Method of Selecting A Source of Electrical Energy Suitable for The Site

DANA PROCHAZKOVA, JAN PROCHAZKA
Department of Energy, Machinery Faculty
Czech Technical University in Prague
Technicka 4, 166 00 Praha 6
CZECH REPUBLIC

Abstract: - To ensure reliable supplies of electricity in a given territory, it is necessary to choose the source that is for the given territory the most suitable in all aspects, i.e. the availability of resources, technology, finances to cover costs and demands on personnel are ensured. With regard to the current situation in energy sector, we are also focus on small modular reactors, which we, therefore, describe in detail. Since meeting the requirements of human society for the safety of energy sources can only be achieved by combining the measures from a wide range of areas that are incommensurable, a multi-criteria approach is chosen. The procedure used is described in detail and it is given a case study in which it is used.

Key-Words: - Power sources; availability; risks; security; multi-criteria approach.

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1 Introduction

To ensure the development and safety of the State, each State needs raw materials, energy, transport, industry, agriculture and services to ensure the basic functions of the State. In the article, we focus on energy production, which is the basis for the extraction of raw materials, industry, transport, the operation of critical infrastructures and services that ensure the protection of the lives and health of the population, the protection of property and the protection of the environment.

Energy production for each State must be sufficient in terms of need and must be cost-effective and it must not damage public assets, so as not to harm the public good. This can be achieved through an appropriate combination of cost, quality, time, flexibility and innovation [1]. Daas et al. [2] developed a Decision Support System (DSS) for designing business models. A Decision Support System (DSS) consists of a design process that follows different design methods. Its application ensures compliance with legislative requirements.

Due to the current energy crisis, we are paying attention to small modular reactors, which seem to be promising because they are reliable, sufficiently powerful and affordable in terms of costs, construction time and small emergency planning zones.

2 Requirements of Energy Sources

In general, energy in a particular locality can currently be provided by the construction of a technical facility, i.e.: hydroelectric power plants; large nuclear power plants; gas-fired power plants; thermal power plants; geothermal power plants; diesel engine systems; wind power plant systems; photovoltaic power plant systems; and small modular reactor (SMR) systems.

A basic analysis of the conditions of individual technologies shows that for the implementation of the mentioned technical facilities it is necessary to have at your disposal:

- river with a sufficient amount of water throughout the year in the first case,
- territory that meets the requirements for location of large nuclear power plant, water source for cooling and available and safe nuclear technology,
- stable and affordable gas supply,
- stable and affordable supply of coal, wood or others biomass,
- a stable and affordable local source of geothermal energy,
- stable and affordable supply of diesel,
- stable and sufficient wind,
- stable and sufficient source of solar energy,
- territory that meets the location requirements for SMR.

3 Used Terms

All used energy sources are technical facilities, which used specific technologies for production of electric energy or heat. At their description we used terms, the context of which is given in work [3]. They are used:

1. ***Technical facility*** is the result of engineering process, which ensures products and services supporting the human lives and development. *In our case, we follow the facilities, which produce electric energy or heat.*
2. ***Fundamental State function*** is the State mission in ensuring the protection of public interests (assets) and their permanent sustainable development.
3. ***Basic human system assets*** (protected interests or fundamental interests of the State) are items that are protected with priority (in the CR and in the most of the other countries there are human lives and health, property, welfare, environment, existence of the State and recently critical infrastructures and technologies) and there is pursued the care to their development.
4. ***Critical infrastructure*** is the set of interconnected physical, cybernetic and organizational (service) systems, that are necessary for ensuring the support and protection of human lives and health, property, minimum function of economy and administration of the State. *In our case we follow energy sources that are critical elements of energy infrastructure.*
5. ***Security*** is a condition of system at which the occurrence of harm or loss on system assets (protected interests) has an acceptable probability (it is almost sure that harm and loss do not origin). To this there is also belonged a certain sure stability of system in time and space, i.e. a sustainable development in time and space which means that the system is protected against to internal and external disasters. It is a forming the sense of safety, safe feeling, certainty, ensuring the public welfare, permanent development of sound environment and reliable operation of technical (physical and cyber) facilities. In this view, it is necessary to understand that human is also system.
6. ***Safety*** is basic attribute of quality of followed entity. It is a set of human measures and activities for ensuring the security and sustainable development of certain system and its assets. Its measure is effectiveness size of appropriate measures and activities at ensuring the system assets security and sustainable development. By other words it is the capability of system to precede critical conditions of the system (active safety uses the elements of management; passive safety utilizes protective physical elements) and at their occurrence not to threaten the existence of neither itself nor its surroundings. From the engineering viewpoint [13,15], the system safety means the system integrity, reliability and functionality.
7. ***Risk*** is a probable size of non-demanded and unacceptable impacts (losses, harms and detriment) of disasters with size of normative hazard on system assets or subsystems in a given time interval (e.g. 1 year) in a given site, i.e. it is always site specific.
8. ***Criticality*** denotes a limit (boundary) from which the risk impacts are significant up to eliminative for
9. ***Inherent safety*** is a set of measures inserted into the entity design for reduction of hazard.
10. ***Limits and conditions*** are margins in which it is ensured the safety of operated system. They are tools of technical facility safety management. They are the set of positively defined conditions, for which it is proven that the technical facility operation is safe (in reality with probability $\geq$ 0,95). The appropriated set includes data on permissible parameters, requirements on operation capability, setting the protection systems, demands on the workers´ activities and on the organizational measures leading to the fulfilment of all defined requirements for design operation conditions. For ensuring the safety, i.e. also the reliability and the functionality, the control system of given technical facility needs to keep the determined physical quantities (parameters of appropriate subsystems) on values determined in advance. During the process of regulation, the control system changes the conditions of individual controlled systems by bearing upon the efficient quantities, with aim to reach the required state (condition) of whole system. In terms of integral safety, the following properties of control system are pursued in the order: level of observance of established operation conditions and prevention of damaging (unacceptable) impacts on the system itself and its vicinity; functionality (level of satisfaction of required tasks); operability, i.e. level of fulfilment of required tasks at normal, abnormal and critical conditions; operation stability, i.e. level of observance of established conditions during the time; and inherently included resilience to possible disasters.

4 Small Modular Reactors

Small modular reactors (SMR) have been in development for decades [4-13]. The International Atomic Energy Agency [12] defines small, medium and large reactors according to output electrical performance;

reactors up to 300 MWe are classified as small reactors. They are increasingly used in practice, as they are cheaper and their area of emergency planning is smaller compared to large nuclear power plants [9,13,14]. In the Czech Republic , we work on the Energy Well reactor [15,16], which we want to use as energy sources in technical installations producing the energy for: train and ship drive; operation of processes as reverse osmosis; hydrogen production and hydrogen storage; and mining the minerals in remote regions [17,18].

The advantages of SMRs are mainly in the low installed performance. This advantage is conditioned by a high degree of inherent safety of the system. Due to the low power, passive cooling and the possibility of connecting to low-voltage networks are often talked about in connection with SMRs. If it were not a passive cooling system, batteries could be used for emergency power instead of diesel generators [19]. Due to the low installed capacity, it is possible to reduce the emergency planning zone and generally reduce the licensing period due to the greater simplicity of the system in comparison with large nuclear power sources [19]. With outputs of less than 60 MW, it would be possible to cool the generator with air [20].

Another advantage is the size of the device. Due to this fact, it is possible to build nuclear facilities that are, compared to conventional nuclear sources, more resistant to earthquakes. At the same time, it is possible to renew older ideas about the operation of a nuclear reactor under the Earth's surface, which would be economically unacceptable in the case of conventional nuclear power plants [17]. Burying the SMRs would increase the safety of the system against windstorms, tornadoes and hurricanes, for example, as well as the possibility of a terrorist attack. At the same time, however, access to the equipment during the shutdown work or accident is noticeably reduced. Burying it under the Earth's surface would also be lucrative for military use, drawing on an extremely small built-up surface. However, for military purposes, the installation process would need to be extremely accelerated. At the same time, underground systems could be less sophisticated, reducing the price of SMRs in direct proportion [19].

Furthermore, the relatively small dimensions of the entire system would not cause much difficulty in transport or in the selection of suitable locations. Possibility of connection where it is not possible to build large power plants for many reasons (logistics, subsoil, cooling, etc.) [19]. According to the IAEA, the advantage is, of course, lower investment risk, improved cash flow or shorter construction time [21]. With smaller component dimensions, the price also decreases due to greater competitiveness among suppliers potentially bidding for contracts [20].

The largest economic indicator for nuclear power plants is LCOE (Levelized Cost of Electricity), which is the ratio of the final price of a nuclear power plant to the installed electrical capacity. From the point of view of SMR optimization, it is, therefore, essential to reduce LCOE [17]. Opinions on the method of reduction vary, one of them is, for example, a decrease in installed capacity, which should also have an impact on greater simplicity of the system, and therefore, lower investment costs [12]. The estimated costs according to [22] are as follows: SMART – construction costs 5000 \$/kWe, operation and maintenance 6.1 cents/kWh (which is lower than hydropower), NuScale – construction costs 4000 \$/kWe (40 months of construction), fuel costs 5.5 \$/MWh.

According to [20], it is reality that in SMRs around 15 systems and components necessary for LOCA disaster resolution are eliminated and, for example, in NuScale units, they are replaced by only one system due to the low electrical power of 50 MWe. As a small facility, SMRs have also benefit in terms of supply chains. The production of smaller pressure vessels gives the opportunity to more companies, including the domestic ones. At the same time, there are no complications in dealing with large manufacturers of heavy components, respectively with their workload [20]. The same approach applies to the production of turbines and generators. A larger group of possible manufacturers encourages a more vigorous competition in a competitive market, and therefore, a possible reduction in acquisition costs. In addition, as already mentioned, smaller equipment is easier to transport, maintain and possibly dispose of. In the case of turbogenerators with lower outputs than 50 MWe, it would be possible to transport the entire equipment on a "separate pallet" and, in addition, it would be possible to cool it with air [20].

The impacts on investment decisions can be summarized in 11 classes, which include, for example, the stability of the electricity grid, public acceptance, technical constraints on location, project risks, national industrial system, time of market launch, competences required for operation, effects on employment, design robustness or political relations [23].

In a 2016 document [24], the OECD argues that the problem still remains that capital costs, operating and maintenance (O&M) costs and fuel costs are not yet known. On the other hand, it confirms the advantages of SMRs, among which it states: increased nuclear safety and implementation of unique passive elements; reducing the number of systems and simplifying the energy conversion; easier financing; better network flexibility, e.g. load monitoring modes;

lower transmission system requirements due to lower power outputs; identical SMRs are advantageous in terms of human resource management; easier decommissioning; and the ability to avoid downtime by help of suitable SMR configurations.

At the same time, the report [24] states that the following will be key for customers: GDP and its possible growth; electricity consumption per person; credit rating; self-sufficiency of electricity supply; environmental protection; national membership of the IAEA; electricity price; and specifics of the electrical network (size, voltage, quality, interconnection, load).

For SMR manufacturers, according to [24], it is a matter of ensuring: technology readiness and demonstration possibilities; financial background; and supply chain and public procurement. At the same time, the report [24] mentions a comparison of the aviation industry with nuclear facilities, which is a frequently used parallel, but it is not as simple as it may seem to others. In particular, the efficient full assembly of SMRs at the factory may not allow the inspectors of supervision office to check all the steps (an on-site inspector could be preferred to optimize the assembly process at the factory) [25]. With regard to the deployment of SMRs, the innovative licensing system should separate the general approval or licensing of production equipment for SMRs, the SMR itself and the site for SMRs [24].

It can be argued that SMRs have reached a certain degree of maturity and are competitive with other energy sources [25]. In addition, large nuclear power plants and SMRs are expected to have the same LCOE of USD 70/MWh (at a reasonable weighted average cost of capital) with a load factor of 85 %, but a slightly different distribution between fixed and variable costs [9]. This leads to the idea that SMRs may have lower investment costs due to factory production, shorter construction times, simpler financing and the like, but higher variable costs due to higher O&M costs per MWh due to the fixed component of O&M costs, lower fuel efficiency, etc. In this example, SMRs are most competitive with load factors of 60-85 %, replacing the coal and large nuclear power plants to this extent [24].

The DoE [25] states that the safety of SMRs might not be as perfect as it is generally claimed. The main argument concerns passive safety systems and elements that are not infallible. A smaller containment is disadvantageous in terms of the ppm value of hydrogen, which would be enough for an explosive concentration in the containment area. If the reactor were to be buried, earthquake resistance could be increased, but flood safety decreased. At the same time, safety is reduced due to fewer operating staff or in the event that the manufacturer decides to reduce costs [19].

The advantages of SMRs according to DoE [25] are modularity, the ability to build units in a factory and transport them to the site. It is suitable for small electric markets, places with low logistical support and places with smaller industrial plants. At the same time, it is possible to replace old coal-fired power plants with green sources, which are SMRs. There is also the possibility of connecting SMRs with other sources of electricity, which could increase the stability of the network or the safety of the transmission system. A large part of the SMRs is planned in such a way that there would be no situ betting, but it would be done directly in the factory [19].

In the case of multiple SMRs, this technology could be less safe than in the case of a large nuclear power plant, when the SMR manufacturer fails in one project [19]. However, this presumption is applicable not only to SMRs or large nuclear units, but to series production in general.

The advantage of SMRs in terms of safety is also the so-called integral arrangement, where the reactor and the components of the primary circuit are placed in one pressure vessel [20]. This eliminates the amount of cooling pipe and its dimensionality. Due to this, the sleeves leading out of the TNR are also drastically narrowed, which has a positive impact on the course of the LOCA accident. Heat exchangers are usually seated higher than the core, thereby contributing to the natural circulation of the refrigerant. However, some systems, due to the natural circulation of the refrigerant, completely eliminate the main circulation pumps and the associated possibility of a LOCA accident [20].

Sources of risk were monitored at work [26]. Other factors that are sources of high risk, which is common to a capital-intensive industry, are according to [24,27]: large initial expenses; the uncertainty of the return on initial investment; the danger that the work will not be completed, or changes will be necessary, which will require enormous additional costs for completion; long building and construction time; sensitivity to demand; reliability, availability and load factor of the power plant; electricity price; unstable public support; low acceptance of nuclear power installations with the public (although nuclear technologies used in medicine and food, which are not as secure as energy [26], do not create public disfavor); decisive influence of the regulator; and decommissioning – decommissioning and subsequent decontamination of equipment and surface treatment, which does not yet have a clear procedure, although there is experience [28] and civil procedures [29].

According to the work [27], the advantages of the reduced power plant size, complexity and simplified design offered by SMRs would allow: better control over construction; less risk associated with suppliers; and better control over the cost of equipment design. According to works [17,18,20, 30] SMR can be used for: long-range heating; desalination and water purification; advanced oil extraction and oil refining processes; production of hydrogen for the enrichment of liquid fuels and, where appropriate, the use of fuel cells; advanced energy conversion processes such as coal liquefaction and petrochemical production; general process heat for chemical or manufacturing processes; the standby power of a nuclear power plant; data centers; military bases; mining sector; remote island operations; industrial complexes; production and liquefaction of hydrogen; steelworks; oil and gas terminals; large chemical plants; desalination of seawater; propulsion of ships etc.

5 Method of Selection of A Suitable Source of Electrical Energy

In any case, it is a question of choosing a technology for which there are conditions in the territory and which is safe, which means reliable and functional and procure quickly, while its demands on safety, operation, human resources and other service systems are such that it will be cost-effective. This means that the benefits for the territory while ensuring a level of safety will be optimal. The optimal solution is obtained by assessing possible variants [31,32].

According to [32], any suitable solution for meeting the specified goal is considered a variant solution, i.e.: various localization of the construction site and traffic route management; various technological processes; variant type of activity, e.g. choice of import instead of domestic production; different implementation timetables; substitution of raw materials; and various solutions for the disposal of waste, emissions, etc.

Variant generation is a creative model of thinking that depends on the criteria of the goal. In a State governed by the rule of law, the objective must be consistent with legislation that promotes the security and development of the State. The goal in terms of development and cost in any case is to select a technology that will: safe; tried-and-true; feasible within an acceptable time; easy to maintain; and have reasonable demands on fuel, self-consumption, personnel and finances necessary for safe operation.

In the world, a procedure called "technology assessment", which is codified in each country [32], is used for this purpose. The form of technology evaluation is determined by legislation in each country; the goal is the same, but the form of application varies from country to country [32-44].

According to [32-44], the evaluation in question is a comprehensive interdisciplinary expert evaluation of planned technical facilities, which considers both, the possibilities of the investor and the impacts of current and future on the areas of technology, the environment, social, social and economic; in Europe, it began to be used in the early 90s.

The evaluation in question is not directed against technology; its aim is to detect problems and prevent damage caused by uncritical application and commercialization of new technologies. The results of the evaluation are intended for investors (in the case of public projects for politicians), who ultimately decide to enable the implementation of a technical facility.

When making a decision, based on the evaluation of technology, there is a dilemma: correctly appreciate the impacts of the planned technical facility, which cannot be easily predicted until the technical facility is extensively developed and used; and it is difficult to manage or modify a technical facility once it is widely used. To do a decision is difficult, because in a particular case: it is difficult to estimate the cost of externalities and internalities; it is not easy to select indicators to assess the benefits and impacts of the planned technology; it is not easy to convert damages and injuries into money; and there are also ethical barriers.

Based on the above quotes, "technology assessment" is mainly used in the following areas: information technology; hydrogen technologies; nuclear technology; molecular nanotechnology; pharmacology; organ transplantation; genetic technology; artificial intelligence; internet etc. The evaluation of technology in the selection of technologies associated with the application of nuclear processes is described in the works [11,45-51].

On the basis of the OTA (Office for Technology Assessment) documents collected in the database [33], the specific assessment is carried out in two steps. First, a screening of possible variants is carried out, i.e. an evaluation of essential factors to exclude major unsatisfactory variants, and a detailed evaluation is carried out for the remaining variants, which forms the basis for the decision of the investor (or politicians, in the case of public projects).

Based on the documents cited above, an evaluation based on the following criteria shall be used for screening:

1. Is the operation of the technology tested?
2. Is the power supply safe, i.e. reliable and functional for life?
3. Is the technology available to the investor?

4. Is the performance of the technology stable in the long term?
5. Can the technology be implemented quickly?
6. Is the cost of applying the technology acceptable?
7. Can a source with this technology quickly (less than 1 year) meet the needs of the investor for the entire duration of operation of the building for which it is being built?

The comparison of suitable variants of technologies determined by screening for an investor or supplier of an electricity source in the monitored case for understandable reasons (it is to ensure the needs of a company) does not include or only to a limited extent includes the needs for the territory in which the energy source is located and put into operation (e.g. public welfare, employment, services in the territory, etc.). Table 1 shall be used for the detailed evaluation of variants. The optimal solution is a variant that: has the most benefits; does not have too large specific requirements for operation; and according to [52] losses caused by accidents or failures will not reduce the expected annual return below

ERV = 0.7 x total useful income / lifetime.

Since nothing is absolute, no technology meets the requirements absolutely.

Since this is a complex decision-making problem in which it is necessary to consider criteria from many areas that are often incommensurable, it is necessary to apply a multi-criteria evaluation [31] based on the philosophy put into practice in the work [53].

For the selection of an source of electricity production, in accordance with the knowledge [31,32,54,55], we have constructed a decision support system for evaluating the contributions of individual criteria to the integral safety of the technical facility (energy source) and its surroundings.. We have created the criteria on the basis of the knowledge gained from the critical analysis of [31-36, 54,55] so that "the higher the value of the valuation, the higher the contribution to integral safety" is paid. The criteria for:

1. The criteria for judgement of safety of technology are based on the assessment of rate in which technology: has inherent safety; is a clean source of energy; is able to ensure a stable supply of electricity (this means that it is still operational and does not depend on frequent specific deliveries or specific external conditions); has the ability to operate without trouble; does not require frequent repairs; operation do not require qualified operator intervention; impacts of the operation on employees are acceptable; and impacts of the operation of the technology on the surrounding environment are acceptable.
2. The criteria for judgements of material demands on the feasibility of technology in a certain place are based on the assessment of rate in which technology: includes measures to manage emergency situations; the operation can be done without specific knowledge; the installation requires a local object; can do without frequent supplies of raw materials for operation; demands on a specific and expensive location; demands on technical tasks during the commissioning; the operation requires the skill of the operator; needs energy for its own consumption to operate; requires a large information provision to operate; has a specific I&C for operations; uninterrupted performance due to maintenance and repairs; the quality of operating regulations for normal, abnormal and critical conditions; level of protection of the technology against local natural disasters; protects the lives and health of operators; does not contaminated environment; does not require on-site waste management; and is protected against insiders and terrorists.
3. The criteria for judgements of accessibility and competitiveness of technology are based on the assessment of rate in which technology: has acceptability of the installation time of the technology; has to ensure power generation for the operation of the monitored entity for 10 years or more; has acceptability of the price of the technology; does not reduce the expected annual return below the acceptable value according to [53]; the transport of technology and the supply of spare parts are feasible; the financial demands on the technology and its long-term operation are acceptable; difficulty of granting an operating permit; specific objects are not needed for waste disposal at a given location; The extent to which the technology does not require site-specific equipment to reduce contamination of environmental components; and The rate of acceptability of the scope of the emergency planning zone.

The evaluation of the criteria is carried out by assigning points as follows:

0 point – the criterion is met at less than 5 %, i.e. it does not contribute to ensuring the integral safety,

1 point - the criterion is met at 5- 25%, i.e. it contributes little to ensuring the integral safety,

2 points - the criterion is met at 25 - 45%, i.e. only moderately contributes to ensuring the integral safety,

3 points - the criterion is met at 45 - 70%, i.e. it contributes highly to ensuring the integral safety,

4 points - the criterion is met at 70 - 95%, i.e. it contributes very highly to ensuring the integral safety,

5 points - the criterion is met at more than 95%, i.e. it contributes extremely highly to ensuring the integral safety.

The evaluation of criteria might be performed by specialists from different domains (technology, region safety, public administration, investor, emergency service) [32]. The resulting value is the median for each criterion, and in cases of great variance of the values in one criterion it is necessary, so that the worker of public administration responsible for territory safety may ensure further investigation, on which each assessor shall communicate the grounds for his / her review in the present case, and on the basis of panel discussions or brainstorming session, the final risk rate value is determined.

6 Case Study

We assume an uninhabited area in the Arctic region in which a significant deposit of an important mineral has been discovered, the valuation of the content of which means extraction for 20 years or more. There is no big waterworks with stable big amount of water, source of coal, neither a source of geothermal energy nor a source of gas nearby. Therefore, it was decided to build a railway that will ensure the connection of the site to the manufacturing industry. Since the area is not inhabited, there is no electricity network, so a good selection of electrical sources is of fundamental importance for the implementation of mineral extraction. To ensure mining and the living conditions of workers and their families, the resource must be reliable and of good quality in the long term.

Based on the method described above, we will first carry out a screening aimed at eliminating unsuitable sources of electrical energy. Screening results are in Tables 1-9.

Table 1. Screening results for hydroelectric power plant.

Criterion	**Evaluation**		**Justification**
	YES	NO	
Is the operation of the technology tested?	X		Cut-and-dried
Is the power supply safe, i.e. reliable and functional for life?		X	In real case no.
Is the technology available to the investor?	X		get-at-able - market
Is the performance of the technology stable in the long term?		X	In real case no.
Can the technology be implemented quickly?		X	Project, building permit, building works, commissioning 5-10 years [56].
Is the cost of applying the technology acceptable?	X		Commonly used source.
Can a source with this technology quickly (less than 1 year) meet the needs of the investor for the entire duration of operation of the building for which it is being built?		**X**	In real case, investor cannot ensure the electricity for mining in reasonable time interval.

Table 2. Screening results for a nuclear power plant with PWR or another large reactor. R – application of technology has limitation , it requires special permit – it is not freely accessible.

Criterion	**Evaluation**			**Justification**
	YES	NO	R	
Is the operation of the technology tested?	X		X	It must fulfil demands of the IAEA.
Is the power supply safe, i.e. reliable and functional for life?	X		X	It must fulfil demands of the IAEA.
Is the technology available to the investor?		X	X	The investor must have credit from the IAEA.
Is the performance of the technology stable in the long term?	X		X	The investor must have credit from the IAEA.
Can the technology be implemented quickly?		X		Construction takes about 15 years [56].

Is the cost of applying the technology acceptable?		X		The cost for the project is too high [56].
Can a source with this technology (less than 1 year)meet the needs of the investor for the entire duration of operation of the building for which it is being built?		**X**		In real case, investor cannot ensure the electricity for mining in reasonable time interval.

Table 3. Screening results for a gas-fired power plant.

Criterion	**Evaluation**		**Justification**
	YES	NO	
Is the operation of the technology tested?	X		Cut-and-dried
Is the power supply safe, i.e. reliable and functional for life?		X	In this case no because no source of gas at the site.
Is the technology available to the investor?	X		get-at-able - market
Is the performance of the technology stable in the long term?		X	Stability depends on gas imports and their price.
Can the technology be implemented quickly?	X		[56]
Is the cost of applying the technology acceptable?	X		[56]
Can a source with this technology (less than 1 year) meet the needs of the investor for the entire duration of operation of the building for which it is being built?		**X**	In real case, investor cannot ensure the electricity for mining in reasonable time interval due to problems connected with the unexplained problems with gas source and gas supply. Gas transport may be often limited by extreme meteorological conditions.

Table 4. Screening results for thermal power plant.

Criterion	**Evaluation**		**Justification**
	YES	NO	
Is the operation of the technology tested?	X		Cut-and-dried
Is the power supply safe, i.e. reliable and functional for life?		X	There is no source of coal at the site, it needs to be imported, which can be difficult under certain conditions due to the lack of transport infrastructure.
Is the technology available to the investor?	X		get-at-able – market
Is the performance of the technology stable in the long term?		X	It depends on the timely supply of coal.
Can the technology be implemented quickly?		X	Project, building permit, construction, commissioning 3-5 years [56].
Is the cost of applying the technology acceptable?	X		[56]
Can a source with this technology (less than 1 year)meet the needs of the investor for the entire duration of operation of the building for which it is being built?		**X**	There is no source of coal at the site, it needs to be imported, which can be difficult under certain conditions due to the lack of transport infrastructure and

			extreme meteorological conditions.

Table 5. Screening results for geothermal power plant.

Criterion	Evaluation		Justification
	YES	NO	
Is the operation of the technology tested?	X		Cut-and-dried
Is the power supply safe, i.e. reliable and functional for life?		X	There is no source of geothermal energy at the site.
Is the technology available to the investor?	X		get-at-able – market
Is the performance of the technology stable in the long term?		X	In real case no because none source of geothermal energy at the site.
Can the technology be implemented quickly?			Design, building permit, construction, commissioning 3-5 years [56].
Is the cost of applying the technology acceptable?		X	It would be necessary to find a local source of geothermal energy; prospecting usually takes 5– 10 years [56] and needs finances.
Can a source with this technology (less than 1 year)meet the needs of the investor for the entire duration of operation of the building for which it is being built?		**X**	There is no source of geothermal energy at the site.

Table 6. Screening results for wind power plant.

Criterion	Evaluation		Justification
	YES	NO	
Is the operation of the technology tested?	X		Cut-and-dried
Is the power supply safe, i.e. reliable and functional for life?		X	It depends on the direction and intensity of the wind, which are variable.
Is the technology available to the investor?	X		get-at-able – market
Is the performance of the technology stable in the long term?		X	It depends on the direction and intensity of the wind, which are variable.
Can the technology be implemented quickly?	X		[56]
Is the cost of applying the technology acceptable?	X		[56]
Can a source with this technology (less than 1 year) meet the needs of the investor for the entire duration of operation of the building for which it is being built?			In real case, the source is not stable and cannot ensure permanent energy support.

Table 7. Screening results for photovoltaic power plant.

Criterion	Evaluation		Justification
	YES	NO	
Is the operation of the technology tested?	X		Cut-and-dried
Is the power supply safe, i.e. reliable and functional for life?		X	It depends on the length and intensity of solar radiation, which are insufficient in the

			subarctic region for most of the year.
Is the technology available to the investor?	X		get-at-able – market
Is the performance of the technology stable in the long term?		X	It depends on the length and intensity of solar radiation, which are insufficient in the subarctic region for most of the year.
Can the technology be implemented quickly?	X		[56]
Is the cost of applying the technology acceptable?	X		[56]
Can a source with this technology (less than 1 year)meet the needs of the investor for the entire duration of operation of the building for which it is being built?			In real case, the source is not stable and cannot ensure permanent energy support.

Table 8. Screening results for "motor" power plant – a set of diesel engines.

Criterion	**Evaluation**		**Justification**
	YES	NO	
Is the operation of the technology tested?	X		Cut-and-dried
Is the power supply safe, i.e. reliable and functional for life?	X		It requires regular diesel transport and local diesel backup storage.
Is the technology available to the investor?	X		get-at-able – market
Is the performance of the technology stable in the long term?	X		It requires regular diesel transport and local diesel backup storage.
Can the technology be implemented quickly?	X		get-at-able – market
Is the cost of applying the technology acceptable?	X		Delivery of technical equipment. Operation depends on the diesel costs.
Can a source with this technology (less than 1 year) meet the needs of the investor for the entire duration of operation of the building for which it is being built?	**X**		It requires regular diesel transport and local diesel backup storage. Variable diesel costs affect energy price.

Table 9. Screening results for SMRs.

Criterion	**Evaluation**		**Justification**
	YES	NO	
Is the operation of the technology tested?	X		Cut-and-dried – [9,11,19, 22,60].
Is the power supply safe, i.e. reliable and functional for life?	X		[9, 11, 19,22,61].
Is the technology available to the investor?	X		[11,22,60]. In future it will be get-at-able – market.
Is the performance of the technology stable in the long term?	X		[11,22,60].
Can the technology be implemented quickly?	X		In near future – it will be achievable by supply
Is the cost of applying the technology acceptable?	X		In near future [56]. Production costs are decreasing [46].
Can a source with this technology (less than 1 year)	X		In near future, it can fulfil needs of mining.

meet the needs of the investor for the entire duration of operation of the building for which it is being built?			

The result of the screening based on Tables 1-9 shows that the suitable variants for the monitored project are:

- a set of diesel generators, when the system of functional diesel generators is ensured for a long time by the supply of diesel fuel,
- application of SMRs (the price of the device is gradually decreasing; uranium reserves are larger than oil reserves [56]).

For the final strategic selection of a long-term source of electricity with regard to local conditions, we will perform on the basis of the overall degree of integral safety (sum of the measures of contributions to the integral safety of individual cases) according to Table 1. The results of the evaluation are presented in Table 10.

Table 10. Results of a detailed evaluation of the diesel generator system and the SMR system.

Criterion	**Evaluation SMR**	**Notes**	**Evaluation diesel set**	**Notes**
		Safety of technology		
The rate in which technology has inherent safety.	**4**	Basic property of nuclear technology; for SMRs e.g. [57-59].	**2**	It requires that the diesel fuel warehouse, which is the source of the fire, be at a sufficient distance from the operation [22,66-68].
The rate in which technology is a clean source of energy.	**4**	Sophisticated design [58-60].	**1**	Combustion fumes contaminate the air [61]. Lubricating oils pollute the subsoil when they are not caught by the baths.
The rate in which the technology is able to ensure a stable supply of electricity. This means that it is still operational and does not depend on frequent specific deliveries or specific external conditions.	**4**	A service life of 80 years and a fuel change every 3 years [48] are great advantages [58,59].	**2**	Diesel fuel must be imported by air under adverse conditions, which means additional costs.
The rate in which the technology has the ability to operate without trouble.	**4**	Long fuel cycle [48].	**3**	It depends on the maintenance and quality of diesel fuel [67].
The rate in which the technology does not require frequent repairs.	**4**	High reliability is ensured by specific backup of critical parts and containment [58].	**3**	It depends on maintenance and its quality [67].
The rate in which the demands of the technology operation do not require qualified operator intervention.	**3**	The quality of the management of the whole, which is sophisticated [59], is decisive.	**3**	The quality of the management of the whole is decisive.
The rate in which the impacts of the operation of the technology on employees are acceptable.	**4**	Sophisticated design [58].	**3**	Noise and fumes [61,67].

The rate in which the impacts of the operation of the technology on the surrounding environment are acceptable.	**4**	Sophisticated design – containment [58].	**2**	Air contamination [61,67].
Material demands on the feasibility of technology in a certain place				
The rate in which technology includes measures to manage emergency situations.	**4**	It has built-in principles of inherent safety, barriers to increase reliability, containment, etc. [58,59].	**3**	It must have protective measures against fire and mechanical damage. The stockpile of diesel fuel is at a sufficient distance [22,66-68].
The rate in which the operation of the technology can be done without specific knowledge.	**3**	Autonomous [60].	**3**	Autonomous management is possible if it is secured [66-68].
The rate in which the installation of the technology requires a local object.	**3**	Safe location [32,66].	**3**	Safe location [32,66].
The rate in which the technology can do without frequent supplies of raw materials for operation.	**4**	Fuel change every 3 years [48].	**2**	It is necessary to import diesel fuel by air several times a year [66].
The rate of demands of technology on a specific and expensive location.	**3**	It contains dangerous substances and therefore according to the OECD there are specific conditions for placement [22,62]. The sophisticated design solves the problem [58,59].	**3**	It contains dangerous substances, and therefore, according to the OECD there are specific conditions for placement [60].
The rate of demands of the technology on technical tasks during the commissioning.	**3**	Commissioning is carried out by supplier. It can be transported by truck [59].	**3**	Commissioning carried out by supplier. Special measures are necessary [60].
The rate in which the operation of the technology requires the skill of the operator.	**3**	High degree of automation [60].	**4**	It is required specific maintenance [68,67].
The rate in which the technology needs energy for its own consumption to operate.	**3**	For the operation of each technology, energy and refrigerant are needed to be able to control it. Technically solved in design [59].	**3**	For the operation of each technology, energy and refrigerant are needed to be able to control it [68,67]. .
The rate in which technology requires a large information provision to operate.	**3**	Monitoring of the condition of the equipment is necessary for safe operation. Sophisticated design ensures [58].	**3**	Monitoring the condition of the equipment is necessary for safe operation [60,66,67]. .
The rate in which the technology has a specific I&C for operations.	**3**	The management is already tested; high degree of automation [58,60].	**3**	The management is already tested [66].

The rate of uninterrupted performance of the technology due to maintenance and repairs.	**4**	Fuel change every 3 years [48]. Risk based maintenance is usually introduced, which eliminates the risk of sudden failures requiring repair [59].	**3**	It depends on the type of maintenance [67]; replacing the lubricant and checking the tightness of the valves is usually on the order of months.
The rate of the quality of operating regulations for normal, abnormal and critical conditions.	**4**	They are subject to the licensing process [48,57].	**4**	According to technical standards [66,67]. .
The rate of level of protection of the technology against local natural disasters.	**3**	The problem is solved – seismic design [48,58, 59,62,63].	**3**	Buildings, in which diesels are located, must be protected according to legislation [60,66,67].
The rate in which technology protects the lives and health of operators.	**4**	Specific design + OHAS [58,62,63].	**4**	OHAS [63,66-68].
The rate in which technology does not contaminate environment.	**4**	Under normal and abnormal conditions, it is not a source of contamination [59,63].	**3**	Operation has dangerous fumes [66]. .
The rate in which the technology does not require on-site waste management.	**4**	The spent fuel is disposed of by the supplier [63].	**3**	It requires specific handling of used hydrocarbons (oils, lubricants) [66].
The rate in which technology is protected against insiders and terrorists.	**4**	Specific design and protection are required by legislation.	**4**	Legislation requires physical protection [67].
Accessibility and competitiveness				
The rate of acceptability of the installation time of the technology.	**4**	Supply. Imports by truck [59].	**4**	By supply.
The rate of the technology's capability to ensure power generation for the operation of the monitored entity for 10 years or more.	**4**	Lifespan 80 years [48,66] and fuel replacement 1x in 3 years [48]. Autonomous operation [60,62].	**3**	It depends on the supply and price of diesel fuel, which are variable [66].
The rate of acceptability of the price of the technology.	**2**	Prices are decreasing due to the short construction time and long service life [48,59, 60,63,65]. In 2030, the price should be acceptable as conventional energy sources [66].	**3**	Diesel prices are highly variable.
The rate in which the technology is such that it does not reduce the expected annual return below the acceptable value according to [53].	**3**	At an early stage, the costs associated with the fees for granting permits to	**3**	When the price of diesel fuel and air travel does not jump.

		operate are decisive – they are expected to decrease over time [69]. This shortcoming today balances stable operation and a service life of 80 years [48].		
The rate in which the transport of technology and the supply of spare parts are feasible.	**3**	Supply conditions.	**3**	Supply conditions.
The rate in which the financial demands on the technology and its long-term operation are acceptable.	**4**	Fuel change once every 3 years, service life 80 years, the price of the technology decreases [9,48, 60,62,65].	**3**	It depends on the supply and variability of prices of diesel fuel [66].
The rate of difficulty of granting an operating permit.	**2**	The difficulty of granting a permit to operate is large, but it is acceptable due to the long trouble-free operation based on quality design [59,63].	**3**	The difficulty of granting a traffic permit depends on the building permit for the building and the way diesel fuel is handled [60].
The rate in which specific objects are not needed for waste disposal at a given location.	**4**	The spent fuel is disposed of by the equipment supplier.	**3**	It is necessary storage of used oils and lubricants [66].
The extent to which the technology does not require site-specific equipment to reduce contamination of environmental components.	**5**	At normal and abnormal conditions, it does not cause contamination.	**3**	It requires special filters [66].
The rate of acceptability of the scope of the emergency planning zone.	**3**	The range of the emergency zone is 3 – 5 km [47,64].	**4**	It depends on the location – it is considered: a distance of 1 km from residential buildings, forests and a warehouse of hazardous substances [32,60,66].
LEVEL OF INTEGRAL SAFETY	**127**			**108**

Table 10 shows that the integral safety rate for SMRs is 127 and for the diesel generator system is 108. In long-term perspective, it means that the result of the evaluation of two suitable variants shows that the optimal option is the application of SMR technology. The main reasons are:

- the price of SMRs is gradually decreasing [56],
- uranium reserves are larger than oil reserves [56],
- other advantages of SMRs according to [46-48] are: clean energy source; inherent safety; service life 80 years; fuel replacement in 2 – 3 years; small zone range for emergency planning (3-5 km); low price per kWh; the existence of seismically resistant devices; and a simple financing model.

Everything means that the profitability of SMRs is constantly increasing, and therefore, in the long run, the SMR option is the most competitive for the investor. That is why every reasonable investor chooses SMRs in terms of sustainable development and safety.

7 Conclusion

Since no objective decision-making on real matters is usually black and white, the benefits and impacts caused by the risks taken must always be weighed. The thesis shows a method that is in line with professional knowledge and procedures in the EU and developed countries. The method considers all important aspects that are important from the point of view of long-term sustainability of the solution. Therefore, evaluations also need to be carried out by a team of experts who are not under political, financial or other pressure.

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