Study Committee C1

Power System Development And Economics

Paper 10556_2022

Implementation and Application of the Demand Response Mechanism and the Concept of Active Energy Complexes for the Development and Improvement of the Efficiency of UPS of Russia

Maxim A. KULESHOV, Ksenia A. DATSKO, Evgenia I. SMIRNOVA, Stanislav A. UTTS

JSC SO UPS, JSC NTC UPS

Motivation

System Operator of the United Power System of Russia is looking at new technologies enabling the following items:

- more efficient electricity generation,
- ensuring a reliable power supply to consumers,
- guaranteeing power system resilience.

Such technologies are considered from the perspective of their most efficient implementation into the existing structure of the power system and the electricity and capacity market.

The RES and dispersed generation integration, climate agenda and energy transition aspect are also considered for power system operation improvement.

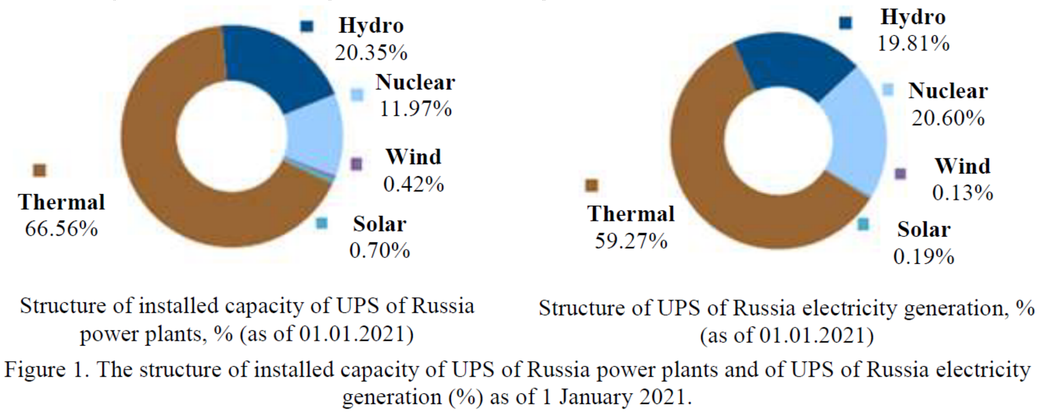
Approach

Based on motivation above, two brand new technologies are introduced into the UPS of Russia: **a demand response mechanism and active energy complexes**.

This report describes the fundamental principles of the demand response mechanism and active energy complexes, aspects of their operation in the UPS of Russia and future development of these technologies.

Objects of Investigation

The UPS of Russia consists of 71 regional power systems grouped in seven interconnected power systems of the East, Siberia, Urals, Middle Volga, South, Centre and North- West. All these power systems are interconnected by high-voltage power transmission lines with a voltage rating of 220–500 kV and above, and their operation is synchronous.



Structure of installed capacity of UPS of Russia power plants, % (as of 01.01.2021)

Structure of UPS of Russia electricity generation, % (as of 01.01.2021)

Figure 1. The structure of installed capacity of UPS of Russia power plants and of UPS of Russia electricity generation (%) as of 1 January 2021.

The UPS of Russia has the following operational aspects:

- the country's vast territory and operation of long-distance HV and UHV transmission lines,
- 11 time zones and ability to shift daily load peaks within the territories of the interconnected PS to ensure sustainable use of the active power reserves,
- general frequency control provision within the interconnected PS of the synchronous area, which includes the PS of the CIS, Baltic states and Georgia,
- the existing climate pattern (winter season and presence of low temperature zones) requires a district heating supply to be implemented,
- prevalence of zero-carbon (RES, hydro and nuclear power plants) and low-carbon (modern combined-cycle cogeneration plants) generating facilities.

Main characteristic of DR mechanism

There is currently no shortage of generating capacity in the Russian Federation so the demand response mechanism is designed primarily to increase the economic efficiency of the electricity and capacity market and provide resilience services.

Implementation of DR into wholesale market consumers was the first step in integrating DR resources within the UPS of Russia. The DR for wholesale consumers was integrated into the day-ahead market in 2017 and it has been used on the capacity market for competitive capacity auctions since 2020.

Development of the mechanism for engaging retail electricity market consumers was the second step in integrating demand response resources within the UPS of Russia.

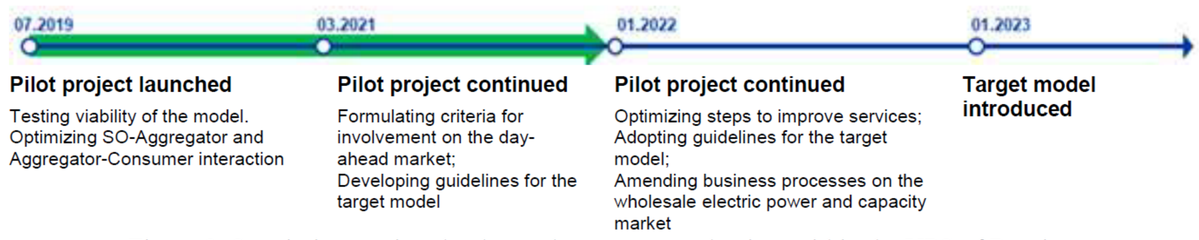


Figure 2. Step in integrating the demand response mechanism within the UPS of Russia.

Main characteristic of AEC mechanism

AEC is a type of microgrid connected to the UPS of Russia in which a specified balance of electricity and active power is maintained and which engages in economic relations in relation to generation and consumption of electricity and active power both within the AEC and from a power grid that is external to the AEC.

An AEC may only include generating units that are not involved in the wholesale market and whose installed capacity does not exceed 25 MW, as well as power consumers.

Conclusion

The demand response project proved to be effective and sparked a lot of interest among power sector players during the pilot period of 2017–2021. The volume of power auctioned for provision of demand response services in Q4 2021 exceeded 1 GW. We expect to see further integration of the mechanism into the power sector in 2022–2023, including drafting of a procedure for assessing the impact of the demand response mechanism on reducing the power industry’s carbon footprint.

The active energy complex project is still in its early stages. AEC introduction is crucial for incorporating a distributed generation approach within the UPS of Russia, given the exponential growth in the number of distributed generation sources. The AEC operation concept and relevant regulatory framework were developed in 2018–2021. By 1 March 2023, the Russian Ministry of Energy is expected to review AEC operation practices and formulate proposals for further employment and development of AEC.

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Basic parameters of the DR project:

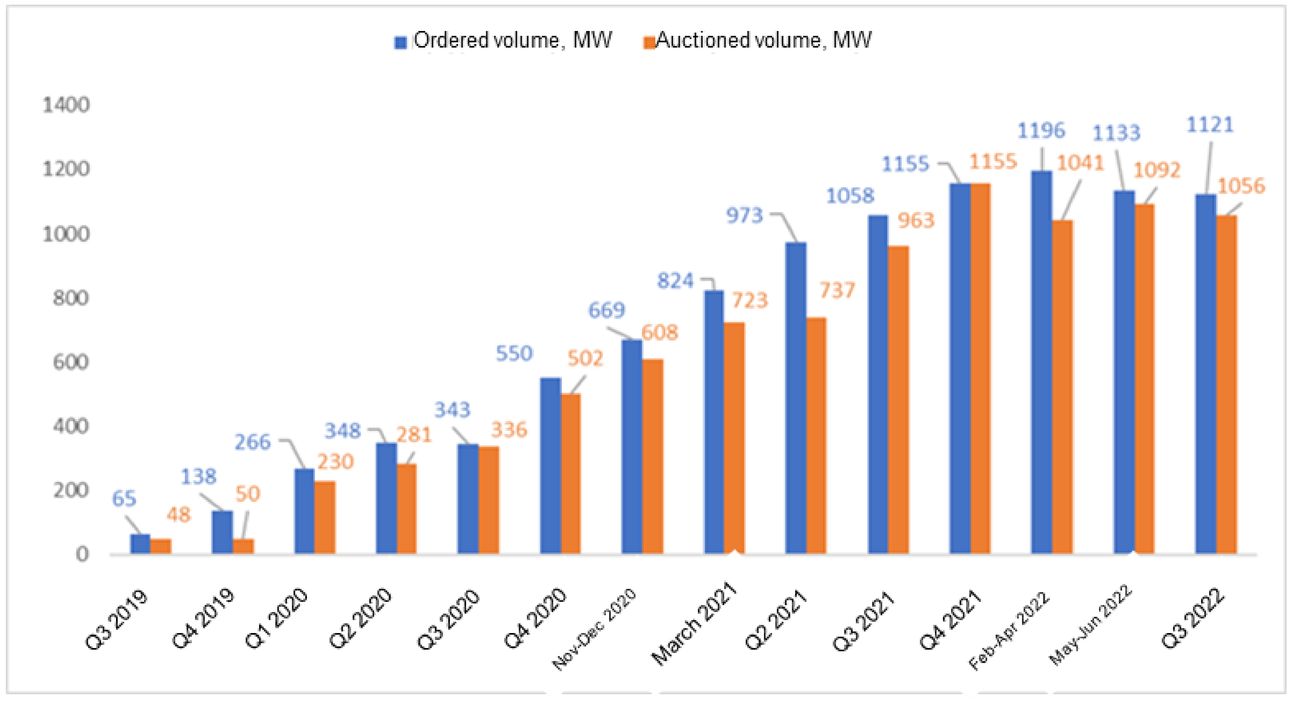
- number of load reliefs per month: 1 to 5;
- duration of load relief: 2 or 4 hours in a row, at the provider's discretion;
- curtailment volume: as stated by the provider;
- planned scope of services: determined as the product of the stated load relief depth and the load relief duration coefficient (1 for 4 hours and 0.5 for 2 hours);
- price of service: as stated in the requisition submitted at the competitive auction;
- non-marginal pricing;
- the marginal price of services does not exceed the non-regulated price of capacity purchased by consumers on the wholesale electricity market;
- the decision to employ demand response event is made during computation of the day-ahead and it must be communicated to the demand response service providers on the day before load relief. A DR event is when the cost impact of load relief exceeds the established threshold value. The cost impact is determined by double computation of the day-ahead market, with and without load relief conditions.

In Q4 2021, the project involved 61 DR aggregators providing services to 353 service recipients including 440 electricity consumption assets of retail consumers located in 54 regions of the Russia.

The fundamental approach that consumers employ to capitalize on the demand response mechanism is to provide a resource for a fixed fee. This fee may go down in the event of default on obligations.

Performance of obligations is monitored relying on the electricity metering data. The key requirement for metering is that all points at the limits of asset consumption must be equipped with interval meters that provide 30-minute or hourly readings. The hourly (30-minute) metering data are furnished to the System Operator on a daily basis.

A procedure for evaluating the impact DR on the reduction in the carbon footprint of the power industry is currently under development. In the short term, emission reduction will be achieved by reducing inefficient generation during peak hours and by loading more efficient generation in off-peak hours. In the long term, the DR will curb the need for new generating units to be constructed or delay the timing of such construction and thus cut emissions.

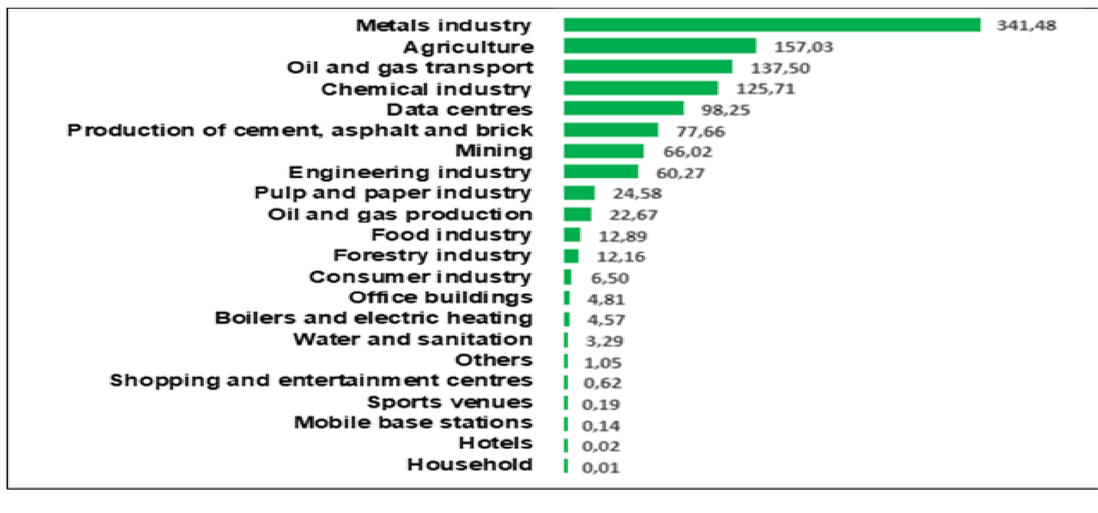


Goals of the DR project

- evaluate the mechanism's practical relevance;
- test various technologies that help manage electricity consumption by different types of consumers;
- assess the market value of services;
- assess the cost impacts in various market segments;
- test various technologies for interaction among market players;
- test the legal framework;
- evaluate the quality of load relief obligation performance by different types of consumers;
- test the mechanisms used for controlling actual performance of obligations in terms of both methodology and technical concept;
- formulate and test the requirements for registration and admission of aggregators and consumers to demand response operations, to include requirements for setting limits on consuming assets and for management of electricity metering.

Development of the DR mechanism

- to include optimizing mechanisms that encourage better performance under demand response service contracts,
- incomplete load relief capability for the controlled asset (within 75–100% of the stated volume) within the demand response event,
- testing (test load relief) of consumers to enable qualification of an aggregated demand response asset.
- allocation of liability for default, with a possible negative financial result (fine) for the aggregator,
- establishment of requirements on the minimum demand curtailment for the demand response asset.
- The following additional features will be implemented in the long term:
- selective employment of demand response resources – load relief in a demand response event will apply only to consumers for which such load relief ensures an optimal result. Desynchronized employment of the resource will help increase the overall number of demand response events, if necessary;
- complete integration into the electricity and capacity market and shaping of a new type of service on the wholesale market.



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The AEC Concept

Since 2020, AEC pilot project was run and will be completed in 2023.
An AEC may only include generating units that are not involved in the wholesale market and whose installed capacity does not exceed 25 MW, as well as power consumers (industrial enterprises, administrative and business centres, shopping centres and agricultural clusters) that have electrical connections with such generating units.
The AEC project will allow the total cost of electricity to be cut, thereby lowering the prime cost of goods and services offered by industrial enterprises and agricultural clusters.
The key AEC requirement is strict observance by AEC entities of the balance between power generation and consumption.
The overall cost impact for AEC entities is achieved through guarantees that each AEC entity will not exceed its individual level of approved capacity. In exchange, consumers (AEC entities) can pay the grid maintenance tariff for the approved capacity value, in order not to exceed their actual consumption from the grid operator's power grid. This constraint mechanism allows external grid infrastructure optimization and, in the long run, permits electricity costs to be substantially reduced.

CSC features

CSC is a distributed system that monitors, controls and adjusts the electricity and active power balance within the AEC including power flow from the UPS into the AEC, consumption by all AEC entities, and power output from generating units and all power sources.
CSC elements are installed at the side of all consumers, all generating assets, and consumer points of connection to generating assets within the AEC, or within maximum proximity to such limits.
The architecture of AEC CSC includes both hardware and software.
The hardware component consists of semiconductor devices for switching control and fulfilling additional protection functions, as well as smart electricity metering systems. The software component is in charge of mathematical algorithms and AEC constraint measures.
The key functions of the CSC are to:

- monitor technical and operational conditions of power facilities to ensure that they comply with the mandatory requirements;
- control parameters of power plants and manage distribution of electricity to consumers;
- calculate and measure consumption within the AEC at specified time intervals. If the instant values of power flow from the public grid rise above the preset AEC threshold, the automated control system restricts consumption by the AEC entity whose operations caused this to happen;
- determine annual, monthly, weekly, daily and hourly electricity and active power balances of the AEC;
- maintain a repair and maintenance schedule for generating equipment;
- measure and record electricity generation for each power plant;
- measure and record consumption for each consumer;
- control financial settlements between AEC entities and external players of the power sector.

Benefits from AEC integration

- consumer self-balancing and load levelling;
- monitoring of parameters of electricity (capacity) consumption from the UPS that are within the AEC area of responsibility.
- for regions of the Russian Federation:
  - creation of consistently developing industrial energy clusters;
  - release of grid capacity;
  - greater investment potential.
- for electricity consumers:
  - lower power supply costs due to changes in the concept for payment for electricity transmission services;
  - greater competitiveness due to a reduced manufacturing prime cost.
- for power generators:
  - optimized operating expenditure due to synchronization of consumer and generator performance;
  - higher retail price of electricity supplied to the end consumer;
  - higher loading of equipment due to connection of new consumers.

Legislation requirements

a) only one of the AEC facilities is directly connected to the network system of the grid operator;
b) all AEC facilities are connected with one another through power grid facilities that do not belong to the power grid operator;
c) production and consumption of electricity (active power) within the AEC is controlled using controllable smart connection (CSC) hardware/software suite;
d) there are no power consumers within the AEC that are classified as general public or equivalent consumer categories, and no electricity (active power) consumers for whom any consumption restrictions might cause an economic, environmental or social impact.

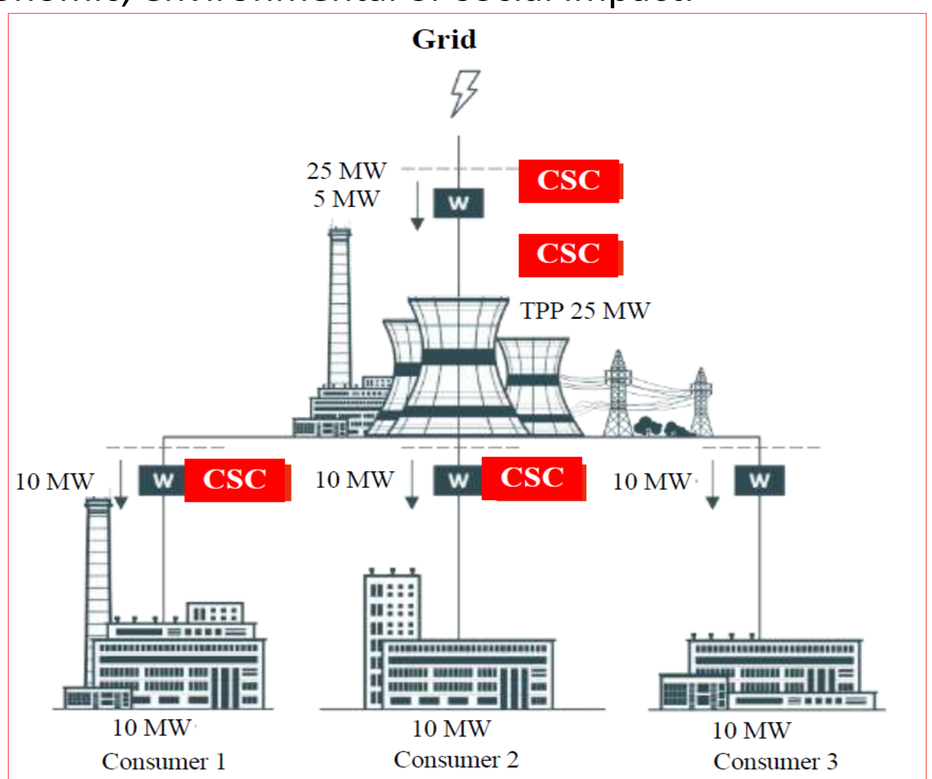

Figure 5. AEC operation concept.