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REDUCTION OF CLIMATE GASES BY ENERGY EFFICIENCY

Summary

Carbon-dioxide (CO_2) cannot be depolluted in practice. However, there are two areas where measures can be taken to avoid CO_2 emissions:

1. Energy-efficiency.
2. Use of sustainable energy sources in energy production.

It is characteristic that many measures which are good for the environment are also good from the point of view of cost efficiency, preparedness and employment. This is true, for instance, of the greater use of biofuels instead of fossil fuels, collective heating systems as opposed to individual ones and economy measures - especially more efficient use of electricity. It is a question of thinking of the system as a whole.

Methane is another factor which contributes to the greenhouse effect. Methane emissions can also be avoided, or reduced, by system-thinking. System-thinking is, for instance, not to deposit combustible waste but to use it as an energy source. And why not produce electricity by using methane from existing landfill sites.

Electrical energy is the most useful form of energy. Therefore, electricity should not, as a principal rule, be used for heating, or as process energy.

The fact that energy-efficiency and emission of greenhouse gases are interrelated is shown in the following two examples.

1.Only about 25% of the energy content in extracted coal will reach the consumers as electricity when the production takes place in an ordinary, coal-fired condensing power station.

2.When district heating (room-heating and hot water) is produced in a modern heat-production plant by flue-gas condensation, about 90% of the energy is utilised for heating purposes.

To obtain an overall picture of the amount of energy used for a purpose, e.g. heating or electricity, you must view the entire process from extraction to final use. Such a picture can show the energy efficiency and what losses arise.

Efficiency measures can reduce the energy bill. They can also reduce pollution, greenhouse gases among other things. Examples will be given in this paper of energy losses during the course of its conversion from resource to use. The concept of energy quality will also be dealt with.

This paper is, to a large extent, based on the report "Environmentally-Adapted Local Energy Systems", EB 7:1998, Swedish National Energy Administration (STEM), Box 310, SE-631 04 Eskilstuna, Sweden.

SMANJENJE STAKLENIČKIH PLINOVA POMOĆU ENERGETSKE EFIKASNOSTI

Sažetak

Ugljični dioksid (CO_2) u praksi ne može biti lišen svojstava zagađivača. Međutim, postoje dva područja kojima se mogu poduzeti mjere za smanjenje emisije CO_2:

1. Energetska efikasnost

2. Korištenje održivih izvora u proizvodnji energije

Značajno je da su mnoge mjere pogodne za okoliš, također dobre i sa stajališta efikasnosti troškova razvoja i zapošljavanja. Ovo je točno npr. za veće korištenje bio-goriva umjesto fosilnih goriva, zajedničkih sistema grijanja nasuprot pojedinačnim sistemima i ekonomskih mjera - naročito za efikasnije korištenje električne energije. To je stvar razmišljanja o sistemu kao o cjelini.

Metan je još jedan faktor koji doprinosi efektu staklenika. Emisija metana također se može izbjeći, ili smanjiti promišljanjem o sistemu. Promišljanje sistema je npr. da se gorivi otpad ne odlaže, nego koristi kao izvor energije. A zašto se i električna energija ne bi proizvodila koristeći metan iz već postojećih podzemnih odlagališta otpada.

Električna energija je najkorisniji oblik energije i zbog toga u osnovi ne bi trebala biti korištena za grijanje ili kao procesna energija.

Činjenica da postoji veza između energetske efikasnosti i emisije stakleničkih plinova prikazana je u sljedeća dva primjera.

1. Samo oko 25 posto energetskog sadržaja izvađenog ugljena doći će do potrošača kao električna energija, kada se proizvodnja odvija u običnoj elektrani na ugljen.

2. Kada se proizvodnja iz centraliziranog toplinskog sustava (grijanje prostorija i topla voda) odvija u modernoj proizvodnoj elektrani na plin, oko 90 posto energije iskoristivo je za svrhe grijanja.

Da bi se dobila ukupna slika o količini energije koja se koristi za određenu svrhu npr. grijanje ili električna energija, mora se uzeti u obzir cijeli proces od vađenja do konačnog korištenja. Ovakva slika može pokazati energetsku efikasnost i nastale troškove.

Mjere efikasnosti mogu smanjiti račune za energiju, a isto tako mogu umanjiti zagađenje i stakleničke plinove. Referat daje primjere gubitaka energije tijekom konverzije od izvora do korištenja, a razmatra i koncepciju kvalitete energije.

Ovaj referat se većim dijelom oslanja na izvještaj "Environmentally-Adapted Local Energy Systems" ("Lokalni energetski sistemi prilagođeni okolišu"), EB 7:1998, Swedish National Energy Administration (STEM), Box 310, SE-63104 Eskilstuna, Švedska

1. ENERGY LOSSES EVEN BEFORE OIL IS IN THE CONSUMER'S TANK

This example shows energy losses occurring from the moment the crude oil is collected to becoming the heat by combustion. Right from the start, 6% of the energy is lost in flaring gases and in extraction. In Norway, new methods have halved this loss and in the figures below it is lowered to 3%. The loss during transport to the refinery is less than 1%.

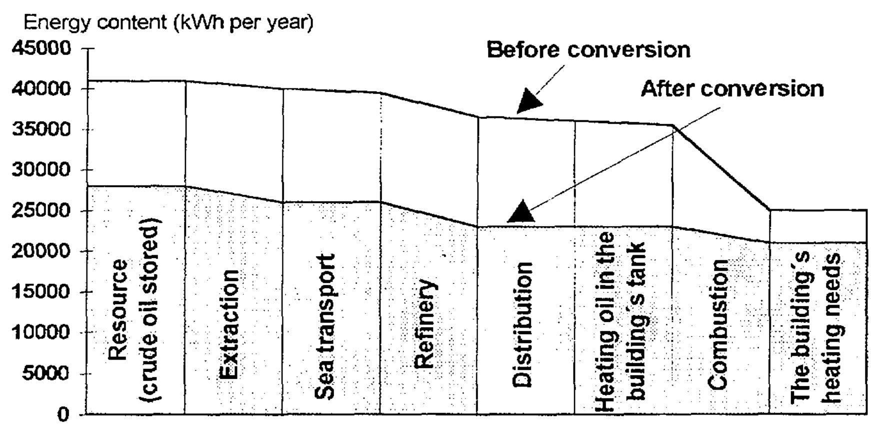
The crude oil is processed at the refinery and it costs some energy to produce gas oil. 9% of the oil's energy content is required to produce the quality used in Sweden. It is a paradox that some 4% of this amount is consumed in producing the low-sulphur oil used in this country. Thus emissions of carbon-dioxide (CO_2) and nitrogen increase as a result of removing the sulphur. Less than 1% of the energy content is used up in distributing the oil from the refinery to the consumer.

Thus almost 14% of the energy content disappears before the end user starts to burn it. The corresponding figure for propane gas is 16% and natural gas 14%.

Figure 1 shows the example converted to a single-family house with an annual heating requirement of 25,000 kWh, including hot water.

Fig. 1: Energy losses for an oil-heated building from the 1960s, before and after modernising its energy system.

Prior to the modernisation, the house has a total annual energy requirement for heating and hot water of 25,000 kWh. The heat is produced by a boiler with an annual average efficiency of 70%. The crude oil consumed has an energy content of a little more than 40,000 kWh. This means that more than 15,000 kWh, or 40%, disappears to no avail. The lower curve shows the situation after the modernisation involving the installation of a pulsation oil-fired boiler with an annual average efficiency of 90% and a 15% increase in efficiency in the use of energy. The result is that extraction can be reduced by more than a third. Emissions into the atmosphere of carbon dioxide, sulphur, nitrogen oxides and dust are cut to a corresponding extent.



2. ENERGY LOSSES FOR BIOFUELS

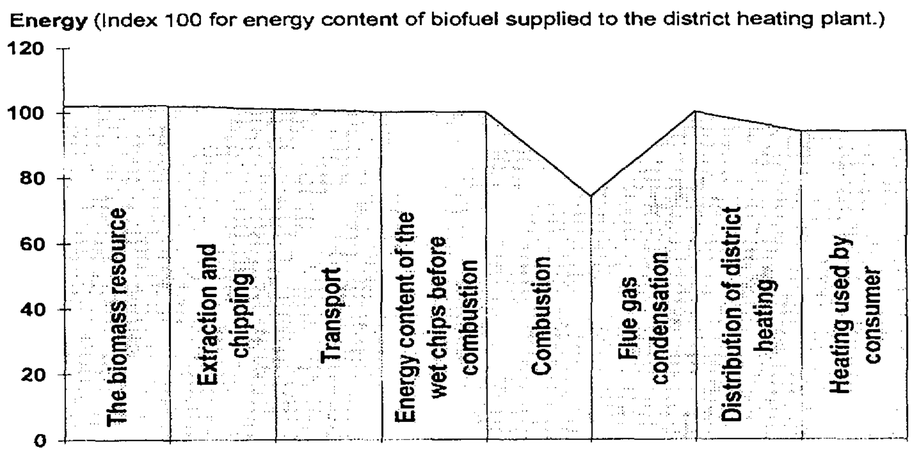
Extracting, storing, processing and transporting of indigenous renewable fuels also cost energy. Certain quantities of fossil energy and electricity are also consumed in using renewable fuels for heating. Production and transport etc. of wood pellets, for instance, requires the equivalent of 10-15% of their energy content and this amount is usually fossil energy or electricity. If wood chips (wet chips) are used directly for heating with no preliminary processing and drying, the addition for collection and transport is only 4%.

Wood-fired domestic boilers, or use of wood chips in bigger plants, requires transportation to the boiler, but it is interesting to note that the energy losses due to transport are low, in the case of firewood about 2% of its energy content. Extraction and processing losses for firewood and chips also amount to only a few percent. Thus the energy losses on the firewood's or chips' way from extraction to combustion are small, approximately 3-4%, compared to oil or natural gas, where they are some 14%, see Figure 2.

Fig. 2: Energy efficiency in modern heat production using biofuel in district heating.

Biofuel (wet chips) is extracted, processed and transported about 300 km to a district heating plant, where its energy is converted to hot water, which finally reaches the consumer as heating in a district network. Greater efficiency is achieved by installing a flue-gas condensing plant, making the total efficiency of the plant's combustion 100%. The district heating plant also has an accumulator tank, reducing the plant's power requirement as well as the need for peak-load energy. The energy content of the biofuel just before combustion has been given the index number 100.

Total energy loss (mostly as fossil energy) in extracting biomass for chipping and in transport to the district heating plant, is 4% of the energy content. The loss in distributing the heating in the network from plant to consumer is 6%. Total energy loss during conversion from biomass extraction to the energy reaching the consumer as heating is only 10%.



3. ELECTRICITY AND ENERGY EFFICIENCY

There are energy losses in producing and distributing electricity. Production losses in the existing, fossil-fired condensing power stations are exceedingly large, about 60%. The loss in the Swedish national grid alone is about 7.5%. If all losses are included, only 25% of the energy content will reach the consumer as electricity. As a ratio it can be anticipated that coal-fired condensing power emits 1 kg of CO_2 for each kWh of electricity used by the consumer. To this the methane emission from coal extraction and storing should be added (1 kg of methane as a greenhouse gas is equal to 25 kgs of CO_2).

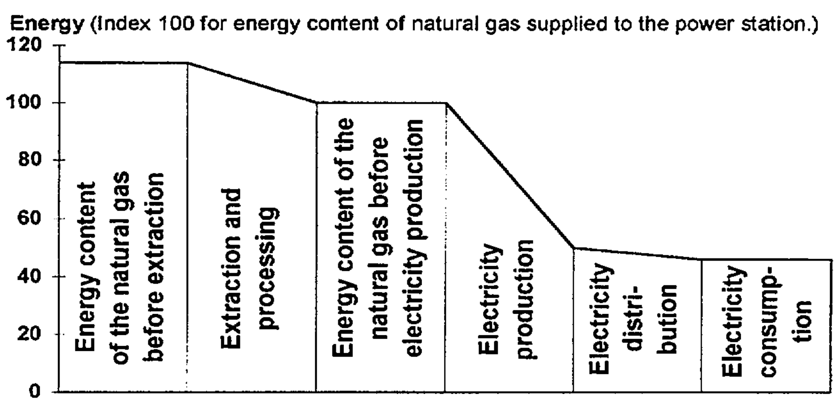
Energy efficiency has increased in recent years in the combined-cycle process using natural gas. The annual efficiency ratio for this completely new type of production is 50-60%, which means that the production loss is 40-50%.

Energy is also required for extraction, processing and transportation of fossil fuels. The energy loss in this case can be 10-15%. When for instance coal is used for the production of electricity in a condensing power station, only 25-30% of the total energy will reach the consumer as electricity. The remaining part of the energy, i.e. 70-75%, will disappear and be of no use.

Figure 3 shows energy efficiency throughout the chain from the extraction of natural gas to the production of electricity in a modern combined-cycle plant fired by natural gas, and in power transmission to the consumer.

Fig. 3: Energy efficiency in producing electricity in a modern combined-cycle plant fired by natural gas.

The energy content of the natural gas just prior to electricity production has been given an index number of 100. Less than 40% of the gas's original energy content reaches the consumer as electricity. The efficiency level of the production plant is 50%. In a plant with 60% efficiency, total efficiency is improved to a corresponding extent.



Combined heat and power production is considerably more energy efficient. The loss in producing both electricity and heating is only 10-15%. From the efficiency and environmental points of view it is preferable to produce combined heat and power to generate only electricity in a condensing plant.

4. FUNCTIONAL REQUIREMENTS FOR ENERGY EFFICIENCY

Energy efficiency, technology procurement and functional requirements are key words in the programme for a more efficient use of energy adopted by the Swedish Riksdag. The programme is administered by a department at STEM. It stimulates efficiency and a large number of concrete projects are being carried out. The experience of technology procurement has been very positive. The result is that a new energy-efficient technology has been introduced to the market in a number of fields, such as fridge-freezers, lighting, computers, electric vehicles, ventilation systems, windows and heat pumps. Examples of functional requirements for an energy-efficient technology drawn up by STEM are given below. They can be used in buying products and for entire contracts by tender.

Fig. 4: Examples of functional requirements for energy-efficient technology

Functional requirements, energy-efficient technology, examples Recommendations from STEM, the Swedish National Energy Administration		
White goods (ELOFF requirements)	Washing machine	0.3 kWh/kg, 60+40 0C
	Tumble dryer	0.7 kWh/kg
	Dishwasher	1.2 kWh/wash
	Fridge-freezer	0.8-1.0 kWh/l and year

5. ENERGY QUALITY

So far in this paper we have discussed energy efficiency. It is also important to emphasise quality. One dimension of quality is whether or not a source of energy is renewable.

Among the renewable sources are: water power, wind power, solar energy and all kinds of bioenergy. Examples of bioenergy are forest fuel, wood, wood pellets, liquors, straw, energy forests, energy grass, energy crops, digester gas, biogas and landfill gas. Waste matter (sorted fuel fraction) can also be categorised as bioenergy. All these systems do not contribute to the net increase of CO_2.

Among non-renewable sources are: natural gas, coal and all mineral oil products such as domestic fuel oil, liquefied petroleum gas and petrol, as well as uranium.

Even if the use of renewable sources such as bioenergy, wind power and solar energy is greatly increasing (and water power marginally so), it is not sufficient to cover the requirements. We are thus in a situation in which it is not possible for everyone to choose and use energy from environment-friendly, renewable sources.

In general, lower primary-energy requirements reduce the need to expand energy production plants and thus result in fewer conflicts with the nature and the environment. Renewable sources of energy also give rise to pollution and should be used in the most efficient manner. Only solar and wind energy do not pollute the atmosphere.

Another dimension of energy quality is what it can be used for. The first law of thermodynamics deals with the amount of energy in the world. It is constant. Energy is not created, nor does it disappear when “used”. Coal can be converted into steam, or oil into household heating, but all that happens to the energy is that it changes from one form to another. But everyday language is not so incorrect, for there really is something that disappears when you heat your house; you cannot get the oil back.

Thus something happens when you "use" energy, even if the first law of thermodynamics says the world's energy is constant and impossible to consume. Energy can be used for something and that is what the second law of thermodynamics deals with. Energy exists in many forms and even if the quantity is constant, the forms are not absolutely equal. Some can be used to carry out types of work. Electrical energy is the most useful. Therefore, electricity should not, as the principal rule, be used for heating, or as process energy.

The second law of thermodynamics describes the situation very precisely: Each time we convert energy, it is less accessible and less usable. We cannot get as much from it. And progression is always in the same direction. Every conversion makes the energy less accessible than before.

6. SYSTEM EXAMPLES

In practice, CO_2-emissions cannot be reduced by purification. But, by thinking in terms of energy-system changes, effective CO_2-reductions can be achieved. Here are some examples.

Measure — **Players (examples)**

Reduce carbon dioxide by changing fuel

There are no technical methods of separating carbon dioxide which are financially within reason. On the other hand, a tax on carbon dioxide has been introduced to influence the choice of fuel. Different fuels give different carbon dioxide emissions.

Coal	91 g/MJ	LPG	65 g/MJ
Oil	76 g/MJ	Natural gas	56 g/MJ

Biofuels are renewable and do not affect the carbon dioxide content when burnt if there is a balance between felling and new plantation. Changing fuel can also reduce emissions of sulphur and nitrogen oxides.

Players (examples):
Municipalities
Energy companies
Property managers
Industrial companies

Waste can replace fossil fuels and reduce CO_2

First and foremost, waste should be recovered and recycled. There should be less of it and the waste that nevertheless arises, should be treated properly. By sorting waste from households, industry and building sites at source, a fuel fraction is obtained that can be used in energy production to the advantage of the environment. Waste can replace fossil fuels. With the current purification technology, burning waste does not pollute more than other fuel. It requires heavy investment and must be done in large plants. A fuel fraction contains mainly biomass and is therefore largely renewable energy. By not depositing, CO_2-emissions are reduced and methane emissions are cut down.

Players (examples):
Municipalities
Waste-management companies
Energy companies
Industrial and construction companies and other suppliers of sorted waste

Measure	Players (examples)
Use methane from existing landfill sites	
Landfill gas consists largely of methane and is formed in the decomposition of organic material. Methane contributes to the greenhouse effect. If possible, it should be used to produce energy, or otherwise flared. The occurrence of landfill gas is the main cause of fires which sometimes break out at landfill sites, even ones that are well looked after. Emissions of air pollutants, including dioxin, from such fires are massive. The gas can be used to produce electricity and heat.	Municipalities Energy companies
District cooling replaces expensive electricity	
Cold water, e.g. from lakes can be led into the district-heating network to cool offices, shopping centres and industrial premises. It can replace large quantities of electricity that are otherwise required for normal cooling with compressors. District cooling eliminates harmful emissions, including carbon dioxide.	Energy companies Property managers e.g. in the service sector
Greater energy efficiency in offices	
As in schools and hospitals, energy used for ventilation and lighting can be reduced. A further reduction is to be had from low-consumption office machines. There are computers, printers and photocopiers which consume little energy, e.g. by switching to stand-by when not used for a while. Note that a modern office building has a heat surplus for 8–10 months of the year. More efficient use of electricity can also reduce any bill for cooling, while having a beneficial effect on the environment as well.	Property managers Municipalities Purchasers of equipment

7. EMISSION OF CO_2 IN DIFFERENT ENERGY SYSTEMS

We have had frequent requests for tables comparing CO_2-emissions in different forms of energy production. Such information is given in Table 1.

To make a clear comparison between different heating systems, all CO_2-emissions are based on the same energy requirement, 25,000 kWh/year, which can symbolise an average value for heating and hot water in an older single-family house. The emissions also include CO_2-emissions from energy production, transport, distribution, etc.

Table 1:

	Alternatives see the standardised description below	Carbon dioxide tonne/year
District heating	1. 90% chips/10% oil 2. 90% waste/10% oil	1* 3*
Central oil-fired boiler	3. 100% heavy fuel oil 4. 100% gas oil	10 10
Individual oil-fired boiler	5. New 6. Average existing	10 11
Individual gas-fired boiler	7. New 8. Average existing	6 7
Individual wood-fired boiler	9. New	1/2*
Individual pellet-fired boiler	10. New	1
Electricity production	11. Existing coal cond. 12. New coal cond. 13. New gas combi 14. New bio combi	20 20 12 1*

*Carbon dioxide emissions from burning biofuels are part of the natural ecological cycle.