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A new training for factory planning engineers to create awareness of climate change

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Abstract

Climate change and global warming are having negative consequences for humans and nature. Manufacturing companies are particularly affected by the consequences of climate change. For example, extreme weather events can cause to production failure or even the collapse of entire supply chains. An adaptation to the impacts of climate change and the implementation of preventive measures requires an awareness and comprehensive knowledge in this topic. In the education of engineers in the field of factory planning and factory operation, the aspects of climate change and its consequences are not or only marginally considered. A systematic involvement in engineering education is shown in the paper. Through the use of innovative teaching methods of problem-based learning, awareness is created in order to effectively prepare manufacturing companies for the consequences of climate change in addition to the pure knowledge transfer.

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Keywords: Factory Planning; Advanced Industrial Management; Global Warming; Climate Change; Education; Awareness; Problem-based Learning

1. Introduction

The effects of climate change have a dramatic impact on all areas of human life. The increasing number and intensity of storms and floods are main reasons for the damage and complete destruction of residential buildings and industrial plants. Between 1995 and 2015 4 billion people were affected by 6,457 weather-related disasters and 606,000 were claimed. [1] The worst result for the people affected were the destruction of their environment and the simultaneous loss of employment due to the destruction of the factory. The numbers are showing that it is necessary to prepare manufacturing companies for the consequences of the climate change. It can be assumed that there is a gap of knowledge and awareness of preventive measures for extreme weather events caused by climate change in the companies, because until today, there is no adequate consideration of climate change in the education of factory planning engineers at German universities. Particularly engineers should have the knowledge about preventive actions since they create and design the working environment. So far, only classic requirements at the factory will be considered. [2] Engineers could develop strategies and actions to protect the factories, if they were sufficiently aware and qualified for the subject. Therefore, it is crucial to raise awareness for climate change and preventive actions in the field of engineering education (see figure 1). [3]

1.1. Background climate change

With the start of industrialization, humans began to emit the in fossil fuels stored CO_2 into the atmosphere to a great extent. In 1750, a resulting increase of the CO_2 concentration was recorded in the atmosphere of about 280 ppm. In 1999, the concentration was already 367 ppm (based on several air bubble measurements in Antarctic ice). [4] The CO_2, as well as other greenhouse gases, causing a re-reflection of the incoming and from the earth reflected sunlight. As a

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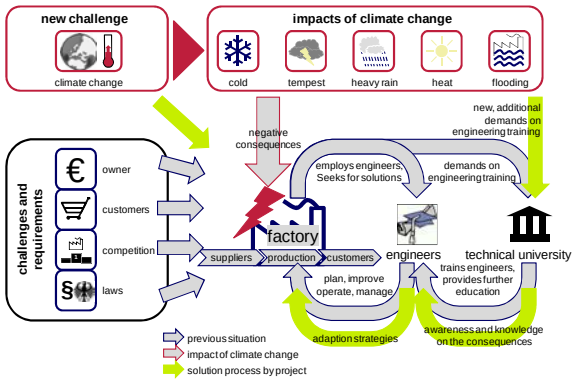

Figure 1: Impact of climate change on factories and approach of the project

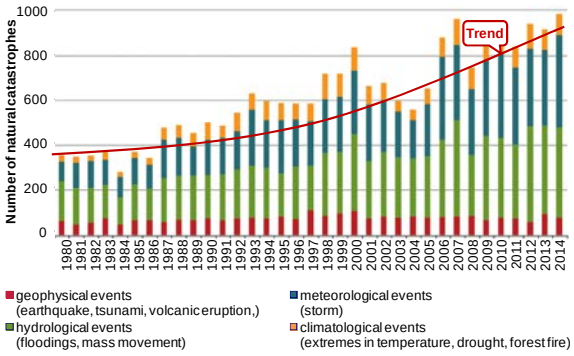

Figure 2: Natural disasters worldwide from 1980 to 2014

consequence, the temperature in the atmosphere increases. This so-called natural greenhouse effect is amplified by the increase of greenhouse gases, so that a rise in the average temperature is recorded (anthropogenic greenhouse effect), which leads to a change of climate. This results further changes in health, agriculture, forests, water resources, coastal areas and biodiversity. More serious consequences are for example the rising sea levels and the increase in extreme weather events. [4]

The effects of climate change can be described with the increase in natural disasters. Figure 2 shows the worldwide evolution of natural disasters since 1980. Furthermore, a clear upward trend can be seen. The meteorological events (like storms) perform a great part of occurred natural disasters. [5]

Germany is one of the largest economies in the world with a large industrial sector. The industry sector has about 260,000 manufacturing enterprises with approximately 6.4 million employees. The increase in natural disasters such as storms has negative effects on the building material of factories. For example, a tornado in Großhain (Saxony) caused major damage at manufacturing plants in November 2010. In addition, the increased snowfall in the long cold spell and the above-average snowfall lead to a collapse of hall roofs (e.g., January 2011 in Bochum-Westenfeld, December 2011 in Eisenberg).

The consequences of climate change have different effects for a factory. Especially, in factories which have been planned and built several decades ago, are not prepared for extreme weather events, such as increasing precipitation or high snow loads. Thus, the German government elaborates the German Adaptation Strategy. The following aspects of the strategy have intersections with factory planning: 3.2.2 building industry; 3.2.9 energy sector; 3.2.11 transport, transport infrastructure and 3.2.12 industry and business. [6]

The German Adaptation Strategy described changes for the construction industry should be applied especially during the building structure planning, building insulation, cooling and heat engineering, floor loads etc. At these planning steps previously the climate was assumed as a static value and changes are not taken into consideration. This can lead to expensive retrofits or to a lower energy efficiency of the factory building. [2] The risks referred to the German Adaptation Strategy for industry and business are becoming increasingly real. [6] In addition to the cases of damage referred to above, subsequently examples of damaged factories and supply chains will be furthermore mentioned.

1.2. Examples of inadequate consideration of climate

In March 2011, there was a devastating flood in Thailand due to heavy rains. In this example, seven industrial parks with about 1,000 production facilities were flooded and there was massive damage of the factories, due to not-existent flood protection. The consequences were noticed internationally. The global supply chains of the Japanese automotive industry were interrupted for weeks. 300,000 people became permanently and 700,000 temporarily unemployed. A consideration of the greater intensity of extreme weather events combined with an effective flood protection could limit the economic consequences. The strong influence of the Japanese automotive industry also shows that it was inadequately prepared for the consequences. The insurance costs amounted to 16.2 billion USD and the economic damage to 49.6 billion USD. For this, it has been the most expensive flood worldwide [7]. In factory planning phase “location selection” should consider flooding risks or dykes should be built, if no public flood protection is organized.

With an economic loss of 16.5 billion USD in 2013 and 14.1 billion USD in 2002, the two "floods of the century" mainly in Germany and the Czech Republic were the second and third most expensive floods in a worldwide comparison. [7] For example, in 2002 the Czech chemical plant Spolana in Neratovice was flooded by the river Elbe. The insufficient flood protection meant that large quantities of dioxins, mercury and other toxins spilled into the river and had the effect of severe damage to the environment and inhabitants of the Elbe region. [8]

For companies is of particular importance that the follow-up costs are very high in case of a service interruption. About 0.5 % of claims, which have been regulated by the Ecclesia Insurance Service GmbH, came to an interruption, however, which formed 15 % of the total amount of damages. [9] Manufacturing companies needs to take the risk of such disasters into account. [10] Hence, it is necessary to develop strategies for factory adaption. However, there is a lack of knowledge in higher education about factory planning and climate change, which is addressed with following describe project.