

# The Danish Society of Engineers' Energy Plan 2030

SUMMARY

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## Preface

### Denmark has a renewable future

The Danish Society of Engineers' (IDA) Energy Plan 2030 gives reasons to believe that with due care and careful planning, it is possible to create a future with sustainable energy. A future in which it is worth investing, in more than one sense. In addition to very positive economic and environmental incentives, the plan's perspective is based on a continuous increase in the exports of efficient and renewable Danish energy technologies.

I consider it important and extremely positive that Prime Minister Anders Fogh Rasmussen in the autumn of 2006 presented a sharp energy policy agenda which states that Denmark shall keep its leadership position in the energy area and that oil, natural gas and coal shall eventually be phased out in order to create a sustainable energy system.

A restructuring of the energy system, however, will not take place of its own accord. The Energy Plan 2030 contains 11 vital recommendations for Danish energy policy that must be implemented if the visions presented in the plan are to be realized. Primarily, this implementation demands political will and determined decision-making. The report's most important conclusion is that the development of a renewable energy system is both technologically and economically favourable. But this development requires political will and a marked change in the course of energy policy, which can hopefully be cemented by approving the coming energy plan of action.

I hope that the government and the opposition parties will be inspired by the Energy Plan 2030 and its recommendations. Denmark, as one of the richest countries in the world with a leading position in the area of efficient and renewable energy technologies, has an obligation to show that economic growth can go hand in hand with a sustainable development.

The basis of the plan was formed through 2006 at about 40 conferences and meetings in which more than 1600 engineers and other professionals participated. Of course, a great effort was made before, during and after the many conferences.

I would like to express my heartfelt thanks to the technical associations and groups within the Danish Society of Engineers who have taken part in the work on the plan. I also wish to thank the many members and partners that have participated in the Energy Year 2006 and contributed to our knowledge and visions. Their professional input and engagement has made it possible for the Danish Society of Engineers to present a substantial and professional input to the debate on energy policy.

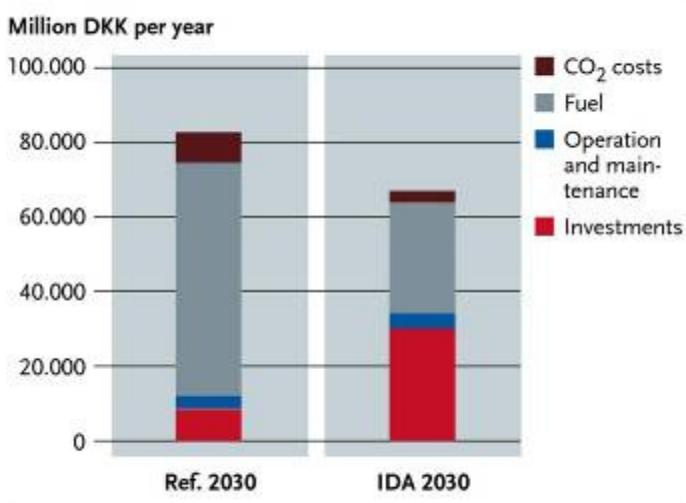
A special thanks is directed to the Energy Year's steering group and its chairman, Søren Skibstrup Eriksen, and to Professor Henrik Lund and PhD student Brian Vad Mathiesen from Aalborg University, who have contributed with a comprehensive analysis to the Energy Plan 2030.

Lars Bytoft  
Chairman, The Danish Society of Engineers (IDA)

# Summary: The Danish Society of Engineers' Energy Plan 2030

The visions of the Danish Society of Engineers' (IDA) Energy Plan 2030 present a picture of a Danish energy future of 2030 that is well on its way to a 100 per cent renewable energy system.<sup>1</sup> The Energy Plan 2030 shows that it is technically and economically possible to restructure the Danish energy system. Greenhouse gas emissions can be reduced by 60 per cent in 2030 compared to 1990, and the consumption of fossil fuels can be markedly reduced in such a way that Denmark's net self-sufficiency can be maintained.

## Economic costs



**Figure 1:** The bars illustrate the economic costs related to Denmark's energy consumption and production, in the reference<sup>1</sup> and in the Danish Society of Engineers' (IDA) Energy Plan 2030.

system in which the need for and the expenses of fossil fuels are minimized.

## Energy savings as the focal point of Energy Plan 2030

The focal point of the Energy Plan 2030 is the achievement of marked energy savings and energy efficiency in buildings, industry, and transportation. The plan proposes that Denmark's total energy needs are reduced from 845 PJ<sup>2</sup> in 2005 to about 580 PJ in 2030. This means a reduction of about 30 per cent. According to the plan, almost half of the Danish energy needs in 2030 will be based on renewable energy sources (see figure 2).

Increased energy efficiency and savings are extremely beneficial for the economy of the country, as stated in the Energy Plan 2030. With this plan, society achieves a sound environment and the optimum supply security for the money spent. Especially, large economic benefits can be gained by improving energy efficiency and savings within industry, business, and transportation.

As shown in figure 1, large economic benefits can be achieved by implementing the Energy Plan 2030. Economic calculations show that more than DKK 15 billion can be saved annually, if the changes proposed in the plan are carried out.

A quantification of the Danish business potential also shows that the realization of the Energy Plan 2030 and its recommendations can increase the exports of energy technologies from the present DKK 30 billion annually to more than DKK 160 billion in 2030.

The Energy Plan 2030 reflects a new energy policy strategy. Through strong investments society can develop an energy

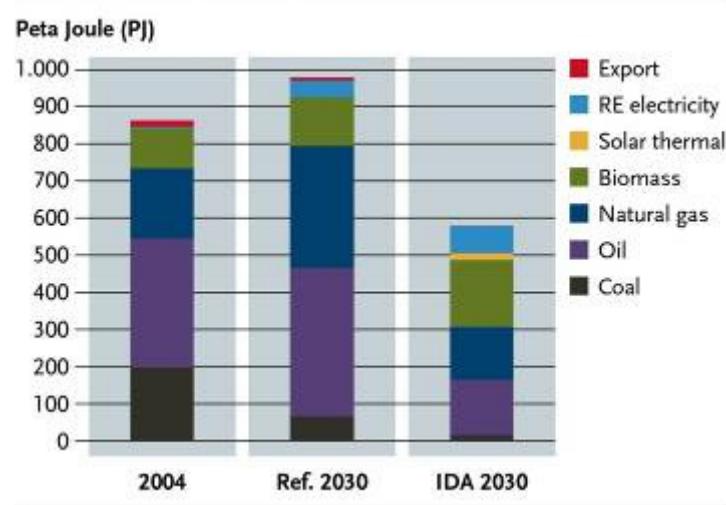
<sup>1</sup> Reference 2030 is identical with a business as usual scenario for the development of the Danish energy system. See "Baggrundsrapport (Background report): The Danish Society of Engineers' Energy Plan 2030".

<sup>2</sup> Peta Joule.

## Great efficiency potentials in industry

According to the Energy Plan 2030, energy savings within industry and business will make a significant contribution to the reduction of Danish CO<sub>2</sub> emissions.

### Primary energy supply



**Figure 2:** The bars illustrate the size of Denmark's primary energy supply, according to energy sources in 2004, in the reference and in the Danish Society of Engineers' Energy Plan 2030.

Enterprises have not achieved such savings earlier, mainly due to the fact that investments in energy savings compete with other strategic investments of high priority to the enterprises.

It is thus crucial that initiatives are taken in supporting the enterprises' motivation to initiate improved energy efficiency and savings. For this purpose, it is proposed, among other initiatives, to establish an industrial savings fund.

### Energy savings and integration of renewable energy in buildings

In the Energy Plan 2030, energy consumption for the heating of buildings is reduced by 50 per cent by 2030; 15 per cent of the heating consumption is based on solar energy; and electricity consumption is reduced by 40 per cent.

Since buildings comprise the area with the highest energy consumption, savings within this area will also have a marked effect on both CO<sub>2</sub> emissions and the security of supply.

In the existing stock of housing, which also in 2030 will constitute most of the housing and the largest share of energy consumption, the proposed energy savings could be implemented in connection with on-going renovations, by which costs can be minimized.

With a long-term perspective on Denmark's energy situation – and since most buildings can be expected to subsist for 50 years or more – buildings which are built after 2020 are assumed to be energy neutral. It is estimated that this can be accomplished at marginal additional costs. It is also proposed that solar heat systems and building-integrated solar cells should cover electricity and heating consumption.

The Energy Plan 2030 proposes that fuel consumption in industry and business is reduced by 30 per cent and electricity consumption is stabilized. The result would be annual economic savings of more than 6 billion in 2030. By implementing radical energy savings in at the offshore plant in the North Sea, increases in CO<sub>2</sub> emissions from this source could be kept below 30 per cent.

Energy savings in industry constitute a significant economic benefit, since they can be effectuated with very short payback time. It is estimated that the goals of the Energy Plan 2030 can be financed by investments in energy initiatives, which can be repaid by the individual enterprise within 6-7 years.

In order to encourage energy savings in buildings, a heating savings fund should be established with the aim of promoting energy savings.

The Energy Plan 2030 recommends that further research and development are carried out, and that low-energy concepts are demonstrated in interaction with indoor climate and architecture. If the energy savings set forth in the plan are to be implemented successfully, consumers' support is essential, and it is of crucial importance that the renovated housing and new construction of low-energy consumption make up healthy and attractive homes.

### **Transportation – an area requiring action**

Transportation is a constant source of problems in energy policy. While energy consumption in general is stable, the energy consumption of the transport sector is steadily increasing – in 2005 by 2.3 per cent. The energy consumption for transportation is mostly based on oil, and if no decisive action is taken at this point, the transportation sector will undermine Denmark's attempts to reduce CO<sub>2</sub> emissions and maintain the security of supply.

In the Energy Plan 2030, the energy consumption for transportation is reduced by about 20 per cent compared to today. 20 per cent of the fuel consumption is substituted by biofuels, and 20 per cent of all cars are electric powered vehicles. Reductions in the energy consumption for transportation can be accomplished by stabilizing the transportation of persons at the level we have today. This can be done by transferring a share of road transport to rail transport and by enhancing the efficiency of the car population.

The Energy Plan 2030 proposes that the vehicle registration fee is changed immediately in order to promote the introduction of energy-efficient cars. Eventually, registration fees should be phased out and replaced by mileage tax in order to tax the use of the car rather than the purchase.

One of the most efficient ways of further reducing energy consumption for transportation is by replacing a share of the road transport by rail transport, which would also contribute to less road congestion and thus an improved mobility. This applies to the transport of both person and goods.

The plan proposes a marked expansion of rail transport through a massive improvement of the existing railways, the development of high-speed trains between the large cities and light rails in the largest Danish cities. If the transfer of passengers to collective transportation is to succeed, rail transport must become an attractive alternative to private cars.

Even though it would be necessary to make large investments in public transport, economic benefits could be achieved. In the capital alone, the annual costs of road congestion is almost DKK 6 billion already today – costs which are primarily paid by the business community. To this saving should be added the saved costs for fuels.

In order to ensure the stabilisation of person transport, urban and national planning must be improved. Among other improvements, housing, businesses and shops should be placed within the same area, just as new housing areas should be accessible through public transport. It is also important to create better conditions for bicycles in cities and suburbs.

## **Electricity produced by sun, wind and waves**

Wind turbines have been Denmark's great export adventure. Denmark's leading position is threatened, however, since the domestic market has stagnated completely. Therefore, the Energy Plan 2030 proposes that motivations are re-established for expanding the use of wind turbines in Denmark. For example, a national plan directive should be made as soon as possible to expand the use of wind turbines, and tenders should be invited to build offshore wind farms.

In the Energy Plan 2030, most Danish electricity consumption is based on sun, wind, and waves. The plan proposes that the amount of electricity produced by wind turbines is doubled in 2030 compared to today, in order to cover 55-60 per cent of Danish electricity consumption. Building-integrated solar cells will cover 2 per cent of the electricity consumption, and with the right motivation, it is expected that wave power can be developed and expanded to cover 5 per cent of the electricity consumption in 2030.

The energy potential of waves is significant, but a considerable effort must be put into developing the technology. Denmark should support this new renewable energy technology through development funds, and prerequisites should be created as those which previously paved the way for the wind turbine adventure. For instance, so-called innovation quotas could be supplied to provide opportunities for technically well-functioning wave power technologies to compete with each other, even though they are not yet able to compete on the energy market as such.

## **Biomass and biofuels**

The Energy Plan 2030 proposes that up to about 30 per cent of the primary energy consumption is covered by biomass. This includes 20 per cent of road transport, which uses liquid biofuels. A widespread use of biomass for energy production is necessary in order to reduce the consumption of coal, oil and gas, and to reduce CO<sub>2</sub> emissions.

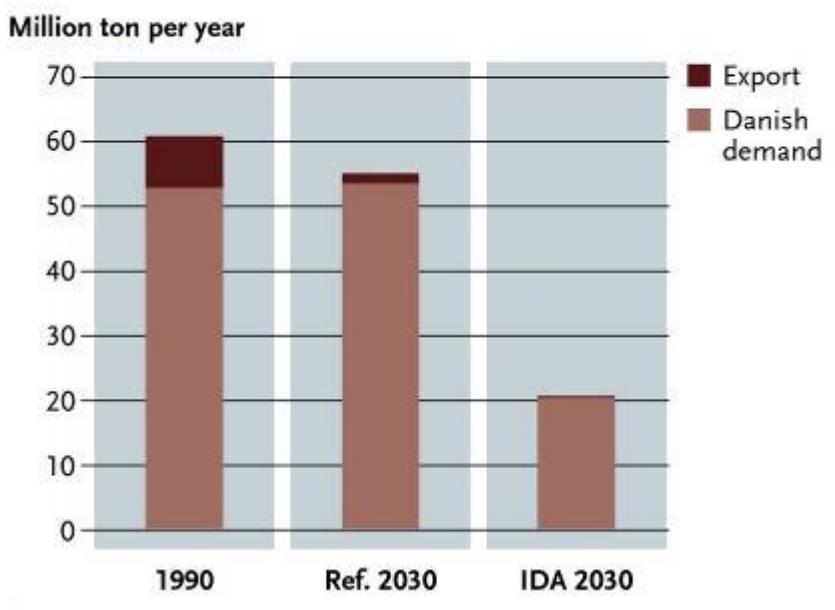
Denmark has good experiences of using biomass in energy production. However, further opportunities can be found to expand the total biomass resource and use it in a more efficient way. The Energy Plan 2030 proposes that a minor share of arable land is re-directed to the cultivation of energy crops without reducing the agricultural production.

The energy potential of biogas is great and a better utilization of liquid manure should be achieved. However, this requires the re-introduction of a payment for electricity produced on biogas, which counterbalances the benefits society achieves by utilizing liquid manure for energy production.

This sector has a great business potential. Internationally, Denmark is a leader in the research and development of equipment for the production of second generation biofuels for transportation. The annual export potential of the biofuel production equipment is estimated to be almost DKK 20 billion in 2030.

## **Coal, oil and gas consumption reduced by half – CO<sub>2</sub> emissions reduced by 60 per cent**

### **CO<sub>2</sub> emissions**



**Figure 3:** The Danish CO<sub>2</sub> emissions after the implementation of the Energy Plan 2030.

In the Energy Plan 2030, the amount of fossil fuels in the energy system is reduced by 60 per cent, which means that Denmark can expect to preserve its net self-sufficiency in oil and gas in 2030. The reductions constitute an important step on the way towards a 100 per cent renewable energy system.

Reductions in fossil fuels and a more efficient energy system will also contribute to a reduction of the Danish CO<sub>2</sub> emissions to one-third of the emissions in 1990.

### **A flexible energy system with high efficiency**

The Energy Plan 2030 includes all energy-consuming and energy-producing units in one coherent system, in which electricity and heating are constantly negotiated in an electronic market place. If the plan is realized, the energy system in 2030 can no longer be divided into heating, electricity and transport sectors. The different energy systems are completely connected in one energy system which is far more flexible than the one we know today.

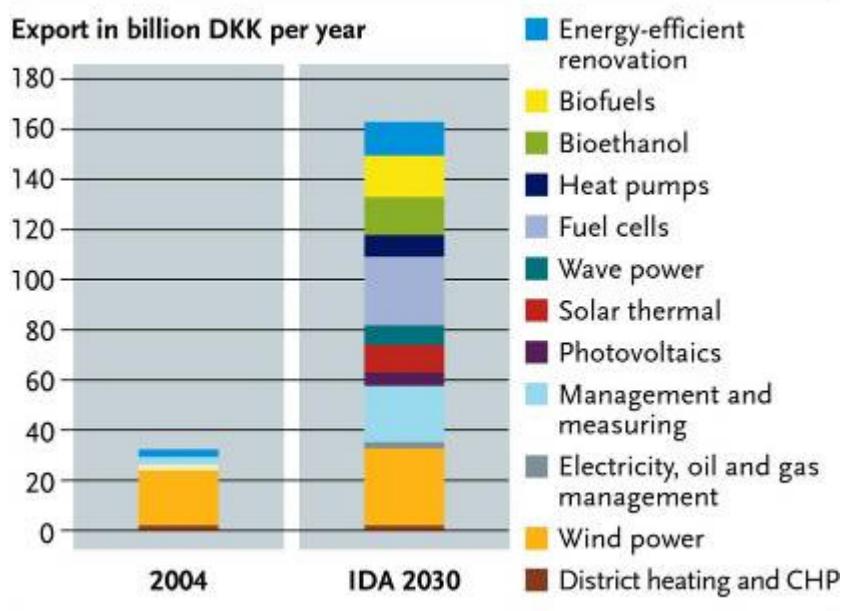
The energy system in Energy Plan 2030 is based on several technologies which contribute to the system's regulatory capacity and efficiency. A comprehensive expansion of the use of heat pumps has taken place. This contributes to the creation of a flexible electricity consumption, which results in a marked reduction of CO<sub>2</sub> emissions. One third of all centralised and decentralised heat and power plants are based on high-efficiency fuel cells, and district heating systems are continuously adjusted to lower heat consumption.

Fuel cells have an important business potential. The export of fuel cells can potentially reach DKK 20 billion in 2030 and will thus approach the experience of the wind turbine adventure. Within the district heating area, Denmark will also continue to have good export potentials.

## Immense business potential

A long-term, ambitious effort in the energy area and a systematic focus on the development of the technologies discussed in the Energy Plan 2030 will significantly increase the possibilities of exporting Danish energy technologies. It is estimated that a realization of the Energy Plan 2030 and its recommendations will increase the export potential of energy technologies from the present more than DKK 30 billion annually to more than DKK 160 billion annually in 2030.

### Business potential



**Figure 4:** Business potential in The Danish Society of Engineers' Energy Plan 2030, calculated as expected exports in 2030.

30 years of focus on efficient energy systems, energy savings and renewable energy has provided Denmark with a unique basis for further development of our position in the energy area. From 1996 to 2004 alone, Danish exports of energy technology and consultancy services were doubled. The Danish competences in the energy area belong to areas which will be increasingly in demand in the international community in the future – as oil and gas production decrease and climate problems increase.

## THE DANISH SOCIETY OF ENGINEERS' ENERGY PLAN 2030

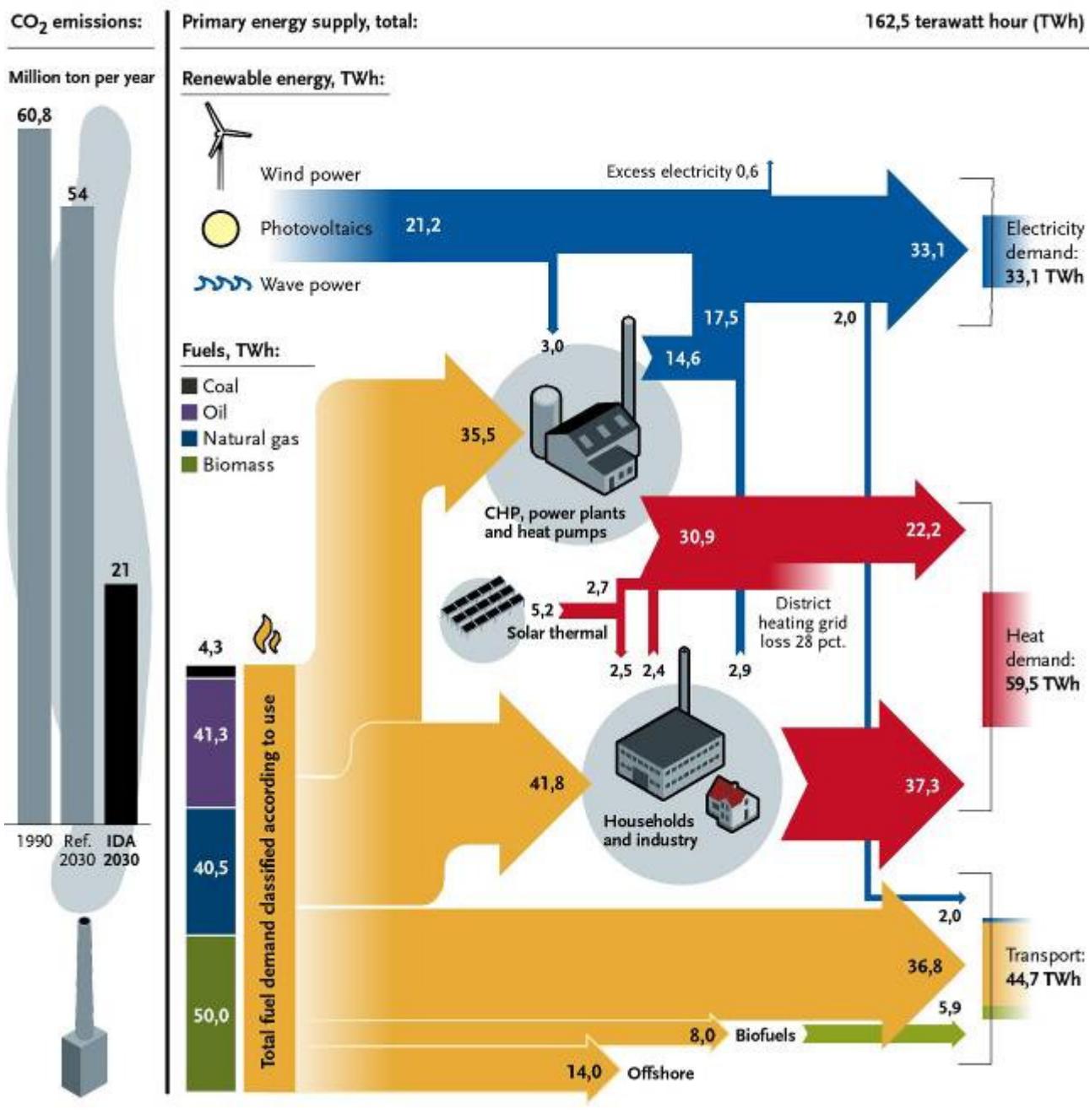
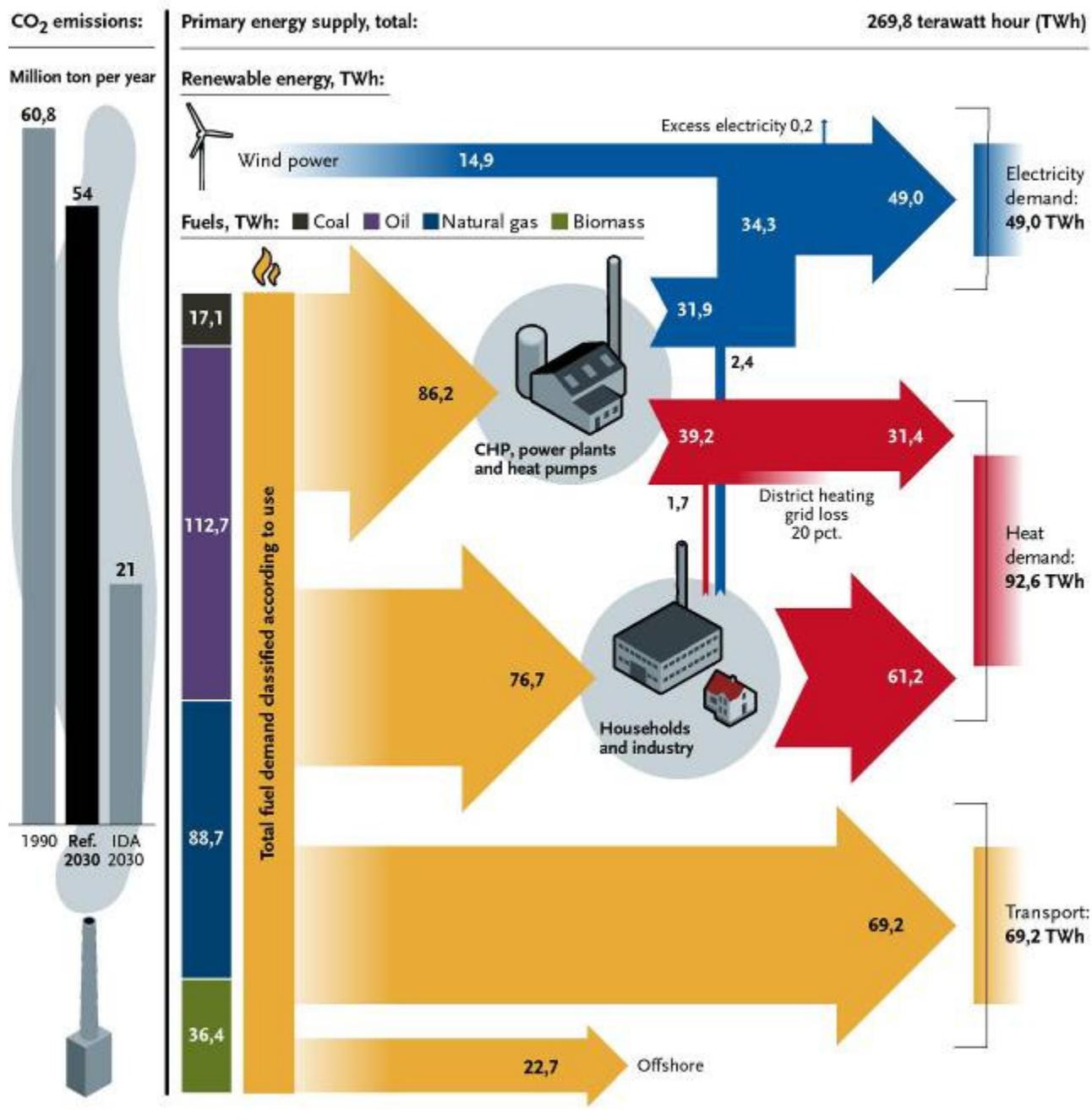


Figure 5: Energy flow in the Danish Society of Engineers' Energy Plan 2030

## DANISH REFERENCE 2030



**Figure 6:** Energy flow in the reference for 2030. Reference 2030 is identical with a business as usual scenario for the development of the Danish energy system.

# **11 central recommendations**

The following 11 recommendations are of central importance to the realisation of the Danish Society of Engineers' Energy Plan 2030 with the expected benefits in mind. These benefits include CO<sub>2</sub> reductions, improved security of supply, and economic savings. The recommendations are also crucial to the realisation of the significant business potential which is inherent in the plan.

## **1. Extension of the agreement on energy savings until 2030**

The agreement on energy savings, which proposes annual savings of 1.7 per cent of energy consumption by 2013, should be extended until and including 2030. Energy savings are alpha and omega in the cost-effective solution of future energy challenges.

The agreement should be broadened to include all energy-consuming sectors, including the transport sector, industry, and oil and gas production in the North Sea.

## **2. Establishment of an industry savings fund**

Great national economic benefits can be gained by reducing industry's energy consumption. Therefore, special focus should be directed to this area. Subsidies for energy savings are necessary, as well as the development of energy-saving solutions which are adapted to the individual enterprise's needs and the production plant's characteristics.

The Energy plan 2030 recommends that an industry savings fund is established with the aim of promoting and subsidising energy-saving measures in production firms. The fund should promote the spread of energy labelling and information on energy-efficient solutions. The fund should have an independent organisation similar to that of the Electricity Conservation Fund, which permits the autonomous cooperation with industrial firms.

The annual budget of the funds should be DKK 800 million.

## **3. Establishment of a heat conservation fund**

The existing housing stock has a great savings potential, but a central authority is needed which can realise this potential.

Therefore, a heat conservation fund should be established similar to the Electricity Conservation Fund. The aim is to promote energy conservation in buildings through information, campaigns and co-financing of energy savings. The heat conservation fund should give priority to the economic and environmentally most beneficial energy savings, which means that renovation of buildings outside the district heating system should have highest priority.

A heat conservation fund should have an annual budget of DKK 1 billion. In addition, it is proposed that the Electricity Conservation Fund's annual budget is increased by DKK 210 million, reaching an annual budget of DKK 300 million.

#### **4. Invest DKK 200 billion in public rail transport over the next 30 years**

It is crucial that the collective rail transport is improved with the aim of reducing energy consumption for transportation. The improvement of rail transport will also contribute to increasing mobility.

Therefore, a long-term plan should be made for the next 30 years which includes investments of DKK 200 billion in the improvement of the existing railway system, upgrading of the main railways to high-speed trains, improved transport of goods, implementation of light trains in the large cities, as well as the electrification of the rail transport's primary network and expansion of the Metro in Copenhagen.

Investments have a significant mobility effect, and these extensive investments should be seen in relation to the fact that the business community already today, in Copenhagen alone, has additional costs of almost DKK 6 billion annually as a result of traffic congestion. Seen in the light of the benefits of moving a share of the transportation from roads to rails – through which more than DKK 4 million extra can be saved annually – it would benefit the national economy to implement such investments.

#### **5. One billion DKK for research, development and demonstration**

Funds for research, development and demonstration in the area of energy should be increased from the present about DKK 350 million annually to at least DKK 1 billion annually. This is crucial in order to realise the energy area's great business potential. The funds should be earmarked for energy-saving and renewable energy technologies and include the following areas: low-energy buildings and indoor climate, second generation biofuels, fuel cells, wave energy equipment, and second and third generation solar cells.

#### **6. Innovation markets – a greenhouse for market maturation of new technologies**

It is of crucial importance to create development conditions which ensure that new technologies achieve market maturity at a stage at which they function technically but cannot yet compete under the existing market conditions. An effective means to this end is to establish innovation markets, where production quotas are offered annually within relevant technologies and at a fixed price which is adjusted to the technologies' actual stage of development.

It is proposed that a plan of action for establishing innovation markets is prepared and implemented as soon as possible for efficient and renewable energy technologies such as offshore wind farms, wave power, solar cells, fuel cells, and second generation biofuel technologies.

#### **7. Pollution costs etc. should be included in market prices through fixed prices (feed-in tariffs) for renewable energy (RE)**

"The polluter pays" principle should be applied to energy markets. Technologies that have achieved market maturity, such as wind energy, solar energy and biogas should be favoured in contrast to polluting fossil fuel-based technologies. Conditions should be established that make the investment in new renewable energy technologies less risky. Insecurity concerning prices has for example caused the complete stagnation of the development of land turbines and biogas plants.

Fixed prices (feed-in tariffs) for new technologies that have achieved market maturity should be introduced in order to support the distribution of these technologies.

## **8. Vitamin shots for popular engagement and co-ownership**

The implementation of the Energy Plan 2030 will only be possible with popular support, engagement and co-ownership. Many investments in energy savings, as well as in solar heating and solar cell installations, must be made by private households and firms. Therefore, the plan requires political support and acceptance of wind turbines and biogas plants in local areas.

Based on successful experiences with local co-ownership of wind turbines and other energy installations, organisational and ownership forms should be developed in such way that ordinary citizens, under secure financial conditions, can become co-owners of Danish renewable energy plants. This can be accomplished with inspiration from the old wind turbine guild arrangement, but should also include new forms.

## **9. Denmark should support the auctioning off of CO<sub>2</sub> quotas**

The distribution of free CO<sub>2</sub> quotas conflicts with the "polluter pays" principle. Such distribution adds indirectly to the capital of fossil-based energy production and therefore contributes to maintaining this form of production.

Denmark should choose to auction off the 10 per cent of CO<sub>2</sub> quotas allowed by the EU. At the same time, Denmark should work for an EU agreement which states that in the future, CO<sub>2</sub> quotas should not be distributed free of charge, but should be sold at auction.

Investments in energy production extend far into the future. It is therefore important that energy firms already know what the general conditions are for future production, also after 2012. Denmark should therefore work towards an EU agreement which defines binding goals for future climate efforts and announces CO<sub>2</sub> quotas for the years after 2012. Denmark should also support the inclusion of international shipping and air traffic in the CO<sub>2</sub> quota system.

## **10. Service control of the energy area's whole tax and tariff system**

At present, some taxes do not function according to their intention; they are out-dated or directly support unsustainable development. For example, legislation prevents some power plants which use natural gas from shifting to environmentally beneficial fuels such as straw, wood chips or waste. This is due to the fact that legislation requires that they only use fuels which are subject to taxation – these include natural gas but not biofuels.

The restructuring of the Danish tax system for private cars – which is neutral with respect to proceeds – should be carried out as soon as possible in order to favour safe and energy-efficient cars. Within a 10-year time horizon, registration taxes should be replaced by taxes based on the distance driven.

Fuel for air travel should be taxed and/or assigned CO<sub>2</sub> quotas, which in total would compensate for the impact on the environment. The process can begin with domestic air travel.

Legislation should be enacted that will provide compensation to heat and power plants for the tax on electricity. They should receive refunds of up to 10 per cent of the electricity produced to run heat pumps for district heating.

It should be ensured that running the decentralized heat and power plants when the present life expectancy and regulations expire is worthwhile. In this connection, the plants should have free choice of fuels, so that the expansion with renewable energy from biomass can continue.

## **11. Establishing a 100 per cent renewable energy town**

The Energy Plan 2030 holds great business potential and export opportunities. If this potential is to be realised in technology development and export orders, it is necessary for Denmark to put itself on the world map with respect to renewable energy. Denmark should therefore establish a 100 per cent renewable energy town, as proposed at the Energy Camp 2006.

The goal is to create a 100 per cent RE-supplied town in Denmark that can function as Danish energy technology's exhibition window to the rest of the world. The proposal can be realised in a town with a population of 25,000. One-half to one billion DKK over 10 years should be allocated for public co-financing of such a project.<sup>3</sup>

### **Financing**

The proposed initiatives, which are focused on energy-saving efforts and the development of new renewable energy technologies, will demand an extra public financing of about DKK 2.7 billion annually. This figure does not include expenses connected with the establishment of innovation markets and "feed-in tariffs".

In addition, it is proposed that during the next 30 years, DKK 200 billion are invested in the development of rail traffic. This investment is necessary to prevent further losses as a result of problems of traffic congestion. At the same time, the investments make an important contribution to the reduction of energy consumption for transportation.

It is clear that a share of the extra proceeds from the North Sea oil should be used for financing the recommendations of the plan. Annually, the income from the North Sea contributes with more than DKK 30 billion to the Danish state treasury. The costs of investing in the railroads, implementing energy-saving initiatives, and developing new renewable energy technologies will annually amount to less than one-third of the income from the North Sea. The proceeds from the sale of CO<sub>2</sub> quotas should also be used for financing the proposed initiatives.

The Danish Society of Engineers' Energy Plan 2030 recommends that Denmark, which is at present in a historically strong position with a considerable balance of payments surplus, choose to invest offensively in the infrastructure for the future.

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<sup>3</sup> See description of the proposal in Appendix, note 3.