Eurasian Economic
Commision

Dissemination of Smart Energy Efficient Technologies in the Eurasian Economic Union

The report was prepared for implementing paragraph 8.3.2. of the Strategic Directions for Developing the Eurasian Economic Integration until 2025

Moscow, 2022

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Introduction

The paragraph 8.3.2, Dissemination of Smart Energy Efficient Technologies, is planned by the Activity Plan for Implementing the Strategic Directions for Developing the Eurasian Economic Integration until 2025 approved by Disposition No. 4 of the Eurasian Economic Commission Board dated April 5, 2021.

The activity under this item is studying international experience in the field of developing and implementing smart energy efficient technologies within the scope of the EEC cooperation with global energy agencies, based on which a report is presented at the EEC Board meeting.

We would like to note that not all energy efficient technologies fall under the 'smart' category. Most of the energy efficient technologies used in economic and industrial sectors, regional and city services do not have the properties of smart technologies.

Taking into account the analysis of practices in using energy efficient technologies,[1] *smart energy efficient technology means an electronic (intellectual) system for controlling a technology and/or device operating procedure allowing to reduce energy consumption and/or energy losses while ensuring the level of useful effect (result) comparable with the effect (result) obtained without using such technologies and/or device operating procedures.*

The EEC structural unit responsible for implementing the paragraph is the Macroeconomic Policy Department (the EEC Integration and Macroeconomics Unit); joint participant - Energy and Infrastructure Unit.

Implementation of this paragraph included the following stages:

1. The Macroeconomic Policy Department compiled the list of international institutions and global energy agencies including those with which the EEC has Memorandum on Cooperation: World Energy Council (Memorandum) and Executive Committee of the CIS Electrical Power Council (Memorandum), International Renewable Energy Agency; German Energy Agency; European Energy Charter; World Wind Energy

[1] Ali, A. S. (Ed.). (2013). *Smart grids: opportunities, developments, and trends*. Springer Science & Business Media; Yu, X., & Xue, Y. (2016). Smart grids: A cyber–physical systems perspective. *Proceedings of the IEEE*, *104*(5), 1058-1070.; Palensky, P., & Kupzog, F. (2013). Smart grids. *Annual Review of Environment and Resources*, *38*(1), 201-226

Association; International Solar Energy Agency. The scope of concluded memoranda covers these areas of interaction between the parties:

- addressing current issues and conducting joint analytical research in the energy field;
- exchange of experience in establishing programs and strategies encompassing all types of energy resources (electric power, gas, oil, alternative and renewable energy sources);
- identifying barriers to developing energy infrastructure and preparing relevant proposals on their elimination;
- introduction of innovative business models;
- joint work on determining priorities of mutual interest within the region.

The abovementioned organizations were sent official requests with the aim of promoting cooperation, exchange of ideas and information with regard to existing smart energy efficient technologies. Following the official and working negotiations willingness to cooperate was expressed only by representatives of the Executive Committee of the CIS Electrical Power Council, and none of the organizations provided the EEC with analytical or any other information.

2. Given the impossibility to obtain information from global energy agencies and international institutions the EEC Macroeconomic Policy Department conducted the study of smart energy efficient technologies including analysis of terminology and contents, areas and experience of use in Member States and third countries. Following the study, a draft analytical report was prepared.

3. The draft analytical report was sent for consideration to the relevant EEC units — Industry and Agriculture Unit, Technical Regulation Unit, Energy and Infrastructure Unit. Having considered the paper, the relevant EEC units provided no comments or suggestions on the draft report.

I. Smart Energy Efficient Technologies and Their Characteristics

The Eurasian Economic Union (EAEU) Member States have not yet regularized the concept of smart energy efficient technologies (hereinafter SEETs). At the same time, public policy aimed at improving energy efficiency both of the economy as a whole and its individual sectors is implemented in all EAEU countries, which implies a regulated conceptual framework.

Republic of Armenia: Energy efficiency indicator is an absolute, weighted or relative volume of consumption or loss of energy carriers defined by National standards during production of any type of goods (service provision) or technological process.[2]

Republic of Belarus: Energy efficiency is a property reflecting the ratio of the effect from using fuel and energy resources to the fuel and energy resources spent with the purpose of obtaining such effect.[3]

Republic of Kazakhstan: Energy efficiency is the consumption of energy resources per unit of output.[4]

Kyrgyz Republic: Energy efficiency indicator is the absolute or specific value of the consumption or loss of energy resources for products of any purpose, established by state standards, various regulatory legal acts, technological regulations and passport data for existing equipment.[5]

Russian Federation: Energy efficiency is a set of characteristics that reflect the ratio of useful effect from using energy resources to the energy resources spent with the purpose of obtaining such effect with respect to products, technological process, a legal entity, an individual entrepreneur.[6]

In the Russian Federation, approaches to improving energy efficiency including those related to digitalizing energy consumption management are codified in the best available techniques reference document “Information and technical reference book 48-2017 “Increasing Energy Efficiency in Economic and (or) Other Activities.”

In the European Union, ‘energy efficiency’ means the ratio of output of performance, service, goods or energy, to input of energy.[7]

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[2] Law of the Republic of Armenia No. ZR-122 “On Energy Saving and Renewable Energy” dated December 4, 2004
[3] Law of the Republic of Belarus No. 239-3 “On Energy Saving” dated January 8, 2015
[4] Law of the Republic of Kazakhstan No. 541-IV “On Energy Saving and Increasing Energy Efficiency” dated January 13, 2012
[5] Law of the Kyrgyz Republic No. 88 “On Energy Saving” dated July 7, 1998
[6] Federal Law No. 261-FZ “On Energy Saving and Improvement of Energy Efficiency and on Amendments to Certain Legislative Acts of the Russian Federation” dated November 23, 2009 (as amended on June 11, 2021).
[7] Directive 2012/27/EU of the European Parliament and Council of October 25, 2012 “On Energy Efficiency”

The difference between SEET and energy efficient technologies is in their digital component

that can also include artificial intelligence features. As a result of applying SEET, efficient use of electric power is supplemented with the effect of energy saving thanks to additional (electronic) adjustment and control of its consumption.

Policy aimed at improving efficiency of electric power use is one of the effective measures against climate change. On the other hand, this is an effective development tool for national economy that contributes to modernizing economy sectors thanks to lowering energy costs and slowing down growing demand for energy that result in a reduced need to invest in new generating capacities, as well as in creating opportunities for developing new ecosystems and green jobs.

Energy efficient technologies are used in various areas of economy and social life (Table 1).

Table 1. Application Areas of Energy Efficient Technologies

Application Area of Energy Efficient Technologies	Applications	+ SEET
Industry	alternative energy source; production line automation.	By using digital and platform solutions aimed at reducing energy consumption with appropriate control of safety risks of operating devices and materials in use.
Construction	low-energy materials; optimizing heating costs; using a heating plant.	
Housing and utility sector, city services	modern heating systems; energy efficient windows and light bulbs; automated building management system; low-energy traffic lights.	
Grids	upgrading production assets (transformers, cables, conductors);	
Transport	electrified transport; optimizing air traffic (air transport); using renewable energy resources (air transport); adopting turbo-charged engines (water transport); lower-energy onboard equipment (water transport);	
Water supply	adopting water circulation systems at water intake facilities; using air washing; installing water meters at the input of water consumption facilities	

Useful effects from introducing SEET are noticed for all economic agents (Table 2).

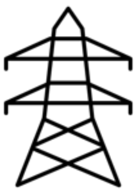
Table 2. SEET Implementation Effects

Economic agent	Useful effect from technology implementation
for population	significantly lowered utility expenses thanks to using energy efficient appliances;
	environmental improvements thanks to reduced negative impact of energy providers and lower greenhouse gas emissions.
for businesses	reduced fuel expenses and financial costs in construction and operation of buildings/structures;
	increased competitiveness of products thanks to lower total costs and cost price;
	increased company competitiveness as a result of introducing new technologies, improving the reputational component and increasing investment attractiveness of the company's business and projects.
for government	saving non-renewable natural resources;
	optimizing budgetary costs of creating and maintaining energy generating capacities;
	advancement of new sectors and fields of economy, service and product manufacturing sectors related to developing energy efficient technologies.

II. Key application areas of smart energy efficient technologies

Thanks to wide adoption of electronic and digital technologies the range of SEET applications is quite broad: from smart gadgets and homes to smart cities and economic sectors. This report analyzes four areas of SEET application: smart grids, smart buildings, housing and utility infrastructure; smart transport system and smart manufacturing. The choice of these areas allows, on the one hand, to ensure that research is comprehensive due to analyzing the industry sector, city infrastructure, as well as the needs of households and citizens.

Smart Grids



A Smart Grid is created by technologically combining electric grids, consumers and electric power producers into a single automated system.

Smart Grid is a concept that integrates energy infrastructure, processes, devices, information and markets into a coordinated and collaborative process that allows energy to be generated, distributed and consumed more effectively and efficiently.[8]

[8] The 36th Annual Conference on IEEE Industrial Electronics Society (2010)

Introducing a Smart Grid means integrating municipal energy infrastructure into the 6th wave of innovation.[9] This technology makes it possible to reduce technical and commercial losses in the electrical power industry, which improves its sustainability and reduces the carbon footprint.

A Smart Grid has the following functions:

- monitoring the causes of grid failures (wire breaks due to wind, short circuit faults, ingress of water into equipment);
- monitoring the quality parameters of transmitted electric power at all stages of generation, transmission, transformation and consumption;
- reporting the status and needs of any grid segment;
- analysis of grid efficiency and economic benefits.

The Smart Grid concept also includes a Smart Metering System[10] that is an electronic system capable of metering energy consumption and providing more information than a conventional meter, as well as submitting/receiving data using an electronic communication form.

In the first quarter of 2022 in the Russian Federation more than 7,500 smart electric power meters were installed in Moscow and more than 2,500 such smart devices were installed in the Moscow region.[11] For consumers, all procedures are simplified: there is no need to take and submit readings, to monitor the meter status or to perform verification procedures. For suppliers, the positive effects include reduced operating costs in the distribution grid, improved electric power quality and stabilized loads at transformer substations.

The tasks of a smart energy resource metering systems are:

- gauging energy resources;

[9] The 6th wave of innovation is characterized by progress in robotics, biotechnologies that are based on advances in molecular biology and genetic engineering, nanotechnologies, artificial intelligence systems, global information networks, integrated high-speed transport systems.

[10] Directive 2012/27/EU of the European Parliament and Council of October 25, 2012 “On Energy Efficiency”

[11] Federal Law No. 522-FZ “On Amendments to Certain Legislative Acts of the Russian Federation in Connection with Developing Electric Energy (Power) Metering Systems in the Russian Federation” dated December 27, 2018

- management and control of their supply, transportation and consumption;
- automated transmission, processing and provision of data on energy resource consumption;
- generating situational databases on energy consumption featuring elements of information support for tasks related to management of energy resource consumption.

In the Republic of Belarus, the issues of introducing a Smart Grid system element, ASECMs (automated systems for electrical energy (power) control and metering) have been regulated at the government level since 2005 and with the purpose of unifying requirements to ASECMs, the Resolution No. 40 of the State Committee for Standardization of the Republic of Belarus dated July 15, 2010, approved and enacted the State Standard of the Republic of Belarus STB 2096-2010 "Automated Systems for Electrical Energy Control and Metering. General Technical Requirements."

Economic effects from introducing a Smart Grid include[12]:

- lower costs for energy providers thanks to optimizing productivity of power plants and power system balance and reducing energy distribution losses by over 30%;
- lower costs for industrial consumers resulting from reduced energy consumption thanks to smart electric motor management (as they consume 65% of electric power in manufacturing);
- energy savings for business customers thanks to smart meter installation, as well as electric equipment monitoring, management and proactive maintenance;
- lower costs for consumers thanks to fewer failures in smart grids;
- reducing household energy needs by up to 40%.

[12] Nidhi, N., Prasad, D., & Nath, V. (2019). Different aspects of smart grid: an overview. Nanoelectronics, Circuits and Communication Systems, 451-456.; Wissner, M. (2011). The Smart Grid–A saucerful of secrets? Applied Energy, 88(7), 2509-2518.; Park, C., Kim, H., & Yong, T. (2017). Dynamic characteristics of smart grid technology acceptance. Energy Procedia, 128, 187-193.

Government of India is implementing the Digital India Mission[13], which among other items provides for wider use of smart energy meters. As of 2022[14], about 1 million of such meters were installed in various cities of the country.

The European smart grid network market is expected[15] to register a GARG of more than 3.1% during the forecast period of 2022–2027. According to forecasts[16], such instruments as increased investments and deployments of smart grid technologies (smart meters, EV chargers, and other associated smart grid infrastructure technologies) will drive the market in the coming years. However, transitioning from power plants running on coal and natural gas to sustainable but less predictable methods such as solar and wind power might strain the growth of the market studied during the forecast period.

For Germany, the priority is digitalization of its distribution grid. This task is covered in the funding program of the Federal Ministry for Economic Affairs and Energy called the "Smart Energy Showcases: Digital Agenda for the Energy Transition" (SINTEG). Within the SINTEG framework, five major German regions developed innovative grid technology and operating strategies involving more than 300 companies, research institutes, municipalities and districts.[17]

For the EU countries, a large-scale transition to Smart Grid technologies in the field of energy and utilities became possible upon adopting the Third Energy Package[18]. One of the main objectives of the energy policy by the EU countries as defined in the Third Energy Package was to roll out smart metering systems for no less than 80% of electric power consumers by 2020. As the EU countries took relevant commitments, they created the necessary incentive for deploying Smart Grid development programs.

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[13] Project website https://www.nsgm.gov.in/
[14] Annual report 2021-2022 by Ministry of Power, Government of India https://powermin.gov.in/sites/default/files/uploads/MOP_Annual_Report_Eng_2021-22.pdf
[15] https://www.mordorintelligence.com/industry-reports/europe-smart-grid-network-market-industry
[16] Mordor Intelligence Forecast for 2022–2027 // https://www.mordorintelligence.com/industry-reports/europe-smart-grid-network-market-industry
[17] Report of the German-Swedish Chamber of Commerce https://www.handelskammer.se
[18] EU legislation liberalizing the gas and electricity markets adopted by the EU Council and the European Parliament on July 13, 2009 (entered into force on September 3, 2009).

Based on analyzed internation experience, Table 3 highlights the key methods of introducing Smart Grids[19]:

Table 3. Key Methods of Introducing Smart Grids

Country	Smart Grid introduction methods
England	• Installing smart meters, creating monitoring and control applications; • Prioritizing renewable energy sources, gradual integration into grid infrastructure systems; • Regular power voltage checks; • Using thermal energy storage systems;
India	• Data collection and processing, energy redistribution in real time (SCADA, Energy Billing, auditing & ABT Meter Interface); • Grid visibility analysis using open access and the system of independent power producers (IPPs); • Operations control with data transfer technology using a satellite terminal (VSAT);
USA	• Using an improved distribution management system (DMS); • Installing automated switches in distribution centers; • Introducing remote equipment control and monitoring at substations; • Adopting new components to stabilize and improve the grid technical status;
Sweden (automation of the intellectual network in a Stockholm seaport)	• Improved peak load management system (DSM); • Electrifying harbors and dockyards; • System automation for structures and buildings of dock services; • Improving quality and efficiency of energy storage systems.

In the EAEU countries Smart Grid technologies are promoted at a slower rate than in the leading developed and developing countries. There are some successful examples.

According to its 12-year (2016–2027) investment plan, CJSC Electric Networks of Armenia plans to introduce automated electric power metering systems in the Republic of Armenia by 2025 ensuring that all consumers will have smart meters installed. At the moment out of 950,000 consumers around 600,000 have meters installed and about 520,000 of them are connected to the automated electric power metering system.

The Republic of Belarus implemented five digital substation projects and one of the latest is Belarus' first 330kV digital substation Mogilev opened in 2021 and utilizing the Smart Grid technology. Also, Belarus implemented five major projects for automating power distribution networks based on the Smart Grid technology; the first Smart Grid-based

[19] I. I. Naumov, M. A. Tarasyuk, D. E. Motorin, Dnevnik Nauki Journal, No. 2021-5(53)

facility was the pilot project implemented in 2016–2017 in the Babruysk rural district of electric grids managed by Babruysk Electric Grids, a branch of Mogilev republican unitary enterprise of electric power "Mogilevenergo".

In 2017, Astana (Republic of Kazakhstan) launched a pilot project for introducing smart grids, within which the Control Center of Power Grid Management was created, that integrates operation of grids and performs complete monitoring of equipment loads. Therefore distribution network visibility was increased to 100% besides reducing the risk of staff errors in operation. The Control Center of Power Grid Management is one of the most innovative and advanced centers in Kazakhstan.

Currently, the Russian language has no established equivalent for the English term of Smart Grid. The concept that is most relevant and widely adopted by domestic academic literature translates as an ‘intelligent electric power system.’ The task of the intelligent power system is to accommodate the interests of many actors included in it based on risk assessment and management, which is achieved by using intelligent management systems and allows to reach the optimal capacity of generating sources and consumer loads taking into account the results of trade operations in the market, changing network topology producing the most cost efficient routes for power supply, as well as accommodating custom requirements for efficiency, reliability and quality of supplied electric power.

In the Russian Federation this concept is called an actively adapting grid (AAG). An intelligent actively adapting electric grid (hereinafter ‘intelligent AAG’, ‘intelligent grid’) is an electric grid of the new innovation wave and part of an intelligent power system the key task of which is to ensure transmission and distribution of electric power. An intelligent AAG independently monitors operating modes of all actors in the process of energy generation, transmission and consumption in real time. It gets online feedback via an extensive sensor system, automatically responds to all changes happening in the grid and takes optimal decisions to prevent accidents and supply power as reliably and cost-effectively as possible.

Intelligent AAGs have the following properties:

- ability to self-recover after power failures;
- possibility of active consumer participation in the grid operation;

- easy integration of new facilities and equipment;
- flexibility, accessibility, reliability and cost efficiency.

At present, the Russian Federation is implementing projects for introducing such essential for intelligent grids technologies as:

- technologies for planning and forecasting, remote mode and energy infrastructure management (including automated management to minimize electric power losses in transmission), monitoring, 'virtual power plant' diagnostics, intelligent metering systems;
- technologies for intelligent and economically optimal demand management (Internet of Energy);
- technologies for intelligent management of electric power assets, repair programs and monitoring the equipment technical status.

One of the priority objectives in developing and deploying intelligent grids is to ensure safety of all systems and components, from a generation facility to individual energy consumption devices. In addition to complying with the physical protection requirements for an intelligent grid, it is necessary to take into account improvements in digital data protection systems. This process is more complex and involves comprehensive measures including the following ones:

- data encryption in meters, processors, routers, etc. that will allow to ensure confidentiality of processes over the entire power supply cycle;
- user identification to detect and prevent unauthorized connections;
- managing application security settings restricting access to the meter to avoid the risk of buffer overflow or malware installation.

Ensuring stable intelligent grid operation requires system monitoring making it possible to detect potential threats and take relevant actions in a timely manner to minimize or reverse damage. Moreover, regular updates of security parameters in intelligent grid applications allow to identify suspicious activities early on and prevent potential attacks. It is also important to create a plan for intelligent grid operation in case of emergencies and to envisage methods for quick recovery of the grid and its individual components if a power facility is partially damaged or completely destructed. There are several types of intelligent grid connections depending on the number of access points, commands and interfaces via which it is possible to access grid software, change load conditions and interfere with the operations, including:

- Home Area Network;
- Neighbourhood Area Network;
- Wide Area Network.

Regardless of the connection type, damage to any intelligent grid section might compromise operation of the whole power facility as the internal systems and components are interconnected. To avoid such situation, it is required to ensure stable operation of an intelligent grid, with its key aspects: integrity (protection against unauthorized access to information for the purpose of its alteration or destruction), confidentiality (keeping information confidential by restricting access to the system) and accessibility (ensuring timely and reliable access both to information and to electric power services).

Smart buildings, housing and utility infrastructure

The smart home concept implies digitalization of household appliances and their connection into a single network capable both to maintain the optimal parameters automatically and to be changed at a remote command.[20] The main indicators of residential premises (heating, lighting, water pipelines, security alarms, etc.) are controlled/adjusted centrally through a predefined algorithm. Home devices switch to the energy saving mode and do not work all the time but only when they are needed. Therefore the system ensures saving of thermal and electric power and water. Table 4 contains the list of functions comprising the smart home system.

Table 4. Smart Home Functions

Smart function name	**Description**

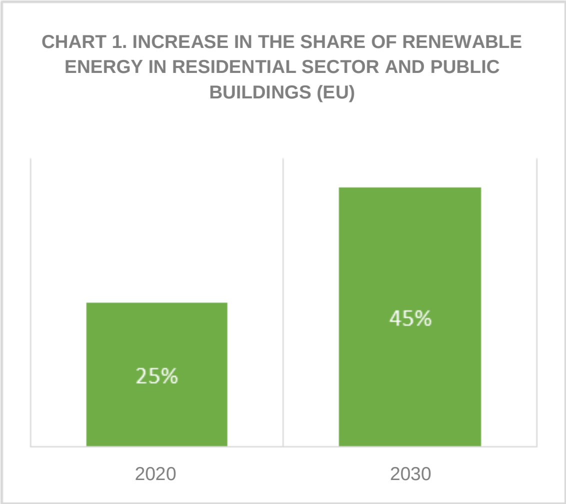
[20] Forecast of scientific and technological development of the Russian Federation for the period until 2030 http://static.government.ru/media/files/41d4b737638b91da2184.pdf

Heating and ventilation	• Climate control adjustments, including the capability to turn off the heating when the windows are open, underfloor heating or radiators are on; • Functional checks of heating appliances, notifications about faults;
Security	• Video surveillance, security alarms; • Home intrusion control, sending an alarm signal to smart devices;
Water control system	• Leak protection, including automatic activation of the emergency water shutoff system;
Lighting	• Adjusting the lighting brightness, selective control of lights; • Controlling curtains, window blinds, etc.
Electricity	• Wiring integrity control; • Automated electricity consumption meters.

Solar cell panels are also among the energy efficient technologies of a smart home. Converted solar energy can power lamps or charge smart devices (laptops, smart phones, wearables). Larger solar batteries are able to power a residential building.

In Abu Dhabi (UAE), there are two 29-storeyed Al Bahar towers that have adaptive facades (Figure 1). The facades move with the Sun to keep the tower rooms cooler and use fewer air conditioners. Moreover, these latticed facades provide natural ventilation of the towers and reduce the need for artificial lighting.

Figure 1. Al Bahar Towers in Abu Dhabi (UAE)



Being among the global leaders in introducing smart building technologies, the EU countries plan to increase the share of renewable energy in their residential sector and public buildings up to 45% by 2030 (Chart 1). This will be conditioned by implementing the EU Green Deal and reforming the energy sector to eliminate dependence on energy resource imports from third countries.

According to forecasts[21], in 2023 the shipment volume of smart home devices to the EU, including those increase energy efficiency, will exceed 187 million items. Such major global companies as Amazon, Google, Samsung develop new lines of business in the field of making products for smart home systems. The broadest market category for smart home

[21] International Data Corporation DC https://www.idc.com/getdoc.jsp?containerId=US48432022&pageType=PRINTFRIENDLY

devices is the video entertainment segment: smart TVs, digital multimedia consoles and other devices having Internet connectivity.

Smart home technologies are widely used in the EAEU Member States, too. The Republic of Armenia produces[22] smart home devices to control various heating and air conditioning systems and supplies them to the EU market.

In the Republic of Belarus[23], the Republic of Kazakhstan[24] and the Kyrgyz Republic[25] there are also a number of companies developing and producing wireless electronics for smart homes (temperature and air humidity sensors, wireless light switches, water leak sensors, etc.).

The Russian Federation[26] developed the Smart Apartment Building standard that proposes a set of principles and requirements for functionality, architecture and makeup of engineering systems of an apartment building. According to the standard, every apartment building will have its software allowing to manage the whole apartment ecosystem, from water supply to waste disposal.

Implementation of measures to meter and control consumed thermal energy, manage and adjust consumption in heating networks, consolidate heating systems and build automated systems — technologically and economically speaking, this task costs several times more than technologies implemented in electric grids. At the same time, the cost of heating accounts for 70% of energy consumption expenses and implementation of smart energy efficient technologies in the field of heat supply allows to get great benefits.

Energy-efficient capital repair projects in apartment buildings implemented through the Housing and Utilities Fund include using the elements of smart energy efficient technologies (individual heat supply station automatics and automated control units of the heating system) constituting first-level automated systems; in the future, that might allow to

[22] Heltun company https://www.heltun.com/
[23] Gira company https://www.gira.com.by/umnyy-dom-2, Nootechnica company https://noo.by/
[24] Smart home https://dom-automation.ru/, Smarta https://smarta.kz/
[25] Smart House company https://smarthouse.kg/, Hero Home https://nero-home.by/
[26] RBC https://realty.rbc.ru/news/620cb0949a7947dfd6d39cf0

integrate apartment buildings into an automated system for managing consumption of utility resources.

In July 2022, the first smart apartment building was presented in the city of Kirov (Russian Federation). Apartments in that smart house are equipped with heating control in each room, the system for switching off power outlets using a smart phone, the water leak protection system, smart meters, air quality monitoring system and the security system that allows only residents to enter the building via 3D facial recognition.

Smart transport system

A smart transport system means "integration of modern information and communication technologies and automation tools with transport infrastructure, vehicles and users focused on improving safety and efficiency of transportation process."[27]

There is a navigator application functioning in the territory of the EAEU countries. With its help drivers get directions and access to information on traffic jams, road accidents and bypass routes. The use of such navigators has positive results in terms of energy efficiency as vehicles consume less fuel and release of harmful emissions into the atmosphere is cut down.

Functions of a smart transport system include:

- real-time monitoring of traffic conditions on roads;
- modelling possible traffic congestions, timely identifying and responding to vehicle accidents, monitoring passenger load on public transport, etc.
- capturing traffic speed, number of cars and public transport vehicles;
- tracking weather and road conditions to warn drivers about driving difficulties when needed and suggest bypass routes.

[27] Decision No. 19 of the Supreme Eurasian Economic Council "On the Main Directions and Implementation Stages of the Coordinated (Agreed) Transport Policy of the Eurasian Economic Union (EAEU) Member States" dated December 26, 2016 https://docs.cntd.ru/document/456056120

Technically, a smart transport system is based on CCTV cameras, traffic sensors, etc. that submit information to the single transport center where the staff can quickly take decisions proceeding from the information they receive.

A smart transport infrastructure also includes smart traffic lights, automated street lighting, parking meters running on power from alternative energy sources (solar cell panels or miniature wind turbines installed on the device body), as well as an automated climate control systems in passenger compartments of public transport that all increase the 'smartness' and energy efficiency of urban environment. Smart traffic lights are managed by a special program allowing the device to switch operation modes automatically based on traffic information from other similar devices.

The system of automated and energy-efficient street lighting functions according to a pre-defined algorithm receiving information from various sensors on the available lighting and current weather conditions, which allows to optimize system functioning and reduce energy consumption. These devices can also automatically switch to consuming power from solar cell panel that can be mounted on the device body. Smart street lights with solar spectrum LEDs are able to withstand temperature extremes ranging from −60°C to +40°C, high humidity and atmospheric pressure fluctuations.

Electronic means of remote fare payment on toll roads allow to make travelling more comfortable and reduce carbon emissions. Therefore there are no traffic congestions at the points of entering and exiting these road sections, which allows to reduce travel time and increase traffic capacity of such sections.

A smart transport system has the following advantages[28]:

- increasing an average speed of vehicles;
- optimizing operation of public transport depending on passenger load;
- ability to choose the best route in terms of comfort and speed;
- lower harmful emissions;
- reduced area of increased roadway wear;

[28] RBC https://trends.rbc.ru/trends/industry/5ef0c7849a7947bad518dfb5

- mitigating traffic hazards, lowering the number of road accidents and related mortality;
- increasing the share of power from alternative energy sources in operation of street lighting facilities, information displays and traffic lights.

Usually the leaders in deploying smart transport systems are megapolises being major passenger and cargo hubs nationally and globally: New York, Singapore, Tokyo, etc.

China leads the world by the number of smart cities (12 cities). At present, China is implementing over 800 smart city programs including those where artificial intelligence is used for monitoring and eliminating problems with urban traffic, as well as for operating control of outdoor lighting networks. Once these tools were introduced, the energy saving indicator grew to 68.4%.

The current program by Government of India, Digital India Mission, includes urban projects covering a smart parking system, smart street lighting and electric buses.

In 2021, Pittsburgh, USA succeeded in reducing the average time that passengers spend commuting by 25% and traffic congestions by 40% through using radar sensors and traffic light cameras that detect traffic activity.[29] Sensor data were processed by artificial intelligence to optimize traffic according to the real-time traffic conditions. This system employs a completely decentralized approach to traffic management: each traffic lights switches its modes autonomously depending on the actual incoming flows of vehicles. Reliance on decentralized junction control ensures maximized real-time response to actual traffic conditions while transmission of anticipated traffic data to nearby traffic lights allows them to coordinate and turn green in succession. Another benefit of optimizing functioning of traffic lights are lower emissions from idling vehicles.

To create a positive living environment in the Orsha district of the Vitebsk region, the Republic of Belarus is implementing the Smart City sub-program in the framework of Orsha District Development Program for the Period Until 2023. It is based on a comprehensive approach to improving the quality of life and lowering the costs of managing the region.

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[29] https://smartcityhub.com/mobility/smart-traffic-control/

This standardized concept of smart city development will be extended to other 11 cities of the Republic of Belarus.

Since 2018, the Russian Federation has been implementing the Smart City departmental project[30] as part of the Housing and Urban Environment national project and the Digital Economy national program. The project scope covers measures aimed at improving competitiveness of Russian cities, creating safe urban environment for city dwellers, increasing human well-being and improving the investment climate.

There is a methodology[31] developed for assessing the effectiveness of digital transformation in Russian cities, according to which the progress of digital transformation of city services in the Russian Federation is monitored annually in several areas including innovations in urban environment, smart housing and utilities, smart city transport, economic status and investment climate, etc.

The evaluated progress and effectiveness of digital transformation of city services in the Russian Federation (IQ Cities) is presented annually.[32] The ranking covers 203 cities, the assessment covers 47 indicators and 10 areas: municipal government, smart housing and utilities, innovations for urban environment, smart city transport, intelligent public and environmental security systems, tourism and services, intelligent social service systems, economic status and investment climate and communication network infrastructure. The first place in the ranking is held by Moscow, followed by Saint Petersburg and Nizhny Novgorod as runners-up.

Gartner Research[33] believes that one of the promising future innovations are digital twins of cities. They allow to manage a city effectively, forecast its further development, collect and analyze data since a digital twin act as some kind of a road map. Consequently, risks for the real city are eliminated, while the efficiency of work improves based on the obtained results.

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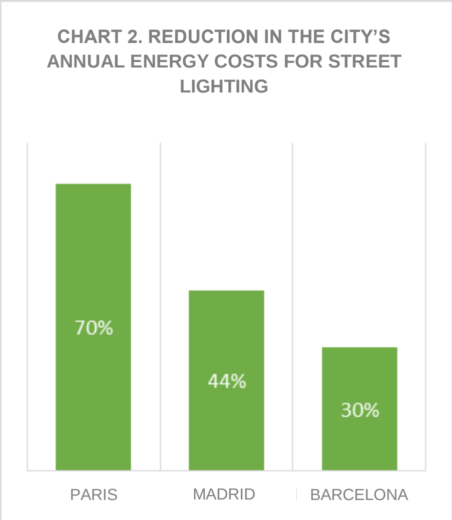
[30] Order of the Russian Ministry of Construction No. 866/pr "On Approving the "Smart City" Project Concept for Digitalizing City Services" dated December 25, 2020

[31] Order of the Russian Ministry of Construction No. 924/pr dated December 31, 2019 "On Approving the Methodology for Assessing the Progress and Effectiveness of Digital Transformation of City Services in the Russian Federation (IQ Cities)"

[32] Russian Ministry of Construction, Ranking of Russian regions by digitalization of city services for 2021

[33] Report "Hype Cycle for Smart City Technologies and Solutions", 2022



The leading cities in smart street lighting are Paris, Madrid, Jakarta, etc. (Chart 2).[34] Switching to smart, energy-efficient street lighting in Paris, France, allowed the city to save around 70% of its annual energy costs for street lighting. Street lights in Madrid, Spain, are controlled remotely from a single command center, which saves 44% of the city's annual energy costs, while in Barcelona, Spain, a transition to smart lighting allowed to reduce the power consumption for street lighting by 30% and improve availability and quality of Internet connectivity thanks to equipping street lights with Wi-Fi hotspots.[35]

Promoting science and innovations in the field of transport, including development and introduction of smart transport systems, energy saving technologies and eco-friendly (green) technologies, is among the priorities of the transport policy by the EAEU Member States.[36] The main stages in cooperation of the EAEU countries in this field are defined as follows:

- analysis of smart transport systems existing in Member States;
- developing and adopting coordinated approaches to interoperation of national smart transport systems;
- improving interoperation of national smart transport systems.

The Road Map for Implementing the Transport Policy of the EAEU Member States for 2021–2023 envisages a wide range of activities aimed at consistent development of all transport modes and systems, including smart transport systems, and harmonizing the legislation in this field.[37]

In recent years, the Republic of Armenia has been making great efforts to deploy a smart and energy efficient transport system through using modern technologies. In 2018,

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[34] https://iot-analytics.com/top-10-cities-implementing-connected-streetlights/
[35] https://www.gihub.org/infrastructure-technology-use-cases/case-studies/smart-street-lighting/
[36] Decision No. 19 of the Supreme Eurasian Economic Council "On the Main Directions and Implementation Stages of the Coordinated (Agreed) Transport Policy of the Eurasian Economic Union (EAEU) Member States" dated December 26, 2016 https://docs.cntd.ru/document/456056120
[37] EEC http://www.eurasiancommission.org/ru/nae/news/Pages/19-02-2021-4.aspx

the Government of the Republic of Armenia approved the Concept for creating the smart city system that among other things includes making the transport network reliable and efficient.[38] In Yerevan, smart street lights will have been mounted at 50 junctions by the end of 2022.[39] The sensors will detect the number of passing vehicles and, proceeding from those data, automatically calculate how often to turn green.

The Republic of Belarus launched some elements of a smart transport system:

- a continuously operating real-time transport model;
- situational traffic management depending on operational information received from other subsystems including
- variable-message signs;
- electronic fare collection and control;
- weather monitoring, etc.

There are more than 100,000 smart street lights in Minsk. Energy saving consists in the following:

- using LEDs that consume two times less power than halogen lamps;
- during the hours of darkness, when traffic intensity decreases, the lights get 30-70% less bright;
- the lights system alerts to faults, which means that regular preventive inspections are not needed;

In May 2022, Minsk, Republic of Belarus, tested the project for installing smart poles equipped with LED street lighting modules having flexible settings (time of switching on/off, brightness adjustment). The poles also have a charging station for electric cars and a payment terminal to pay for charging. Besides, smart light poles are equipped with Wi-Fi hotspots and a CCTV system. Therefore a smart light pole becomes a node in the infocommunication structure.

[38] Disposition of the Government of Armenia No. 8 “The Concept of Creating a Smart City and the List of Measures for Its Implementation Until 2020” dated March 1, 2018

[39] ArmenPress https://armenpress.am/rus/news/1082990.html

Since 2016, the Technical Committee for Standardizing Intelligent Transport Systems has been functioning in Kazakhstan.[40] The Technical Committee is tasked with creating a system combining traffic management and road safety.

The city of Almaty implements the program for using smart street lights: about 100 devices are already mounted. By the end of 2022, it is planned to mount 500 such traffic lights.[41]

In 2021, Kazakhstan together with the EDB implemented the project for building smart lighting based on energy-saving technologies. New lighting facilities were arranged on 238 streets and one highway (Atyrau to Aktobe) having the overall length of 242.6 km. As a result, the cost of power consumed by the street lighting networks decreased by 80%, maintenance costs by 36% and annual carbon emissions by 0.6828 tons. This project won a prestigious international prize at Environmental Finance`s 2021 IMPACT Awards.

Creation and development of a smart transport system in the Russian Federation is provided for in the Transport Strategy for the Period Until 2030. In 2021, 24 constituent entities of the Russian Federation: created or modernized 15 traffic management centers connected to 1,350 traffic sensors, 630 CCTV cameras, 460 smart street lights, 115 devices collecting photographic and video evidence of violating the rules of the road, 70 smart public transport stops, 45 weather stations.

In the territory of the Russian Federation there more than 100,000 smart street lights and smart traffic lights in major cities of the country reduce the time spent in traffic jams by more than 40%; thanks to that there are almost 21% less harmful emissions into the atmosphere.

According to some researchers[42], a promising innovation of the future might be the digital city twin technology. It allows to create a comprehensive model of a real city based on virtually uninterrupted collection and analysis of current data, to make a medium and

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[40] Official Information Source of the Prime Minister of the Republic of Kazakhstan https://primeminister.kz/ru/news/v-kazahstane-vpervye-vvedena-standartizatsija-intellektualnyh-transportnyh-sistem
[41] Sputnik. Kazakhstan https://ru.sputnik.kz/20210519/Sistema-umnykh-svetoforov-polnostyu-17099178.html
[42] Report "Hype Cycle for Smart City Technologies and Solutions", 2022

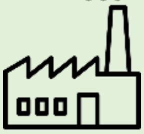
long-term forecast of the city’s development and, which is most important, to test certain projects and solutions on a model and assess their effects and consequences for urban economy and human well-being.

In the field of energy efficient technologies digital twins allow to address not only the technological problem of optimal load distribution, but also economic objectives including search for optimal modes of operation of energy-efficient technologies, optimizing resource consumption and, proceeding from investment evaluations, scenarios for technical upgrading, equipment repair, staff training.

Smart Manufacturing

The concept of smart manufacturing implies a breakthrough approach to organizing industrial production focused on intelligent production process management. Emergence of this concept is associated with the Fourth Industrial Revolution, Industry 4.0. According to research[43], smart manufacturing is the next stage of using digital technologies in the industrial sector. It is based on growing volumes of data; employing manufacturing and business analytics; new forms of interaction between humans and machines; improved methods of transmitting digital commands to the physical world.

Selection of the energy policy optimal for an enterprise and the need for monitoring energy efficiency indicators require a multifunctional automated system for metering and planning electricity and heat consumption. The use of automated systems gives an opportunity to produce and analyse the enterprise energy balance, as well as to perform statistical analysis and cost forecasting.



By 2035, all Chinese industrial enterprises that are larger than specified in China’s plan for the development of smart manufacturing will be digitalized and unified into a single network.

Advantages of smart manufacturing:

[43] McKinsey Innovation Russia
https://www.mckinsey.com/~/media/mckinsey/locations/europe%20and%20middle%20east/russia/our%20insights/innovations%20in%20russia/innovations-in-russia-report.pdf

- ability to produce various types of products employing the same manufacturing capacities;
- automatic detection of deviations in production cycles;
- improving safety in hazardous industrial environments thanks to process models;
- improving product quality thanks to using accurate data in production process;
- lower air pollutant emissions;
- optimizing production processes through the use of best available technologies;
- evaluation of current equipment status and timely repair.

In the EAEU countries, a transition to the smart manufacturing concept is gaining momentum. For instance, in the Republic of Belarus a range of robotics and digitalization projects are to be implemented within the scope of the State Program of Innovative Development of the Republic of Belarus for 2021–2025.

In the Republic of Belarus the Novopolotsk Plant of Technological Steel Structures is planning to introduce a technology for the production of steel structures with multisystem integration of processes based on the Industry 4.0 concept embodied in an automated system for producing workpieces that has the functions of drilling, milling and plasma cutting coupled with 3D modelling.

In the Republic of Kazakhstan, a transition to the smart manufacturing concept is primarily performed by enterprises operating in the sectors of mining and metals, machine building, chemical industry and pharmaceuticals.

At the Karaganda foundry and machine-building plant of Maker, LLP, the production process from design to manufacturing is fully automated. Prommashkomplekt, LLP (producer of railway wheels in Kazakhstan) implemented the project for commissioning high-tech automated full-cycle facilities producing solid-rolled railway wheels. Ust-Kamenogorsk Titanium and Magnesium Plant together with South Korean POSCO is implementing a project for automating and controlling all production stages that will allow to issue electronic certificates with verified data sheets for manufactured products to be sold to major shipbuilding companies.

Smart manufacturing is also developed in the Russian Federation. For instance, to ensure that each industrial enterprise section operates smoothly and that issues are address effectively, special *MES (Manufacturing Execution System)* software is used. It is intended to solve the tasks of synchronization, coordination of production processes, analysis and optimization of output, which contributes to cost reduction and productivity, including improved process performance. Thanks to quick response to events and applying mathematical methods compensating deviations from the production schedule, *MES* systems also facilitate production optimization and profitability growth. Additionally, to optimize operations of industrial facilities, enterprises can be supplemented with automated process control systems.

Moreover, *SCADA (Supervisory Control And Data Acquisition)* software suite can be part of automated process control systems and is designed to ensure operations of real-time data collection systems; to display and archive data on the current power system mode of operation and equipment status; to process obtained information according to various criteria; and to provide data to subsystems of the automated operations control system. To select an energy strategy that is optimal for enterprise development to achieve maximum economic and environmental effect, it is possible to distinguish an individual software class for automated fuel and energy resource management systems: *Energy Management Software (EMS)*.

In the Russian Federation, at Novolipetsk Steel, artificial intelligence assists steelmakers in introducing additional chemical elements, for example ferroalloys, during smelting. The key element of this system is a mathematical model based on machine learning algorithms that predicts the chemical composition resulting from adding certain materials at a given point in time.

At the moment, the functions of automated fuel and energy resource management systems are most often performed by *SCADA* ystems as part of introducing automated process control systems. Energy Management Software reduces energy costs. However, there is an additional environmental effect: the use of energy is accompanied by pollutant emissions so energy savings reduce negative environmental impact. The economic effect is achieved through lowering the energy intensity of products or services, which lowers their cost price. There is a significant trend towards introducing systems for monitoring and predictive diagnostics of failures in electromechanical equipment (electric motors, pumps, reduction drives, etc.).

Introduction of such systems allows to:

- prolong useful life and assess residual life of equipment;
- transition from scheduled equipment maintenance to condition-based maintenance (which was specified as a target indicator in the Strategy for digital transformation of manufacturing industry No. 3142-p in November 2021);
- improve equipment reliability;
- reduce the cost price of manufactured products;
- eliminate the need to keep a large number of spare parts.

Due to the exit of foreign suppliers of solutions and services, best practices by enterprises of the military-industrial complex found active use (for instance, by JSC VIMPEL Interstate Corporation).

Conclusion

Studying of SEETs demonstrated a large scale and broad scope of their application both in economic sectors and at the municipal and household level. The undoubted advantages of SEETs are their versatility, convenience, flexibility, adaptability to various demands and informational value allowing to get additional data (big data) for addressing other issues nationally, regionally or municipally.

The leaders in developing, manufacturing and introducing SEETs are the top developed and developing countries such as the USA, South Korea, Japan, Singapore, the EU countries, China and India. The EAEU Member States actively develop and implement programs for modernizing their economics sectors, energy infrastructure and transport systems employing SEETs.

The main positive effect from using SEETs is electric power savings thanks to additional (electronic) adjustment and control of its consumption. Moreover, this Report highlights other positive aspects of using SEETs, in particular in the following fields and sectors:

- environment, thanks to lower harmful emissions into the atmosphere;
- economy, thanks to reduced energy intensity of production in the industrial and agricultural sectors;
- transport system, thanks to strengthened traffic control and lower load on transport infrastructure;
- quality of life, thanks to using smart home devices and lower costs of housing and utilities services.

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