publishing

Journal of Quality and System Engineering

Journal homepage www.q-sci.rs

ISSN 2812-975X
1 (2022) 1

The complexity of the modern DNO business - the importance of maintaining IMS and ICT support

Velimir Strugar

EPCG AD, Vuka Karadzica 2, Niksic, Montenegro

Abstract

This paper deals with the identification of the necessary conditions for the smooth integration of power systems in the implementation of new smart technologies in network operations, from the aspect of organizational and technical integration of systems while meeting the requirements of relevant ISO standards.

Modern Distribution systems as Network Operators (DNO), are exposed to intensive transition processes. These processes are based on requirements related to the integration of renewables (RES), reduction of CO_2emissions and the implementation of smart technologies to support the integration of storage, renewables andelectric vehicles (EV). Compliance of such systems with the requirements of ISO standards is of great importance for the successful implementation of energy transition as a global business goal and to improve the position of these companies at the market. The implementation of new technologies directly depends on sustainable resource management, knowledge management and competence of all employees, including top management. The financial sustainability of the network operator (NO) in the conditions of increasing operational requirements directly depends on the competence and commitment of the top management to the realization of the determined goals. Integrated Management System (IMS) is a business environment in which it is easier to implement Energy system integration (ESI).

Key words

IMS and ESI
Change management
Risk based approach
Smart technologies
Computer modeling
Sensor technology

Corresponding author

velimir.strugar@epcg.com

Article info

Original Scientific Paper
Received 04.05.2022.
Accepted 18.05.2022.
Online available 20.05.2022.

1. Introduction section

Nowadays modern economies, more than ever, are heavily dependent on a sustainable and secure energy supply. As the most acceptable type of energy today, electricity is in special focus, and thus the electricity companies for which it is the core business. In the conditions of emphasized demands for reduction of greenhouse gases emission, the technology of electricity generation is of immense importance, but also the type of primary energy that is converted into electricity. Under the deregulation of the electricity sector, complex power systems have been decomposed into units that are clearly focused on electricity generation, grid operations, and the supply of electricity.

Regulation in these fields has evolved over time and today the operating energy market framework is clearly recognized.

Reducing the impact of climate change and trying to heal the planet are closely linked to changes in electricity generation. In that sense, the transition is intense, technologies are evolving, their efficiency is increasing, and prices are decreasing. Technologies are also changing in network industries. By applying sensory techniques, modern networks become smart. Network management is aimed at increasing efficiency, and network design must meet the integration of new technological solutions. Energy storage and electric vehicles are intensively penetrating the network and becoming its inseparable entity. All of them must be managed in an integrated and sustainable way. The quality of products and services as well as customer satisfaction must be preserved while maintaining high safety requirements and with the least impact on the environment. Computer system modeling is the right approach and a necessary tool for change management in both the technical and organizational spheres. Risk-based thinking is a prerequisite for choosing the optimal solution.

2. Socio-economic framework of modern electric power systems

The use of electricity is in the focus of the professional and lay public. The development of technologies is not evident only in the field of conversion of primary energy into electricity. There is an intensive development of technologies aimed at increasing energy efficiency at the level of individual appliances, networks in a limited geographical area and finally entire power systems. The development of smart technologies is directly related to the sector of construction, architecture, spatial planning, transport, but also agriculture, education, culture....

Changes cannot always be applied easily. There are different interests that oppose each other and that often hinder the energy transition. Replacing the production of electricity by converting energy from fossil fuels with production from CO2 free can have an impact on the social sphere and be associated with the emergence of problems that the state must solve. Unjustified fear of causing new problems is sometimes not a good strategy and is often the result of a deficit of sustainable solutions.

Security issues are strongly emphasized in the power industry and energy in general. Several EU directives deal with security issues, both in the field of information security, occupational safety, environmental protection, and in the field of critical infrastructure protection. Many power plants and networks at the national economy level will be recognized as critical infrastructure. The availability and reliability of other parts of the national critical infrastructure (health, defense, transport ...) largely depend on the operational readiness of these elements. Identifying and assessing risks in this area is crucial for sustainability.

Risk-based thinking is essential in the management of power systems. Investing in new power facilities, but also maintaining the existing ones in the state of their technical operational acceptability is not cheap. Planning activities in these areas, adequately setting priorities, and implementing sustainable actions in this regard are crucial for the economic viability of electricity companies and often national economies. Risks are never fully managed, they are just hibernating.

Regular operational activities in electricity companies, whether it is the conversion of energy from fossil fuels, large hydro systems, or the conversion of primary energy from the sun and wind, are directly related to the impact on the environment and human safety. Identification of environmental aspects, their evaluation and identification of adequate measures to reduce the adverse impact on the acceptable measure are directly related to the level of awareness of all employees and the levels of their competence. The same goes for occupational safety.

All the problems mentioned are anticipated by ISO standards. The philosophy on which ISO standards are based, their genericity and interconnectedness is of great importance for practical application. Not without reason, companies that have a relevant certificate of compliance with the requirements of ISO standards have a greater competitive advantage at the market and can gain greater consumer confidence [1]. Although some segments of the electricity sector do not have a pronounced problem with competition and rivalry in the market (because they are natural monopolists such as network operators, for example), they also have a visible benefit of aligning operations with standards because they cooperate with many other market players. . An example of this is the system of procurement of goods and services for the needs of the DNO. The level of service quality of the network operator is directly affected by the quality of the purchased goods or services of the external supplier. If the business of this supplier complies with the requirements of the standard, it will directly have a positive impact on the quality of service of the DNO. But will the DNO require its suppliers to be certified and what certificates will they require to have? The answer to this question is directly related to the level of awareness of employees in network companies, their competence, but also the competence of top management. Obtaining any kind of certificate, regardless of the relevance of the certification body, should not be an option.

Electricity is a market-determined price commodity, which should correspond to a certain level of quality offered (European Commission Directive - Product Liability (85/374 / EEC)) [2]. The technical quality of the electricity is determined by a family of IEC 61000 standards with clearly defined quality quantifiers. Legislations oblige DNOs to act on these standards in different ways. The non-compliance results in reduced delivery reliability, damage to electrical devices, and ultimately reduced customer satisfaction.

The process of certification, i.e. verification of compliance of electricity companies with the requirements of ISO standards (ISO 9001, ISO 45001, ISO 14001, ISO 50001, ISO / IEC 27001, etc.) is not a simple process. The complexity of this transition becomes greater in conditions of insufficient understanding of the importance of certification. Certification should never be an end in itself. Certification is a process when the company will prove to all stakeholders that it operates in a safe and sustainable way. Internal audits are a good way to make all employees feel in the important role of an entity that can contribute to the continuous improvement of the business.

The energy business has a large number of operational and support processes. For each of these processes, the corresponding activities, inputs and outputs must be clearly defined, as well as the performers with defined responsibilities. The effectiveness of the process must be measurable, so performance indicators (PI) must be clearly defined. To improve process efficiency, risks and opportunities with measures must be prescribed.

After identifying key processes, the identification of key performance indicators (KPIs) is a consequential action. And in this step, risk-based thinking is emphasized. Setting the corporate goals is a particularly sensitive step. This is not only because the realization of goals often requires investment, but also because the goals must deal with the impact on safety and environmental protection, but also on the circular economy. Once established, goals can be changed, but they are always a reflection of top management's awareness of the sustainable business.

Establishing IMS in energy companies is a good way to improve business. The appearance of major changes is the best moment for IMS sustainability testing. These may be related to technological changes or improvements. Then it is necessary to adapt all processes to the new state and ensure their full operation. This implies both the necessary change of documented information and the implementation of the necessary training and the competence compliance of all in the chain. The need for controlled change management is emphasized. Another important impact on the sustainability of the IMS is the change of top management. System sustainability and business continuity should not be associated with personnel changes, but any new member of senior management should be competent enough to follow the requirements of the standards applied in the company. This is an important criterion for the selection of management structures [3]. Competence in the field of project management are of special importance in the conditions of intensive investment activities, which is a characteristic of electric power companies [3].

Digital transformation also has a prominent role in the field of standardization of energy companies. The application of dedicated applications, to company needs tailored, can help maintain an integrated management system. Generally speaking, knowledge management is closely related to the digital transformation of companies and society [4].

It is necessary that such an application has control over the requirements that are set out in all documented company information, both process and time. Analysis of compliance with the requirements set out in internal documents and standards, as well as automatic generation of reports on compliance with these requirements, helps companies and management to gain full control in this area.

3. Challenges of integration of electric power systems and smart concepts

Energy system integration (ESI) is a process that currently captures the attention of experts. There are various projects launched with the aim of identifying the main challenges in this area. The modelling of the integration process is based on the application of computer models [5]. This process is important both from the aspect of research of independently managed technical integration systems and from the aspect of organizational changes that such a form of integration requires. It is a multi-vector process of coordinating the work and planning of energy systems in order to provide reliable, cost-effective energy services with minimal impact on the environment. This integration means connecting different energy carriers - electricity, heat, and gas, solid and liquid fuels - with each other and with end-users, such as buildings, transport, or industry. This paper deals with the integration of electricity subsectors.

Dramatic changes occur in the functioning of DNOs during the integration of RES into the network. The new network faces a number of challenges that are insurmountable without smart technologies. Such a network is based on artificial intelligence systems and expert systems that enable its decision-making function. The new distribution network is a smart network.

3.1. Distribution smart grid architecture

Recent years have seen a power system paradigm shift. In order to cut CO_2 emissions, more and more RESs have been integrated into the grid. This significantly changes the system topology from top to bottom, moving it from the concept of several large production units connected to towards a decentralized structure with numerous distributed

RESs. This new system structure poses challenges to network stability, not only due to the two-way flow of electricity but also due to the volatile nature of weather-dependent RES. To address these challenges, smart ICT devices are being introduced to automatically monitor and control the power system, which, in conceptual terms, constitutes a smart grid [6]. Both the power and ICT systems are part of the national critical infrastructure and therefore require flexible system design. The term elasticity can be defined as the ability of a system to "anticipate, absorb and recover quickly from an external attack of high intensity and low probability" [7]. The definition of resilience in the context of an ICT system can be given as the ability of a network to provide and maintain an acceptable level of service in the event of various failures and disruptions that may occur under regular operating conditions.

The integration of data blockchain technology and electrical networks makes electrical networks smart and enables their decentralization. Also, the application of blockchain technology allows NOs to decentralize their business. Decentralization of business implies the absence of the need for central control units in the smart grid that would control and manage network resources for electricity distribution.

Decision-making and the flow of transactions in a smart grid do not have to be centralized. All transactions and operations performed in the network are stored in publicly available registers in the databases of the blockchain. All energy transactions in the network can be performed through a computer program by confirming predefined transaction clauses. Thus, data blockchain technology helps to establish a real-time energy market and preserve the identity of transactions at a much lower cost. This is particularly true and applicable in the smart grid in terms of energy management and end-user demand and supply management.

There are four main principles in Industry 4.0; interconnection of all devices via the Internet; data processing through transparency of information for better decision making, support systems and intelligent entities capable of making decisions and performing autonomous tasks. In the context of Industry 4.0, the smart grid uses an advanced information and communication system to connect generation units, transmission and distribution resources and consumers. Advanced data processing enables electricity distribution processes to be more efficient, decentralized, flexible, reliable and secure. The smart grid also integrates the use of RESs into the existing electricity grid, in order to feed local electricity demand. The new functionalities represent challenges for the existing network, not only in the technical or infrastructural sense, but also at the transactional level.

A smart grid is an electrical grid that integrates the behavior and actions of all connected entities (Fig. 1).

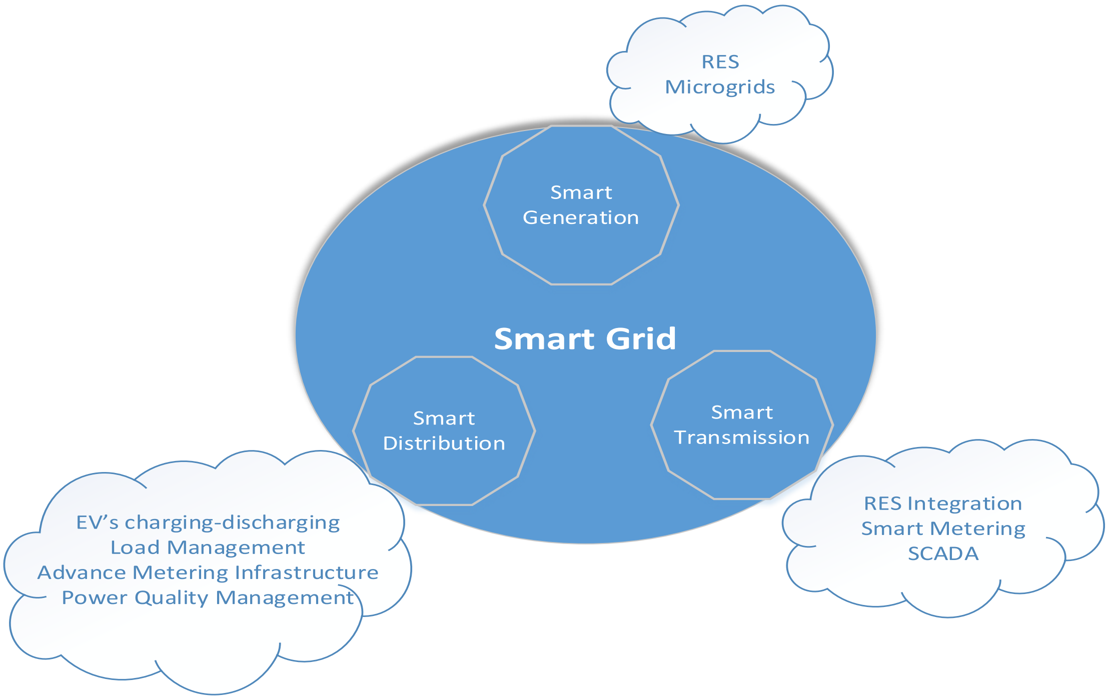

Figure 1. Smart grid entities

There are three types of entities; generators generating electricity (including energy storage); consumers who consume electricity; and those who can do both, i.e. prosumers. Together, these entities create a peer-to-peer network to ensure efficient electricity distribution; low losses and a high-power quality and security of electricity supply (European Technology Platform, 2010)[1]. The peer-to-peer network eliminates intermediaries in trade between trusted entities, giving buyers and sellers the freedom of preference, choice and price. A smart network is expected to be able to solve more complex problems more effectively and securely, through intelligent monitoring, control, communication and self-healing technology[2].One of the challenges in the smart grid deployment is how to support a communication infrastructure consisting of millions of entities operating and trading in a single market. Energy traceability is also becoming a serious issue. Blockchain data was also used to optimize energy transactions in μGs. In this case, a green certificate is used, which attests that the energy was produced from renewable energy sources.

Important features of a smart grid that make it very different from conventional electrical grids are:

- integration of renewable sources in the network;
- two-way communication;
- advanced metering infrastructures;
- advanced energy storage systems;
- data management and processing;
- cyber-physical network security.

Today, there are mainly three standardized models on which the architecture of smart grids is analyzed and built. Those are:

- Conceptual model of smart networks of the NIST institute (The NIST - National Institute of Standards and Technology)
- IEEE 2030 standard (IEEE Smart Grid Vision for Computing: 2030 and Beyond, 2013) and IEEE grid vision 2050
- SGAM (Smart Grid Architecture Model) model of smart grid architecture (CEN-CENELEC-ETSI Smart Grid Coordination Group, 2012)

SGAM was developed by three leading European standardization organizations: CEN (The European Committee for Standardization), CENELEC (The European Committee for Electrotechnical Standardization), and ETSI (The European Telecommunications Standards Institute). This model is a key outcome of a working group tasked with devising the optimal concept and standardizing the architecture of smart grids since the smart grid concept must be operable in the communication system, information system, controlled energy generating units and demand management settings. Conceived as an information system, the smart grid relies heavily on other information systems. The source of basic data for the operation of smart grids, especially for the visualization of its structure and operational management of such a virtual system is the Geographic Information System (GIS).

Communication networks play a crucial role in enabling smart grid functionality as they are able to adapt to the load and demands of change, intelligently manage two-way data flow and crucially improve system reliability, robustness, security and sustainability. Increasing the transmission of data through the communication network opens a number of problems related to network security and privacy, after all, as with any information system that communicates with other systems or its parts or peripherals network.

Given the smart grid setting, the amount of data and consequently the complexity of their processing will increase tremendously. Conventional data storage and management is becoming increasingly difficult. Such problems are solved by the use of cloud technologies (Cloud Computing). The economy of the smart grid is a significant challenge. The costs of switching from conventional to smart grid must be strategically and planned and set.A smart grid can intelligently integrate the actions of all its customers to efficiently ensure a sustainable, cost-effective and secure electricity supply.In line with the International Renewable Energy Agency (IRENA) 2013, smart grids include information and communication technologies in every aspect of electricity generation, supply and consumption to minimize negative environmental impacts, improve market transparency and competitiveness, improve the reliability and quality of services and reduce costs while improving business efficiency.

Generally speaking, the transmission network is developed on significantly different principles than the conventional distribution network. The fact is that, historically, much more was invested in the transmission network, the most modern technologies were applied and special attention was paid to it due to the fact that this network level significantly determined the national economy and that disruptions in this network led to technological and

---

[1] https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0202:FIN:EN:PDF

[2] https://ec.europa.eu/energy/sites/ener/files/documents/xpert_group3_first_year_report.pdf

socio- economic disturbances in a much wider area than the distribution network. Therefore, much more knowledge, modern technologies and money were invested in the transmission network, and all this resulted in a much more advanced state of all segments of the transmission network, whether primary and secondary transmission equipment or relay protection and automation systems or advanced metering systems. That is why today's transmission network is much closer to the requirements of a smart grid than a distribution network.

By applying modern technologies, both ICT and technologies that produce primary and secondary equipment are capable of describing their operational condition based on data on measured quantities based on which the insulation condition is diagnosed, measurement accuracy, quantified quality parameters or predict future operating conditions, distribution networks are getting smart. Smart grid technologies raise the level of intelligence of networks by collecting the necessary data based on sensor technology and processing that data.

3.2. A smart grid - functional requirements

Several types of technology can be used in a smart grid. As some of them are specific to the smart grid, other technologies can often be used in both conventional and smart grids. Smart grid technologies should facilitate communication, information management and network control. Smart grid technologies must perform the following categories of functions.[3]

- Integrated communications, which implies connecting components to open architecture that supports exchange of information and real-time control, creating an integrated system that allows every part of the grid to exchange information with another corresponding part of the grid or central control unit;
- Application of metering technologies and exporting of all metering data in a suitable format in real time, thus enabling the most effective and rapid response to any change detected in the system;
- Application of smart components in the fields of superconductivity research, storage, power electronics and diagnostics;
- Application of smart control methods to monitor grid components in order to enable rapid detection and effective response to any event in the system;
- Improved interfaces and decision support, to support human decision-making. The application of expert systems, neural networks and fuzzy logic, should enable better event prediction and provide the most effective possible event responses.

To make the network smart, data needs to be collected from many location systems that use different types of sensors. These main sensors measure the characteristics of power system components as a function of their performance. Such is, for example, a smart meter, technologically capable of registering a lot of data in the long run, whether it is energy data on energy and power, currents and voltages in all directions of their movement or quantifiers of energy supply quality, or registration of important events for reliable energy supply. These numbers are connected to the network by the Advanced Metering Infrastructure (AMI), which refers to two-way electricity meters and equipment for communication and data processing required for the collection of smart number data and their network transmission.

An example of sensor technology is a set of sensors that monitor temperature, vibration and other characteristics of energy transformers. Other sensors integrated in relay protection devices can also be used for data collection.

The smart grid must also have tools for data acquisition, processing and visualization, as well as tools that will enable the prediction of the state and changes in the system.

The PM must have controllers who monitor the behavior of other devices to provide information to the administration center in a timely manner. Examples of this functionality are the reduction of energy consumption during peak load, load management, voltage regulation, improving the quality and quality of electricity, the quality of energy and electricity.

Finally, the smart grid integrates energy sources, especially RES. This category includes technologies that can contribute to electricity generation, electricity storage or reduce demand.

The implementation of a smart grid goes through several phases that require an implementation strategy and involve a number of challenges. The challenge associated with technology is finding ways to efficiently use large amounts of data collected by

---

[3] prod/files/oeprod/DocumentsandMedia/DOEhttps://www.energy.gov/sites/_SG_Book_Single_Pages.pdf

smart numbers. In this regard, Geographic Information System (GIS) technology plays a key role in automation strategy by providing initial infrastructure data that will drive automated analytics. In addition, the results of smart grid analysis are best presented in a geographical dimension. A smart grid is also a large investment that requires financial risk analysis. Similar to electronic banking, a smart grid is not a collection of all its components but a choice of the most efficient way to integrate these components into a complete system.

3.2.1. Micro grid – part of a smart grid

The concept of μG entails the existence of a consumer cluster in a particular limited geographical area where there is distributed generation and a single, local control system. Thus, a μGcan be defined as a system integrating demand, distributed generation, and energy storage devices which are all coordinated in order to maintain the stability of the plant and the smooth flow of energy in the system to which it is connected at the point of common coupling (PCC).

In the process of ensuring the most efficient integration of renewable energy sources into the distribution network, several questions need to be answered first:

- how will the load be distributed among production units within a μGin the conditions of unreliable production and ensuring an adequate level of mandatory reserve;
- how to secure reliable and economical operation of a μG with a large share of variable production from RES when running as an island;
- what should the demand management be like in terms meeting grid needs;
- which market participation models will enable market participants that integrate RES and DG in general, electric vehicles, energy demand and storage to participate in the market and what kind of incentives can be introduced;
- how to parameterize relay protection at the DSO level taking into account two-way power flows;
- what management techniques should be employed for voltage and frequency control that will take into account the increase in the share of generation that injects energy into the grid indirectly through nonlinear energy converters.

In order for μG to be fully efficient, it is necessary to ensure the flexibility of the demand and generation in terms of achieving the ability to balance the variability of the load and the uncertainty of renewable energy. If this is not always possible, such systems may be sources of instability when it comes to maintaining the balance between electricity production and consumption. Quantifying the ability to provide flexibility in managing different units within a μG is an important segment of a successful integration of renewable sources. As a μG can run in two basic operating modes, namely independent (island) and synchronised (parallel) with the rest of the network –flexibility should be considered for both of them.

Today, we are faced with the important question: how to design the future power system to provide greater resilience and fast recovery in case of disturbances that cause interruptions of electricity supply? The approach to solving this problem is multi-layered. Namely, the problem should be considered from several different angles and system levels: from applying general methods for increasing the resilience of the power system to some particular strategies for system restoration. For example, the restoration can begin at the level of the distribution network when there are enough RE power plants connected to it and when it is possible to provide a sufficient level of μGstability.

It is also particularly important to look at μGs in terms of flexibility. In general terms, system flexibility refers to its ability to adapt to disturbances and new operating circumstances as system inputs, without or with the least possible alterations in system outputs.

The flexibility of a distribution network as a system refers to its ability to engage all its available resources that can provide the demanded amount of energy and power to respond to any change in demand coming from the consumer side. The flexibility of a distribution system especially refers to its ability to maintain the balance between production and consumption, especially in the context of high RES penetration. Reduced flexibility which can be caused by impermissible frequency oscillations and the resulting sudden and costly lead shedding, can seriously jeopardize system sustainability, and, from an economic point of view, have costly consequences for all market participants. In traditional systems, reserves could be provided by engaging large hydro capacities that could relatively quickly and inexpensively compensate for the missing power. With high penetration of RES, especially wind and solar, sudden changes in the level of production of power plants with unpredictable production require swift interventions to provide the missing power which cannot always be found in the demanded amount and on time. This problem can be effectively solved by increased deployment of new energy storage technologies (power storage devices, electric vehicle batteries, µCHPs, and controllable loads).

3.2.2. Energy management in µG

The International Electrotechnical Commission in IEC 61970 standards dealing with application program interfaces for energy management systems (EMS) defines energy management as a "computer system comprising a software platform providing basic support services and a set of applications providing the functionality needed for the effective operation of electrical generation and transmission facilities so as to assure adequate security of energy supply at minimum cost" [8]. A µG energy management system, which has the same characteristics, usually comprises modules for the application of decision-making strategies. DG modules (demand prediction), HMI, supervisory controls and data acquisition (SCADA), among other things, ensure effective application of decision-making strategies by sending optimal decisions to every generation unit, energy storage devices, and consumer units. The energy management system in a µG performs a variety of functions including the monitoring, analysis and forecasting of DG output, consumption i.e., load levels, prices on the electricity market, prices of ancillary services and meteorological factors. These functionalities are organized as shown in the Figure 2 below.

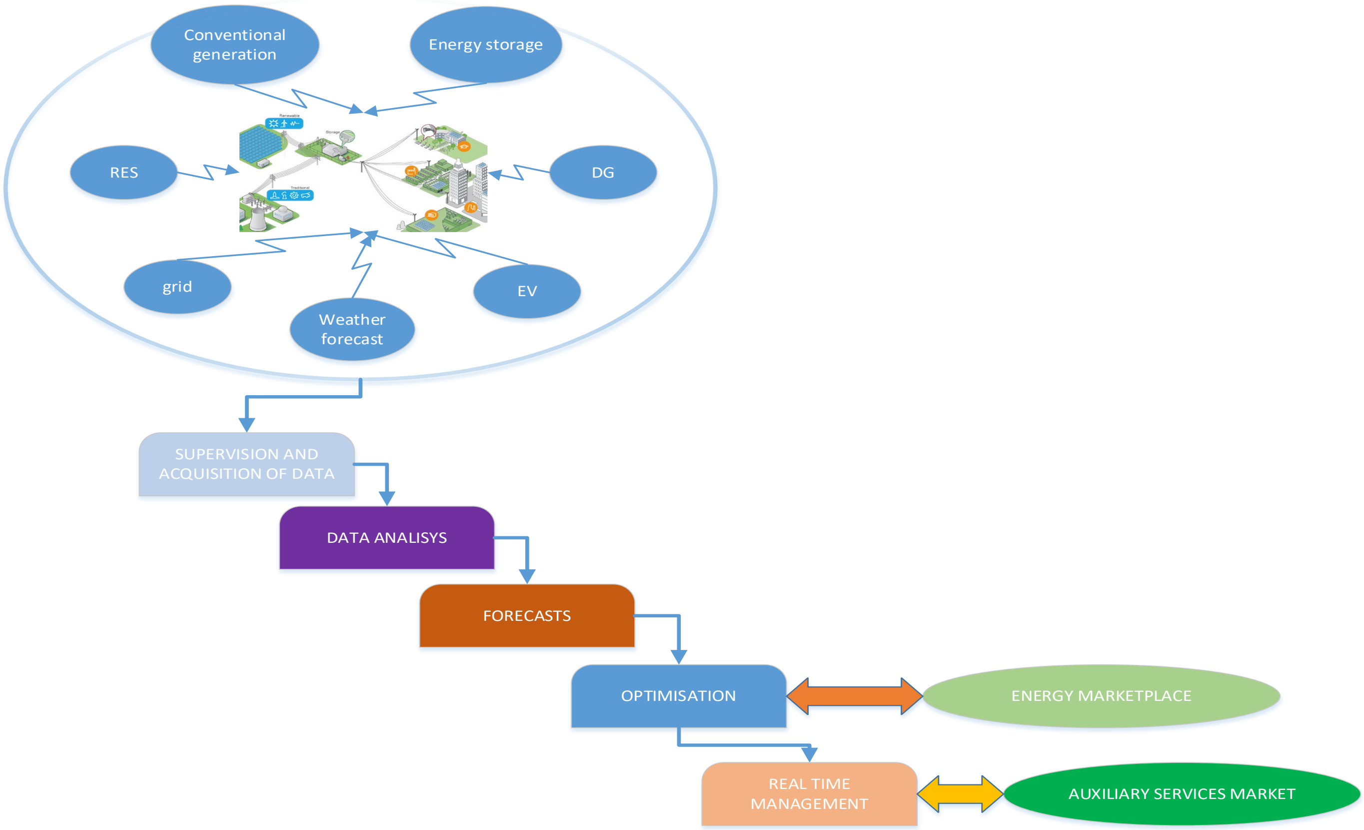

Figure 2µG environment and µG functionalities

The integration of RES, energy storage devices, e-vehicles and DER requires a clear and sustainable µG management strategy which will make a µG's objectives achievable. Not all µG management strategies are the same nor are the objectives of different µGs. It is however necessary that all µGs within the same power system have management strategies that can reconcile the requests and objectives of individual µGs and the power system and find compromise solutions. There will be no compromise on the basic principles of EMS such as operation stability, for example. Interests may be reconciled concerning the level of power quality (which can match the price of service) or the level of losses which is directly related to the technical level of equipment in a grid. Different management strategies focus on different objectives, from minimizing losses, increasing reliability of supply, controlling the intermittency and instability of RES, to achieving economical, sustainable and reliable operation of the µG. Various aspects of these strategies are presented in Table 1. The strategies are devised based on objectives, which generally concern cost reduction and objective constraints which, alone and synergistically, stand in the way of reaching the set objectives.

Table 1. Objectives and barriers to achieving objectives

OBJECTIVES	CONSTRAINTS
• CO_2 emission costs • EMS operating and maintenance costs • Conventional generating unit operation and maintenance costs • Penalties for load shedding • Cost of losses • Load management incentives • Cost of outages • Cost of waste battery disposal • Cost of energy transactions • Equalising the RES production costs	• Network capacity constraints • Energy balancing • Production limits for renewables • Demand management • Reactive power support • Reliable operation • Technical constraints of conventional generators • Technical constraints of energy storage systems

Strategic approaches to the establishment of energy management systems in μGs are based on[4]:

- linear and nonlinear programming methods;
- dynamic programming and rule-based methods;
- metaheuristic approaches;
- artificial intelligence methods;
- stochastic and robust approaches to programming and
- predictive model control.

Hence, the energy management system in μGs is a complex system that solves technical, economic and environmental issues. Different approaches and methods are available for structuring thus system, and the choice of method depends on its suitability and adaptability to a particular μG and its capability to optimise μG operation.

The types of a management system depend on the system's mode of operation - centralized or decentralized - economic aspects and intermittency and variability of renewable energy sources. Also, these systems look at the environmental impact of conventional generators, the operational and functional condition of batteries as electricity storage devices, active integration of DG, system losses and reliability, and customer privacy. Customer privacy management is particularly challenging, especially in the light of obligations arising from the GDPR documents. Furthermore, safe and reliable management of communication system costs, especially for decentralized systems, has been the subject of extensive research. These costs affect greatly the economic sustainability of global EMS and μG operator in particular, which reiterates the need for careful reflection in the process of decision making regarding the structure of a communication system and the choice of optimal technology or combination of technologies.

3.2.3. μGand Virtual Power Plant (VPP)

The aim of forming VPP is to network distributed generators in order to predict, optimize, and trade their power.Fluctuations in RES generation can be balanced by increasing and decreasing energy production and energy consumption of controlled units.VPP helps to stabilize networks, enables the integration of RESs and markets through the aggregation of smaller units that could not independently provide the service of flexibility or balancing.

By aggregating the power of several small blocks, VPP can provide the same services and trade them in the same markets as large power units can independently. The role of VPP is also reflected in the management of load in μGand the elimination of peak periods or their shifting along the time axis. Commercially developed software platforms are used (AutoGrid VPP, Next VPP, eg).

4. ESI model and supply chain

The complexity of the new distribution network concept is described. This concept assumes the interaction of the NO with several other entities that may appear at the energy market. The NO will establish business-to-business (B2B) or business-to-customer (B2C) relationships with all of them. The NO will perform various purchases of goods and services for the needs of network equipment maintenance, but also for the needs of system development, or will often outsource system maintenance services. A very important segment in the electricity distribution and supply business is electricity metering, billing (invoicing), and collecting. In this sense, many power energy systems have organized metering operators who are only in charge of metering and invoicing and operate this service as outsourced to the suppliers. At the same time, the end-user is provided with an easy supplier change service. This is possible by using sophisticated web-based applications.

All of this leads to the establishment of specific supply chains, which must function perfectly in terms of ICT, in order to maintain the quality of service and increase customer satisfaction. Supply chains will function more easily if all companies in the chain standardize their business. This is necessary so that both management and all employees are aware of

---

[4] https://www.sciencedirect.com/science/article/pii/S0306261918306676

their role in the supply chain and the consequences to the end-user that could be caused by the potential disruption of chain synchronicity.

For the traditional distribution network, the freedom to appear on the energy market in accordance with the law and the introduction of new technologies today (solar and wind energy, energy storage) is a disruptive innovation. Great efforts are being made to find business models that will limit the increase in supply prices to the end customer [9].

5. Conclusions section

Today, dramatic changes are taking place in the field of production and supply of electricity. They are mainly aimed at reducing the production of CO2 emissions. Efficient management of companies in such an environment requires well-skilled top management with a highly developed environmental awareness. Also, customers have a very active role and are not just energy consumers. Their needs are changing rapidly and need to be accurately anticipated. Electricity network operating business is mostly monopolistic, but with the development of µGs, this business is changing and becoming more complex. Complexity is increased by the integration of energy systems that require computer modeling for operational implementation. Managing energy companies in the conditions of intensive penetration of new technologies and development of intercompany software to support business integration requires precise application of business principles established by the ISO 9001 standard. Environmental management and occupational health and safety is also strongly emphasized. The integration of management systems and related benefits can be important in achieving the goals of integrating energy systems. Risk-based decision-making is an indispensable principle in this process. Top management must have enviable skills in this area as well.

6. References

[1] Piotr Kafel, BENEFITS OF MANAGEMENT SYSTEMS INTEGRATION, Cracow University of Economics, Faculty of Commodity Science, Department of Quality Management, STUDIA OECONOMICA POSNANIENSIA 2016, vol. 4, no. 10, DOI: 10.18559/SOEP.2016.10.9

[2] Product Liability (85/374/EEC), www.ikev.org/docs/eu/385L0374.htm

[3] Michael Shearn, THE INVESTMENT CHECKLIST: THE ART OF IN-DEPTH RESEARCH, November 2011, ISBN: 978-0-470-89185-8, https://www.scribd.com/document/525985325/The-Investment-Checklist

[4] TSEKHOVOY, Alexey Philippovich; ZHOLTAYEVA, Aibarsha Serzhankyzy & STEPANOV, Alexey Vladimirovich, THE ROLE OF KNOWLEDGE MANAGEMENT IN ORGANIZATIONAL DEVELOPMENT, Revista Espacios, Vol. 40 (Number 25, page 11), 2019. ISSN 0798 1015, https://www.revistaespacios.com/a19v40n25/19402511.html

[5] Antti Silvast, Simone Abram & Claire Copeland, ENERGY SYSTEMS INTEGRATION AS RESEARCH PRACTICE, Technology Analysis & Strategic Management, DOI:10.1080/09537325.2021.1974376, https://doi.org/10.1080/09537325.2021.1974376

[6] Hans-Jürgen Appelrath. Future Energy Grid – Migrationspfade in das Internet der Energie. Springer-Verlag Berlin Heidelberg, 2012.

[7] Mathaios Panteli and Pierluigi Mancarella. The Grid: Stronger, Bigger, Smarter? Power and Energy Magazine, IEEE, 13(june):58–66, 2015.

[8] IEC 61970: Energy management system application program interface (EMS-API). IEC; 2005.

[9] Stevenson, Tim, Wrigley, Cara, and Matthews, Judy (2016). A design approach to innovation in the Australian energy industry. Journal of Design, Business and Society 2 (1) 49-70. https://doi.org/10.1386/dbs.2.1.49_1