

Environment Risk Management of Warehouse and Production Hall Investment Projects

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Abstract. Planning, implementation and operation of buildings and related outdoor areas in accordance with the principle of sustainable construction represent a current topic. Important elements of sustainability include the environmental impact assessment of construction works which may include CO₂ emissions. Warehouses and manufacturing facilities are significant environmental polluters and emitters of CO₂. Management of industrial companies seeks to manage this environmental risk and find ways of its reduction within the framework of sustainable development.

The article deals with environmental risk management in general, its identification, assessment methods and development of the countermeasures to reduce or eliminate them. Continuous monitoring and control of the functioning of the measures represent an important component of their management. An analysis of a research sample of warehouse and manufacturing facility projects located in industrial zones shows that if companies fail to continuously reduce emissions, they may face secondary risks which may be related to the company's social impact, sales or reputation of the company and may affect, for example, their share prices.

The output of the research presented in this article is a list of initiatives on reducing environmental risks (especially CO₂) of warehouses and manufacturing facilities, determination of the costs associated with them and assessment of the socioeconomic impacts (benefits to society). The research serves as one of the steps towards determining the overall socio-economic effectiveness of these measures.

1. Introduction

The environmental risks include the risk to human health and well-being such as pollution, radiation, noise, poor infrastructure, water quality worsening, diseases caused by the microbes and climate change. These risks are driven by policies in various sectors, such as energy, industry, agriculture, transport, and land planning.

According to the statistical data, emissions were very low prior to the industrial revolution. Growth in emission production was still relatively slow until the mid-20th century. In 1950 the world emitted 6 billion tonnes of CO₂.

By 1990 this amount had almost quadrupled, reaching more than 22 billion tonnes. Emissions have continued to grow rapidly, over 34 billion tonnes are currently emitted each year [1].

The authors of this paper deal with environmental protection in the context of industrial zone development.

Industrial zones are areas where the warehouse and manufacturing facilities specialised in a particular industrial field, strategic services, or technological centres are located. Both services and industry represent the main economic engines of the Czech Republic with services accounting for 62% (2020 est.) [2] of Gross Domestic Product (GDP) and industry for 30% (2020 est.).



Industrial zones in the Czech Republic have developed a lot in recent years representing a part of the innovation strategy of the government for the 2019-2030 period [3]. This development is positive in terms of production capacities, on the other hand, it has negative effects in terms of increased emissions. Owners of warehouse and manufacturing facilities and investors should therefore participate in environmental risk management. If these risks are not addressed, they may meet secondary risks such as the social impact on the investment, sales risks such as loss of market share, product liability and product boycott, reputation risk on national and internal levels or equity risk as fall on the share price. The purpose of this article is to research environmental risk management. Risk assessment means simply identifying hazards, assessing risks and implementing and checking control mechanisms. Warehouse and manufacturing facility projects were analysed in this research to find out whether projects include adequate provision for actions and determination of the costs necessary for preventing, controlling and mitigating negative impacts on the environment as well as improving environmental quality. The list of initiatives to reduce environmental risk in warehouse and manufacturing facilities was identified. The cost and social impact of the environmental management system represent the output of this research.

2. Scientific literature research

According to the CTP annual report 2021[4], the company that builds and owns multiple warehouses in Europe mentioned that climate change-related risks can be split into three types from the risk management perspective:

- 1) Environment risk under the category Strategic risk/ ESG (Environmental, social, and governance)
This captures the ethical element of doing the right thing to help mitigate an environmental catastrophe as a company responsibility.
- 2) Climate risk category under operational risk
It is designed to capture the potential physical damage to the property that could result from extreme weather phenomena related to climate change.
- 3) Climate change related to risks in other risks category

Examples include customer behaviour change risk, pandemic/acts - of force majeure risks, reputation risk, business continuity risk, regulatory noncompliance risk and regulator change risk. The risks should be quantified and ranked by expected loss.

The company should perform a high-level analysis of the climate-related risk impact on the company's business and operation in the longer term and on the accounting of the current financial statement.

The above-stated risks affect both the final amount of investment and operating costs, the length of the construction period and the expected amount of revenue during the operational phase of the project. [5] It emphasizes that errors in the project are usually transformed into price adjustments (overrun of planned costs) and extended duration of the construction phase. According to Kennedy et al. [6], uncertainty in cost estimation evolves over the project life cycle and arises from the difficulties in estimating construction, maintenance, operation, and financing costs. Therefore, environmental risk should be included in the risk management for the whole life cycle of the warehouse and manufacturing facility projects.

In the manufacturing and warehouse facilities, the equivalent CO₂ emission is generated during their operation when the items such as electricity, water, natural gas, and diesel engine are used.

Consumption of natural gas, electricity and water, creates CO₂ emissions during the production of these items, which pollute the atmosphere resulting in big consequences for society.

The carbon dioxide equivalent is used for CO₂ emission measurement in the facility.

The carbon dioxide equivalent or CO₂ equivalent, abbreviated as *CO₂-eq* is a metric measure used for comparing emissions from various greenhouse gases on the basis of their global-warming potential (GWP), by converting amounts of other gases to the equivalent amount of carbon dioxide with the same global warming potential [7].

It is calculated using the mass of a given greenhouse gas (GHG) multiplied by its global warming potential according to the International Organization for Standardization ISO 14064-1:2006[8].

The following table shows the calculation of CO₂ equivalent for the company operating 3 manufacturing and warehouse facilities in Brno, Czech Republic. It has about 800 employees and an area of 32,472 m² in total.

The items mentioned in the table below are the items used during the operation of the warehouse and manufacturing facilities, their consumption has its *tCO₂ equivalent* according to the related emission factor.

Table 1. Emission factor related to the consumption of the manufacturing facility in Brno, Czech Republic

Item	Consumption	Unit of measure	Emission factor	Unit of measure	tCO ₂ equivalent
Natural gas	40	MWh	0.20000	t CO ₂ / MWh	8.0
Electricity	62	MWh	0.86000	kg CO ₂ / kWh	53.3
Water	322	m ³	0.00038	t CO ₂ / m ³	0.1
Heat	35	MWh	0.23200	t CO ₂ / MWh	8.1
Diesel oil	6,000	l	0.00266	t CO ₂ /l	16

3. Materials and methods

During the operation of the warehouse and manufacturing facility, the emissions that pollute the climate are generated leading to climate change resulting in heatwaves, droughts, apocalyptic wildfires and floods as we have seen in recent years. Therefore it is essential to reduce these emissions.

In order to reduce emissions, a number of actions have to be taken. Table 2 shows the actions leading to emission reduction in a different number of warehouse and manufacturing facilities around the world.

3.1 Data

A research sample of 26 initiatives to reduce emissions in warehouse and manufacturing facilities has been collected and analysed.

The sample research of countermeasures that should mitigate the environmental risks caused by the emission in the warehouse and manufacturing facility investment projects follows.

The top 12 initiatives to reduce emissions are shown below instead of all 26 initiatives that were analysed. The aim of these initiatives is to reduce the consumption of items that represent a source generating emission during their creation such as electricity, natural gas, and diesel engine oil.

The reduced consumption was transferred into the *tCO₂ equivalent* by multiplying the reduced consumption by its equivalent emission factor as in Table 1.

Table 2 below is sorted from the largest *tCO₂ eq* emissions to the smallest.

The reduced consumptions represent the yearly reduction and its equivalent of tCO₂ emissions yearly.

Table 2. Top 12 initiatives to reduce emissions per year

Region	Location	Initiatives	Reduced consumption	Unit of measure	tCO ₂ eq/year
America	Colorado - USA	Update of roofing and installation of solar option	664	MWh	571
America	Queretaro - Mexico	Photovoltaic system (25% of the building)	455	MWh	391
Europe	Bielefeld - Germany	Installation of a photovoltaic system	362	MWh	311
Europe	Bielefeld - Germany	Elimination of vehicles with diesel consumption	63,910	tCO ₂ /l	170

Europe	Bielefeld - Germany	Completing LED conversion in the production	186	MWh	160
America	Rockford - USA	Converting the whole site to LED lighting	114	MWh	98
America	Queretaro - Mexico	KAIZEN for Energy Reduction	86	MWh	74
America	Queretaro - Mexico	5-day working week	65	MWh	56
Europe	Bielefeld - Germany	Reduction of sandblasting process	56	kg	48
Asia	Noida - India	Extension of solar power plant	35	MWh	30
Europe	Bielefeld - Germany	Modernisation of process water cooling	47,368	m ³	18

Initiatives to reduce electricity consumption are the most efficient as electricity represents the high emission emitter for manufacturing and warehouse facilities.

3.2 Reduction in the CO₂ emissions – savings in the operational costs

- 1) Savings calculation from the consumption cost reduction
Savings are calculated by considering the reduction in the quantity of consumption of items creating emissions. The implementation of these environmental risk countermeasures results in the reduction of consumption such as energy consumption which leads to the reduction of costs that represent saving from these initiatives.
The following table shows the reduced consumption, reduced *tCO₂ equivalent* and related savings.
Only the top 12 out of 26 initiatives with the highest reduction in consumption are shown below.

Table 3. Top 12 saving initiatives with a quantity of consumption reduced and its cost savings per year

Region	Location	Projects	Reduced consumption	Unit of measure	Reduced tCO ₂	Savings (EUR)
Europe	Bielefeld - Germany	Complete LED conversion in the production area	186	MWh	160	118,700
Europe	Bielefeld - Germany	Installation of a photovoltaic system	362	MWh	311	107,165
America	Queretaro - Mexico	photovoltaic system 25% of the building)	455	MWh	391	96,682
Europe	Bielefeld - Germany	Replacement of old injection moulding with electrical drives	105	MWh	90	15,300
Europe	Bielefeld - Germany	Modernisation of process water cooling	47,368	1	18	15,000
Asia	Noida - India	Solar Panels - Install solar panels into the facility	8	MWh	7	7,300

Europe	Leeds – UK	Lighting - Replace T8 lighting with LED system	7	MWh	6	5,700
Asia	Noida - India	Extension of the solar power plant by 150KWp	35	MWh	30	5,388
Asia	Shanghai - China	Solar street lamps on the site Install electricity meters to monitor key power consumption	47	MWh	40	5,188
Asia	Shanghai - China	Replacement of HQL lights with LED lights	3	MWh	3	5,000
Asia	Bielefeld - Germany	Compressors - compressor 75kW with 50 kW.	3	MWh	3	2,578
Asia	Leeds - UK		3	MWh	3	2,100

- 2) Payback calculation for cost savings from the CO₂ emissions reduction initiatives
- The simple payback period calculation method was used to assess the return on investment. The payback period is defined as the number of years required to recover the original cash investment. In other words, it is the period of time at the end of which the investment has produced sufficient net revenue to recover its investment costs.
- The calculated payback period in years for 26 initiatives is 5.8 years, which is very good compared to the USA homeowners' solar panel return on investment which is 8 years according to the USA ecowatch.com that works with solar experts [5].
- One way to determine whether the solar energy investment has a good return is the comparison with the entire lifespan of the analysed system. Most solar systems last between 25 and 30 years [10]. If the payback period is 5.8 years, the investment will be “making a profit” for 19.8 to 24.8 years.
- The 26 addressed initiatives will reduce 3,425 tons of emissions and the total investment will reach 5.47 million EUR which will bring total savings of 0.94 million EUR. This is a very good investment financially and environmentally.
- The effectiveness of the investment for investors is shown by determining the FNPV (Financial Net Present Value) at a 7% discount rate, which represents the average expected return on investment in the area of these warehouse and manufacturing facilities.
- 3) Impact on the environment - CO₂ reduction
- On July 14, 2021, the European Commission adopted a series of legislative proposals to reduce the total volume of greenhouse gases that can be emitted by power plants, industrial plants and the aviation sector. The implementation of 26 environment risk countermeasure initiatives should lead to the reduction of 3,435 tCO₂ per year.
- These savings can be valued at the market price of the emission allowance, which current price (07th September 2022[12]) is EUR 69.85/t.
- The effectiveness of the investment for the public is shown by determining the ENPV (Economic Net Present Value) at a 5% discount rate currently used for projects affecting the public, in this case improving the environment in the Czech Republic. Table 4 shows the payback period, FNPV and ENPV of each project, calculated on the basis of the evaluated period of 10 years according to the procedures mentioned above.

Table 4. Economic efficiency indicators of the 12 top cost-saving initiatives

Location	Projects	Reduced consumption	Unit of measure	tCO ₂	Savings (EUR)	Investment (EUR)	Payback period (Years)	FNPV (EUR)	ENPV (EUR)
Bielefeld Germany	Complete LED conversion in the production area	186	MWh	160	118,700	317,797	3	482,152	122,584
Bielefeld Germany	Installation of a photovoltaic system	362	MWh	311	107,165	586,000	6	155,778	238,273
Querétaro México	photovoltaic system 25% of the building)	455	MWh	391	96,682	325,000	3	330,892	299,565
Bielefeld Germany	Replacement of old injection moulding with electrical drives	105	MWh	90	15,300	95,000	6	11,646	68,954
Bielefeld Germany	Modernisation of process water cooling	47,368	1	18	15,000	75,000	5	28,368	13,791
Noida India	Solar Panels installation	8	MWh	7	7,300	22,000	3	27,357	5,363
Leeds UK	Lighting - Replace T8 lighting with LED system	7	MWh	6	5,700	17,000	3	21,527	4,597
Noida India	Extension of the solar power plant by 150KWp	35	MWh	30	5,388	21,844	4	14,952	22,985
Shanghai China	Solar street lamps on the site	47	MWh	40	5,188	32,000	6	4,148	30,646
Shanghai China	Install electricity meters to monitor key power consumption	3	MWh	3	5,000	3,000	1	30,017	2,298
Bielefeld Germany	Replacement of HQL lights with LED lights	3	MWh	3	2,578	4,100	2	13,090	2,298
Leeds UK	Replace compressor 75kW with 50 kW.	3	MWh	3	2,100	10,000	5	4,439	2,298

4. Conclusions and recommendation

Emissions have been growing rapidly since the mid-20th century. Currently, over 34 billion tonnes are emitted each year. Carbon dioxide (CO₂) and other greenhouse gas levels in the atmosphere are rising to new records and climate change affects every country on every continent. According to the United Nations, this situation is disrupting national economies and affecting lives. Weather patterns are changing, sea levels are rising, and weather phenomena are becoming more extreme.

If the emissions continue to increase, they will cause global catastrophic risks to the world. All activities, especially commercial ones, need to focus on environmental protection. This applies to warehouse and manufacturing facility projects. However, initiatives to reduce environmental risks need to be managed effectively in order to reach good social and economic impact. The effectiveness for investors was demonstrated on a research sample of 26 initiatives leading to the improvement of the living environment (impact on direct operating Cash Flow, saving of expenses). Furthermore, the procedure for the valuation of environmental improvement by reducing CO₂ emissions using the price of emission allowances was presented.

References

- [1] Our World in Data. *CO₂ emissions*. Retrieved from <https://ourworldindata.org/co2-emissions> accessed on 09th October 2022
- [2] Deloitte Czech Republic *Výhled české ekonomiky pro rok 2020 (Outlook of the Czech economy for the year 2020)* pp.2,2020
- [3] Council for Research *Development and Innovation, The country for the future* pp.p-2, 2019
- [4] The CTP n.v., We are park makers The CTP 2021 annual report, pp 215-219,2021
- [5] J. D. Pilger et al. *Environmental impacts and cost overrun derived from adjustments of a road construction project setting* pp 2, 2020. *Journal of Cleaner Production* **256** (2020) 120731 ©2020 Elsevier Ltd
- [6] J. Kennedy et al. *Risk Pricing in Infrastructure Delivery: Making Procurement less Costly* Research Report, 2018. private investment in transport infrastructure: dealing with uncertainty in contracts — © oecd/itf 2018
- [7] Eurostat / Statistics explained / Glossary: Carbon dioxide equivalent, *accessed on 09th October 2022*
- [8] The International Organization for Standardization [ISO 14064-1:2018]
- [9] United Nations Sustainable Development, *Goal 13: Take urgent action to combat climate change and its impacts*. Retrieved from <https://www.un.org/sustainabledevelopment/climate-change> accessed on 09th October 2022
- [10] EcoWatch *Solar Payback Period Guide* Retrieved from Ecowatch.com, accessed on 09th October 2022
- [11] The European Commission's *series of legislative proposals setting out how it intends to achieve climate neutrality in the EU by 2050*, 2021
- [12] Trading economics *EU Carbon Permits* Retrieved from <https://tradingeconomics.com/commodity/carbon> accessed on 09th October 2022
- [13] M. Synek, *Manažerská ekonomika (Managerial economics)*, Grada Publishing, spol. s r. o., 2000.
- [14] S. C. M. Richard A. Brealey, *Teorie a praxe firemních finance (Theory and practice of corporate finance)*, Praha: EAST PUBLISHING, s.r.o., 1999.
- [15] J. D. H. H. Jiří Fotr, *Manažerské rozhodování (Managerial decision making)*, Praha: Ekopress, 2010.
- [16] M. Moravenov, „*financial evaluation of property development projects. cash flow method,*“

- Journal of International Scientific Publications, pp. 9, 2015.
- [17] KORYTÁROVÁ, J., HROMÁDKA, V., *the economic evaluation of megaprojects – social and economic impacts*. Procedia - Social and Behavioral Sciences, 2014, 495-502 s. ISSN 1877-0428.