A METHODOLOGY OF TECHNOLOGICAL TRANSFORMATION TO CO2 FREE INDUSTRY

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Introduction

The energy-intensive industrial sectors account for one-third of global energy demand and more than 30% of total greenhouse gas emissions in the world. In Austria, the industry sector consumes about 126 TWh of primary energy representing 34% of total primary energy consumption [1] and emits approximately 17 Mt[1] greenhouse gas (GHG) corresponding to 21% of total national emissions[2]. About 70% of this primary energy is consumed in the energy-intensive industrial sub-sectors: iron & steel, cement, pulp & paper, aluminium and chemical & petrochemical industries [1]. These industries are also responsible for around two-thirds of sectoral CO_2 emission.

According to the Paris agreement, Austrian industry intends to reduce GHG emissions by 40% by 2030 and 80-90% by 2050 compared to 1990 levels. For this reason, the industry needs to create an infrastructure that will have a vital impact on CO_2 emission abatement.

The current work is a part of the NEFI[2] (New Energy for Industry) project. One of the goal of NEFI is providing an integrated concept for the deep decarbonisation of the Austrian industry energy system driven by a transformation of the Austrian industry toward a sustainable, efficient and low-carbon economic sector.

The following parts are describing a framework for the development of scenarios for industrial decarbonisation. Firstly, the methodology of study is described, secondly an overview of energy-intensive industry in Austria is considered and following a comprehensive decarbonisation options are provided. Thereafter, the mitigation scenarios are discussed and followed by overall conclusion in the last parts.

Keywords: energy intensive industry, CO_2 emission, decarbonisation scenario, innovative technologies

Methodology

The aim of this report is to assess the decarbonisation options that could be employed in the

Austrian energy intensive industrial subsectors: chemical and petro chemical, iron and steel, non-ferrous metals, non-metallic mineral and pulp and paper

[1] Process related emission

[2] www.nefi.at

To consider the long-term GHG mitigation in the industrial sector a framework is built. As shown in figure 1 the work started by analysing the current status of the industrial subsectors to find the energy carrier, energy demand as well as GHG emission.

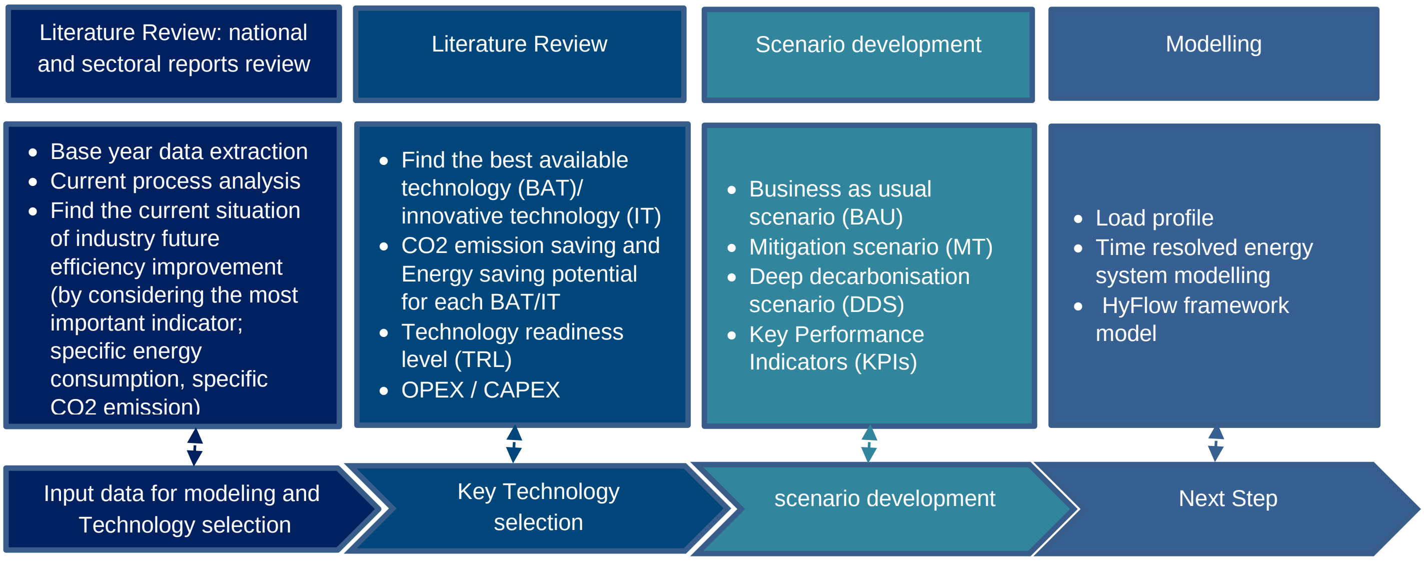

Figure 1: scenario development framework for industrial decarbonisation.

This is followed by a comprehensive literature review on the individual sectors and industrial sub-sectors. The aim was to identify opportunities, barriers and enablers for the implementation of decarbonisation throughout the industry. The goal is to answer the most important questions such as identifying the main obstacles and conditions for the implementation of CO_2 reduction, determining the necessary conditions for investments by companies and considering CO_2 management as a strategic issue in order to identify suitable technical options for the sectors.

Finally, by considering the current condition as well as the abatement options of the industrial subsectors a baseline scenario is designed to forecast the sector development and associated energy consumption. In addition, two mitigation scenarios are developed to assess the achievement GHG reduction potential in the industry

Overview of Austrian industrial sub-sectors

The industry sector accounts for a significant share of Austrian GHG emissions. In 2015 greenhouse gas emission from industrial process amounted to 16676 Kt CO_2 equivalents, which correspond to 21% of total national emission. The indirect emission from generating the electricity used in industry resulted in 13.6 % of total national emission. Between 1990 and 2015, process GHG emissions from the industry sector increased by 22% and energy related GHG emission increased by 5.8%. The most important greenhouse gas of this sector is CO_2 with a contribution of 86% to total sectoral emissions (2015). [2]

In 2015, almost 80 percent of industrial process emission is from manufacturing of metal industry and mineral industry, which generating 65% and 16% of total sectoral emissions respectively. Figure 2 illustrates the share of emission by industry sector from total GHG emission in Austria as well as energy-intensive industrial emission from sectoral emission. [2]

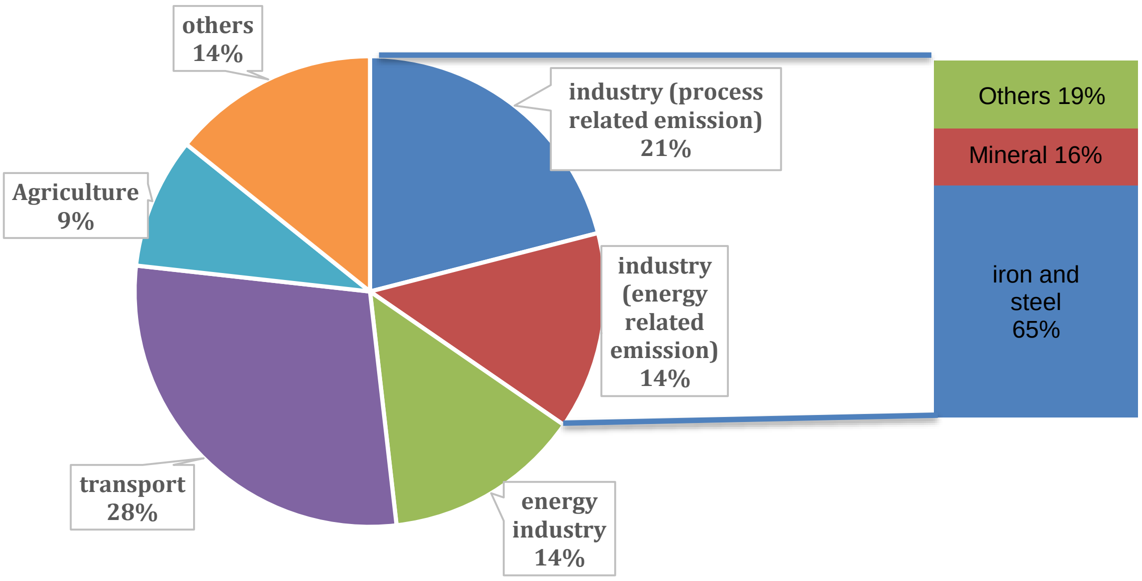

Figure 2: CO_2 emission production in Austria in 2015

The industry sector is also responsible for approx. 35% of total primary energy consumption in Austria which 70% of this energy consumed by energy- intensive subsectors as feedstock and energy carrier. [1]

Industry sector emission is among the hardest to abate in the energy system because of both technical and financial perspectives. Firstly, the largest emission by industrial sectors is process emission (in Austria two-third of industrial emission) that results from chemical and physical reactions of feedstock producing the material. This emission can be reduced only by changes to processes. Secondly, another part of emissions come from burning fossil fuels to generate high-temperature heat (in the mentioned sectors, process temperature varies between 700 °C and 1,600 °C). Abating these emissions by switching to alternative fuels such as zero-carbon electricity would be difficult, because this would require significant changes to the furnace design. Moreover, some of energy-intensive industrial processes are highly integrated, so any change in one part of a process leads to changes in other parts of that process. Finally, production facilities have long lifetimes, typically exceeding 50 years with regular maintenance. Changing processes at existing sites requires costly rebuilds or retrofits. [3].

Nevertheless, the Industrial companies can reduce CO_2 emissions as well as energy consumption in various ways. In the next section some alternative options for decarbonisation of industry sector is explained.

Decarbonisation Abatement Options

In order to investigate the abatement technologies, a comprehensive literature review in international, EU and national levels was done and a list of technologies with CO_2 emission and energy saving potential was prepared. Most of publications deal with analyzing options using both best available technologies (BATs) and innovative technologies (ITs) with CO_2 emission reduction and energy saving potential in both industry sector and individual industrial subsectors. [3-10]

In this work the above classification has been used. Energy-intensive industries have the technical potential to reduce their current total energy consumption as well as CO_2 emissions by improving their energy efficiency through the use of BATs, however BATs are not sufficient to achieve deep decarbonisation by 2050. Thus, a comprehensive innovative technology with low CO_2 emissions should be taken into account.

Technology visioning and selection have been started with the evaluation of current development status of Austrian industry and it is completed by monitoring two important key performance indicators (KPIs), specific energy consumption (KJ/ ton of production) and specific CO_2 emission (Kton of CO_2/ton of production) of Austrian industrial sub-sectors. The results of key indicators prove that the industrial subsectors in Austria have made significant resource and energy efficiency improvements over the past decades by using most of BATs. Therefore, further significant improvement for CO_2 emission reduction by use of the BATs seems to be limited. Hence, to reduce the energy consumption and CO_2 emission of industrial subsectors for the short mitigation and deep decarbonisation until 2030 and 2050, it is necessary to focus on innovative technologies.

The important considered options for industrial decarbonisation can be categorized into the following groups:

Energy-efficiency improvements: Improvement of the energy efficiency can economically decrease fuel consumption. Achieved potentials in energy efficiency will differ between sectors and facilities.

Electrification of industrial processes: Switching to renewable electricity is an option towards carbon neutrality for industrial processes (e.g. electrochemistry, electric furnaces or kilns, plasma or microwave technologies). Electrification of industrial process also offer the opportunity to help balance supply and demand on the electricity grid, which will become more effective with the relative increase of the share of renewable energy sources.

Use of Hydrogen as fuel or feedstock: Emissions from fossil fuel consumption and certain feedstock's can be reduced by using hydrogen, especially when the hydrogen is generated by zero-carbon electricity via water electrolysis.

Carbon capture storage and usage: With carbon-capture technology, CO_2 can be collected from the exhaust gases produced by an industrial process and prevented from entering the atmosphere. The CO_2 can be stored underground (CCS) or used as a feedstock in other processes through carbon capture and usage (CCU).

Other innovative options: In addition to the decarbonisation options listed above, other techniques for performing industrial processes can lead to reduction of CO_2 emissions. For example, alternatives to limestone as a raw material could reduce process emissions in cement production.

Table 1 contains a brief summary of the most relevant innovative technologies for individual energy-intensive industries by considering the Technology readiness levels (TRL):

Table 1: list of innovative technology

Industry sector	TRL < = 5	TRL 6	TRL7	TRL 8-9
Iron and Steel	Hisarna with CCS (TGR-BF) Steel making with H_2 CCS / CCU High quality steel making by EAF		Top Gas Recycling Blast Furness with CCS (TGR-BF)	Direct reduction with natural gas
Cement	Calcium looping CCS Alternative new binder (CO_2 efficient material)	Oxyfuel CCS		Alternative fuel use
Pulp and paper	Deep eutetic solvents New drying technology Water less paper prodcution		Electiricication of heat prodcution	Black liquor gasification

Scenario development

In order to investigate the future energy saving and CO_2 mitigation potential of Austrian industry sector, three alternative techno-economic development scenarios are constructed under different assumptions with regard to the abatement options and technology innovation and diffusion. The scenarios describe pathways to low carbon Austrian industry sector (Figure 3).

The business as usual scenario [BAU] is developed in order to predict the future of industry sector without any significant change and by using the currently available technologies and energy policies.

The mitigation scenario (MGS) is built on currently feasible reduction measures (technological and structural) to reduce CO_2 emissions in the industrial sector. The development of the Mitigation Scenario (MGS) is based on the #Mission 2030 of the Austrian Climate and Energy Strategy and the current EU targets. The trends arising in the process are taken into account until 2050. The modelling in this scenario is based on the utilisation of BATs and ITs with a short to medium-term implementation horizon and by especially considering the renewable energies as an important source of energy.

The deep decarbonisation scenario (DDCS) represents a radical shift by focusing on individual innovative CO_2 emission reduction technology option for every sector as well as using the carbon capture storage and usage (CCS/ CCU) to achieve the Austria goal which is 80- 90% reduction by 2050 compared to 1990. The ITs with low readiness level are included in this scenario.

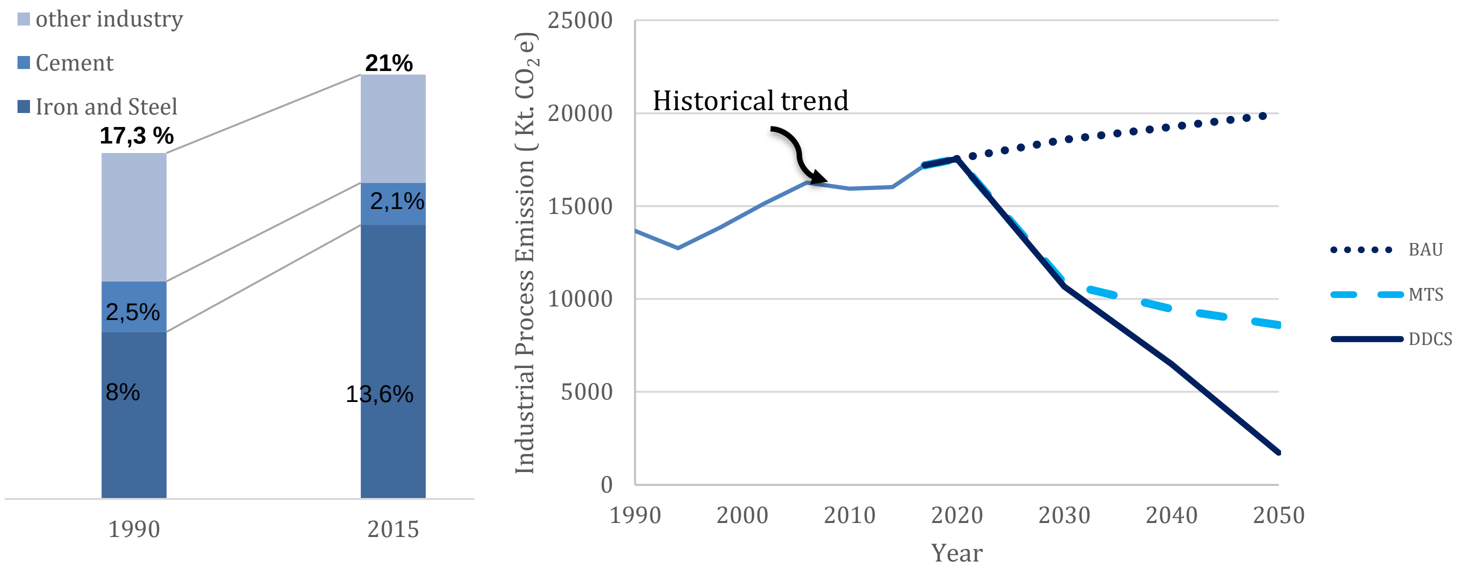

Figure 3: Industrial process emission and decarbonisation Scenarios development to 2050

Conclusion

In this study a methodology of technological transformation and scenario development for decarbonisation of Austrian industry sector was discussed. Industrial companies can reduce CO_2 emissions in various ways. The combination of decarbonisation options such as energy efficiency improvements, electrification, using hydrogen (made with zero-carbon electricity) as feedstock or fuel, using biomass as feedstock or fuel, carbon capture and storage (CCS/ CCU), and other innovations can bring industry emissions close to zero.

The optimum mix of decarbonisation options depends greatly on several factors. The most important factor is access to low-cost zero-carbon electricity. In industry the fossil fuel must be replaced by renewable energy sources and total primary energy consumption must be reduced significantly. However, in the industrial sector the transition from current fossil fuel based energy supply towards renewable energy source is a major change.

Finally, the decarbonisation of the industrial sector requires more investments in industrial sites and must be accompanied by an accelerated development of CO_2-free electricity generation.

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