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Are Corporate Energy Saving Measures Effective? - Lessons from a Small Sample Analysis in Hungary

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The European Union has set a climate neutrality goal that requires all member countries to reduce their energy consumption. In 2021, businesses accounted for approximately one-quarter of the EU's energy consumption therefore, they play a significant role in its reduction. Hungary has taken steps to encourage companies to improve their energy efficiency, mandating large consumer companies to perform annual energy audits and publish their results. Our research focuses on the results of energy efficiency measures implemented by these large consumer companies. Based on online energy reports that were readily available, we analysed the energy performance of companies with more than 1,000 employees between 2017 and 2021. Data narrowing resulted in a sample of 24 companies that are not considered representative, but their analysis indicates that low-cost employee awareness-raising and lighting upgrades were the most used efficiency measures. Results show that energy savings resulting from lighting modernisation ranged from 11 to 844 GJ per year, while savings from cooling/heating modernisation ranged from 4,7 to 47,000 GJ per year. By modernising building systems such as ventilation, the studied companies achieved energy savings ranging from 10 to 403 GJ. The annual energy savings achieved through production modernisation ranged from 972 to 510,435 GJ. Due to the inconsistencies in the data, our analysis also highlighted the importance of stricter monitoring and establishing a database of energy consumption data from companies performing annual audits.

1. Introduction

As a result of human activities, global warming has increased by about 1.1 °C since 1850-1900, according to the UN Intergovernmental Panel on Climate Change. In order to limit global warming to 1.5 °C by 2030, global greenhouse gas emissions need to be reduced by 43 % (IPCC, 2022). The International Energy Agency (2021) estimates that globally, energy production and consumption account for more than two-thirds of total greenhouse gas emissions. Over the past two decades, all countries have made significant efforts to mitigate the adverse impacts of anthropogenic activities, with a particular emphasis on the energy sector. The European Union, in its Climate and Energy Policy Framework, has identified energy efficiency as a crucial factor in reducing greenhouse gas emissions. It has set targets for 2030, including a 55 % reduction in greenhouse gas emissions compared to 1990 levels, a cut of final energy consumption by 11.7 % and a goal of supplying 32 % of energy from renewable sources (European Council, 2020).
In accordance with the objectives of the EU's Clean Energy Package, each Member State is obligated to establish indicative targets within an integrated national energy and climate plan and report the outcomes of implemented measures to the European Commission (European Parliament, 2018). Hungary has outlined these targets in the National Energy and Climate Plan, aligning them with the National Energy Strategy 2030 and the country's development goals. The strategy aims to enhance energy efficiency through the modernisation of the energy sector, the implementation of energy modernisation measures in businesses, as well as improvements in production technology (Erdélyi and Pulay, 2021). According to the targets outlined in the National Energy and Climate Plan, Hungary aims to reduce greenhouse gas emissions by at least 40 % by 2030 compared to 1990 levels, meaning that gross emissions should not exceed 56.2 million t of CO_2 equivalent in 2030. The energy efficiency target in Hungary is to maintain the country's final energy consumption in 2030 at or below the 2005 level, which was 785 petajoules (PJ) (Ministry of Innovation and Technology, 2020).

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To effectively combat global warming, all sectors must undergo a transformation, but it is important to note that businesses account for approximately one-quarter (25.6 %) of the EU's energy consumption based on data for 2021 (Eurostat, 2023). Therefore, they play an important role in accomplishing the targets set for 2030. In Hungary, the Energy Efficiency Act LVII of 2015, along with Government Decree 122/2015 (May 26, 2015), establishes the requirement for large consumer companies to undergo an energy audit and prepare an efficiency report every year as part of their energy modernisation efforts. This report must be published by the company publicly online or offline and submitted to the National Energy Network. The publication of these reports offers the scientific community an opportunity to analyse the outcomes of energy efficiency investments made by the respective companies, draw conclusions, and provide recommendations.

In addition to adhering to international and national regulations, companies may choose to enhance their energy efficiency for various reasons. Mills and Rosenfeld (1996) identified both direct and indirect economic advantages of energy efficiency measures. Energy efficiency improvements are considered one of the most cost-effective methods for reducing carbon emissions and combating climate change. At the firm level, such improvements can reduce production costs and enhance firms' competitiveness (Worrell et al., 2009). This competitive advantage not only leads to lower costs but also garners a more positive perception from customers, employees, and investors who are increasingly interested in supporting environmentally conscious companies (Tan et al., 2022). Additional benefits highlighted by Mills and Rosenfeld (1996) include improved working environments, labour and time savings and other direct and indirect economic benefits from downsizing or eliminating equipment. However, the literature also emphasises the need to address rebound effects the unintended consequences of such investments (Jeong and Lee, 2022).

Traditionally, companies can enhance their energy efficiency through a combination of "hard" and "soft" measures. Soft measures involve raising employee awareness and implementing an efficient energy management system (Finnerty et al., 2017), while hard measures encompass investments such as equipment upgrades or the installation of new technologies (Malinauskaite et al., 2019). Regarding "soft" measures, the extent of energy savings achieved through changes in employee attitudes has received relatively little scientific attention. However, scientific evidence has shown that information-only campaigns have no impact on employee energy consumption, but education combined with active employee participation and feedback can effectively reduce energy consumption (Young et al., 2015).

Companies take several factors into account when deciding which energy efficiency measures to implement. These factors include the cost of implementation, potential energy and financial savings, feasibility, life cycle cost analysis of the measure and the return on investment (Drobyazko and Hilormem, 2022).

This study aims to review and evaluate the energy efficiency measures implemented by large companies with more than 1,000 employees utilising online readily available energy efficiency reports to gain insights into the progress made. As energy efficiency reports typically do not provide information on the processes leading up to implementation, the analysis is on the outcomes achieved.

The novelty of this research lies in the fact that at the time of the submission, there has not been any scientific analysis carried out based on energy efficiency reports of large consumer companies listed by the Hungarian Energy and Public Utilities Regulatory Authorities. This evaluation is particularly timely and valuable because Hungary needs to double the savings achieved thus far (an average of three petajoules per year between 2014 and 2020) to meet the targets outlined in the National Energy and Climate Plan. The new target is seven petajoules per year starting in 2021 (Hungarian Energy and Public Utilities Regulatory Authority, 2021).

The study begins with the methodology for selecting companies. The results section focuses on the analysis of secondary data extracted from online corporate energy efficiency reports spanning from 2017 to 2021. The discussion section provides an evaluation of their effectiveness and provides recommendations.

2. Methodology

In Hungary, Act LVII of 2015 on Energy Efficiency and Government Decree 122/2015 (26 May 2015) on its implementation requires large consumer companies to prepare energy efficiency reports. According to these regulations, companies whose annual energy consumption exceeds an average of 400,000 kWh of electricity, 100,000 m³ of natural gas, or 3,400 GJ of heat in the three years preceding the reference year are required to engage the services of an energy auditor. To fulfil their annual reporting obligations to the Hungarian Energy and Public Utilities Regulatory Office (referred to as "the Office"), companies must submit a data sheet as prescribed by Act LVII of 2015 on Energy Efficiency. This report should include information on the level of energy consumption in the previous year, energy efficiency measures and improvements implemented, as well as data on energy savings resulting from these solutions.

To gather company-specific data on energy consumption and energy efficiency measures, an in-depth qualitative analysis of the companies' energy reports was conducted. This analysis focused on online energy efficiency reports from the years 2017 to 2021. The initial implementation period began in 2017, and the last list

of large consumer companies available at the time of analysis was for the year 2021. The Hungarian Energy and Public Utilities Regulatory Office provided a list of large consumer companies in 2021 for scientific research purposes. From this list, which initially comprised 1,529 companies, the selection was narrowed down to companies with more than 1,000 employees, resulting in a total of 135 companies. Data collection took place between June and July 2022 by reviewing the companies' online energy efficiency reports. Through qualitative analysis of the energy efficiency reports from these 135 companies, 24 companies were identified that had their energy efficiency reports available online for at least two consequent years between 2017 and 2021. To analyse progress in energy consumption and savings, we established measurement criteria of at least two consequent years of online reporting. Analysing data of 2-5 consequent years allowed the evaluation of short to midterm results of implementations. Although the minimum reporting requirements are regulated by law, there were some formal variations in the reports studied. Individual energy efficiency measures were summarised in a separate table, which formed the basis for grouping these measures.

3. Results

The resulting sample of 24 companies is not representative of large consumer companies with over 1000 employees operating in Hungary or companies required to provide energy reports. The database includes common variables such as company size, activity, and turnover, which were based on the OPTEN company database. Due to the small number of elements in the population, it was not feasible to provide a detailed classification by activity. Therefore, the companies in the sample were analysed based on their main activity. 67 % of the surveyed companies primarily operate in the industrial sector, with the largest portion of companies engaged in energy supply and manufacturing road and land transport equipment (8.3 %).
Regarding company size, seven categories were established using data from 2020. The majority of companies (33 %) employ between 1,000 and 1,500 employees, while only two companies have more than 10,000 employees. Additionally, based on 2020 data, the companies studied can be divided into nine categories according to their net turnover. From the distribution of the data, it can be observed that one-quarter of the companies have a turnover ranging between 50-100 billion HUF, while another quarter has a turnover exceeding that range (Table 1).

Table 1: Number of employees and net turnover of the studied companies

Number of employees	Frequency	Percentage	Net turnover (10^9 or giga HUF)	Frequency	Percentage
1,000-1,500	8	33 %	<5	2	8,3 %
1,501-2,000	6	25 %	5-10	0	0 %
2,001-2,500	1	4 %	10-15	1	4,2 %
2,501-3,000	3	13 %	15-30	3	12,5 %
3,001-5,000	2	8 %	30-50	2	8,3 %
5,001-10,000	2	8 %	50-100	8	33,3 %
10,000<	2	8 %	100-200	3	12,5 %
			200-500	3	12,5 %
			500-1,000	2	8,3 %

The individual energy efficiency measures of the companies were divided into two groups and nine subgroups. The literature distinguishes between 'hard' and 'soft' types of energy efficiency measures. Therefore, the activities reported were first analysed according to these two categories, which formed the two main groups of measures. Figure 1 summarises the implemented energy efficiency measures according to their frequency. This shows that out of the 24 analysed companies, the highest proportion of measures implemented was related to employee awareness, which falls under the category of soft measures. The energy reports distinguish between two types of employee awareness-raising: active and passive measures. Active awareness raising includes training and actively involving employees in information campaigns, while passive awareness raising includes newsletters, educational materials, and posters in highly frequented places of the company. Awareness raising with active involvement was carried out in 11 companies, but awareness raising combined with employer feedback, which is considered effective in the literature, was not included in the energy efficiency reports of any of the surveyed companies. These results indicate that while 65 % of the surveyed companies have paid attention to employee awareness, the reviewed literature suggests that awareness raising without feedback is not effective in reducing energy consumption in a sustainable way. Out of the 16 companies, only four used the passive form of awareness, and out of the 16 companies that engaged in employee awareness raising, 12 also used measures that could be classified as hard, ranging from lighting upgrades to investment in new technology.

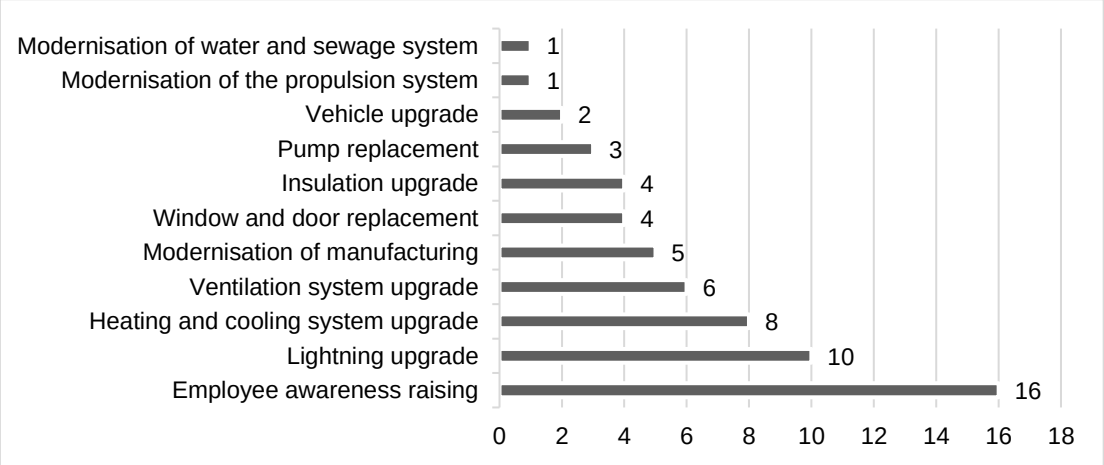

Figure 1: The implemented energy efficiency measures according to their frequency

Replacing an existing lighting system was the second most common type of measure, implemented by 10 companies. According to the literature, lighting replacement measures are considered the most cost-effective, as the investment costs for replacement are relatively low compared to the resulting savings. Additionally, higher electricity tariffs lead to a shorter payback period (Dubois et al., 2015). Alongside lighting modernisation, the upgrade of heating and cooling systems is the third most commonly undertaken measure, implemented by 8 companies. The energy reports do not always provide a clear view of the scope, amount of investment, and the resulting savings achieved. As seen in Table 2, out of the 24 companies studied, only 10 provided a detailed breakdown of the amount of energy saved.

Table 2: Minimum and maximum savings achieved by the studied companies

Company	Type of "hard" energy efficiency measure	Energy saving (GJ)	Saving in t CO_2
Budapest Airport	Lighting upgrade	74.2	14.6
	Window and door replacement	84.9	16.7
	Ventilation system upgrade	154.9	30.5
	Heating and cooling system upgrade	12.4	2.4
	Not specified in report	577	114
FÉMALK	Modernisation of production	972	191
NKM Áram	Heating and cooling system upgrade	4.7	0.9
	Window and door replacement	55.8	11
	Lighting upgrade	11.2	2.2
thyssenkrupp	Lighting upgrade	844	166
MÁV-HÉV	Lighting upgrade	731	144
E.ON Észak-Dunántúli	Lighting upgrade	354	69.7
	Window and door replacement	24	4.7
	Ventilation system upgrade	10	2
	Heating and cooling system upgrade	35,287	6,946
MVM Paksi Atomerőmű Zrt.	Modernisation of production	510,435	100,482
Fővárosi Vízművek Zrt.	Modernisation of production	25,693	5058
ZF Hungária Kft.	Ventilation system upgrade	403	79.3
	Modernisation of insulation	604	119
	Lighting upgrade	972	191
ATOMIX Kft.	Lighting upgrade	21	4.1
	Heating and cooling system upgrade	612	120
	Modernisation of insulation	54	10.6
	Vehicle replacement	32	6.3
	Heating and cooling system upgrade	47,000	9,252

Based on the summarised data, energy savings resulting from lighting modernisation ranged from 11 to 844 GJ per year, while savings from cooling/heating modernisation ranged from 4,7 to 47,000 GJ per year. By modernising building systems such as ventilation, the studied companies achieved energy savings ranging from 10 to 403 GJ. Since each sector has its own unique technological processes and energy requirements, the most specific and challenging energy efficiency measure to compare is the modernisation of the production process, which was undertaken by only 5 of the analysed companies. The annual energy savings achieved through production modernisation ranged from 972 to 510,435 GJ. The data demonstrates that although production modernisation may involve higher costs, it is also the type of investment that yields the highest energy savings.

4. Discussion

This research focused on large consumer companies that are required to publish energy efficiency reports. The aim was to analyse the results of their implemented energy efficiency improvements based on their annually published energy efficiency reports. However, the data collection method posed limitations as the study only focused on companies with more than 1,000 employees that had online reports available for at least two consequent years for the period of 2017-2021. Consequently, the sample size was small, consisting of 24 companies, which cannot be considered representative of large companies operating in Hungary or companies obligated to prepare energy efficiency reports.

In the data analysis, two main groups, soft and hard energy efficiency measures, were identified. The most common measure was raising employee awareness, which is part of the soft measures, but this alone did not lead to quantifiable energy savings. Out of the 16 companies, 11 companies carried out active awareness raising, and 12 also used measures that could be classified as hard, ranging from lighting upgrades to investment in new technology. Caricco and Riemer (2011) suggested that the efficiency of employee awareness raising can be improved by providing feedback to employees.

After employee awareness raising, the second most common measure (implemented by 10 companies) was lighting upgrade, which is considered the most cost-effective hard measure. Energy savings resulting from lighting modernisation ranged from 11 to 844 GJ per year. The third most common measure (implemented by 8 companies) was upgrading the heating and cooling system, which resulted in savings ranging from 4.7 GJ to 47,000 GJ per year. Six companies modernised building systems such as ventilation and achieved energy savings ranging from 10 to 403 GJ per year. Significant savings have been only achieved by companies modernising their production processes. Undertaken by 5 of the 10 companies that provided a detailed breakdown, the savings achieved through production modernisation ranged from 972 to 510,435 GJ. Out of the 10 companies, only two had a consistent decrease in their energy consumption, MVM and ATOMIX. MVM achieved this through modernising the production processes, while ATOMIX achieved the most significant savings through upgrades to the heating and cooling system. While general conclusions cannot be drawn from this limited sample, our results show that for consistent and sustainable energy savings, implementing soft measures and lightning upgrades is not sufficient, and the implementation of a mix of hard measures should be encouraged.

The lack of significant savings from other hard measures listed, such as window and door replacement and the lack of consistent decrease in consumption may be attributed to the rebound effect mentioned in the literature review, where energy saved through efficiency measures is consumed elsewhere. This issue can be addressed by implementing appropriate energy management systems. In our opinion, the information gap is one of the biggest obstacles to achieving energy-saving goals in a sustainable way. Based on international experiences, this can be addressed by creating energy efficiency networks for companies. Regular meetings and factory visits among network participants could not only maintain motivation but also increase knowledge about effective energy-saving solutions and reduce perceived risks (Barsi et al., 2022). Participating in energy efficiency networks provides an opportunity for quantitative and qualitative benchmarking as well, which allows companies “to preliminary identify a set of potential resource efficiency measures/investments able to address the identified inefficiencies / low performances” (Maffini et al., 2021).

During data collection, we encountered inconsistencies in the content and format of the energy efficiency reports. The minimum content requirements specified by Government Decree 122/2015 on the implementation of the Energy Efficiency Act were not always followed. The reports did not consistently provide exact annual energy consumption figures or detailed information on the savings achieved by each measure, which are part of the minimum requirements. Out of the 24 companies studied, only 10 provided a detailed breakdown of the amount of energy saved. To address these issues, we recommend the development of a standardised detailed form that requires energy auditors to provide a detailed breakdown of energy savings, enabling the scientific analysis of the actual results of each measure. This should be accompanied by stricter monitoring of these energy reports and the possibility of sanctions for non-compliance. Given the limitations of this research, the future research direction is to expand the scope to include companies with fewer than 1,000 employees.

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