Quality improvement in Cleaner Production aspect

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Abstract. The aim of the paper is presented the Cleaner Production (CP) issue in the aspect of the benefits that it gives the company in the competitiveness productivity and efficiency aspect. The research object is a company that is a leader in the Cleaner Production area - cement plant CEMEX. The research was based on a comparative analysis the company's sustainable development in 2008-2012. It was shown that substitution of alternative fuels (an increase of 43% in 2014 compared to 2010) and the construction the first world's alternative fuels dryer enabled not only for carbon dioxide reduction, but also hard coal consumption reduction and as a consequence allowed to relieve landfills waste. Thanks to elimination a part of the water contained in alternative fuels up to 8%, the unit heat consumption in the clinker production process is reduced. This is due to avoiding evaporation of water at high temperatures. Analysis the presented data showed that the use of CP not only effectively protects the environment by reducing / minimizing waste streams, but also leads to increased profitability, productivity, efficiency and competitiveness of industry, which in turn leads to economic growth. The paper emphasizes that the CEMEX Rudniki cement plant has saved 132,000 Mg of carbon thanks to the use of alternative fuels over the last 5 years.

1 Cleaner Production - literature review

Cleaner Production (CP) is an environmental protection strategy based on continuous, integrated, preventive action in relation to processes, products and services, aimed at increasing production and service effectiveness and reducing risk for people and the natural environment [1]. The primary goal of Cleaner Production is to restructure the industry in an economically beneficial way, while improving the industry's environmental performance by reducing water and energy consumption, pollutant emissions and waste, while improving product quality and safety at the workplace. The foundation of Cleaner Production is the idea of sustainable development, i.e. the emphasis on preventing pollution at the source of their formation. CP emphasizes that it is important to apply **good pro-ecological practices,** the use of which may bring measurable benefits, including economic ones [2]:

Less water, energy = lower bills
Less emissions to air = less or no fees.

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Authors [3] emphasize that Cleaner Production has a significant contribution to the reduction of environmental impact. Authors [4] emphasize that cleaner production, applied in a systemic manner, by means of an appropriate procedure, becomes a voluntary, informal environmental management system that allows any organization, regardless of its size and profile, to achieve in a short time measurable environmental and economic benefits and diversify your position on the market.

2 Cleaner Production in the CEMEX company

CEMEX is a leading manufacturer of cement, ready-mix concrete and aggregates in Poland. Chełm Cement Plant has been an active member of the Polish Cleaner Production Movement since 1997. CEMEX is a CP leader which means that not only fulfills all obligations resulting from environmental law and administrative decisions, but applies an appropriate system of responsible entrepreneurship principles and is successful in achieving particularly high production parameters while limiting emissions. CEMEX as a component of products uses process waste from other industries such as energy, metallurgy. These are wastes such as: slag, fly ash from coal combustion processes, fluid sands, which, in order to be introduced into the production process in a cement plant, are removed from landfills of industrial waste in the environment. Waste as alternative fuels (fraction of municipal and industrial waste properly processed and sorted) and sewage sludge can be safely burned in the production of clinker (instead of conventional fuels). Alternative fuels contain flammable fractions from renewable sources such as: paper, wood, rubber, natural textiles and are partly produced from municipal waste. The use of these wastes significantly reduces the impact of the company on the environment as it reduces the consumption of coal, and at the same time CO_2 emissions from combustion processes and relieves the local municipal waste site. The Rudniki Cement Plant, up to 3 long rotary kilns currently in use (dry method) uses grinded solid waste (including municipal waste) in the amount of 8Mg / hour as a fuel, as well as dry sewage sludge. The use of rotary kilns by the plant enables the recovery of energy and the total utilization of waste, as these furnaces are considered to be the safest and state-of-the-art equipment used for co-firing. At the same time, high combustion temperatures ensure a significant reduction of harmful emissions in the process itself, which is described as waste-free, because the ash produced during the combustion of alternative fuels is permanently embedded in the clinker structure and becomes part of the product [5-7]. The CEMEX Rudniki company eliminated the unorganized emission due to the construction of the clinker silo. The reduction of the clinker index by reducing its share in produced cements and increasing additives (ie: fly ash, blast-furnace slag, limestone) is associated with a decrease in the unitary CO_2 emission / tonne of the product. The plant aims to reduce the clinker index by increasing the production of cements with additives and by applying new solutions. The article analyzes the results of sustainable development in 2008-2010 and 2010-2014. The article also analyzes the situation of the company before the implementation of cleaner production and the implementation of the strategy of cleaner production. Table 1 presents the example of sustainable development in 2008 - 2010.

Table 1. Sustainable development results in 2008-2010.

GREENHOUSE GAS EMISSIONS					
Issue of NOX compounds (in relation to limit values from the integrated permit)					
Chełm (mg/Nm^3) NO_X (800Limit NO_X)			**Rudniki (mg/Nm^3) NO_X (800Limit NO_X)**		
2010	**2011**	**2012**	**2010**	**2011**	**2012**
468	506	480	510	349	297

Emission of SO_2 compounds (in relation to limit values from the integrated permit)					
Chełm (mg/Nm^3) **SO_2 (50Limit SO_2)**			**Rudniki (mg/Nm^3)** Derogation from the limit in accordance with the Regulation on emission standards for installations		
2010	**2011**	**2012**	**2010**	**2011**	**2012**
20	13	19	130	93	98

Dust emission (in relation to limit values from the integrated permit)					
Chełm (mg/Nm^3) **Dust limit 30**			**Rudniki (mg/Nm^3)** **Dust limit 30**		
2010	**2011**	**2012**	**2010**	**2011**	**2012**
6	6	5	13	5	10

TOTAL ISSUE					
Total net CO_2 emissions [thousand] tons] (in relation to the allocation of allowances in accordance with the National Allocation Plan - 1796 CO_2 allocation)					
Chełm			**Rudniki**		
2008	**2009**	**2010**	**2011**	**2012**	**2008**
1093	1068	1239	1297	1035	445

WATER							
Unit water consumption (liters / ton of cement)							
Cement (liters / ton of cement)			**Concrete (liter / m^3 concrete)**			**Aggregates (liter / ton of aggregate)**	
2010	**2011**	**2012**	**2010**	**2011**	**2012**	**2010**	**2011**
216	181	182	185	174	175	137	143

Use of recycled water for concrete production		
2010	**2011**	**2012**
15.6%	12.8%	17.4%

Substitution of alternative fuels in CEMEX Polska cement plants				
2008	**2009**	**2010**	**2011**	**2012**
34%	64%	69%	70%	72%

ALTERNATIVE FUEL	
Heat consumption from alternative fuels (GJ)	
2011	**2012**
$6.6 \cdot 10^9$	$5.4 \cdot 10^6$

Unitary fuel consumption by the CEMEX own fleet (liters / 100km)								
Cement			**Concrete**			**Aggregates**		
2010	**2011**	**2012**	**2010**	**2011**	**2012**	**2010**	**2011**	**2012**
32	32	33	62	63	62	34	33	32

Individual energy consumption								
Cement (kWh / ton of cement)			**Concrete (kWh/m^3 concrete)**			**Aggregates (kWh/tonę aggregates)**		
2010	**2011**	**2012**	**2010**	**2011**	**2012**	**2010**	**2011**	**2012**
124.5	124	125	3.4	2.9	3.2	5.8	6.2	5.6

Table 2 presents sustainability results at CEMEX in 2010-2014. Table 3 shows Rudniki Cement Plant before and after CP implementation.

Table 2. Sustainability results at CEMEX in 2010-2014.

Individual energy consumption					
Cement (kWh/ton)		**Concrete (kWh/m³)**		**Aggregate (kWh/tonę)**	
2010	**2014**	**2010**	**2014**	**2010**	**2014**
124.5	113.9	3.4	3.1	5.8	1.9
↓ **10.6**		↓ **0.3**		↓ **3.9**	

Substitution of alternative fuels in CEMEX Polska cement plants	
2008	**2014**
34%	77%
43% ↑	

Heat consumption from alternative fuels **(GJ)**	
2008	**2014**
$6.6*10^9$ = 719.4	$5.4*10^6$ = 572.4
↓ **147**	↓

Total emissions CO_2 **(thousands of ton)**			
Chełm		**Rudniki**	
2008	**2014**	**2008**	**2014**
1093	997.9	445	247
↓ **95,1**		↓ **198**	

Issue of compounds NO_x **(mg/Nm³)**			
Chełm		**Rudniki**	
2010	**2014**	**2010**	**2014**
468	530	510	589
62 ↑		**79** ↑	

Issue of compounds SO_x **(mg/Nm³)**			
Chełm		**Rudniki**	
2010	**2014**	**2010**	**2014**
20	19	130	194
↓ **1**		**64** ↑	

Dust emission **(mg/Nm³)**			
Chełm		**Rudniki**	
2010	**2014**	**2010**	**2014**
6	10	13	16
↑ **4**		**3** ↑	

Individual water consumption					
Cement (kWh/ton)		**Concrete (kWh/m³)**		**Aggregate (kWh/ton)**	
2010	**2014**	**2010**	**2014**	**2010**	**2014**
216	165	185	165	137	101
↓ **51**		↓ **20**		↓ **36**	

Table 3. Rudniki Cement Plant before and after CP implementation.

Before CP introduce 2010	**After CP introduce 2011**	**Difference**
Issue of NO_X compounds (in relation to limit values from the integrated permit) **(mg/Nm^3) NO_X (800Limit NO_X)**		
510	**349**	**161**
Emission of SO_2 compounds (in relation to limit values from the integrated permit)		
130	**93**	**37**
Dust emission (in relation to limit values from the integrated permit)		
13	**5**	**6**

3 Conclusion

Analysis of issues related to Cleaner Production has shown that the use of CP not only effectively protects the environment by reducing or minimizing waste streams, but is also profitable because it leads to increased profitability, productivity (mainly by minimizing manufacturing costs) increasing the efficiency and competitiveness of industries that lead as a result of economic growth. Thanks to the use of alternative fuels, CEMEX Rudniki cement plant has saved 132,000 Mg of carbon in the last 5 years. The ideal of a Cleaner Production strategy is waste-free production. In the current economic and technological situation enterprises can only look for different ways of waste management and use closed cycles of supply streams, eg water. This often leads to the integration of production lines, where waste from one line is used to supply material or energy to another production line. There may also be cooperation between entities under the so-called the supply chain. The reduction of pollutant emissions can be reduced by considering the entire life cycle of the product, paying attention to the materials used, water and energy flow, and the economic impact of switching to CP. Enterprises that decide to implement CP on a voluntary basis constantly strive to reduce pollution, reduce energy consumption and costs associated with environmental charges by developing and implementing so-called CP projects. The benefit of implementing CP projects is the limitation of the amount of fees for economic use of the environment, as well as the cessation of paying penalties for non-compliance with environmental conditions, if such penalties were imposed [7-13]. The use of CP as a tool for environmental management ensures that the objective in the field of environmental management becomes the most important environmental effect. ISO 14000 does not take into account the tools used, while CP provides them. The analysis of the data showed that in the plant in 2010-2014 the following environmental actions were carried out:

- Individual energy consumption: cement 10,6 kWh / ton, concrete 0,3kWh / m3, aggregate 3.9 kWh /ton.
- Total CO_2 emissions: Chełm, 95,1 thousand tons, Rudniki 198 thousand tons. Emissions of SOx compounds: reduction by 1mg / Nm^3.
- Unit water consumption: cement 51 kwh / ton, concrete 20 kWh / m^3, aggregate 36 kWh / ton.

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