

Active consumers in Russian electric power industry: barriers and opportunities

I.O Volkova¹, E.A. Salnikova², L.M. Gitelman³

¹*National Research University «Higher School of Economics, Russia*

²*Non-profit partnership «Market Council», Russia*

³*Ural Federal University named after the first President of Russia
B.N Yeltsin, Russia*

Abstract

Development of Russian electric power industry in recent years is characterized by a multitude of problems and a decrease in a number of performance indicators. It dissatisfies consumers and encourages them to implement various measures to reduce risks and costs of energy supply. This creates preconditions for the emergence of «active» consumers in the domestic electric power industry. Given this trend it would be appropriate to switch from Supply Side Management to Demand Side Management. This will require the implementation of a wide range of measures, including strategic issues of industry development, legal framework and transition to a customer-centric market model.

Keywords: active consumer, demand response, demand side management.

1 Introduction

Change in the technological basis of electric power industry by development of Smart Grid System leads to decentralization of economic decision-making, significant changes in industry management and rules of interaction between economic agents in market especially households and companies which until recently were only consumers of services. New technological basis creates conditions for a fundamental change in economic behavior of relevant market agents from «passive» to «active» accompanied by a change in functions and roles of consumer agents; from agent accepting terms dictated by the electric power system to an «active» consumer who orders services. New roles manifest in demand management actions and provision of additional system services for load management which gives the consumer an ability to compete with generation.

2 Introduction

The main trend in development of Smart Grid related to the fact that level of network control and automation increases, technologies become available to a consumer, consumer becomes not just a subject that consumes electric power but begins to play an important role in the energy system by ordering a set of services that he needs. From a subject subordinated by strict regulations and requirements he becomes a customer. The analysis of international studies and developments on this problem allows us to formulate two main characteristics of an active consumer (Figure 1). First – technological capabilities and devices that can either generate electric power or use electric power storage system. Second – opportunity and implementation of consumer demand management. The key changes include a new consumption patterns. Centralized energy system was focused on large consumers: large steel mills and factories that were not interested in implementing energy efficiency programs and energy saving, now the world trend is the increasing share of consumption of domestic sector, new customers, such as data processing centers, (e.g., Google consumes more energy than some industrial consumers).

Thus an «active» consumer is a subject of electric power market which has a technological capability to change its consumption mode and willingness to participate in demand management programs forming the main characteristics of generated electricity: volume, quality, consumer characteristics and energy services.

Formulated above characteristics of «active» consumers determine their main functions in energy system:

- Coordinated and automatic management of power consumption devices operation mode in accordance with their needs determined by the production plans or household's needs;
- Control operation mode of generating equipment and electricity storage systems;
- Development of a strategy for participation in provision of ancillary services [1].

Our study allows estimating opportunities of implementing «active» consumer functions and behavior strategy of consumers from various fields and economic activities selected based on various power consumption devices' characteristics (Table.1).

The analysis shows that in the current environment the ability to implement the functions of the «active» user is limited due to low availability of electricity storage technologies and small generation and electricity market model specialties: absence of consumer services market sector, inability to sell electricity from its own generating capacity to the grid (for small generation). In addition technological features of some areas of activity result in inability to implement functions of an «active» user now and in the near future.

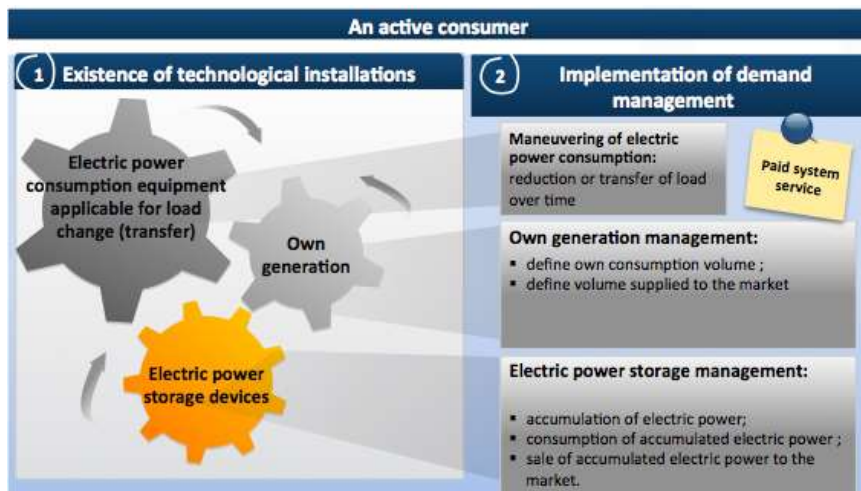


Figure 1: An active consumer in energy sector

Key requirements for energy system that determine the significance of a consumer «activation» process are: [7, 2]:

- *Motivation of active consumer behavior*

This includes creating conditions for independent determination of volume and functional properties (safety and quality) of consumed electric power by consumers in accordance with their needs and grid capabilities based on information on prices, volume, reliability and quality of electric power.

The above mechanism is implemented through the establishment of automation systems among consumers that respond to the excess electricity price above the specified level at peak times and change the operation mode of power consumption devices. The use of such control systems for both industrial and household users is assumed. The proposed mechanism allows users to optimize the cost of electricity while energy companies achieve reduction in capital and operating costs (including due to the decommissioning of inefficient peak generating capacity).

- *Integration of consumers' own generation of electricity*

This includes improvement in procedure of technological connection and certification of small and distributed generation and power energy storage systems in order to ensure their integration into the power system. Distributed generation is characterized by less stable operation characteristics which may lead to reliability decrease so an increase of its share is accompanied by additional risks. To eliminate these risks it is necessary to conduct two-way communications, intensive provision of information, as well as introduction of «intelligent» control and accounting.

Table 1: Analysis of possibility of realization of «active» consumer functions in Russian electric power industry

Scope	Parameter	Now	In perspective
Household consumers	Electric power consumption management	Not implemented or carried out in small volumes in manual mode.	Automatic control of the operation mode of electrical appliances (electric isolated devices, for which there is the possibility of changing work schedule: washing machine, dishwasher, air conditioning, heaters, refrigerators, electric) on the basis of minimizing the cost of energy and satisfaction with the work schedule.
	Own generation	None.	Presence of own generation (increase in the availability of renewable energy); Possibility of transfer its own generation of electricity to the grid.
	Electric power storage	None.	Availability of electric power storage device
	Strategy	Electrical devices mode planning is not carried out or done manually	<ul style="list-style-type: none"> ▪ Planning of operation mode of each appliance with automatic on/off option for those devices which has a possibility of transferring load in time ▪ Define strategy of own generation loading; consumption and the volume of electric power output to the network; ▪ Define strategy of using electric energy storage device: charging, selling of accumulated electricity to the grid, own consumption of accumulated electricity.
Industrial consumers	Electric power consumption management	Reduction in load at peak hours is not considered by the market as an alternative to downloading a backup / peak generation and is not paid by the market.	Participation in programs of demand management: <ul style="list-style-type: none"> ▪ Automatic load reduction in case of emergency; ▪ Automatic control of equipment operation modes (load time transfer) on the basis of cost minimization; ▪ Provision of system services of reduction in energy consumption to produce the equivalent of the payment in the amount of peak-load / backup generation.
	Own generation	No possibility of selling electricity on the market.	Possibility of selling electric power from own generation to the network
	Electric power storage	None.	Presence of electric power storage devices with large volumes
	Strategy	In some cases (for example, OJSC «Surgutneftegas») planning of consumption mode and load of own generation is carried out on the basis of market prices.	<ul style="list-style-type: none"> ▪ Planning of equipment operation mode with automatic shutdown option in case of participation in relevant programs with interruption, transferring the load to provide ancillary services to the corresponding payment; ▪ Define strategy of own generation loading; consumption and the volume of electric power output to the network; ▪ Define strategy of using electric energy storage device: charging, selling of accumulated electricity to the grid, own consumption of accumulated electricity.

Scope	Parameter	Now	In perspective
Agricultural consumers	Electric power consumption management	No technological possibility of transferring the load in time.	
	Own generation	Self-developed generation is not developed (including due to the lack of development of renewable energy sources). There is no possibility of selling electricity on the market.	Development of own generation, including increasing the availability of renewable energy. Possibility of transfer its own generation of electricity to the grid.
	Electric power storage	None.	Presence of electric power storage devices with large volumes
	Strategy	Electric power consumption from the grid	<ul style="list-style-type: none"> ▪ Define strategy of own generation loading; consumption and the volume of electric power output to the network; ▪ Define strategy of using electric energy storage device: charging, selling of accumulated electricity to the grid, own consumption of accumulated electricity.
Railroad transportation: no strategy	Electric power consumption management	No technological possibility of transferring the load time	
	Own generation	No technological possibility of having own generation.	
	Electric power storage	No technological possibility of electric power accumulation.	
Construction: no strategy	Electric power consumption management	No technological possibility of transferring the load time	
	Own generation	No technological possibility of having own generation.	
	Electric power storage	No technological possibility of electric power accumulation.	

In addition in order to realize the possibility of selling electricity of consumers' own generation to the grid, it is necessary to ensure the provision of information to consumers about prices and parameters of power system.

- *Provide access of «active» consumers to electric power markets*

The ability to implement functions of the «active» consumers in electric power system is provided through mechanisms of power management (Demand Side Management), which involve a variety of forms of interaction between consumers and other members of the power system. Figure 2 shows the classification of these parameters, developed on the basis of generalization of different terminology and definitions [3, 4].

The first reason for classification of Demand Side Management mechanisms is the duration of exposure to consumer behavior:

- Long term perspective: mechanisms to improve energy efficiency
- Short term: demand management mechanisms (Demand response and Load Management). [5, 6]

Furthermore one of the important parameters of classification is a type of response:

- Static response (increase in energy efficiency, including through the use of standards) – actions to be taken at any time, depending on the specific signals received from market, or technological system operator requests. Basically, these actions are long-term, for example, the replacement of old equipment with energy efficient will reduce energy consumption throughout their lifetime.
- Dynamic response – actions to be taken in response to signals received from the market or to a predetermined system conditions. Such actions are carried out in accordance with short-term requirements and have a short-term impact (only at run time) although the accumulated effect of the actions of a few consumers can contribute to changing consumer behavior in terms of consumption and market development.

Third parameter of classification is the level of participation of consumer: active or passive. An example of a static response with passive participation of consumers is regulation through establishment of energy efficiency standards of manufactured equipment by the state. This demand management mechanism is the most common nowadays. Active participation of consumers is provided by making a decision, for example, of installation of energy efficient equipment.

In case of dynamic response passive consumer response is influenced by the other participants, and not due to the action of a consumer (e.g., technological operator or energy supply companies, etc.). Most often, these actions are planned and fixed in the contract, and are required to maintain the reliability, balancing the energy system or for case of emergencies. In order the consent of consumers is the required condition to implement such actions, however, timing and composition of action is determined by the other participants. To be able to implement such programs one needs to implement a choice of consumer parties and offer conditions for their motivation. The active participation of consumers implies implementation of proactive actions by the consumer, for example, the transfer of electric power consumption to another time as a reaction to high prices in power

system during peak periods. In this case consumers make choice based on information received from market and decide to change their behavior in response to said signal. Examples of mechanisms ensuring the implementation of such actions in the electric power market are dynamic pricing, trading on power management. Barriers for implementation of such actions are the concept of management of electric power, focused on producers, lack of information necessary for decision-making for participants from the demand side [4].

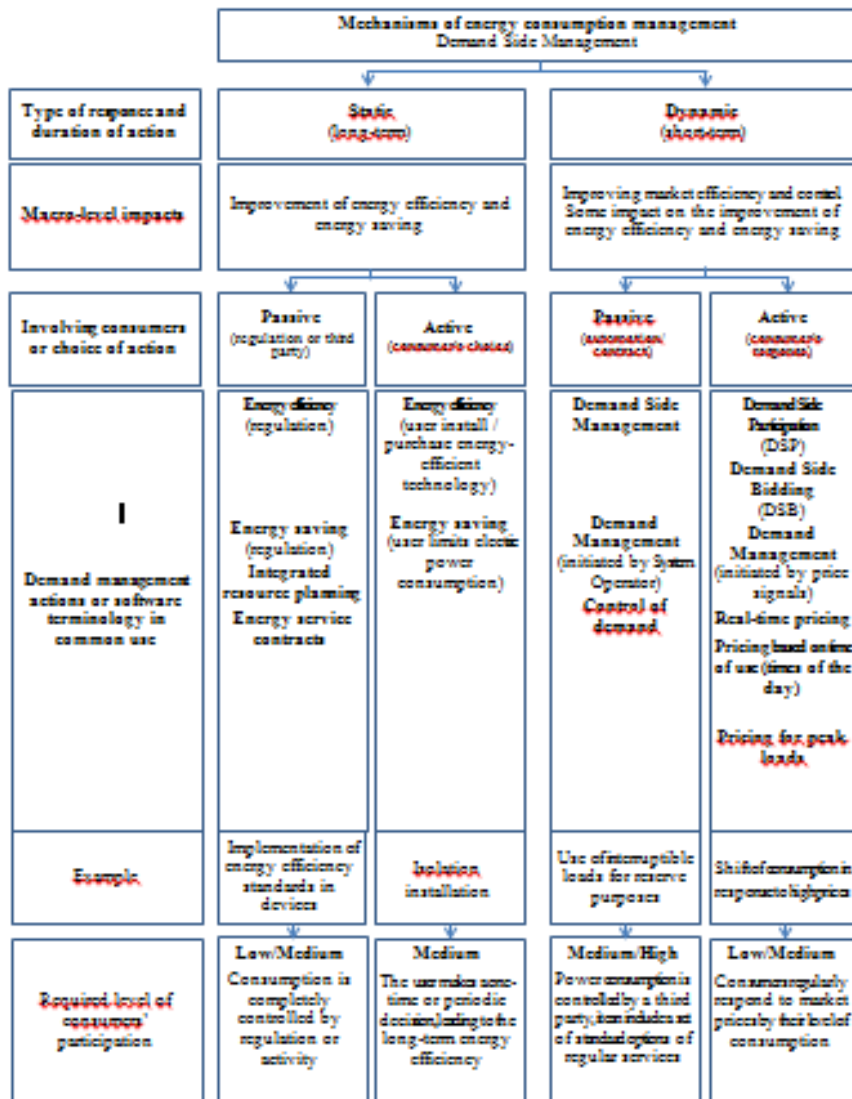


Figure 2: Mechanisms of Demand Side Management

On the basis of these characteristics of an «active» user as well as the analysis of current rules, principles and technological parameters of energy system the authors formulated a system of requirements for development of energy required for emergence and integration of an «active» user, which are presented in Table 2.

Table 2: System of barriers to overcome for emergence and integration of «active» consumers to the power grid

Barriers	Measures
Technological	
Underdevelopment of electricity accounting and measurement systems as well as information and communication technologies of transferring and processing data	<ul style="list-style-type: none"> ▪ Development and equipping of power consumer devices with automation systems of remote control modes; ▪ Development and implementation of intelligent systems for accounting and measurement, allows to monitor the price of electricity in real time ▪ Implementation of information and communication opportunities for two-way interaction between a consumer and energy system using smart metering.
Technological complexity of integration of distributed generation to the grid	<ul style="list-style-type: none"> ▪ Improvement of technologies, methods and standardization requirements for the integration of the small distributed generation (including renewable energy) to the grid while maintaining the stability and reliability of its work.
Economic	
Creating incentives for consumers' «activation»	<ul style="list-style-type: none"> ▪ Development of motivational management mechanisms; ▪ Formation of demand management programs system: ▪ Dynamic pricing methods; ▪ Direct load control methods (voluntary participation program): direct load control, Demand Buy Back, Demand Bidding, Interruptible Load, etc. ▪ Creating a market of system services for a consumer
Organizational	
Need for coordination of consumer retail market	<ul style="list-style-type: none"> ▪ Agency contracts in terms of selling the potential volume of reduced loading on retail market; ▪ Interaction with consumers and aggregation of consumers' offers in terms of costs and volume of potential loading reduction.

In this study authors systematized and highlighted a wide range of components of an effect due to emergence of active consumers. The study shows that this effect is distributed among all market participants. Its appearance in any aspect will be an interesting and positive impact on the development of all sectors of electric power market. (Figure 3).

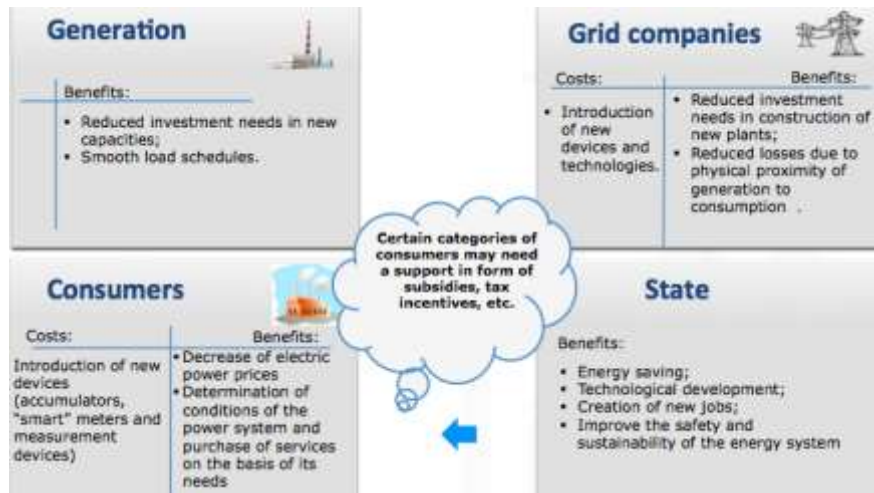


Figure 3: Effect of «active» consumers appearance and its components

An example of household consumers shows absence of opportunities in varying degrees of management: presence of own generation, ability to control through dynamic pricing methods, participation in work. Possible level of activation of industrial consumers is high enough. Currently, some elements of activation are realized only in a few companies. Authors believe that the developed system of mechanisms of implementation and encouraging active consumers in Russia will form a system of measures to change organizational and economic relations in Russian electric power industry needed for the emergence of an active consumer.

3 Conclusion

Current situation in the electric power market characterized by a decreasing efficiency of the industry (lack of competition, extensive practice of «manual» control, etc.) and increasing discontent of consumers on the one hand and the development of technology - on the other hand creates preconditions for changing the role of consumers in the electric power system from «passive» to «active». This transition calls for revision of management approaches in industry: reorientation from Supply Side Management – the concept of focusing on cost management of producers companies to a Demand Side Management – a concept based on the direct involvement of the consumer in the value creation process.

Switch to a new paradigm of innovation development of electric power industry including integration of «active» consumers involves the following stages:

- Adoption of a strategic decision to move to the development of industry based on the concept of intelligent electric power fixing that

- provision in all documents that define the long-term development of the electric power industry,
- Development of key provisions of the concept of Smart Grid taking into account the requirements of all participants,
 - Development of technologies for the formation of intelligent infrastructure,
 - Development of legal framework of Smart Grid system, as well as a pilot application of «breakthrough» technologies;
 - Launch of a new customer-centric electric power market model including the mechanisms of the «activation» of consumers (Demand Response).

References

- [1] Volkova I.O., Salnikova E.A., Shuvalova D.G., Aktivniy potrebitel' v intellektual'noi energetike, *Akademiya energetiki*, 2 (40), pp. 50-57, 2011.
- [2] Kobec B.B., Volkova I.O., Smart Grid: konceptual'nie polozheniya, *Energorynok*, 03 (75), 2010.
- [3] Brandon Davito, Humayun Tai, Robert Uhlaner. The smart grid and the promise of demand-side management, *McKinsey & Company*, 2010 http://www.calmac.com/documents/MoSG_DSM_VF.pdf
- [4] Michael Grubb , Tooraj Jamasb, Michael G. Pollitt, Delivering a Low Carbon Electricity System. Technologies, *Economics and Policy – University of Cambridge*, UK: Cambridge University Press, p. 536, 2008.
- [5] Zgurovets O.V., Kostenko G.P. Effectivnie metody upravleniya potrebleniyem elektricheskoi energii, *Problemi zagal'noi energetiki*, 16, 2007, http://dspace.nbu.gov.ua/bitstream/handle/123456789/3094/2007_16_St_11.pdf?sequence=1
- [6] Oboskalov V.P., Panikovskaya T.J. Upravlenie energopotrebleniyem v konkurentnom rynke elektroenergii: <http://www.sei.irk.ru/symp2010/papers/RUS/S4-14r.pdf>
- [7] Kobec, B.B. and Volkova, I.O., Innovatsionnoe razvitiye elektroenergetiki na baze kontseptsii Smart Grid (Innovative Development of the Electric Power Industry Based on the Concept of SMART GRID), Moscow: IATs Energiya, 2010.