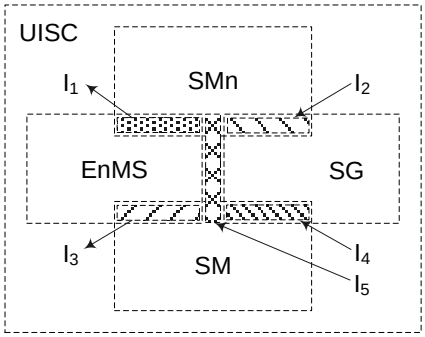

Figure 2. Graphic scheme illustrating the relationship between the components of levels of management within the ESEE

Let's look the SmartGrid energy savings support process multiple-theoretic description on basis of the offered scheme of the relations between components of levels of management ESEE. The main elements from the ensemble of elements will select:

$SM = \underline{SM} \cup \underline{\underline{SM}}$ - a multitude of components and operation in Smart Metering (the information recourses, signals, data), used under distributed monitoring of municipality power objects; here with $\underline{SM} = \{\underline{SM_1}, \underline{SM_2}, ..., \underline{SM_m}\}$ - an ensemble of the processes of instrumental data logging of the accounting in mode of the hard real-time, which are sending on level of Industrial Control and can be used for the technical accounting reasons; $\underline{\underline{SM}} = \{\underline{\underline{SM_1}}, \underline{\underline{SM_2}}, ..., \underline{\underline{SM_n}}\}$ – a host of the processes of registrations of commercial data;

$SG = \underline{SG} \cup \underline{\underline{SG}}$ - a multitude of components and operations in SmartGrid, considered for ESEE, herewith $\underline{SG} = \{\underline{SG_1}, \underline{SG_2}, ..., \underline{SG_i}\}$ – a host of data about all generating device installed on the energy system and data related with consumers of the municipality; $\underline{\underline{SG}} = \{\underline{\underline{SG_1}}, \underline{\underline{SG_2}}, ..., \underline{\underline{SG_j}}\}$ – a quantity of intellectual devices of monitoring and control using for providing of communications between consumers and suppliers of energy, which are interacting with external systems;

$EnMS = \{EnMS_1, EnMS_2, ..., EnMS_k\}$ – a host of operations, executed by the system of energy management;

$SMn = \{SMn_1, SMn_2, ..., SMn_l\}$ – a great number of components and operations of the situation management;

$I = I_1 \cup I_2 \cup I_3 \cup I_4 \cup I_5$ - a multitude of interfaces applied for interaction of key components within the framework of offered method of ESEE; herewith:

$-I_1 = SMn \cap EnMS$ – a host of channels for transferring data using for administration of region or city organizations (such data as the amounts of financing or data about motivations, stimulation and results estimation);

$-I_2 = SMn \cap SG$ – a host of the channels for delivery of statistical data (generalized factors of the consumption and energy producing, energy savings key indicators) and management information transmission channels (the commands and desksides of the equipment of actively-adaptive networks);

$-I_3 = EnMS \cap SM$ – a host of the measuring channels of energy management;

$-I_4 = SM \cap SG$ - a set of data transferring channels of the united communication and energy supplying infrastructure of the region or city;

$-I_5 = SM \cap SC$ – a host of channel for transferring of technical and commercial data of the energy consumption.

A generalized many-structural model of support of Smart Grid energy savings on basis of the situation management can be built using regulations of the theory of sets. Such model is linking the enumerated above multitudes each with other:

$$UISMN = <SM, SG, EnMS, SMn, I, M, K, S>, \quad (1)$$

where $M = \{M_1, M_2, ..., M_r\}$ - a multitude of the possible structures of support ESEE. Such structures as math ensuring, algorithmic providing, software and dataware which is realized by means of SMn - a situation management may be marked out; $S = \{S_1, S_2, ..., S_p\}$ - a quantities of measuring situation at moments of time $t \in T$; $K = \{K_1, K_2, ..., K_o\}$ - a multitude of assessment criterions of the measurement results.

The offered model UISMN (united information space management) is the united information space of the processes of management of energy consumption of Smart Grid including optimization solutions [8, 9]. This model is uniting strategic management based on system of energy monitoring and tactical on base Smart Grid.

Discussion

The visual models of variants of usage and functioning of the support of Smart Grid energy savings activities can be created by using the language of the graphic description of object modeling. These visual models are founded on hierarchy of levels of management in ESEE, on the shown previously schemes of the relations between components of management level and theoretical-plural generalized model how ones were shown above.

The formalization of operations of situation management includes modeling of collections its key processes such as accounting of energy resources, planning, an estimation of efficiency of actions and etc.

The organizations with SmartGrid participation spend the needed energy resources during their current activity. The information about quantities of consumption passes to the level of situation management via levels of SM and SG. The analysis of situation and the estimation of actual level of efficiency of energy spending are producing on basis of data which are received from the systems of various levels. The analysis of the finished, current and the planned actions within the estimation of the actual values of financing are executes additionally. The results of analysis and estimations are using as the basis for the following recommendation for further local and general corrective impacts on the ESEE process of separate Smart Grid objects.

The reporting documentation for federal state authorities about the achievement of goals which were set to organization by legal texts in area of ESEE is forming at the final stage when the integration of received information was taken into account also were produced calculations and the modeling of situation was finished.

Similar way uses for modeling of each key process of situation management. The realization of set of these key processes and their integration allows seeing fulfilled the complex mechanism of the ESEE processes support.

Conclusion

The usage of the situation management SMn is a perspective direction of Smart Grid energy savings development or demand response [10]. The considered method of administration carries a significant social-economic effect and assists to evolve the modern theories and the practices of energy consumption reduction with reference to the large territorial and administrative portioned objects.

The versatility of the offered approach allows to replicate repeatedly the systems of the situation management on territory with the advanced infrastructure that will allow to form a generalized data base of systems and processes ESEE, and also one allows to conduct the statistical analysis of the collected and active information in scale information space. The perspective experience of functioning SMn in regions will be useful and necessary for specialists who has a job at the field of energy savings and managers of energy departments, power engineers, employee to administrations, operative and emergency services and others. The international cooperation enables to use the best experience of the leading countries.

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