Chapter 14

Tools for Categorizing Industrial Energy Use and GHG Emissions

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Additional information is available at the end of the chapter

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1. Introduction

The political target to cut energy use and greenhouse gas (GHG) emissions has various expressions. For example, the European Union some years ago set the target that energy efficiency must be improved by 20% by 2020. In good policy making, regional strategies must be parallel with national strategies. When the approaches in the national strategies are top-down, the regional approaches ought to be bottom-up. Therefore, the issue is to have policies that work in practice or "in the real world" (Johansson, 2006).

The policies whether they are carried out in a company, or at a regional, a national or even continent-wide level need tools. Industry is diversifying all the time. Does this development path mean that industrial energy use is diversifying as well? At first glance when going very deeply into energy use this seems to be true. The energy use may be diversified when looking at the details, but to conduct an energy-efficiency policy or GHG emission reduction policy with a wide scope requires generalisations. This is certainly the case when we withdraw from the detailed level. The energy use must be categorised. This article will mainly discuss these tools and how to generalise and categorize industrial energy use.

2. Energy policy levels and decision-making

One can set many policy levels when looking at the policies that aim to mitigate climate change and cut energy use. On a national basis, the levels for industry can be as follows:

Company level

This can be either one company or an enterprise or a group of enterprises that have the same owner. At present, only companies belonging to the EU Emissions Trading System (the EU ETS) have a direct responsibility to control their CO_2 emissions. Companies that do not belong to the ETS have no direct responsibility other than the country of their location.

Regional level

Regional may mean different things in different contexts. For example, in Finland one province has one million inhabitants, another one has a few hundred thousand, whereas in some bigger countries one city may have many millions of inhabitants.

National level

Countries make agreements on GHG mitigation and they are responsible for fulfilling the agreements under the Kyoto Protocol or under some more limited agreements such as among the EU countries.

International level

A level where conclusions are made on the GHG emissions mitigation goals and how the mitigation targets are divided among the countries or groups of countries.

The service and public sectors are taking an ever-bigger role as an employer. In 2007, industry directly employed only 18% of the workforce in Finland. This is still a moderate number for an industrialised country among the EU-15, where the average is 17%. The decline in industrial employment has been very fast. In 2000, industrial employment in Finland was 20% (Eurostat, 2008). Whenever fewer people have a direct relation to industry, it is more and more difficult for industry to have a fair and effective communication with citizens and the authorities.

These thresholds for fair communication due to limited information will always exist. To lower the thresholds, information must be clear and jargon must be avoided. One precondition is that the subsidiary principle is applied. The decision-makers must understand the key points of industrial energy use in the target area of the policy as well as other conditions affecting industry. For those conducting the actions of the selected policy, choosing the correct policy level is even more important. The policy level must be selected so that the area of decision-making is understandable "in one man's head". The level is a very personal question. It depends on the persons and their personal experiences and skills. In Finland, one reasonable level is the province so as to cover "the scope of in one man's head".

3. Opportunities to improve industrial energy efficiency by 2020

The main goal of this review of the past is to forecast for the year 2020 with today's knowledge. The review is based on an article (Aro, 2009).

3.1. Pumps and fans

The electric motors of pumps and fans consume electrical energy. When looking at only the improvements opportunities in the motors, pumps and fans, no large consumption reductions can be expected by 2020. However, the situation is not necessarily all that bad. The system level can give opportunities. This means how the components are used as a part of technical systems. The lower the air and liquid flows with fewer pressure lifts, the smaller the electricity consumption. At the systems level, frequency converters and more energy efficient motors give a good option to achieve the best possible level of efficiency with fans and pumps. At the systems level, there are always endless opportunities for energy savings and efficiency improvements.

3.2. Compressed air

It is well known that compressed air systems require good maintenance to run efficiently. If not, air leakages may be more than 70% of the total compressed air production. Therefore, there always exists potential savings with compressed air systems. In the past, compressors were piston or screw types, as they are today. However, there have been efficiency improvements due to novel control systems and the use of frequency converters. Some 10-30% improvements have been seen compared to the past. In total, over 10% of improvements can be expected in the near future.

3.3. Heat recovery from exhausted waste gas flows

Heat recovery from exhausted waste gas flows is used to heat fresh air for air-conditioning or process air use. During the last 30 years, no remarkable success has been achieved in the efficiency of the various types of heat recovery equipment applicable to air-conditioning.

Recovery of process exhausts is more demanding because of corrosive substances and particles. For these applications, new types of heat recovery have been developed as well as new materials tested. Although in the past success on the equipment level has been rather limited and it does not seem that it is going to be much better by 2020, there have been improvements due to advanced control systems that help to better run the systems than in the past.

Heat recovery is meant to decrease heat consumption. Heat recovery equipment causes pressure losses in gas flows, which means that the fans and pumps must produce higher pressure and, therefore, more electricity is consumed. However, if they are well designed, the increase in electricity consumption is clearly less than the decrease in heat consumption.

3.4. Cooling and heat pumps

Compressors for cooling and heat pumps were piston-operated ones in the past, whereas today they are mainly scroll or screw types. The latter ones are easy to control. The new compressors and improved control technology have given opportunities for an improvement in energy efficiency of 10-20% compared with the past. In Finland, free cooling by outdoor air or lake and river water has become more popular compared with the past. Free cooling still has many opportunities, especially in industrial process cooling and also in offices, where computers require cooling also during the heating season. Through free cooling, the electricity consumption of cooling can be reduced by dozens of percents. Although there have been improvements in cooling applications, the demand for electricity for cooling can be expected to increase due to the need to improve working environments and due to new process requirements.

Heat pumps have in principle still many opportunities in industrial processes but heat sources i.e. liquids and gas flows for heat pumps are difficult to exploit. There are blocking and corrosion problems with heat exchangers. No leap forward can be expected by 2020.

3.5. Heat production

Heat production and heat use have been areas where energy efficiency improvements have been remarkable since the 1970s. There are various reasons for this positive development in Finland:

1. Transfer from steam to hot water, hot oil, and electricity.
2. Transfer from a factory's own boilers to district heating. This type of outsourcing has in most cases caused improvements in efficiency or at least savings in operating costs.
3. Increased use of natural gas. Natural gas is easy and clean to burn compared with other fuels.
4. Outsourcing of boiler plants is comparable to district heating. There are opportunities for efficiency improvements when heat production is outsourced to a company specialised in heat production.

Boiler efficiencies with gas and oil were at a good level even 30 years ago. When one thinks about the future, no remarkable improvements can be expected. With solid fuel boilers, there are opportunities for improvements. With all types of boilers and heat distributing systems, there is always some potential as a result of good maintenance and operation.

3.6. Lighting systems

Incandescent lamps have disappeared in general lighting, but fluorescent and mercury lamps are still on the market with more efficient applications. High -pressure sodium lamps are taking more and more of the market due to their good energy efficiency. Many people think that the future is in light emitting diodes (LEDs). High expectations have been set for the good energy efficiency and long service life of the LED lamps. It is not certain what their market penetration will be by 2020. For the moment, barriers to market penetration include limited LED lamp applications for general industrial lighting as some of the existing lamps (such as sodium lamps) already have rather good energy efficiency and that the LED lamps need their own light fixtures. However, general lighting may give dozens of percents in saving opportunities through novel lamps, lighting fixtures, control of lighting, and good maintenance.

3.7. Conclusions

For a variety of reasons, the changing of individual technologies to more energy efficient ones is not an easy way to achieve high reduction cuts by 2020. The service life of individual technologies is 10-30 years, which means that most of the motors, pumps, fans, etc that are now in use will still be in use in 2020. With many individual technologies, there are not very remarkable efficiency improvement expectations. If a deep cut in energy consumption and CO_2 emissions is pursued, it will be found through novel system thinking. This in turn means a lot of work for skilful people. Based on the past, the general energy efficiency in industry has improved 1% per year (Blok, 2007) and in future the expectations on the growth of production are clearly more than 1%. An equation to be solved means something else than what we have seen in the past. In future, energy efficiency policy must be more target-oriented, and not more or less a by-product of normal industrial development, as it has been until now. A study by Blok (2004) discusses the preconditions by which new equipment will achieve an energy efficiency improvement rate higher than 5% per year. According to the study, it may be possible but it will require substantial efforts from all parts of society.

4. Sectoral and cross-sectoral approach

In a study (Stigson et al, 2008), the concept of a sectoral approach was seen to depend on the person who defines the concept. In the study, the following scope was categorized:

Sector-wide transnational approaches, e.g. transnational industry-led approaches that aim to engage a sector on a broad international basis or global sectoral industry approach; bottom-up *country commitment*, possibly combined with no-lose targets; and top-down sectoral crediting as an incentive mechanism, e.g. sectoral Clean Development Mechanism

The same study found three common features typical of sectoral approaches: 1) collection of data and information about the sector to establish performance indicators or benchmarks; 2) sharing and distributing best practices within companies to enhance monitoring, reporting and verification of emissions and operational efficiency; and 3) engaging with major companies in emerging economies, where the greatest emissions growth and reduction potential lie.

Of these three, the first one lays an information foundation for the other two, where the target is to achieve practical improvements in GHG mitigation, in energy efficiency, or in other fields of energy policy.

Sectoral approaches are most useful especially in the fields of industry where rather homogenous products are handled, such as in the steel and other metal industries, the cement industry, and in the pulp and paper industry. Sectoral approaches provide useful background information on industry but they are time consuming, need a lot of work and a constant updating of the information. The main defect is the collection of reliable data, especially in global comparisons. Collected data is particularly poor even from "the easy sectors" such as the iron and steel, chemical and petrochemical, and pulp and paper sectors (Tanaka, 2008).

Sectoral analysis based on economical figures, e.g. value added (€) or turnover (€) per tonne of steel produced, is easier to collect but not so useful in emission-reduction target setting compared to physical data such as steel produced per consumed form of energy or per CO_2 emissions, see for example (Worrel et al., 1997).

Thus far, much of the discussion on GHG mitigation has been targeted at international or national levels where sectoral approaches illuminate the origins of CO_2 emissions and are useful for general industrial GHG policymaking. To achieve real results in the mitigation policy, more and more activities must be set at local or regional levels. That is where the real results in the tackling of climate change will take place.

In the United States, where commitment to international agreements is weak, the sub-national GHG policies have developed strongly. It has been estimated that if those states, which have set their own GHG emission reduction targets, achieve those targets, nationwide US GHG emissions would be stabilized at 2010 levels by 2020. And this, without any serious mitigation action taken by over half of the states (Lutsey and Sperling, 2008).

At a local or regional level, successful policy means co-operation among different industries and not only among specific industrial sectors. This is because at the local level there are many industrial sectors and one sector may have only one or very few separate companies. Furthermore, co-operation is needed between industry and other sectors of society. A cross-sectoral approach is a must.

5. Industrial cross-sectoral approach

How should one develop a target-oriented and bottom-up approach to reduce the CO_2 emissions and energy consumption of industry? First of all, what kind of tools is needed to conduct a target oriented policy? Because the problem is energy use, we should have a view on industrial energy use. What is common in general? One way is to classify and categorise the sectors and companies according to their energy use. In Aro (2009), this is done in the following way: building energy users (HVAC and lighting), process heat users, process electricity users, and direct combustion users, see table 1. This classification based on the form of energy use is useful when designing regional energy efficiency policies, since energy efficiency improvement/CO_2 reduction strategies can be built specifically for each of these four categories. These policies can also be, however, applicable to several industrial sectors as long as they belong to the same category of energy use.

At local or regional levels this categorization can be used in many ways such as at company, energy utility, and zoning levels. Of course, there are no limits to use it also at national or international levels whenever it is seen to be useful.

Building energy users are good for district heating and zoning must be targeted to collecting these kinds of industries in areas where district heating is possible. Companies using heat in production are good as a part of district heating or (CHP) where they can guarantee constant heat load throughout the year and/or they are considered to be a good target for biofuel power plants. It is beneficial to locate direct combustion users near a natural gas network.

Form of energy use	Description
Building energy users	Small amounts of electricity and heat are used in the production. HVAC and lighting are clearly the main energy consumers. Assembly lines, the production of equipment and machines are typical industrial sector representatives for this category. In general, many industries that are often described as non-energy intensive can be considered building energy users.
Major users of electricity for process/production	Electricity use in process/production is clearly bigger than the building electricity consumption. Typical branches of industry falling into this category are pulp and paper, metal production, the production of plastic products, and glass making.
Major users of heat for process/production	Heat use in the process/production is clearly bigger than the building heat consumption. Heat means energy forms that are transmitted by pipes such as water, steam, and hot oils. Typical branches of industry belonging to this category are pulp and paper, dairies, part of the textile industry, chemical industry, production of rubber products.
Direct combustion users	In some applications, the product can be heated directly or indirectly by fire and/or flue gases. Especially natural gas is good in many applications. Typical representatives are cement and lime production, glass and brick production, bakeries, and the production of metals.

Table 1. Ways to use energy in industry (Aro, 2009).

Table 2 shows an example of this categorization as applied to various industries. Although the companies may belong to different industrial sectors, they may have common aspects in the ways they use energy. For this purpose, the categorisation is useful. It can be used for benchmarking and exchanging information between industries and industrial sectors. At local and regional levels, it is good to have co-operation among industries. For this, categorisation gives opportunities to build up workshops and common development projects under the same theme of energy use in spite of being from different industrial sectors.

If a cross-sectoral approach is needed among industries, the regional energy policy also needs a cross-sectoral approach between industry and other sectors of society. This approach means district heating, biofuel use, and other society-wide energy projects, where advantages are achieved if industry is involved in the projects.

5.1. A company level

Categorization is a tool to reduce energy use and CO_2 emissions. The reductions are always realised at the company or plant levels because energy is used there.

If one sets a general target to reduce energy consumption to a certain level such as the EU target of 20%, improvements in energy efficiency, and reductions in CO_2 emissions, what do the targets look like at the company level? The driving forces for a company are external and internal ones. The external ones are, for example, EU targets and the internal ones are the company's own policies to reduce CO_2 emissions. Therefore, the question is how to react to the external ones. In principle, company-level energy related CO_2 emissions are formed by a multiplication of the form of energy and specific CO_2 emissions of the energy form. The development path of company-level CO_2 emissions is a phased process where in every step the quantity of the energy form or specific emissions of the energy form or both are changed (Fig. 1).

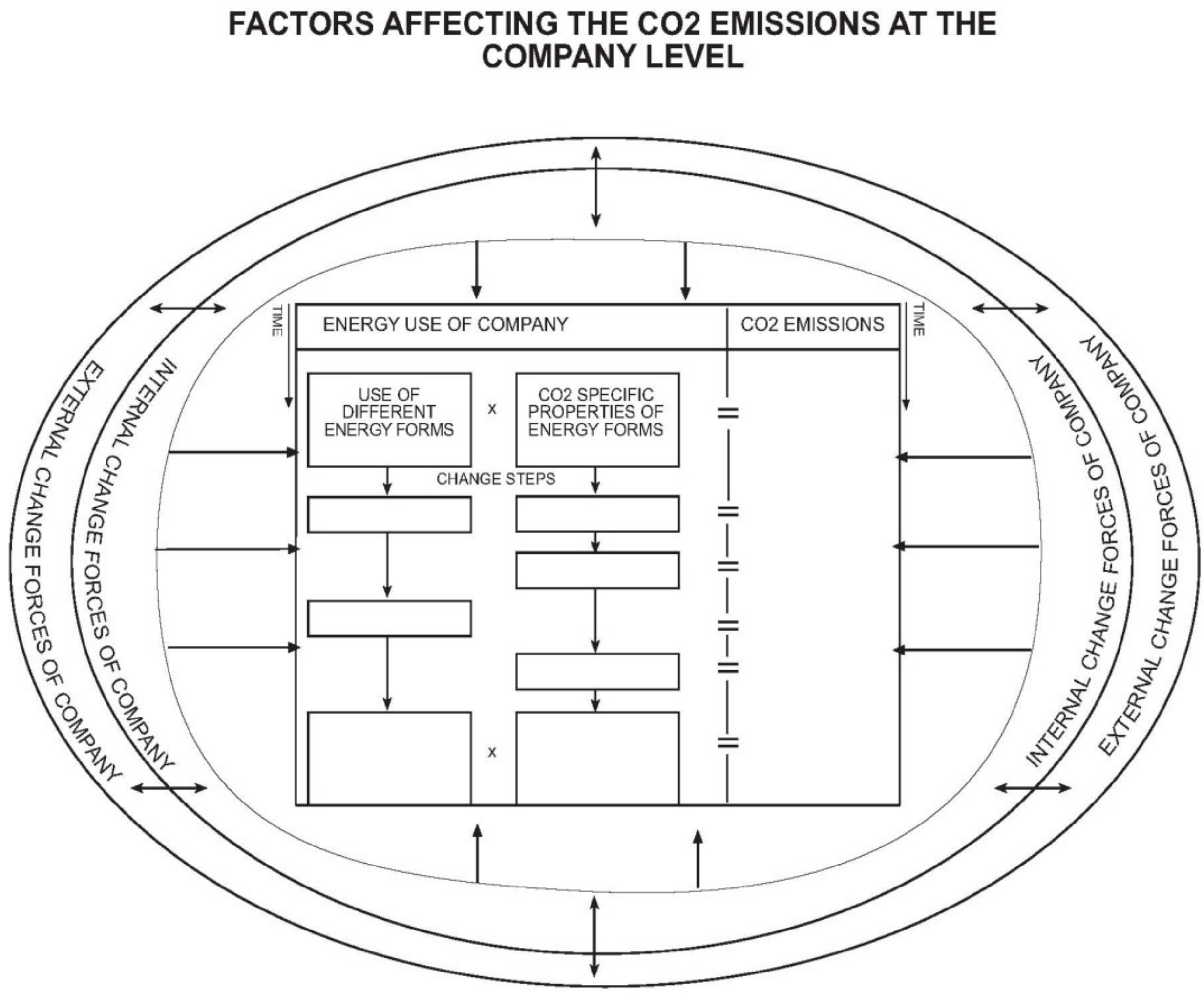


Figure 1. Development of a company's CO_2 emissions path.

Standard Industrial Classification 2002	Industry	Significant building energy user, typical user of the district heating	Significant process electricity consumption	Significant process heat consumption (water, steam, hot oil)	Significant process direct combustion user (oil, natural gas and solid fuels)
15	**Manufacture of food products and beverages**	If the processes can be managed with electrical heating, the usage of district heating is reasonable. If a boiler is needed for the process, it is often used to heat up the buildings as well.	Electrical ovens Cooling Grinding machines Mixing machines Concentration plants Pumping	Cooking Washing Sterilization, acid and alkali washes Pasteurization Dewatering Manufacturing of cheeses	Baking and rising
17	**Manufacture of textiles**	Typical building energy users	Drying Production machines	Dye works Drying Manufacture of special textiles	Drying The number of factories using direct combustion is diminishing.
18	**Manufacture of wearing apparel; dressing and dyeing of fur**	Typical building energy users	Machines and devices	Small steam generators are able to provide enough steam for pressing	
19	**Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear**	Typical building energy users	Drying	Low temperature level water heating and leather drying	
20	**Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting matter**	Building energy users. Only some of the buildings are heated.	Wood processing Drying Sawdust removal	Drying	Drying
21	**Manufacture of pulp, paper and paper products**	Some paper products processors are mainly building energy user.	Processes use a significant amount of electricity: Wood	Drying Water heating Pulp production	Drying

Standard Industrial Classification 2002	**Industry**	**Significant building energy user, typical user of the district heating**	**Significant process electricity consumption**	**Significant process heat consumption (water, steam, hot oil)**	**Significant process direct combustion user (oil, natural gas and solid fuels)**
			processing Grindery Pulp and paper machines Drying Pumping		
22	**Publishing, printing and reproduction of recorded media**	Small plants are typical building energy users.	Printing presses Drying	Drying	Drying
24	**Manufacture of chemicals and chemical products**	Small plants are typical building energy users	Pumping Fans Negative and positive pressures Heating Cooling Drying	Process heating Drying	Drying
25	**Manufacture of rubber and plastic products**	Small plants are typical building energy users	Extruders and other melting procedures Process cooling especially in the summer time	Process heating	
26	**Manufacture of other non-metallic mineral products**	Small plants are typical building energy users	Refiners Grinders Pumping Thermal treatments Melting processes	Water heating Thermal treatments	Incineration Melting Thermal treatments
27	**Manufacture of basic metals**		Processes use a significant amount of electricity: Melting Thermal treatments		Melting Thermal treatments
28	**Manufacture of fabricated metal products, except machinery and equipment**	Some plants are building energy users	Surface finishing Thermal treatments Processing and shaping Welding	Drying	Thermal treatments

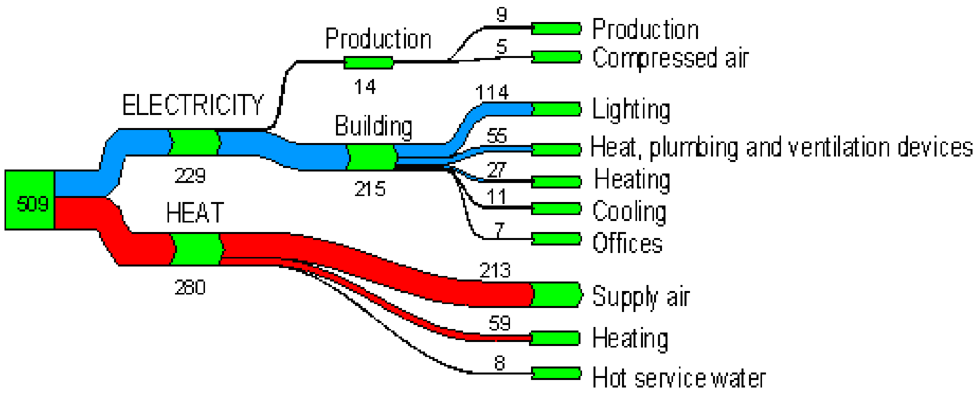
Standard Industrial Classification 2002	**Industry**	**Significant building energy user, typical user of the district heating**	**Significant process electricity consumption**	**Significant process heat consumption (water, steam, hot oil)**	**Significant process direct combustion user (oil, natural gas and solid fuels)**
29	**Manufacture of machinery and equipment n.e.c.**	Some plants are building energy users	Shaping Thermal treatments Surface finishing Welding	Drying	Thermal treatments
30 and 31	**Manufacture of office machinery and computers, electrical machinery and apparatus n.e.c.**	Typical building energy users			
32	**Manufacture of radio, television and communication equipment and apparatus**	Typical building energy users			
33	**Manufacture of medical, precision and optical instruments, watches and clocks**	Typical building energy users			
34 and 35	**Manufacture of motor vehicles, trailers and semi-trailers, other transport equipment**	Some plants are typical building energy users	Surface finishing Welding	Surface finishing	
36	**Manufacture of furniture; manufacturing n.e.c.**	Some plants are typical building energy users	Drying Surface finishing Machines	Drying Surface finishing	

Table 2. Example of energy use categorising in different industries (Aro, 2009).

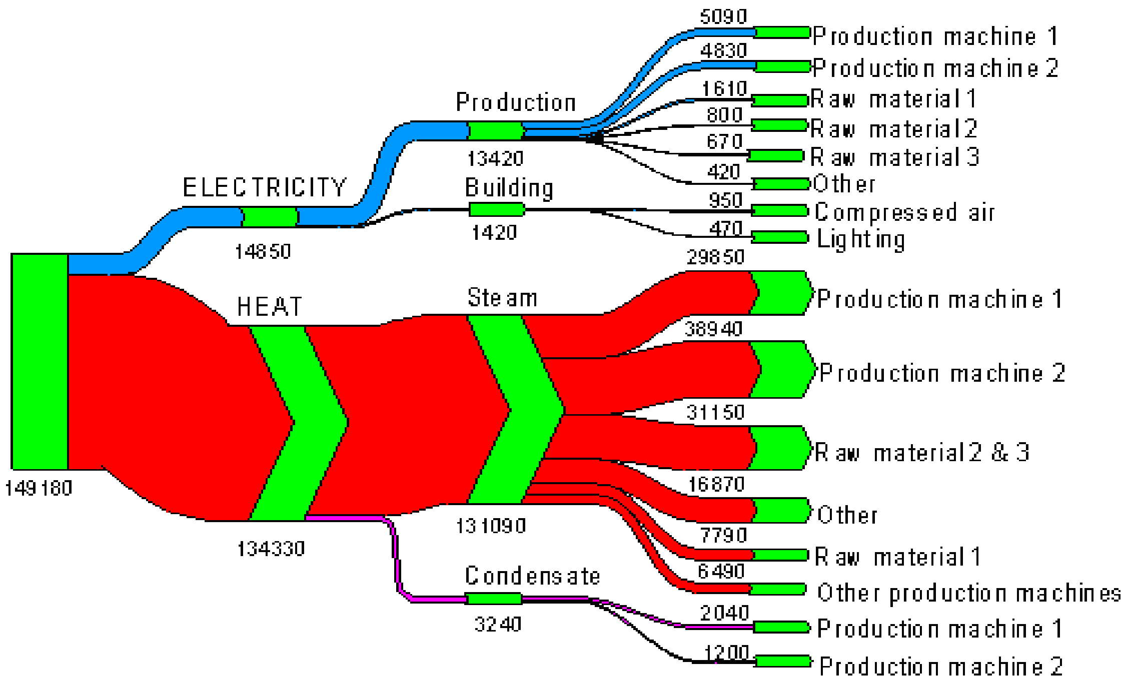
In the article (Aro, 2009), the energy consumption and CO_2 emissions of 6 industrial plants located in the Pirkanmaa region, Finland is reported, see table 3. Plant number 1 is a typical building energy user and plant number 6 belongs to the category of heat in process user, see table 2. The others were in the middle. Their energy use was analysed and, on the basis of the analysis for each plant, a Sankey diagram was drawn of the origin of energy related CO_2 emissions. The diagrams are shown for plants 1 and 6 in fig. 2. The potential for reduction of CO_2 emissions was estimated on the basis of the energy/CO_2 emission analysis. For plant 1, the economic reduction potential (payback period less than 5 years), based on energy prices only was some 15% and for plant 6 2-3 %. For the other four plants, it was between 4% and 25%.

	Energy consumption [MWh / a]	CO_2 emissions [t CO_2 / a]	Energy consumed in production	Own energy production	Sector
Plant no. 1	2,500	510	3%		Machinery and equipment
Plant no. 2	10,000	2,250	65%		Other non-metallic mineral product
Plant no. 3	20,000	4,300	73%	x	Food products and beverages
Plant no. 4	20,000	5,100	70%	x	Other non-metallic mineral product
Plant no. 5	25,000	5,200	40%		Rubber and plastic products
Plant no. 6	500,000	150,000	over 95%	x	Chemicals and chemical products

Table 3. Key figures of six industrial plants in the Pirkanmaa Region, Finland (Aro, 2009).



Plant no. 1



Plant no. 6

Figure 2. Sankey diagrams for plants 1 and 6. Origin of CO_2 emissions, t CO_2(Aro,2009).

What does the general target of a 20% reduction in CO_2 emissions mean for the 6 plants? Only plant 6 belongs to the EU ETS. For this plant, it was possible to calculate - other than the indirect CO_2 emissions - what the 20% reduction will mean for the plant economy in relation to the EU ETS allowance price (€/CO_2 tonne). For the other five, the relation is only indirect (through acquired electricity and heat and fuel prices) and, therefore, hypothetical. The economic effects of the allowance price (5-40 €/CO_2 tonne) for different reduction targets (5-30%) were calculated for the six plants' economy as a share of turnover. Plants 4 and 5 can even cover the 20% reduction with their own energy saving measures, but the others cannot. Except for plant 6, the burden of the reduction is not very demanding. Plant 6 has to expect costs of more than 1% of turnover whereas for the others it is less than 1%.

In interviews with the employees of the 6 plants, most of them saw that there is an opportunity to manage with a 20% reduction by 2020 at the existing production levels. However, successful business requires an increase in production. They see that this growth demand will be the main threat for achieving the reduction target.

Other barriers for the target are excessive outsourcing and the reduction of staff and lack of knowledge. Another barrier to rapid change is the rather slow rate in the construction of new industrial buildings comprising some 2% per year of the existing industrial building stock.

5.2. A regional level

5.2.1. Finland and Pirkanmaa region

Finland's population is rather small, only 5.3 million. With an area of 340 000 sq km, Finland is the 6th largest country in Europe. Finnish industry is versatile. We have light industry like the telecommunication industry, but we also have very heavy industry like the pulp and paper and steel industry. Most of the heavy industries belong to the EU Emission Trade System (EU ETS), while the light industries mainly do not.

In Finland, we have two schemes that promote the rational use of energy that are partly funded by the government: energy audits and energy investments regimes to improve energy efficiency and to increase the production of renewable energy. Furthermore, we have a voluntary agreement to improve energy efficiency. All these activities are applicable also for industry.

Finland consists of 15 provinces. Finnish regional energy policies have primarily focused on the promotion of biofuels. There have, however, been practically no regional activities for industry, especially as regards energy efficiency. In the past, the efforts to improve energy efficiency were mainly motivated by corporate economy and to some extent by the nation's fuel reserve supply stock. Today, because of climate change, the government of Finland is more interested in what is happening in industry. Improving energy efficiency means tackling climate change.

In a sparsely populated country with a lot of energy intensive industry such as Finland, it is a challenge to formulate a regional energy policy with a focus on industry. If we want to tackle climate change in the long run – as many estimate the GHG emissions must be cut by some 60% – the policy must be very comprehensive and well-organised, and one must keep one's finger on the pulse of what is going on in the industry.

What does the regional level give in fight against climate change? The aim is to build foundations for starting a regional carbon dioxide reduction programme and to discuss what opportunities the provincial aspect offers to the reduction of the industrial CO_2 emissions related to energy use. The approach is limited to D-sectors of the industrial statistics: the manufacturing industry. The fishing, farming, forestry, mining, construction industries, and the electricity, gas, and water supply industries are excluded from the study. Fuels used by industrial vehicles are also left out. The Pirkanmaa region, some 150 kilometres to the north from Helsinki, served as a target province. The centre of the region is the city of Tampere. The area of The Pirkanmaa region is some 4% and the population some 9% of the whole country. The work partly serves as one of the contributors to the establishment of the Pirkanmaa region energy programme.

Carbon dioxide emissions arising from the use of energy are divided in emissions originating from the combustion of fossil fuels and in emissions from the production of heat and electricity acquired by industry. Acquired heat and electricity are the sources of indirect emissions allocated to the industries. The classification of industrial statistics made by Statistics Finland was used in the calculations. The goal was to look at the energy related carbon dioxide emissions generated by different industrial sectors in the Pirkanmaa region. The emissions are also compared between the Pirkanmaa region and the whole country. Of all the greenhouse gases, the energy related emissions have the biggest impact and they represent 80% of Finland's greenhouse gas emissions (Finland's FNC, 2006).

5.2.2. CO_2 emissions by industry and source

Carbon dioxide emissions from the use of energy were calculated from the industrial statistics (Statistics Finland, 2006) and they were complemented with data from other public sources. When estimating the emissions of industrial sectors, both the use of fossil fuels and emissions related to the acquired heat and electricity used by the companies were taken into account. Following these principles, carbon dioxide emissions related to the energy use of industry in the Pirkanmaa region were estimated at 1.5 million tons in 2004. This is about 2% of Finland's total greenhouse gas emissions. In Finland as a whole, the energy related CO_2 emissions of industry are some 35% of the total GHG emissions.

Acquired electricity and heat and natural gas were identified as the main sources of CO_2 emissions. In total, some 70% of the emissions are indirect, i.e., originating from acquired electricity and heat (for example district heat). In Finland, the average CO_2 value for acquired electricity is 200 CO_2 g /kWh and for acquired district heat 220 CO_2 g /kWh (Motiva Oy, 2008).

The distribution of carbon dioxide emissions in both the Pirkanmaa region and the whole country was calculated on the basis of industrial statistics from 2004. The distributions between industrial sectors and emission sources are visualised in figures 3 and 4. Clearly, the biggest CO_2 emitting sector is the manufacturing of pulp, paper, and paper products. Labour intensive sectors, such as the manufacturing of machinery and equipment and the manufacturing of fabricated metal products are the sources with the least emissions. The use of electricity is the biggest source of CO_2 emissions.

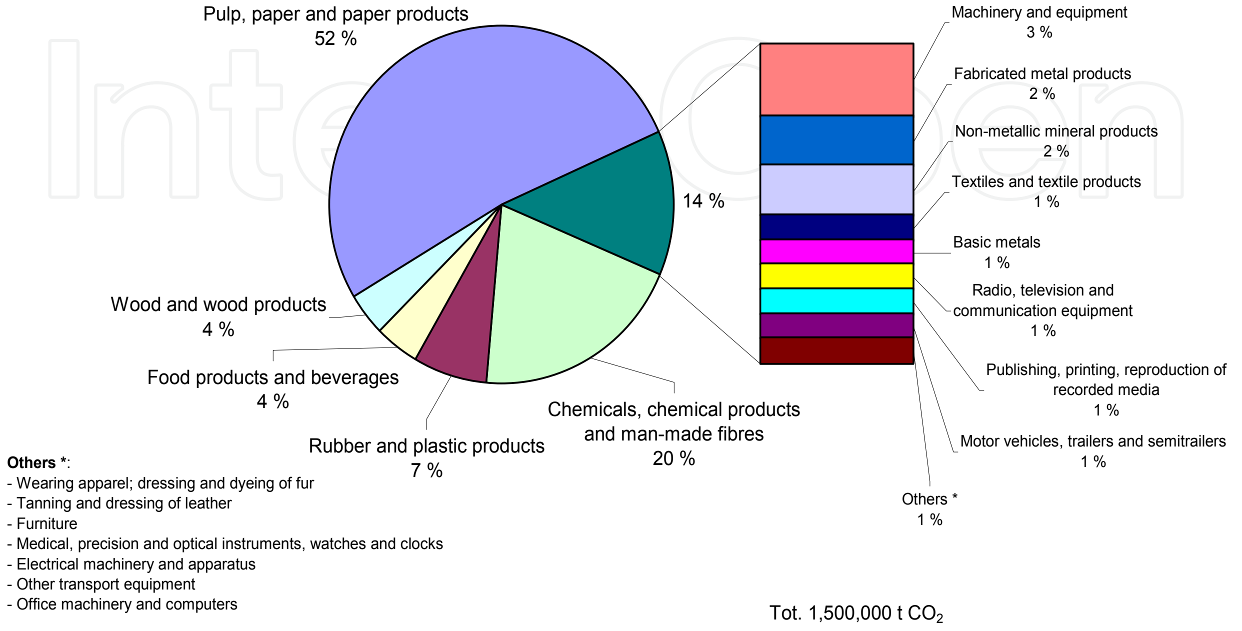


Figure 3. CO_2 emissions distribution by industrial sector in the Pirkanmaa region (Aro, 2009).

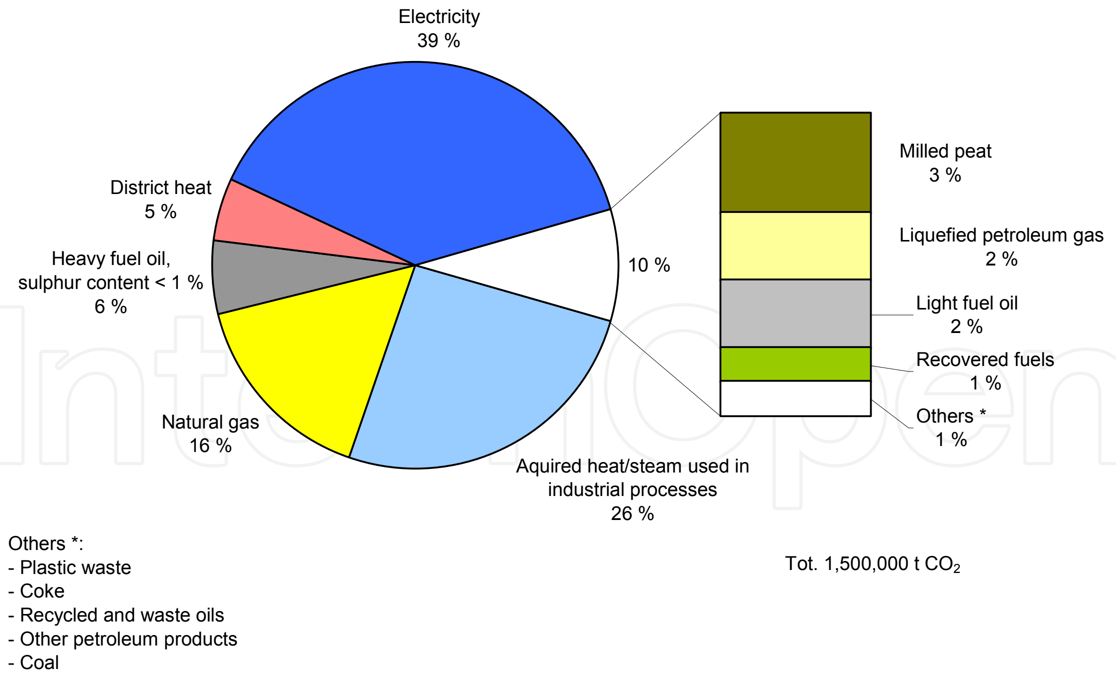


Figure 4. CO_2 emissions distribution by source originating from the industrial energy use in the Pirkanmaa region (Aro, 2009).

The emission sources for different branches of industry were visualised both for the Pirkanmaa region and for the whole country. Such pie charts are vital for understanding the differences between the regions and the whole country. Figure 5 is an example of the pie chart for the food products and beverage industry.

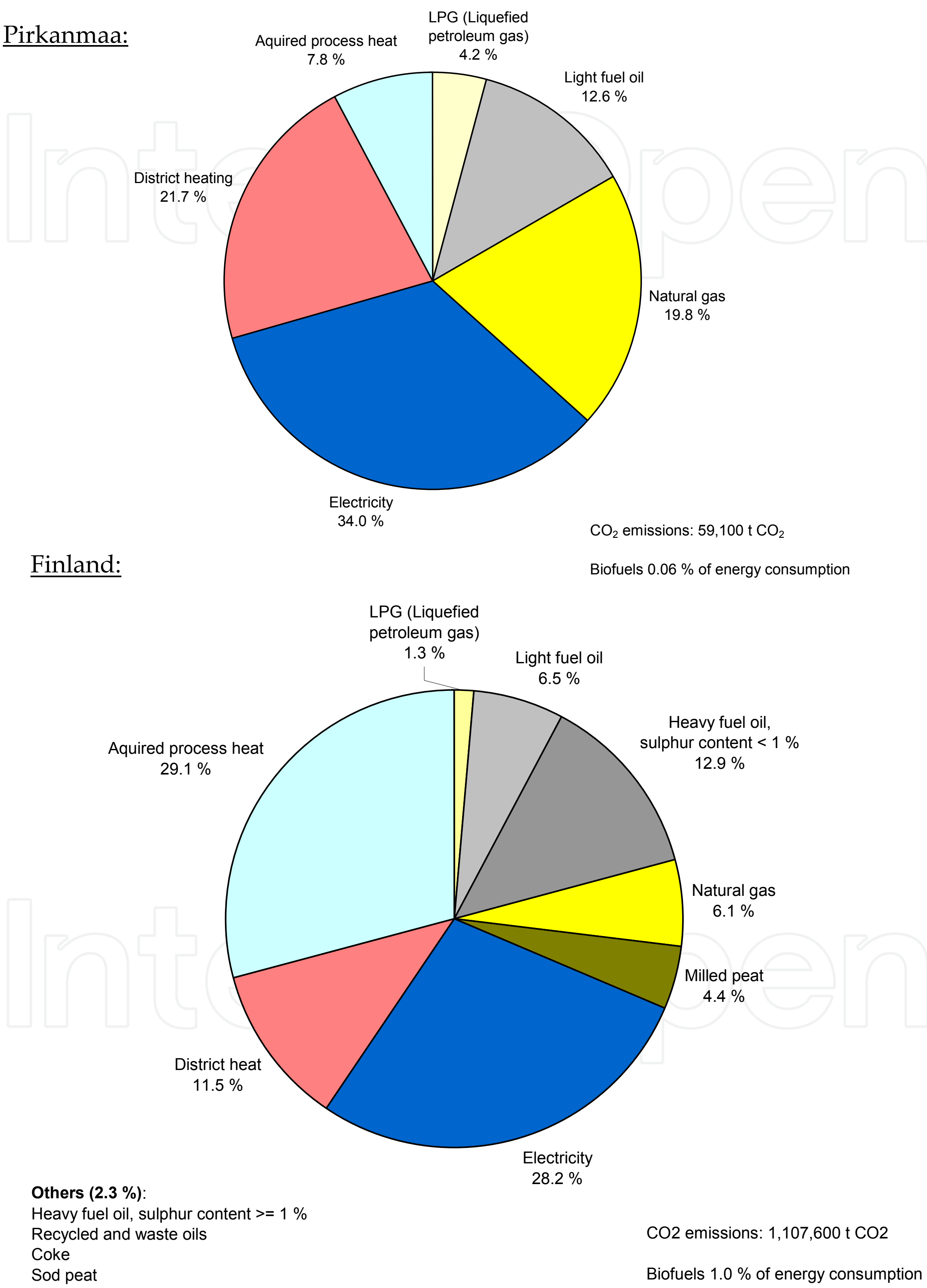


Figure 5. CO_2 emissions sources for food products and beverage industry in the Pirkanmaa region and in the whole country (Aro, 2009).

5.2.3. Parameters as a tool in energy efficiency and GHG control policies

Some key parameters were calculated and studied for the industrial sectors as a tool for the target-oriented approach, for example:

- District heat usage / total energy usage, %
- Value added / total energy usage, 1000 €/GWh
- Value added / CO_2 emissions, 1000 €/t CO_2
- Value added / electricity usage, 1000 €/MWh or GWh
- Total energy usage / value added, kWh/€
- Employment / CO_2 emissions, number of employees/1000t CO_2
- Employment / electricity usage, number of employees /GWh

The key parameters were also found suitable for comparing other characteristics of sectors and companies in relation to their CO_2 emissions. These comparisons showed, for example, that the Pirkanmaa region is more industrialised than provinces on average but industry in the Pirkanmaa region is less energy intensive than Finnish industry on average: the added value of the industry of the Pirkanmaa region is 12% of the whole country whereas its population is 9%. As regards the industry energy intensity, in the Pirkanmaa region the energy intensity is lower than in the whole country, see table 3. Table 3 also indicates that Finnish industry is in general very energy intensive because the average number is 9 kWh/€, when one definition of an energy intensive industry is 6 kWh/€ or higher (Blok, 2007).

Industry	**Whole Finland kWh/€**	**Pirkanmaa region kWh/€**
Food products and beverage	2	2
Textiles and textile products	2	1
Wood and wood products	6	7
Pulp, paper and paper products	29	8
Chemical and chemical products	6	15
Rubber and plastic products	1	1
Non-metallic mineral products	5	1
Production of basic metals	16	2
Fabricated metal products	1	1
Machinery and equipment	1	0.4
Average	9	3.5

Table 4. Energy consumption of the main industries per value added in the Pirkanmaa region and in the whole of Finland (Aro, 2009).

The structure of the industry has an influence on how much CO_2 emissions are "needed" to create a certain amount of employment opportunities or added value. For example, the manufacturing of machinery and equipment produces up to 20 times more jobs and wealth than the manufacturing of pulp, paper, and paper products with the same amount of CO_2 emissions, see figure 6. Deducing from this, the structure of industry should be steered towards sectors such as machinery and equipment. In this way, industry could reduce a remarkable portion of the current emissions with the present number of jobs and amount of welfare. In fact, industrialized countries have already taken this route. For example, parts of the steel industry, which produces significant amounts of CO_2 emissions, have been shut down or moved abroad. There has been a lot of debate about this intended or unintended carbon leak since the start of the EU ETS. In any case, global warming is indeed a global problem. Moving emitting sources from one place to another is the wrong way of dealing with global warming in both Finnish regional politics as well as in global politics. The Pirkanmaa region looks greener than the other provinces of Finland on average but it will not manage without the products of the less green Finland or the less green world.

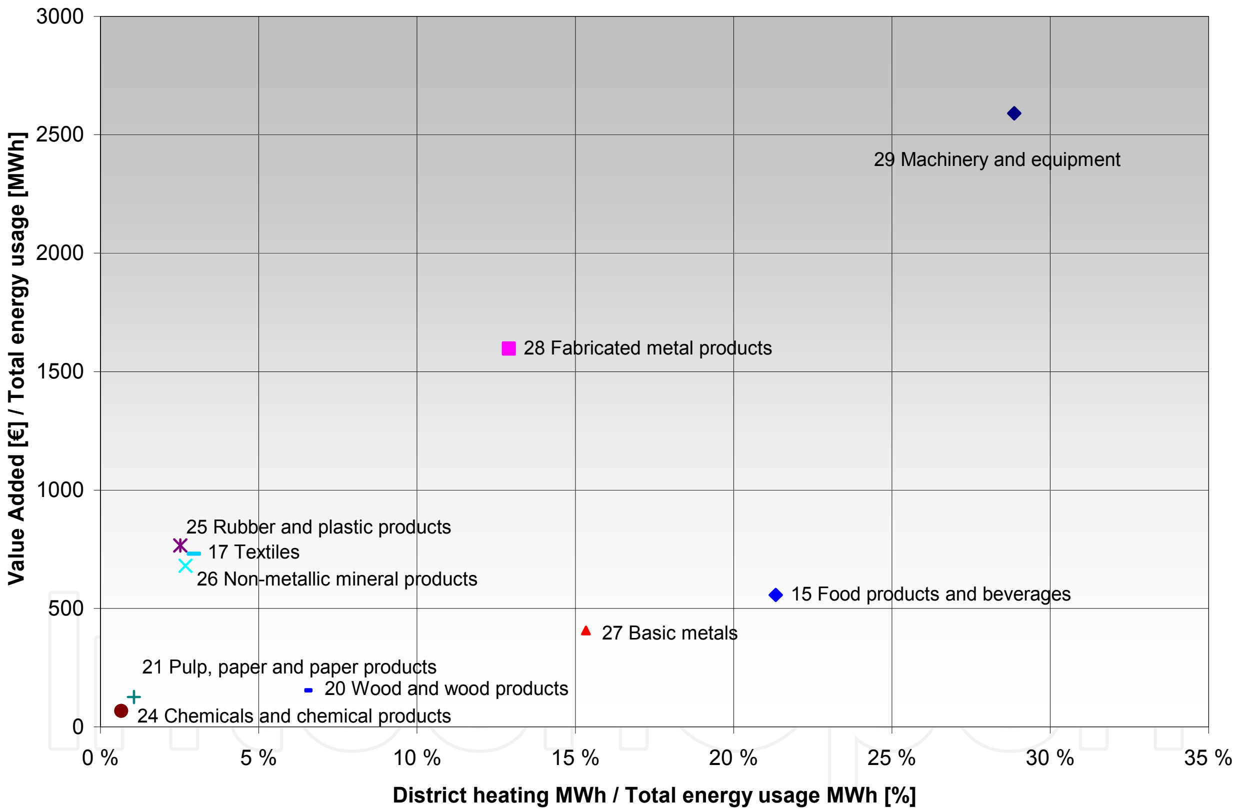


Figure 6. Value added per total energy consumption and the share of district heating from total energy consumption in the main industries of the Pirkanmaa region (Aro, 2009).

District heating produced in CHP plants is commonly known as an efficient way to generate power. In the Pirkanmaa region, district heating is common in industries that fall into the building energy users category, see figure 6. In these industries, no heat is needed in the process and, therefore, they do not necessarily need their own heat production. On average, the share of district heating may represent 30% of the total energy consumption among "building energy users" but on average in the energy intensive industries only a few percent. Due to Finland's long tradition of CHP, the opportunities for using this technology for the production of district heating are today limited, but there is still unused potential for small scale CHP in enterprises that need heat in their production.

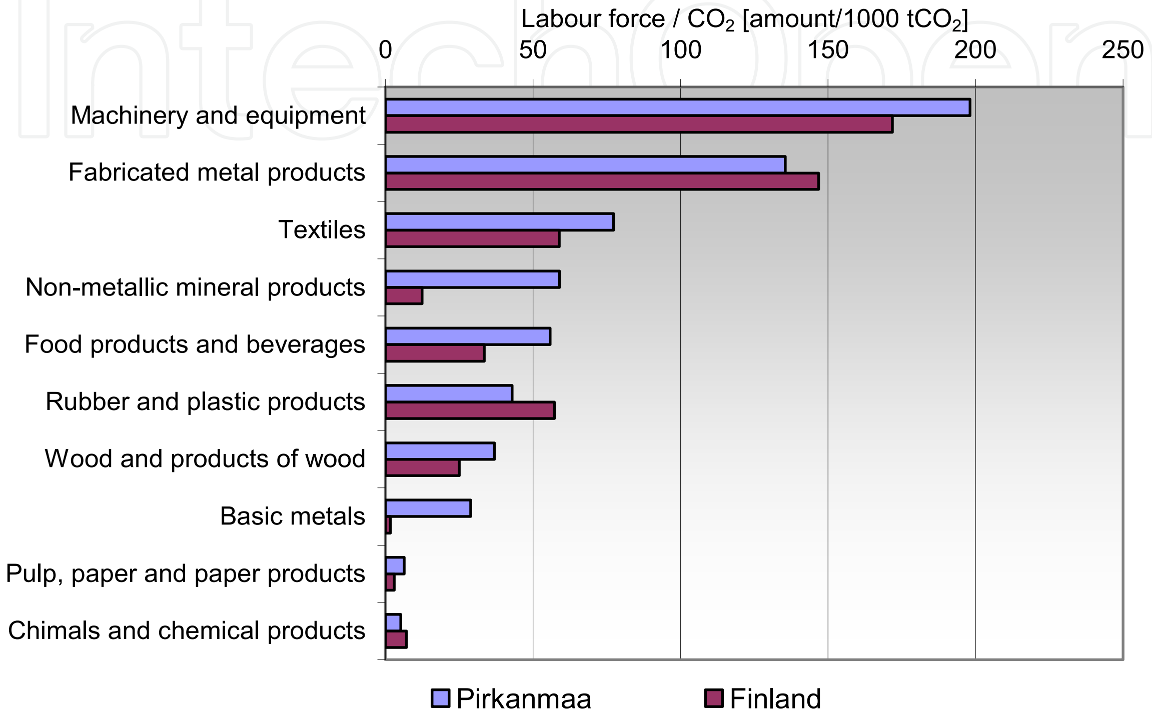


Figure 7. Number of jobs in relation to CO_2 emissions in the Pirkanmaa region and in the whole country (Aro, 2009).

5.2.4. Drafting a scenario for Pirkamaa region

In the article (Aro, 2009), the opportunities for the Pirkanmaa region to achieve a 20% reduction are estimated. In the region about 70% of industry's energy related CO_2 emissions are indirect. This means that these emissions come with acquired electricity and heat. Companies have only limited possibilities to influence the specific emissions of indirect emission sources. In practice, the best way to reduce indirect emissions is to improve energy efficiency. Biofuels are rarely used. Only the manufacturing of pulp, paper, and paper products and the manufacturing of wood and wood products use a significant amount of biofuels compared with their total energy use.

With the existing level of production in the Pirkanmaa region, a 20% cut in CO_2 emissions means some 300 000 tonnes annually. How can we get rid of these tonnes?

Heavy fuel oils are a source of some 100 000 tonnes of CO_2 emissions annually, which can be reduced at least by half by increasing biofuel-based energy production.

During the project, a case study of six companies was carried out. This study and other experiences show that there are energy saving opportunities – with a payback period of less than 5 years - between 4 – 25% depending on the company. On average, it can be estimated that 10% energy savings are possible.

Of the emissions, 70% are indirect. In Finland, there are many plans targeted at reducing the specific CO_2 emissions of electricity. By 2020, Finland will have at least one new nuclear power plant and the share of wind power and biofuels will have increased. It is very likely that the specific CO_2 emissions of electricity will decrease by around 10 – 15% which translates into some 100 000 tons of CO_2 emissions.

This drafting "road map" shows that in the Pirkanmaa region it is possible to achieve the target of a 20% reduction in CO_2 emissions by 2020 with constant production, but if the industrial production grows by some 2% per year as expected, this target will be challenging.

6. Discussion

Whatever policy is conducted it requires generalisations and categorizations. Details are starting point and a base for the categorization and the categorization is a tool to change the details. This is also true with the target oriented energy policy whether you are conducting it at company, regional, national. or even international levels.

In this article, an approach that starts from the ways in which industry uses energy has been discussed. The energy use is categorised for four ways: building energy users (HVAC and lighting), process heat users, process electricity users, and direct combustion users. This categorisation can be applied at company, regional, or national levels. Of course, the details must be in balance with a selected level. This approach and other tools are only to conduct some policy, the tools are not the policy. The approach described in this article is used for the drafting of the energy management of industrial parks in Flanders. As a part of other tools, it has been seen as valuable (Maes, T., et al 2011).

For benchmarking and navigating their position in energy efficiency and GHG emissions, companies need parameters and specific numbers. For these purposes, there is still much to do. One source of information is industrial statistics. Based on these statistics, CO_2 emissions and energy use parameters for national and regional comparisons can be developed. An approach, which combines company level CO_2 emissions and energy analyses, energy use categorization and parameters, gives opportunities to develop a comprehensive industrial energy and GHG policy at the regional level.

Industrial cross-sectoral and energy use categorization approaches support an industrial symbiosis that has been well documented at Kalunborg (Ehrenfeld and Certle, 1997). In Finland, a common example of this symbiosis is the use of saw mill residuals for heat production and as raw material for other areas of the forest industry. These symbioses have thus far developed more or less for economic reasons. The same is also true of the use of district heat by the industries belonging to the building energy users category.

To conduct an energy policy, means that we have to build sandboxes where to play and to use the described tools. Unfortunately, in today's world this is more and more difficult. The life cycles of industrial plants have become shorter and production may be transferred from one place to another very quickly without forewarning. For example, the financial crisis has been with us since 2008 and there are no good predications when it will end. Anyway, it is quite sure that there will be changes in how the industry is located in the future.

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