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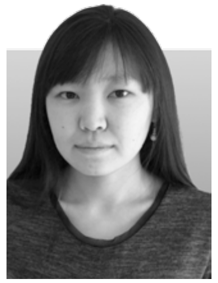
THE EFFECTS OF THE IMPLEMENTATION OF SMART GRIDS[1]



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ABSTRACT

The economy digitalization is one of the priorities endorsed by the programme documents defining the Long-term Development Strategy of Russia. One of the key components of the digital economy is a smart grid. (Smart Grid).
In this study, the aim is to identify and systematize the technological, economic and other effects from the implementation of smart grids. Sources of these effects can be both the transition to digital management methods in the electricity sector and the changing of behavior of the companies-consumers, business practices, utility and service companies.

KEY WORDS

ENERGY COMPLEX OF RUSSIA, SMART GRIDS, DISTRIBUTED GENERATION, DEMAND RESPONSE.

INTRODUCTION

New technologies are especially relevant for Russia, which has a historical large-scale centralized energy supply system, and it's more than 2.5 million miles of transmission lines, about 500 thousand substations, 700 power plants with a capacity of more than 5 MW. In terms of production and consumption Russia is one of the largest energy markets in the world, so we can say that the development potential of the industry is huge. Electric power complex of Russia is on the threshold of significant changes that will change the model of the functioning of the industry in the future. The necessity of changes is caused by the factors that, on the one hand, are connected with the increase of the requirements of the concerned parties, and on the other hand – inside troubles of the industry. The latter include high functional obsolescence of the equipment used, the shortage of qualified staff, high cost of the capital and construction, insufficient load of the network and generating capacities, low labor productivity [Nalbandian H. H., Zholnerchik S. S., 2018; Linder N. V., Lisovskyi A. L., 2017; Trachuk A. V., 2011b] table. 1). The situation is aggravated by the presence of cross-subsidization, industrial and commercial consumers have to make up for the public subsidies [Linder N. V. Trachuk A.. V., 2017; Khovalova T. V., 2017; Zolotova I. Yu. 2017], as a result of price misalignment for industrial and commercial consumers it's set one of the world's highest electricity prices [Trachuk A.. V., Linder N. V., 2017; Trachuk A. B., Linder N. V., Zubakin V. A. et al., 2017]. In Russia the final cost of electrical energy includes both the fee for the generating capacity, and for the fee for maintenance of the grids, that is independent from the consumption volume [Trachuk A. V., 2010b; Dolmatov I. A., Zolotova I. Yu, Maskaiev I. V., 2017]. These and other factors limit the competitiveness of the economy of the country, make it difficult for its industrial development. [Digital energy, [b.g.] (table 1).

Table 1
Problems of energy sector development in Russia

Factor	Indicator
Long distances and low load density(network assets per 1 kW)	1.5–3.0 times more, 1.5–3.0 times more,
High cost of capital	2-3 times higher than in Europe
High cost of construction	20-40% higher than in Europe
The low loading of network and generating capacity	Load of magistral grid complex is 26%, of distributional – 32%; installed capacity utilization factor – 50%
Low labor productivity (amount of workers for 1MW of installed capacity	10 times less workers than in the US

Changing of the technological and economic model of the electricity in industrialized countries cannot be ignored primarily because of electric power industry can become expensive and uncompetitive. The best option for the development of the industry is the transformation of the existing model of the Russian electrical energy industry to the network of producers and consumers connected by a common infrastructure.

In this study, the aim is to identify and systematize the technological, economic and other effects from the implementation of smart grids. Specified effects can occur as a result of the transition to digital ways of the management techniques in the electricity industry, changes in the patterns of behavior of consumers, business practices of the utility and service companies.

THE IMPACT OF SMART GRID TECHNOLOGY ON THE PERFORMANCE OF THE ENERGY SECTOR

Aging of basic funds and the dynamics of the electricity demand determine the beginning of a new investment cycle in 2022-2025 and according to the Ministry of energy of the Russian Federation, the modernization of power facilities and construction of new facilities will require more than 200 billion dollars of investment. Moreover, the development of a distributed network will require about $ 50 billion. [Trachuk A. V., 2010a]. The solution of the problems is seen in the radical restructuring of the existing technological and economic models of the electric power complex, primarily in its digitization. Table 2 shows the key differences between the new energy paradigm and the current one, [Digital transition [s.a.]].

The economy digitalization is one of the priorities endorsed by the programme documents defining the long-term development strategy of Russia. The digitalization of the electric power industry can, in particular, be understood as the introduction of various automation elements, creating an integrated "smart" grid.

In accordance with the definition given in one of the strategic documents of the Russian Federation, smart energy systems of the future include the smart power system; it is assumed the integration of different types of energy resources and means of distributed generation. Expected results of the of such projects implementation: quality improvement of the manageability, reliability, and efficiency of the basic energy systems, including electric power [Projection of scientific and technological development of the RF, 2014].

In the literature there is no single definition of the smart grid, but the essence of different approaches boils down to the fact that smart grid is a combination of information and communication applications that combine the generation, the transmission, the distribution, and technology of the end users; it's the system integration [Smart Grid 101, [s.a.]]. This is the grid, which is based on the analogue technology of the twentieth century and has been converted to use digital technology for communications, monitoring, computation and control; a large part of the situational information necessary to ensure safe, efficient and reliable operation of the grid, is in its digital information infrastructure [Software Engineering Institute, 2010]. The smart grid has also been defined as "the system of delivery of electricity from the energy generating companies to consumers, integrated with communication and information technologies and providing improved transparency of the functioning of the power system, quality service to customers and providing environmental benefits" [Smart Grid Information [s.a.]]. You can also say that Smart Grid is a technology that allows to transmit and distribute energy on a new technological level between distributed generation sources and consumers that use electric energy both in a stationary way (buildings, industry facilities) and in the process of movement (cars, gadgets).

Changes in the technologies and the economy require to improve the characteristics of the grid complex, and it is a global trend. So, in the documents that define the direction of technological development in the electric power industry of the United States it's noted that the changes in demand, generation structure, integration of RES, problems with reliability and security require the innovations to improve key characteristics of the electricity transmission and distribution systems. The requirements for this system determine the smart grid: system must be flexible in terms of the model of supply and demand, have low operational losses, be sustainable, accessible and safe [Technology development, 2018].

The modern power system is a vertically integrated structure which in the future will be transformed into a horizontal grid, where supply and demand are regulated with the use of smart meters, promoting the bidirectional transmission of information [Trachuk A. V., 2011a].

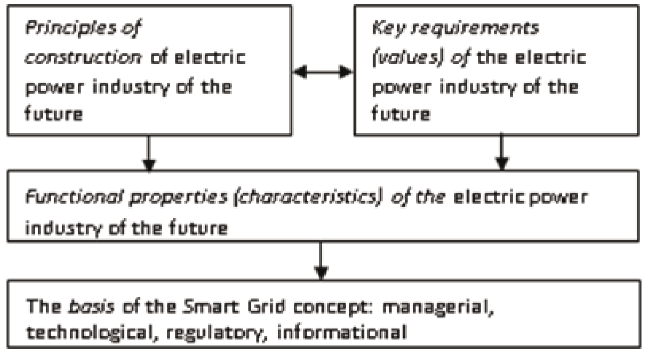
It appears that the introduction of smart grids will contribute significantly to improving the efficiency of industry and reliability of its infrastructure, to reduce expenses for the electricity producers and consumers. "Smart" grids will open new opportunities for the industry development. The implementation of smart grids has arisen from the significant need related to the changing of the con-

Table 2
Comparison of traditional and new energy paradigms

The current (dominant) energy paradigm	Approaching energy paradigm
Dominance of energy sources based on hydrocarbon fuel	«Clean energy» of RES.
Large vertically integrated energy companies with powerful reactors, large deposits, large processing facilities	Decentralized markets, private investment
Centralized electrical networks	Intellectualization of basic infrastructure, development of technologies for smart rids
Simultaneity of electric energy flows – from generating unit to the consumer	The transition of consumers to the active behavior (active consumer at the center of the grid).
Simultaneity of electric energy production processes and consumption	Technologies of energy accumulation are as "stored" goods.
The widespread use of fossil fuels in the manufacturing industry and transport	The deepening of the production sector electrification and transport.

[1] The article has been prepared on the basis of research "Development of smart energy grids in order to improve energy efficiency of industrial companies" conducted for budgetary finance within the state assignment of Financial University, 2018

sumers' role, the increasing demands for reliability, and quality of the grid. The basis of the smart grids concept is shown in Fig. 1 [Kobets I. I., Volkova I. O., Okorokov V. R., 2010].



It appears that the key features of the smart grid are the customer orientation and informational support.

Customer-focusedness. In the emerging system, the consumer has a key role of an active participant: he affects the system and optimizes its work, in his role both of a consumer and a producer of electric energy. The consumer is responsible for generating the requirements to the volume, timing, sources, and quality of energy consumed. The implementation of innovation, information and communication, and computer technologies contributes to a greater control over the individual elements and the system as a whole. Such mechanisms include the "smart" metering for the two-way transmission of information between consumer and producer. This helps to build a kind of virtual map of the physical world, the developing system allows, for example, quickly and efficiently to determine the location of the accident and to forward the energy flows to minimize the damage to consumers and to avoid increasing of the scale of the accident.

Information. This is the main tool for system control, with the result that the system becomes not of electrical power, but the energy-information.

THE ELEMENTS AND EFFECTS OF IMPLEMENTATION OF SMART GRIDS

The model of modern electric power industry does not deny and does not preclude the existence of a centralized supply system, but there are elements of the smart power sector, not significant for electric power industry of the twentieth century:

- consumers, including those with private, and also surplus generation;
- micro-grids, distributing the electrical power among a small group of consumers, not integrated in a centralized energy system;
- distributed generation, including renewable energy sources;
- demand management;
- smart metering;
- modern systems of storage of electricity. Given the formation of new elements of the system of electrical networks, the discussion of which is given next, can be grouped, focusing on stakeholders:
- for industrial consumers:
  - o income from electricity sales
  - o managed optimization of energy costs;
  - o reduction of price and technological risks associated with centralized power supply;
  - o provision of independent or integrated operation with existing network infrastructure, improving the availability of electricity;
  - o the possibility of using different types of generation;
- for domestic consumers:
  - o optimizing the cost of electricity due to various factors – from extension of suppliers competitive environment to the additional income from the reduction of the investment component in the electricity industry as a whole;
- for science, IT sector and manufacturing industry:
  - o the emergence of a sustained domestic demand for high-tech equipment (alternatives for generation and electricity storage) and software;
  - o the growth of competitiveness, the possibility to export the technical and software solutions within a context of growing global demand;
- for network complex:
  - o the increase in the number of technological connections in relation to development of the distributed generation;
  - o reduction of losses due to the introduction of smart metering;
  - o the increase in volumes of flows in the network.

Consumers. In the traditional model of the power generating industry, the key consumers always played a passive role, but present customers have been building their own generating facilities, especially in energy-intensive industries. Moreover, the population as a consumer strives to develop their own generating facilities, including based on the renewable energy sources. Therefore, a consumer of a new type that can simultaneously be a consumer and producer of electricity in the implementation of an appropriate model of the market. In countries where the share of distributed generation is high, there is the problem of integration of such consumers in the market system; it is one of the important reasons for the development of smart energy. The surplus, produced at the generation of consumers, are used to create individual reserves through electricity storage or are sold to other consumers, in this case we are talking about the decentralization of electricity production, and the development of distributed generation [Trachuk A. V., Linder N. V., 2018].

Distributed generation. The effects of implementation of "smart" grids are determined, in particular, by the development of set of power plants located close to energy consumption and connected or direct - but to the consumer or to the electrical distribution system (in the case of consumers) [Khokhlov A., Melnikov Yu., Veselov, F., et al., 2018].]. Type of used primary energy source, the identity of the station from the point of view of ownership does not matter.

The efficiency of distributed energy can be comparable with the implementation of the capacity of large power stations; also due to the close location to the consumer it has lower network losses in power distribution. This system meets the requirements of the consumers about the availability and quality of electric energy and provides the higher reliability of consumption. A distributed network of energy sources enhances the energy security, as it allows reducing the risks of complete isolation and the disruption of energy supply facilities, especially in remote regions of the country.

A distributed network can quickly adapt to emergency situations associated with natural disasters, accidents. On the basis of well-developed energy infrastructure, distributed storage and processing of data, the distributed generation is similar to the Internet, therefore the new energy system you can call the Internet of energy [Shulga S., 2015; Khokhlov A., Veselov F., 2017]. Internet energy can also be called the alternative energy system operating on different principles and with other subjects against the existing one.

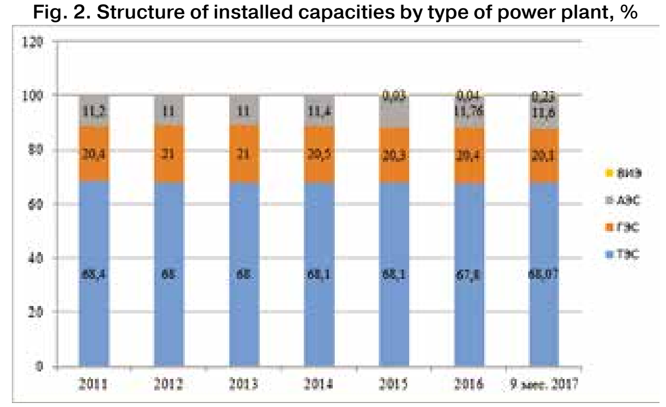
In the modern electric power industry, the distributed generation is generally understood as the generation using renewable energy sources (RES). Today, the share of RES in the total structure of the Russian production is not big [Report [s.a.]], just over 2% of the installed capacity) (Fig. 2), but it's growing [Zubakin V. A., Kovshov N. M., 2015; Balyberdin V., 2015]. Reducing the cost of electricity to renewable energy sources is the reason for the growth of its production.

So, from 1980 to 2013, the cost of wind turbines decreased by 10 times, the cost of solar power plants dropped by 70% between 2009 and 2014, [the Digital transition, 2017]. Notably, the expert estimation of the normalized cost of electricity (including life cycle costs) for alternative energy show a steady trend: the prime cost of the electricity production from renewable energy sources is approaching to them traditional technologies.

In North America and Western Europe "smart" grids allow to organize the movement of electricity in two directions, actively involving households in the market where they can sell the excess electricity generated from renewable sources [Klimovets O. V., Zubakin V. A.., 2016].

Demand response is the regulation of energy consumption depending on the time of day and in response to market signals. This is one of the key components of distributed generation [How to remove (Kak izvlech), 2016]. In the case of voluntary reduction of electricity consumption during the peak hours the customer receives a cash reward. New technologies allow increasing the observability, controllability and economic efficiency of the power system. So, in recent years System Operator of the Unified Power System could radically (in 24 times) reduce the time of issuance of plan targets to the power plants in the framework of balancing market – from 1 time per day to 1 time per hour. Now the power plant may upload its power and to change the schedule of the hourly load, earlier, regardless of the phenomena of the ability it had to wait a whole day. System Operator of the Unified Power System had introduced an element of demand management in order for economically viable ways to increase the flexibility in the management of the system and to find an alternative to construction of new facilities. The more opportunities to control the mode

Fig. 2. Structure of installed capacities by type of power plant, %



of operation of the power system, the more effectively you can use the network infrastructure and generation.

While in the Russian wholesale market, the cost-depending reducing of the consumption is not sufficiently widespread [Dziuba A. P., Solovieva I. A., 2018]. The reasons for the slow distribution are difficult conditions for small and medium consumers, difficult calculated effects of energy supply companies [Modernization, 2017]. Presently, to meet the demand during peak hours, the System Operator of the Unified Power System is forced to use the most expensive power plants, which leads to the fact that the price includes not only the cost of power generation, but costs on a per start for backup generators. Demand response will allow abandoning the use of expensive, inefficient generation, resulting in increased prices for electric energy. The assessment of annual savings will be 1.6 million rubles per year, if the demand management is used. [Modernization, 2017].

The calculation of the effects of participation in the mechanism of the cost-depending consumption reduce for a typical consumer:

- payment for the cost-depending consumption reduce mechanism (+2.7 million RUB / year);
- the decline in purchasing power (+0,4 million RUB / year);
- reduction in the purchase price of electricity (+ 0.05 million RUB/year);
- оплата отклонений при завышении плана (– 1,5 million RUB / year);
- ensuring fulfillment of obligations (– 0.1 million RUB / year).

While the mechanism of demand response involves only 69 MW of the connected capacity of aluminum smelters of "RUSAL", one of the largest consumers of electricity in the second price zone. From January to May 2017 year the paid reduction of the load did not exceed 64 Mw, or 1% of target consumption of plants. As a result, without any financial investment on the part of the company the economic effect of 25 million RUB was achieved.

The economic effect from cost-depending reduction of the power consumption gets not the System Operator of the Unified Power System as the administrator of the energy system and not "RUSAL" as its participant, and consumers in a whole. In the absence of explicit sponsor and beneficiary, the system will not develop without the active participation of the state. The launch of the demand response mechanism had only become possible since the summer of 2016 [Resolution 2016]. Demand response requires a systematic approach. So, in the US, for example, in 2010, the Federal regulator adopted the "National action plan on demand response" [National action plan, 2010].

Smart Metering

– advanced electricity metering, using the modern complexes of software and hardware, including installation of smart meters on the consumer side. Thus, the regular survey, data collection and processing, provision of information on energy consumption, and automatic and remote control are provided.

The advantages of using modern accounting:

- ensuring accurate measurement of energy consumption;
- automated and efficient processing, transmission and presentation on the level of consumption;
- control of consumption mode;
- the possibility of closing a balance sheet for groups of counters and the data comparison to identify the facts of unauthorized consumption;

- obtaining information about the actual losses in electric networks;
- the ability to remotely restrict or disable power consumption;
- evaluation of the effectiveness of measures aimed at energy saving;
- power flow control [Nesterov I. M., 2013].

Modern accounting system is designed to transmit information on the actual consumption of electrical energy in the online mode. To date, the retail energy market in Russia is equipped with automated metering for only 9%. However, smart metering is the first stage of the introduction of smart grid, which allows, in particular, quickly to find areas where losses are generated. So, JSC "Rosseti" has already launched the pilot projects of implementation and use of smart meters; together with the Russian Direct Investment Fund, the company is implementing the pilot projects in Kaliningrad, Yaroslavl and Tula. The development of smart grids could also be accompanied by public funding, for example in the United States the amount was $ 4.5 billion. [Recovery Act, [s.a.]].

It is anticipated that the development of "smart" metering will be due to the combination of the tariff and non-standard sources. In pilot regions the meters are put by the investor, they are paid back for themselves in savings from reduced losses. But the unresolved issue of identification and tenure of savings from reduction of losses does not allow replicating existing good practices. The introduction of Smart Metering could allow approaching to the best world practices, when the losses do not exceed 5–6%, which in absolute terms saves up to 40 billion rubles per year.

As measures contributing to the implementation of systems of "smart" metering, the Ministry of energy in 2018 plans to ban territorial network organizations to upgrade old metering devices that do not meet the requirements introduced by "smart" grid.

The introduction of elements of "smart" metering will reduce the number of accidents on the network by timely receipt of information on non-normative equipment operating mode and timely preventive repairs.

In respect of natural monopoly entities in the electric power industry it's established the mandatory use of the automated remote collection of data on the volume of the consumed resources [Forecast of the socio-economic development, 2017].

In Russia, there are only about 80 million electricity metering units, with about 9% (7 million units) are already equipped with smart meters. According to some estimates, in Russia there are more than 40 million consumers living in apartment buildings, 15 million of private residences and more than 12 thousand of fuel filling stations, more than 2.5 million small and medium enterprises. Most of the new equipment (transformers, switches) already has a system for remote diagnosis [Dolmatov I., Zolotova I., 2015].

By 2020, Europe will have installed more than 237 million of the smart meters of electricity, almost 90% of installed electricity meters will be "smart". Still, the economic crisis in Europe has not been an obstacle for the programs of smart meters, on the contrary, it provides additional pressure on utilities and governments to ensure the realization of the benefits of smart meters [Woods E., Strother N., 2012].

At the level of system, balance and modes control in the electricity industry, a step towards the joining of the various devices and probes in a single system will allow to effectively plan the load of the generation facilities and, most importantly, their volume. As the Russian energy system is built on the redundancy, the creation of the smart distribution model will allow us to take part of the uneffective generation out of operation and to partially solve the problem of oversupply of generating capacities (an increase from 215 GW in 2008 to 235 GW in 2016 due to the absence of correlated consumption growth).

Given the length of linear-type facilities in the electricity sector, the increasing implementation of smart technologies could lead to increased reliability and lower operating costs. The practice of network management "on the state" would become the reality. For example, for the current moment the generating equipment is being repaired only on schedule, the implementation of "smart" grids will allow to monitor the status of equipment and carry out repairs on-demand, as needed. For the purposes of regulatory consolidation of such opportunity in early 2017, the Ministry of Energy of the Russian Federation proposed to consolidate by the government resolution the changes of the relevant regulations for the repair of JSC "Rosseti".

The need for smart metering requires improvement of the regulatory base. From the point of view of the evaluation of public policies and the legal framework for the implementation of smart metering systems the European countries, for example, are at different levels of development. So, as of 2012, the maximum clear regulatory framework and a clear strategy had been developed in Finland, France and the Netherlands, while in Lithuania, Slovakia, Latvia and Luxembourg the strategy and regulatory framework were absent. Other EU countries were at various intermediate stages according to these criteria [Hierzinger R., Albu H. van Elburg M. et al., 2012]

The effects from the deployment of smart metering can be divided into four main groups:

- the benefits received directly from the deployment of smart metering (for example, reduced energy losses, reduced monetary payment of households using different tariffs);
- reducing the costs of the development of the smart grid through the use of existing infrastructure of the smart metering (for example, connection and integration of distributed household generations); functional characteristics of the extensive modern smart metering systems not only solve problems of accounting, but also support a range of functions/technologies of the smart grid (e.g., demand management in real-time, automation, power distribution, etc.);
- benefits from the deployment of smart metering (for example, reduced time outages consumers La, etc.) to achieve which you have to implement separate elements of the smart grid (e.g., automation of the distribution of networks, demand-side management in real time);
- other effects from the deployment of smart metering for society and the state, which are difficult to measure quantitatively, such as social effects (involvement of consumers, increase of public trust in energy companies, job creation, etc.), the contribution to the achievement of strategic objectives of development of the industry (increase of reliability, the development of retail electricity markets, etc.).

As it was shown by ongoing projects, the smart metering provides benefits both for the consumer and for energy companies.

Table 3
The expected effects of the introduction of smart metering [Smart records 2010]

Area	Effect	
	Long-term	Practical short-term
State	The reduction in the energy consumption by 20%; the transparency of energy consumption	—
Generation	The potential reduction in the volume of new capacities by 20%; smoothing of power consumption peaks	—
Networks	Reduction of electricity losses by 50%; Reduction of the operating expenses through the reduction in staff, maintenance and repair up to 10%	Reduction of electricity losses by 50% due to commercial losses;
Sales	Improvement of debt turnover of 30%; reduction of the number of calls of the consumers by 30%	reduction of operating expenses by 10%
Consumer	A higher level of satisfaction with the quality of energy supply; the opportunity to manage the volume and cost of its energy consumption with informing	Goes into reduced operating costs of 5%

Companies are getting more reliable timely information and optimize their costs. The Table 3 presents the key effects expected from results of implementation of "smart" metering, in terms of the network companies.

EFFECTS OF ELECTRICITY STORAGE SYSTEMS

The need of mechanisms of the electricity accumulation is connected with the peculiarity of electric energy as a commodity. At any point in time it must be produced exactly as much energy as it is required by the consumer. Accordingly, it is necessary to build and maintain reserve capacities that allow consistently providing consumers with electricity. The problem is complicated by the fact that depending on the time of day the consumption of electric power varies, so over time the power can work in a suboptimal regime. Moreover, a partial transition to renewable energy sources, that can be used a limited amount of time, depending on weather conditions, also requires the technologies to accumulate the energy.

Power system is aimed to provide multiple reversible accumulation of electric energy and to be able to act both as a consumer (in charge mode) and the source of electric energy (in discharge mode). The volume of Russian market of the electricity storage systems from 2025 will be able to reach $ 8 billion per year that will give the state economy the effect (excluding the investment) at the level of $ 10 billion per year (Concept [b.g.]) (table. 4).

Internet of energy will be used in electric energy supply of isolated and remote areas, in the power supply systems of residential areas, in the power supply system of industrial and commercial consumers, in the electric transport and charging infrastructure, in other cases (mobile emergency power units, collaborative UPS, services for the electric energy quality improvement). The new scheme involves the management of the daily consumption schedule, the power quality management, the backup power grid and other system services. Scenarios of usage of energy storage units for gadgets, equipment, robots and domestic appliances are not included to the concept project. In the Table 4 there are the values taking into account the dollar as for the Central Bank on 04.03.2017: 1 USD = 58.9 RUB.

There are other possible **effects of implementation the electric energy accumulation systems** for the stakeholders:

- *For generation.* The use of storage will allow to optimize the process of electricity production by equalizing the load on the most expensive generating equipment, will reduce the level of cross-subsidization between heating and electric energy, that exists at the present moment. This will inevitably lead to the reduction in costs of hydrocarbon fuel, the increase of the coefficient of installed capacity usage at the power plants, will increase the supply reliability and reduce the need for the construction of new facilities. The storage facilities allow you to create an energy reserve without the excess work of generating capacities, to optimize the mode of operation of the power plants, to ensure a peaceful passing of the night minimum loads and day maximum loads.
- *For consumers.* Electricity becomes cheaper, the reliability of energy becomes higher, it is possible to ensure the operation of critical equipment during power outages and to create a reserve in case of accidents.

Table 4
Assessment of markets and the effects of electricity storage systems implementation (from 2025), bln USD

Parameter	Internet energies	New general scheme	Export of hydrogen
The annual volume of the world market	56.7	18.3	30.0
The annual volume of the Russian market: conservative optimistic	0.7 1.9	0.2 4.0	0.5** 2.9**
The annual effect on the economy of the Russian Federation excluding the investment: conservative optimistic	1.1 (0.5*) 2.1(1.0)	0.4(0.18) 2.6 (0.37)	1.1*** 6.3***

** In parentheses are the share of exports. ** Production systems. *** Export.*

- *For the power grid*. The storage facilities reduce peak load on the substation and the costs for upgrading the network infrastructure, improve the quality and reliability of power supply of consumers [Batrakov A., Shaposhnikov D., 2017].

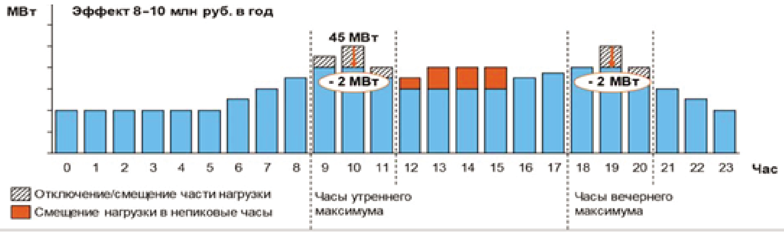
THE FACTORS OBSTRUCTING THE DEVELOPMENT OF SMART GRIDS

The emergence of new actors in the demand management limits the requirement to the minimum amount of consumption. In the price-dependent consumption, only players of the wholesale electricity market that have a capacity of more than 5 MW can participate. Power reduction can be up to 2 MW/h. In practice, this limitation of the loads without stopping the production can by provided by the consumer, the power consumption of which is above 40 MW. As a result of these restrictions the number of potential participants of cost-dependant consumption is narrowed down. So, in the United States a significant proportion of capacity that is reserved to decline, is provided by the small business and population, i.e., the participants in the retail market that are involved in this mechanism on equal terms with the industrial companies.

Power reduction may be paid only if, after the operator's command the actual consumption is below the planned application. The consumer with the power of 50 MW the average planning accuracy is 5% for each hour of the day, however, a possible error can be more than 25%. As a result, in order the operator be enable to register the load reduction for 2 MW, the consumption should always be inflated on the basis of error.

Then the consumer has to pay a deviation that reduces the effect that he could obtain from participation in cost-depending consumption. Accordingly, to obtain the most significant effect of the participation in cost-depending consumption it is necessary to accurately plan your workload.

Fig. 3. The effect of reducing the electricity consumption in peak hours in every working day for a typical user (user is in the first price zone, power is less than 50 MW) [Posypanko N., 2017]



It is worth noting that today the companies are already shifting the consumption to off-peak for their region hours, as a result, there are the electricity savings of 1–2% (Fig. 3). By reducing the load in the unified energy system by 0.3%, the price in certain hours could fall more than for 4% [Report [s.a.]].

THE EFFECTS OF THE IMPLEMENTATION OF SMART GRIDS IN VARIOUS INDUSTRIES

The effects of smart grids include the development of information technologies, both in the technological part and in the software. First of all, we can say that the smart grid is the Internet of things. That's the name of the computer networks that connects things (physical objects) with integrated information technologies to communicate with each other or with the environment without human intervention [Decree, 2017]. However, to date the implementation of this concept in the Russian energy sector is at an early stage. With the aim of development in generating, for example, the Ministry of energy jointly with JSC "ROSNANO" and OJSC "Rostelecom" forms the national project for the industrial Internet on the basis of the pilot project of system development of remote monitoring and diagnosis of CCGT plants. Some private energy companies are actively equipping their facilities with remote monitoring and diagnostics to improve reliability and reduce operating costs.

Table 5

The expected effect of the implementation of smart grids in various industries

Indicator	Mining, manufacturing, production and distribution of electricity, gas and water	Agriculture, hunting and forestry	Construction	Wholesale and retail trade	Transport and communications
2020					
Consumption forecast: standard with the introduction of smart grids Effect	650 591 58	20 18 2	15 13 1	40 36 4	102 93 9
2025					
Consumption forecast: standard with the introduction of smart grids Effect	708 644 64	21 20 2	16 14 1	43 39 4	111 101 10
2030					
Consumption forecast: standard with the introduction of smart grids Effect	766 697 69	23 21 2	17 16 2	47 43 4	120 109 11
2035					
Consumption forecast: standard with the introduction of smart grids Effect	825 750 74	25 23 2	18 17 2	50 46 5	129 117 12

By 2030 the share of renewable sources in Russia will be 4.5%, the introduction of smart grids will reduce the need for installed capacity by more than 10% (predictive value – 34 GW), will reduce energy consumption by almost 9%. The relative level of network losses can be reduced from 30 to 8% [Forecast of development, 2014].

We made an approximate forecast of reducing energy consumption in various sectors of Russian economy (table 5), where is the largest amount of electricity consumption [Balance, 2016]. As an example we have considered 5 industries. It should be noted that the predictive effect of 9% can be achieved under the most favorable conditions.

CONCLUSIONS

State considers the digitalization as a task the solution of which will allow the country to reach a new competitive level.

However, the achievement of the significant results will be possible only if it is ensured an integrated approach to the implementation of the modern paradigm of electric power industry development. Existing legal regulations are mainly of a strategic nature, so it is necessary to form a legal base stimulating the development of intelligent energetics, the positive effects of which are extremely varied for stakeholders.

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