ISSN 1339-3189 5/2023

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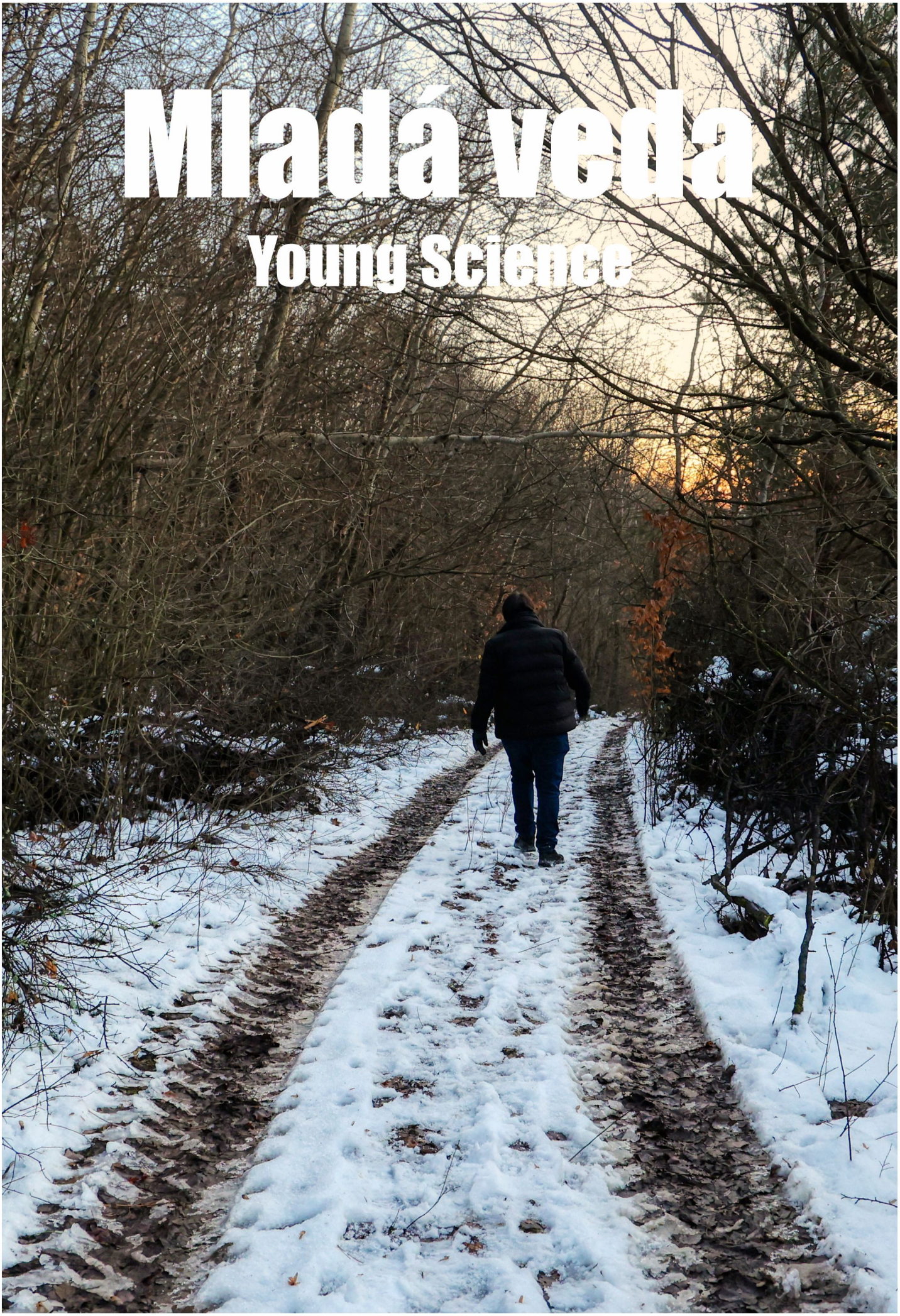
Young Science



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MEDZINÁRODNÝ VEDECKÝ ČASOPIS MLADÁ VEDA / YOUNG SCIENCE

Číslo 5, ročník 11., vydané v decembri 2023
ISSN 1339-3189, EV 167/23/EPP
Kontakt: info@mladaveda.sk, tel.: +421 908 546 716, www.mladaveda.sk
Fotografia na obálke: Zimná prechádzka. © Branislav A. Švorc, foto.branisko.at

VYDAVATEĽ

Vydavateľstvo UNIVERSUM, spol. s r. o.
www.universum-eu.sk
Javorinská 26, 080 01 Prešov
Slovenská republika

Mladá veda
Young Science
ISSN 1339-3189

Vol. 11 (5), pp. 218-224

ANALYSIS OF ELECTRICITY SUPPLY TO CONSTRUCTION SITE OPERATIONS IN SLOVAKIA

ANALÝZA NAPÁJANIA STAVENISKOVEJ PREVÁDZKY ELEKTRINOU NA SLOVENSKU

Štefan Krištofič, Naďa Antošová, Peter Makýš [1]

Štefan Krištofič pôsobí ako interný doktorand na Katedre technológia stavieb, na Stavebnej fakulte na Slovenskej technickej univerzite v Bratislave. V súčasnosti vykonáva výskumné merania spotrieb elektriny v troch rôznych krajinách. Vo svojej dizertačnej práci sa zameriava na udržateľnosť zdrojov elektrickej energie na stavenisku. Naďa Antošová pôsobí ako zástupca vedúceho katedry a docentka na Katedre technológie stavieb na Stavebnej fakulte. Peter Makýš pôsobí ako prodekan pre vzdelávanie a vnútorný systém kvality na Stavebnej fakulte.

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Abstract

In today's construction industry, it is essential to power the site operation with electricity for the efficient execution of construction projects. This paper focuses on an in-depth analysis of the aspects of power supply on construction sites, with particular emphasis on the current trends, challenges and innovations in this area. It provides an insight into the importance of electricity management in the construction industry and highlights its impact on site safety and efficiency. The aim is to address the challenges associated with electrical power on construction sites, such as the use of renewable energy sources and intelligent control systems. By integrating energy-efficient practices and technologies, the construction industry can significantly reduce its environmental impact and contribute to sustainable development. The final section focuses mainly on the findings and provides recommendations for practice,

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in order to provide an overview of the current status and perspectives and to contribute to the efficient management of electricity in the construction sector.
Key words: site equipment, electrification, site power supply, consumption

Abstrakt
V súčasnom stavebníctve je nevyhnutné pre efektívnu realizáciu stavebných projektov napájať staveniskovú prevádzku elektrinou. Tento príspevok sa zameriava na dôkladnú analýzu aspektov napájania elektrinou na staveniskách, s osobitným dôrazom na aktuálne trendy, výzvy a inovácie v tejto oblasti. Poskytuje pohľad na dôležitosť riadenia elektrickej energie v stavebnom odvetví a zdôrazňuje jeho vplyv na bezpečnosť a efektivitu pracovísk. Cieľom je riešiť výzvy spojené s elektrickým napájaním stavenísk, ako napríklad využitie obnoviteľných zdrojov energie a inteligentné systémy riadenia. Integráciou energeticky účinných postupov a technológií môže stavebný priemysel výrazne znížiť svoj vplyv na životné prostredie a prispieť k trvalo udržateľnému rozvoju. Záverečná časť je zameraná hlavné na zistenia a poskytuje odporúčania pre prax, s cieľom poskytnúť prehľad o súčasnom stave a perspektívach a prispievať k efektívnemu riadeniu elektrickej energie v stavebnom odvetví.
Kľúčové slová: zariadenie staveniska, elektrifikácia, napájanie staveniska, spotreba

Introduction

In the current era of construction industry, which is characterized by high pace and technological advancement, proper supply of electricity to site operations is a cornerstone for successful and efficient execution of construction projects. Electricity is not only a means to power machines and tools on site, but is a key factor affecting the safety, productivity and overall quality of the construction process [1].

First some negative environmental impacts of construction processes were identified, such as the generation of waste and dust and air and water pollution, and later the consumption of materials and energy started to be monitored. This led to an increased awareness of the need for sustainable building practices [2]. It is evident that construction sites consume large amounts of materials, water and energy during production activities and temporary installations [3].

Today, solutions are being sought to optimise electricity consumption on construction sites and it is crucial to consider the significant impact of construction activity on energy consumption in relation to the environment. The construction industry is known to be a major energy consumer, with a substantial portion of its total energy consumption attributed to construction activities [4]. This is particularly evident in countries with limited natural resources, where overconsumption of resources and climate change due to construction activities have become critical issues [5].

Electricity monitoring and dilution systems are becoming increasingly well known around the world, even in the construction phase. Different platforms for monitoring and controlling electrical equipment in, for example, office or residential areas are a good example of how to prevent energy wastage [6] in construction sites.

The construction sector in Slovakia is facing increasing demands for efficiency, sustainability and safety. This includes the need to develop and implement advanced power systems that not only ensure reliable power supply, but also contribute to the overall reduction of the environmental impact of construction activities.

Current state of electricity supply to construction sites in Slovakia

The solution to the problem of site electricity supply is described in the publication Site Operation and Site Equipment by O. Makýš and P. Makýš from 2003. According to the publication, electricity creates the conditions for the operation of construction and assembly work, because all electrical appliances located on the construction site are involved in the construction process, either directly or indirectly. Electricity is used to power construction machinery and equipment, to illuminate internal and external areas of the construction site, to power temporary site facilities, in particular for lighting, heating and hot water. In general, electrical appliances on the construction site can be divided into lighting, thermal and rotating [7].

For the distribution of electricity on the construction site, it is necessary to provide conductors, which are cables routed in the ground or on the surface and in the air. The spatial location of the lines must take account of the construction organisation and meet safety requirements. Important related regulations that set out the requirements for low-voltage electrical installations on construction sites are:

1. STN 33 2000-7-704 (33 2000), which describes the criteria for the so-called site switchboard, feeder cable, site distribution, current protectors, etc. The requirements in that standard apply to fixed or movable wiring used at the time of construction work. This includes, for example, construction work on new buildings, repairs, alterations, extensions or parts thereof. The requirements do not apply to employee areas of buildings, such as offices, changing rooms, meeting rooms, canteens, toilets or dormitories [8].
2. STN EN 61439-4 (35 7107), which defines specific requirements for switchgear intended for use on construction sites, both indoors and outdoors, i.e. on temporary workplaces to which the public generally has no access and where construction of buildings, installation, repair, modification or demolition of objects (buildings) or generally all construction work (public works) or where excavation work or any other similar activities are carried out [9].
3. STN 33 2000-4-41, regulation for low-voltage electrical installations. Part 4-41: Assurance of safety. Protection against electric shock [10].
4. STN 34 1610 laying down electrical regulations STN. Electrical power distribution in industrial plants [11].

For a smooth power supply of the construction site, it is necessary to calculate the maximum required power input of the electrical appliances used on the construction site in kW. Depending on the voltage level, it is then important to determine the maximum reserved capacity for the conclusion of a pooled electricity supply contract. The contract is concluded between the electricity supplier and the eligible customer, under which the electricity supplier

undertakes to provide distribution and supply of electricity to the eligible customer's point of consumption, including other regulated services, and to assume responsibility for the eligible customer's deviation. At the voltage level 'LV' - low voltage 0,4 kV, the value of the maximum reserved capacity shall be equal to the value of the reserved capacity determined by the nominal value of the main circuit breaker in amperes [12]. The maximum reserved capacity is the maximum value of power that can technically be taken from the distribution system.

Electrical installations on construction sites are considered temporary and must be decommissioned upon completion of the work. The interface between permanent and temporary wiring is considered to be the main site switchboard [7].

Challenges in the field of electricity supply to construction sites based on research

Important insights regarding energy consumption have been gained in the investigation of electricity consumption monitoring on construction sites. Consumption data at the different sites surveyed were analysed and compared and the main sources of electricity consumption were identified based on the research.

				Consumption of the entire construction site	Consumption of mobile containers		
	Construction system	Period under review		kWh	number	kWh	%
Site A	Reinforced Concrete	Sep´22 - Aug´23	12 months	54 925,0	10	40 392,0	73,5
Site B	Reinforced Concrete	July´22 - June´23	12 months	66 474,0	12	47 682,0	71,7
Site C	Reinforced Concrete	Nov´22 - Sep´23	11 months	256 683,0	28	174 531,0	67,9

Table 1 – Overview of electricity consumption on construction sites
Source: Own elaboration

The results from the investigation are provided in Table 1 and the period of observation for each site was individually determined. For site 'A' and 'B' a one year time period was recorded and for site 'C' only 11 months was recorded. An important finding was that the size of the construction site has an impact on energy consumption. Larger construction sites with more temporary structures tend to have higher electricity consumption.

The data obtained clearly show that temporary buildings at all the sites analysed play a key role in the overall consumption. At two of these sites, the share of temporary buildings in the total electricity consumption was more than 70%, while at the largest site it was almost 68%. This significant share clearly set the direction of energy needs and that implementing the necessary measures in the field of temporary buildings can lead to significant energy savings and a more sustainable industry. To optimize electricity consumption, the following challenges emerged from the investigation:

- implementation of intelligent electricity management systems for temporary facilities,
- integration of renewable energy sources on temporary buildings,
- evaluation of the outgoing power from the network.

Innovations and new technologies in the field of construction site power supply in the world

Innovation and new technologies play a key role in site supply and offer opportunities to increase efficiency, sustainability and resilience in construction operations. The integration of advanced technologies can significantly impact power management and overall project outcomes.

When looking at the complete management of the construction process, one of the world's most prevalent innovations is the use of Building Information Modeling (BIM) technology, which has been designed to optimize material management, reduce waste, and increase construction productivity [13]. Its concomitant impact on electricity consumption is also a phenomenon, but it does not represent a significant focus. In areas of more sophisticated energy source management, systems are not implemented in site operations as for example in other smart grids.

Three elements have been identified as the most innovative impacts on the site's electrical power system, namely the use of photovoltaic panels, the deployment of electric construction vehicles, and the use of large capacity battery storage. The latter innovation has a number of practical applications in site operations. Energy storage options create solutions for later power supply, peak power elimination or charging of electric construction vehicles [14].for example, in construction site operation. In addition, the use of mobile energy storage for emergency support of power systems without the possibility of grid power to the construction site should be highlighted [15].

Electric construction machines have gained considerable attention due to their potential to improve sustainability in construction operations. The development and adoption of electric construction machinery offers a number of benefits, including reduced emissions, lower operating costs, and improved environmental performance [16]. A key challenge for the future is to increase the length of machine deployment without charging to match their internal combustion engine counterparts and to seek optimal charging capacity [17].

In today's construction site environment, the aforementioned innovations and new technologies are emerging and are set to be key elements in achieving efficiency, sustainability and safety. These advanced approaches provide a variety of options that not only optimise energy consumption but also contribute to environmental protection.

Conclusion

Electricity is a key element for the smooth running of site operations, and proper management of electricity has a significant impact on the productivity and quality of the construction process. An analysis of construction site operations in Slovakia reveals important aspects that affect the efficiency and sustainability of construction projects.

The results from the investigation of electricity consumption on construction sites as illustrated in Table 1 are that temporary facilities play a key role on all the sites surveyed, with their share of electricity consumption exceeding 65%. An important element for the energy efficiency of construction sites will be the reduction of consumption in temporary mobile containers. Research should focus on the possibility of powering with renewable energy sources.

In the context of other challenges and innovations such as the use of electric construction vehicles or large capacity battery storage, it presents promising solutions to increase efficiency and reduce the environmental impact of construction operations. However, a key lesson in implementing a sustainable solution must be its replicability and economic viability. For electric construction vehicles, the extent to which the increase in demand from the source can be covered is key.

Overall, it appears that innovation and new technologies will play a key role in moving towards sustainable, efficient and safe electricity supply to construction sites. Their implementation requires not only technical but also regulatory support in order to sustainably develop the construction industry in Slovakia.

This article was recommended for publication in the scientific journal Young Science by:
Ing. Patrik Šťastný, PhD.

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ISSN 1339-3189