



Mondaymorning

**INVEST IN DENMARK
MINISTRY OF FOREIGN AFFAIRS OF DENMARK**

Eco-friendly Transport

Denmark: Key Developer of Climate Solutions



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Denmark is one of the world's most energy efficient countries – Focused strategy has created economic growth without a corresponding growth in energy consumption – Whole-hearted political endeavour, combined with a unique culture of innovation make up the backbone of the Danish energy adventure.

A nation coping with climate change

WHILE THE DANISH ECONOMY has grown by 75% over the last 25 years, energy consumption has remained constant. Since the oil crisis in the Seventies, only a very few countries have managed to erect so many wind turbines, create such an effective local heating plant network, increase industrial energy productivity and save so much household energy as Denmark. See figure 1.

Only a very few Danes are aware that they live in a country that has set world records in energy efficiency. Denmark has been able to decouple energy consumption from economic growth. Private car use and road and sea transport have never been greater, and the Danes increased desire for mobility weighs heavily in the national CO₂ accounts. Yet the truth about the Danish energy adventure is that today only a very few nations can measure up to Denmark when it comes to saving energy.

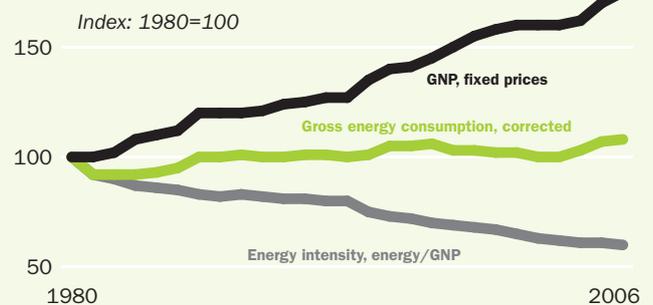
Even the Republican prepagential candidate, Senator John McCain, feels obliged to visit Vestas' factory in Colorado and sign a turbine wing, while China imports Danish pumps and looks on enviously at Denmark's efficient local heating plants. Denmark's cleantech exports are reaching new heights, leaving other Danish exports behind.

The reorganisation of Danish energy policy builds on a number of crucial strategic decisions, taken against a background of increasing global energy prices and geostrategic uncertainty about future energy supplies. Taken as a result of pressure from visionary civil servants and grassroots organisations from the middle of the Seventies onwards, they make up the foundations of a success story now resonating in more and more countries around the world.

- **NEW ENERGY BLEND.** Denmark has gradually replaced coal and oil with natural gas and much more wind power. This has reduced CO₂ emissions. Not using nuclear power has increased the need for alternative sources of energy.
- **INCREASED FOCUS ON ENERGY.** Duties and subsidies have stimulated energy savings and the application of more energy friendly technology in the industrial and private sectors.

MM | High productivity

Energy consumption, GNP and energy intensity

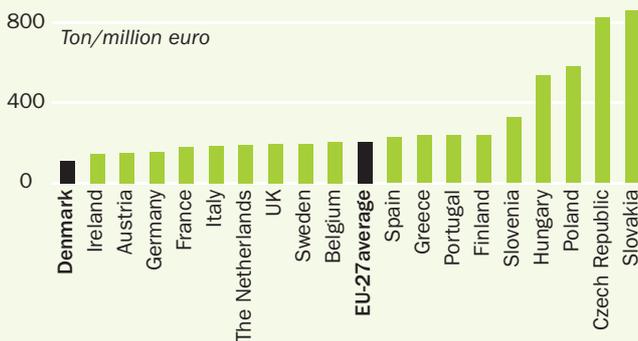


Figur 1: Since 1980, the Danish economy has increased by approx 75 per cent, while the domestic consumption of energy largely has been constant. Maersk international shipping and international air transport are not included in the account, since they are not included in the Kyoto Protocol.

Source: The Danish Ministry of Climate and Energy.

MM | Denmark as European champion

Energy intensity in selected countries



Figur 2: The energy efficiency in Denmark is the best in Europe. No other European country has as low an energy consumption compared to GNP.

Source: The Danish Ministry of Climate and Energy.

- **INFRASTRUCTURE.** The deliberate development of an efficient collective heating plant and district heating distribution network combined with a ban on electric heating has reduced wastage.
- **COMMERCIAL STRUCTURE.** The change to a more service based economy has reduced domestic energy consumption.
- **DEVELOPMENTAL INCENTIVES.** Active public support for innovative companies developing cleaner technologies.

Flexible change

The story of the nation that has made ‘Modern Energy’ its brand and its new source of income started with a jolt in October 1973. Rapidly increasing oil prices and the Yom Kippur War had created severe concerns about Danish energy supplies, where 90% of the country’s energy needs had to be met by oil.

Anker Jørgensen’s Social Democratic government panicked, introduced car free Sundays in November and asked shops to switch off lights outpage of opening hours to save on ever more expensive energy. This was just the beginning. Despite a fall in oil prices over the next few years, Denmark and a generation of politicians never got over the shock of the first international energy crisis.

Jens Kampmann, who back in 1971 was Denmark’s first environment minister and the minister responsible for taxes and excise in the Social Democratic government of 1977-78, is convinced that it was the wake up call provided by the energy crisis that paved the way for a new approach.

“Denmark began thinking in energy and environmental lines at the beginning of the Seventies – long before the majority of other countries. It was realised early on that economic means where necessary to ensure a decoupling of energy consumption. This has resulted in major win-win scenario for Denmark,” says Kampmann. Today, Denmark is number one in Europe. See figure 2.

Mette Wier, Executive Director of the Danish Institute of Governmental Research and with years of environmental economics research experience, believes that underpinning the decoupling of energy consumption and growth is the fact that Denmark is a remarkably flexible society, highly skilled in adjusting to global change. “The two major energy crises did not just change energy consumption. They also spread through an entire society’s production and consumption, making the country much more focused on energy use. Danish energy policy has always been heavily influenced by the global situation, and not least by developments in the Middle East. Changes have forced the Danish model over into a far more energy aware direction,” she explains.

Local energy heroes

Without concerted popular pressure in the land of the cooperative and 1,000 town halls to find solutions to the global challenges created by the energy crises of the Seventies, it is unlikely that renewal would have taken off. The Tvind School erected Denmark’s first wind turbine in Ulfborg on Denmark’s west coast. Popular movements featured prominently in the energy debate, gaining moral and intellectual support from the Club of Rome, which had begun to talk about “limits to growth.” The country’s most visionary business leaders were beginning to realise the value of renewal long before this became one the world’s biggest growth sectors in the 21st century.

“The heroes of the Danish energy story are the entrepreneurs of the wind turbine sector, those responsible for the partnerships between the public and private sector, the insulation advocates within the building industry and – not least – the architects of the finance ministry’s subsidy and duty package. It has created a number of unique clusters in the Danish energy world,” means Lars Goldschmidt, Executive Director of the Danish Association of Consulting Engineers, and who for a number of years has closely followed developments in the energy sector from positions at the Danish Energy Agency and Maersk Oil and Gas.

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“The market cannot cope alone, and it’s important that there are a range of incentives and regulations from the state.”

Jens Kampmann, former Minister of Energy

Generations of politicians – from Erling Jensen and Jens Kampmann through Jens Bilgrav-Nielsen and Svend Auken to Denmark’s first climate minister, Connie Hedegaard – have helped implement the many regulations, duties, subsidies, incentives and energy efficiency campaigns that have gradually changed Denmark from an energy glutton into an energy econo-

miser.

“As a result of intense political demands, we have developed a collective heating distribution network and the world’s most efficient heating plants. A major part of Denmark’s success today is a consequence of political decisions taken many years ago,” states Jens Kampmann. “The market cannot cope alone, and it’s important that there are a range of incentives and regulations from the state that can help innovation along the way.”

1976 turned out to be a key year. A new electricity distribution act was passed, the Danish Energy Agency was established, and the country’s first unified energy plan was set out. Reduced oil dependency and energy consumption were now very much top of the agenda, and Danish homeowners busily began insulating cavities and doors and putting up Hessian on the walls. The government again conpagered nuclear power, but grassroots organisations fought the plans via petitions and anti-nuclear demonstrations and by persuading researchers to develop an alternative energy plan. In 1997 parliament approved an increase in duties on electricity, and oil. More duty increases followed, designed to motivate Danes to save energy – and secure extra funds for the hard-pressed state economy.

The price shock during the second energy crisis in 1978-79 provoked yet another major shift. In 1979, parliament passed acts relating to heating and natural gas distribution, and Denmark set up its first energy ministry.

“From 1979 to 1985 major progress was made towards decoupling Denmark’s energy consumption,” says Peter Bach, Senior Consultant at the Danish Energy Agency. “During this time Denmark reduced its energy consumption by 25-30%, and this is definitely a world record of which we can be very proud. Insulation and home improvements were responsible for the first advance. Later expansion of natural gas and district heating and not least conversion to local heating plants had a major impact.

The Danish heating model

Today, the Danish energy adventure is especially associated with wind turbines. And they are also central to the acceleration that took place during the Nineties. Yet, as many of the experts contacted by Monday Morning point out, seen as a whole it is collective heating distribution that more than anything has reduced Danish energy consumption.

“District heating has been much more important for decoupling than wind power.” Local heating plant expansion increased rapidly after 1980, and today two thirds of industrial energy comes from highly-efficient collective heating systems. On this front, Denmark is way ahead of most other countries. For example, Germany has not been particularly good at building up district heating,” says Professor Mikael Skou Andersen of the University of Aarhus and recently appointed to an international expert committee set up to advise the Chinese government about developing more sustainable energy provision.

Climate minister Connie Hedegaard relates that even today, fascinated foreign ministerial delegations visit Copenhagen heating plants to see how refuse is transformed into heat.

MM | The efficiency of the industry

The gross energy intensity in production, per cent

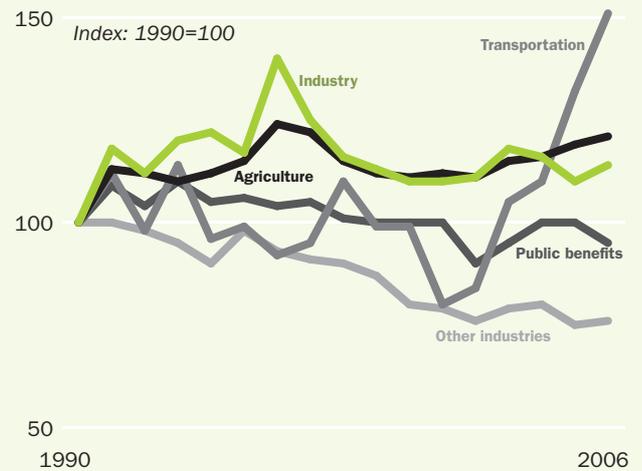


Figure 3: The service industry and the public benefits are the most important contributors to the Danish achievement of lowering energy consumption while continuing economic growth.

Note: “Industry” covers industry, energy, water supply and construction. “Other industries” covers trade, hotel and restaurant and financial services. International refueling of ships and aeroplanes operated by Denmark are included in “Transportation”, which also covers postal services.
Source: Statistics Denmark, 2008.

“Denmark is doing relatively well, with a good basic structure in place. We have a lot of district heating and decentralised heating plants, we are very energy efficient, and we have relatively little transport wastage in relation to other countries,” she says. Hedegaard acknowledges that Denmark still burns too much fossil fuel. See figure 3. Yet points to the fact that wind power now provides 17.5% of total Danish energy needs. The target is 30% sustainable energy by 2020. “We are a wind nation and world leaders in installed wind power,” says Connie Hedegaard.

The interplay between innovative companies and still more demanding energy legislation has helped ensure that Denmark’s energy consumption has not exploded in step with economic growth.

Incentives to encourage change have been regular and consistent, including subsidies to encourage the use of sustainable energy and energy savings in buildings in 1981; energy labelling legislation in 1982, and the definitive decision to drop nuclear power in 1985. “Denmark has done a number of things to keep down energy consumption that other countries can learn from. I’m referring not least to our collective heating system, and the fact that the Danes learnt to save energy and better insulate their houses during the Seventies,” says Greenpeace climate and energy staff member Tarjei Haaland, who in 1974 was a co-founder of Denmark’s biggest anti-nuclear movement, and as such contributed to stopping nuclear power.

From heated discussions about the Brundtland report of the late Eighties to the adoption of the then visionary Energy Plan 2000 in 1990, Danish politicians have constantly pressured the business community. Having increased annually up to 1993, corporate

energy consumption per produced economic unit has since fallen by an average of 2.5% a year. Household energy consumption is lower today than in 1973.

Energy Plan 2000 set targets to reduce energy consumption in relation to 1988 levels by 15% and to reduce CO₂ emissions by 20% by 2005. It has not been possible to meet these ambitious targets, in spite of a major increase in subsidies for sustainable energy and a dramatic increase in energy duties in the Nineties.

“During the Nineties, under Svend Auken, the Danish Ministry for the Environment and Energy was incredibly influential, and the environment was invested with great value,” recalls Mette Wier from the Danish Institute of Governmental Research. “There were no limits to what could be done. However, nobody remembered to ensure—and there was no great desire to work out—whether there was a real return on investment. The environmental movement almost enjoyed too much success, and it has taken a number of years for it to recover. Today, the issue of the environment has been resurrected within the wider climate debate, where it now represents business worth billions.”

MM | ‘Naval Battle’ unresolved

There are a number of ways of looking at the Danish energy decoupling process. Between 1982–1986 and 1995–2001, energy consumption fell while the economy expanded. Yet these figures are controversial. Not least the question of whether to include shipping and air transport in the national CO₂ accounts. A. P. Møller-Maersk’s global fleet emits almost as much CO₂ as the entire country. No other nation in the world has such a relatively large marine element in its national accounts.

Specialist consultant Peter Rørhose Jensen at Statistic Denmark believes that, “shipping and air transport should not be omitted from economic development statistics. If the figures for shipping and air transport are included in the CO₂ statement then no decoupling can be said to have taken place.

Tarjei Haaland of Greenpeace believes that Anders Fogh Rasmussen and Connie Hedegaard are travelling around “boasting”. Suggesting that Denmark has been able to decouple energy consumption in relation to economic growth is a clear distortion. Foreign shipping and air transport contributes to our GDP yet is not included in our energy consumption figures. The numbers should be adjusted to show a more truthful picture.”

Connie Hedegaard maintains however that a major decoupling has taken place in domestic production and, pointing to the Kyoto Protocol, adds that no country includes its foreign shipping and air transport in its CO₂ statistics. “Maersk ships transporting freight from Shanghai to San Francisco should not be included in the Danish CO₂ statement,” she states. Statistic Denmark is yet to include the transportation of foreign goods carried out by Danish companies abroad. However, they can confirm that Maersk ships refuelling in Danish harbours or SAS aircraft refuelling at Copenhagen Airport are included in the Danish CO₂ statement. It is difficult to unravel all the threads and determine responsibility in a globalised world. Negotiations are currently taking place within the International Maritime Organisation to reduce CO₂ emissions from shipping. Connie Hedegaard is among those hoping for a global agreement that treats everyone equally.

Global sales of Danish success

Climate Minister Connie Hedegaard is clearly proud of how long Denmark has come on its journey of renewal. “Since 1981 we have had 70% growth in GDP while keeping energy consumption more or less stable within the same period,” she says. Along with the Danish Prime Minister, Anders Fogh Rasmussen, she now travels the world with figures from the Danish Energy Agency showing how successful decoupling has been.

If there were an energy efficiency world championship, Denmark would be a serious contender for gold. “Denmark has had the advantage of not having much heavy, energy consuming industry to begin with, and support has been available to carry out energy savings in a number of areas,” assesses Lars Goldschmidt.

Even Tarjei Haaland of Greenpeace accepts that Denmark has been a pioneer in this area. “Denmark is a small country with very low energy consumption. For example, Norway’s energy consumption is four times greater and Sweden uses two and half times more energy than Denmark,” he says.

Associate Professor Anders Christian Hansen of Roskilde University, who is writing a book about the Danish energy story, believes that Denmark can teach the rest of the world a thing or two. “The rest of the world can learn about our experiences with decentralised power plants and wind turbines, as well as gain inspiration from our way of applying environmental taxes,” he says. For instance, Denmark is one of the countries where environmental taxes contribute most to GDP. See figure 4. In 2006, the state collected DKK 78 billion or 4.7% of GDP in environmental and energy duties. This naturally affects corporate and private behaviour.

“If you do not include sea transport, Denmark has experienced a major increase in energy productivity in relation to other countries. Industrial energy consumption has fallen since 1993, and household gross energy consumption is lower today than in 1973.

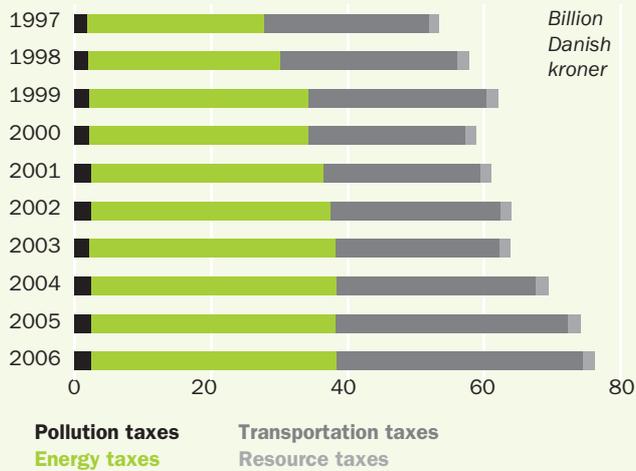
New deal

Yet according to the Danish Energy Agency and Statistics Denmark, gross energy consumption – and CO₂ emissions – have begun increasing again over the last few years. The current Danish Liberal-Conservative government has been criticised for not doing enough to reduce energy consumption. “This government put a stop to many good energy and environment initiatives in the Nineties, and this has led to years of energy policy idling,” says Tarjei Haaland of Greenpeace. “Gross energy consumption has been increasing in the last few years, CO₂ emissions are beginning to grow again, coal consumption is going up, and wind power has been put on hold – no new turbines have been erected in Denmark since 2004,” says Haaland, and points to among other factors the adjusted figure for CO₂ emissions, which increased by almost 3% from 2004 to 2006.

Anders Christian Hansen from Roskilde University agrees: “The last couple of years have seen a decline in energy productivity, CO₂ emission reduction and conversion to sustainable energy. Not applying duties that would have otherwise made it more costly to pollute and the abandonment of the climate targets in 2002

MM | Incentives of conduct

Environmental taxes distributed in main groups



Figur 4: There has been a general increase in Environmental taxes in the past ten years.

Source: Statistics Denmark, 2008.

have had an impact. Yet a new consensus in parliament regarding the latest energy bill would appear to have stopped the decline. And this broad consensus is encouraging for new agreements regarding what should happen after 2011," he adds.

However, it was not just the government that lowered its ambition levels at the beginning of the new century. It could also be seen in a broader shift in thinking, where it became modern to say, 'Cool it', and where voters stopped showing the same enthusiasm for environmental issues as before.

During the economic boom of the last ten years, where we have experienced historically low rates of interest, Danes have borrowed money to build new kitchens, buy new cars and spend money on things that give status. Yet they have invested remarkably little in energy savings and house insulation. It would appear to demand a combination of regulation, motivation and information to get people to save energy," says Peter Bach from the Danish Energy Agency.

Yet recent dramatic increases in oil prices and a new, more pragmatic awareness of climate issues – in Denmark and in the rest of the world – have once more changed the basis for energy policy. A paradigm shift is taking place. A majority of ordinary Danes and politicians wish to bring climate and energy policy up to speed, in order to save more energy and ensure an increase in the use of sustainable energy.

Connie Hedegaard still regrets that the Liberal-Conservative government postponed a number of wind farms during its first years in power. "We lost valuable time, and we would not have postponed the farms today. Yet this has changed now," she says and points to the decision to erect numerous wind farms on land and sea since the latest energy act was passed in February.

Instead of looking back at previous disagreements, the climate minister thinks that we should look forward, and agree to exploit the first mover advantage that Denmark has built up in many areas. Ever higher oil prices over the next few years combined with a global climate consensus should lead to major growth in the worldwide market for energy saving technology. And Denmark has great potential in this market, emphasises Connie Hedegaard:

"Now it's about maintaining our advantage. Danish cleantech exports grew four times faster than all other sectors in 2007. Exports have tripled within the last ten years, and sources within the industry believe that a turnover of DKK 200 billion is realistic by 2020.

MM

Bjarke Møller | bjm@mm.dk

Sources

- Danmarks Statistik, Statistiske Efterretninger 2008:2, Miljøøkonomisk regnskab for Danmark 2006.

The transport sector of the future will be closely linked to the energy sector – Denmark is an ideal test case for the development of new infrastructure, as it has one of the world’s most advanced electricity systems – Massive earnings potential for Denmark in developing the electric and fuel cell driven cars of the future.

The transport sector’s green laboratory

“DENMARK CAN BE at the forefront of the development of the eco-friendly transport of the future. Tomorrow’s cars will still be built in Germany and other major car manufacturing countries. Yet we have certain competencies and companies in Denmark that make us very interesting as a test market.

Aksel Mortensgaard, a program coordinator at the Danish Energy Agency, hits the nail on the head in Monday Morning’s analysis of the opportunities open to Denmark in the transport market of the future. As chairman of the Danish Hydrogen and Fuel Cells Partnership, he sees huge potential in the global transport industry’s conversion to more eco-friendly fuels, and an opportunity for Denmark to play a key role in this process.

“We believe there will be a breakthrough for an electric-powered hybrid solution based on battery technology, and for onboard production of electricity using fuel cells. Both are a perfect match for Denmark’s energy infrastructure and Danish key competencies,” says Mortensgaard.

Industry inpagers and experts agree that in the future transport and transport infrastructure will be closely integrated with energy infrastructure. All over the world, climate change and a desire for reduced dependence on politically unstable oil states has led to efforts to use fuels and energy resources more efficiently. A new wave of development points towards using the transport sector as a ‘buffer’ for the energy sector. The idea is that the transport sector functions as both an energy producer and a storage facility. The transport sector can take the extra energy made available as a result of overcapacity in the energy sector (e.g. at night or when there is a lot of wind in a wind turbine area) and store it in, say, electric car batteries. Conversely, the transport sector can sell energy from batteries and fuel cells, etc., back to the energy sector for use in peak periods if so required.

Denmark has an advantage in this area due to its advanced and highly decentralised electricity system, where 20% of all electricity generated comes from wind turbines. The Danes are used to dealing with a very complex system, with many actors and highly variable levels of production from wind turbines, which generate electricity “as the wind blows”.

“We have the case,” as Kim Behnke, Director of Research and Environment at Energinet.dk, says: “An infrastructure needs to be built to service the transport sector of the future, and this is where Denmark can function as a test facility.”

Working across the electricity, energy and transport sectors, the Danish business environment is currently finding its feet in relation to how best to deal with a new transport future, as exemplified by the Danish Hydrogen and Fuel Cells Partnership. The Danish Foreign Ministry sees an opportunity to develop a range of lucrative business models. Since last year the ministry’s ‘Invest in Denmark’ unit has been marketing Denmark to international manufacturers as a test nation for eco-friendly forms of transport.

“We have a good chance of attracting investments from electric and hydrogen car manufacturers, as well as others with an interest in developing forms of transport based on sustainable energy. This helps us in relation to increasing Denmark’s use of sustainable energy, and in the longer term also provides an opportunity for Danish companies to establish themselves as subcontractors to the car industry of the future,” says Invest in Denmark Project Manager, Peter Bo Sørensen.

Invest in Denmark played a part in brokering the newly announced partnership between the Danish energy company DONG and the American-Israeli entrepreneur Shai Agassi. They will be working to develop a new infrastructure for electric cars. They will be working with car manufacturers such as Renault and Nissan to develop a new infrastructure for electric cars. The aim is to get 500,000 electrically powered cars onto Danish roads by the year 2020. Previous analyses by Monday Morning suggest that such a partnership offers an enormous opportunity for Danish industry. Industry association Danish Energy estimates that the development of a so-called plug in technology, which can connect electric cars to the national grid, represents an export potential of “many hundreds of millions of kroner.” An analysis carried out on behalf of Monday Morning by the University of Aalborg shows that by converting 20% of the total number of cars on its roads to run on electricity, Denmark could harvest an a national

MM | Notorious climate crook

The transport sector is one of the major problem areas when it comes to efforts by the international community to limit CO2 emissions. The sector is responsible for roughly a fifth of global human created CO2 emissions, and all prognoses suggest that this share is increasing. According to the Norwegian Center for International Climate and Environmental Research Oslo (CICERO), up to 30 to 50% of all CO2 emissions will come from the transport sector by 2050. This is due to the rapid rise in global trading and increased transportation from growth areas such as China and India. The primary fuel used by land, sea and air transport is oil, which emits large amounts of CO2 when combusted. Road transport is the major offender, making up 75% of the transport sector's total CO2 emissions.

Paradoxically, emissions from the transport sector have yet to be included in global CO2 reduction agreements, such as the Kyoto Protocol. This is likely to change at the UN climate summit to be held in Copenhagen in 2009. A new treaty is expected to rapidly pick up the pace of development of the huge global market for solutions that can reduce CO2 emissions within the transport sector. The biggest potential lies in developing new motive power technologies, infrastructures and intelligent traffic systems for road transport.

OECD reports show that the transport sector is a major contributor to global CO2 emissions:

- In 2005, 44% of all freight and 84% of all passenger transport took place by road.
- The transport sector's share of global CO2 emissions is greatest in the most developed OECD countries where, in 2005, 30% of all global CO2 emissions were generated by the transport sector.
- CO2 emissions from the transport sector grew in Europe by 27% between 1990 and 2005.

- A third of emissions from the transport sector comes from commercial transport, while two thirds come from private transport.
- Benefits to the climate from more effective cars have thus far been wiped out by the rapid global growth of the number of vehicles.
- China is today the world's second largest car market behind the USA, and car sales in China are expected to increase by 65% in 2008. Last year, over 8.5 million cars were sold in China, of which 5.5 million were registered for private use. The total number of cars sold 10 years ago was 1.6 million.
- In Europe, the number of cars per 1,000 inhabitants increased by 25% from 1995 to 2005, where the number reached 460.

MM | Dirty traffic

CO₂-emissions of transportation spread out on sectors

OECD

(Total share of CO₂ -emissions spread out on sectors: 30 per cent)



The world

(Total share of CO₂ -emissions spread out on sectors: 30 per cent)



Road
Aviation, domestic
Aviation, international
Shipping, domestic
Shipping, international
Other transportation

Sources: European Environment Agency, Center for International Climate and Environmental Research, OECD

economic gain of as much as DKK 2 billion per annum. See Monday Morning, issues 12 and 13, 2008.

Multiple focus areas

It will however take a very long time before the entire transport section is electrically powered. Current battery technology means that the price and range of electric cars for many years will limit their use to cities, or for journeys within geographical areas where – as in Denmark – it is possible to establish a complex infrastructure onto an already existing energy system.

Therefore, it will be necessary in the short term to bring other focus areas into play to deal with the transport sector's growing CO₂ problem. Analysis by Monday Morning shows that Denmark is capable of contributing in many of these areas.

- **BIOFUEL AND HYBRID TECHNOLOGY.** In the short term the car industry is venturing to make the internal combustion engine more efficient and to use alternative fuels and hybrid technology. This brings into play technologies such as 2nd generation biofuel, electric motors and fuel cells. Intense debate in Europe regarding the sustainability of biofuel has led EU countries to focus more and more on developing so called 2nd generation technologies that can produce bioethanol from waste products. Denmark has a good opportunity

to make an impact in this area. Companies such as Novozymes and Danisco are global leaders in the field of producing enzymes that can optimize the production of bioethanol, and a national commitment to 2nd generation biofuels to the tune of many hundreds of millions of kroner over the next few years would also help encourage development. At the same time, Danish companies such as Haldor Topsøe, IRD Fuel Cell Technology and Risø DTU are in the forefront internationally when it comes to developing the fuel cells, which in the future may replace the internal combustion engine. However, hybrid solutions combining internal combustion engines and electric motors will continue to make up the majority of the market for many years to come, with hybrid fuel cell and electric motor combinations gaining ground in the longer term. Battery technology and transport and energy sector integration is important for both hybrid concepts. As such, Denmark's experience in making sustainable energy a central part of its electricity system could be a major advantage in developing the technical solutions needed if vehicles are to run on "clean" electricity.

- **INTELLIGENT TRAFFIC SYSTEMS.** Congestion and poor planning in and around urban environments only serve to increase the transport sector's CO₂ problems. Therefore, intelligent traf-

fic systems that can help improve traffic flow and prevent unnecessary idling, braking and acceleration are an effective method for reducing CO₂ emissions in the short term. The same applies to better city planning and incentives such as congestion charges, which can limit car traffic while increasing the use of public transport, cycle routes and pathways. Many countries around the world are in the process of introducing these measures into their urban environments. “Intelligent traffic systems can reduce CO₂ emissions from transport in urban areas by 10 to 15%,” estimates Professor Oli Madsen from the internationally renowned Institute for Transport at the Technical University of Denmark. He believes that within certain niche areas, such as system software and road pricing, Denmark has the opportunity to bring its competencies into play in relation to the growing market for new, intelligent traffic systems.

- **SMART LOGISTICS AND SHIPPING SOLUTIONS.** A particularly challenging aspect of the transport sector’s CO₂ problem is ever increasing globalisation. People and goods are being transported between the world’s continents in ever increasing numbers, turning the air and sea transport sectors into growing CO₂ offenders. According to the OECD, air transport is today responsible for almost 2% of the world’s total CO₂ emissions, while sea transport is responsible for 2.3%. As one of the world’s leading maritime nations, Denmark has a particular responsibility for the increased emissions generated by shipping. The A. P. Møller-Maersk group’s approx. 1000 ships and oil and gas operations produce a total of almost 50 million tons of CO₂ annually. This equates to Denmark’s entire domestic CO₂ emissions total. Sea transport remains the most eco-friendly method of freight transport, yet growing globalisation makes the sector a growing contributor to the climate problem. This is why the international community is focusing on developing smart CO₂-saving logistics and shipping solutions. A. P. Møller is heavily involved in these developments, and together with IT companies such as IBM, the group has identified a number of solutions that help optimise the logistic process, including optimizing container loading and ship design and developing money-saving routes and manifests that reduce CO₂ emissions. Recently, the company launched a so-called Carbon Foot Print Calculator, which helps optimise the entire freight chain from the customer’s factory door all the way to the customer’s customers. It is expected that demand for these types of solutions will grow as international business increasingly becomes more aware of its carbon footprint. And this also presents Denmark with a great opportunity, not least due to its highly developed shipping industry and expertise within logistics systems.

World leaders in system integration

The greatest opportunity for Denmark lies in the wholly necessary restructuring of road transport. Road and rail transport currently account for 75% of the transport sector’s CO₂ emissions total.

The internal combustion engine will continue to dominate for many years to come, yet global car manufacturing giants such as Toyota and General Motors are investing billions in developing hybrid vehicles and alternative motor technologies. At the same time, more and more companies – such as Think from Norway – are developing and launching 100% battery- or fuel cell driven vehicles.

So there is no doubt that the internal combustion engine will gradually be phased out, eventually being replaced by other technologies. The more integration between the transport and energy sectors, the more CO₂ will be reduced as a result of more effective use of fuel and energy technologies. Danish competencies within transport and electric power systems integration could be very valuable in this context.

“We are out in front internationally when it comes to our systems integration knowledge. This can be used in the transport sector. And the market will be wide open for us if we’re among the first,” says Professor Jacob Østergaard, head of DTU’s Center for Electric Technology. He believes that Danish competencies within software management, physical grid connection and energy system integration are especially interesting when it comes to developing the transport sector of the future.

And according to Østergaard, it is not only Shai Agassi who has shown an interest in making use of these competencies. “DTU is currently working with Siemens in Germany to develop plug-in technologies for electric cars as well as transport and electricity integration technologies,” explains Jacob Østergaard.

Within the last few years, the Danes’ ability to develop technologies and solutions across sectors and businesses has become increasingly formalised in partnerships across knowledge institutions and the public and private sector. Many of them have begun to focus on renewing the transport sector.

This applies to, for example, the EcoGrid research partnership, which is attempting to increase the use of wind energy within the Danish electric power system. The collaboration brings research and commercial interests within the energy sector together with Energinet.dk, the state-owned operator of the Danish electricity and gas infrastructure. One of the particular focus areas is closer integration between the energy and transport sector.

“It’s about using our energy more intelligently. Electricity and fuel cell technology in the transport sector matches Denmark’s high degree of wind energy utilisation perfectly. So we have a good basis for experimenting with linking together these sectors more effectively,” says Kim Behnke of Energinet.dk.

The Danish Hydrogen and Fuel Cells Partnership, which brings together producers, knowledge institutions and the authorities associated with fuel cells, published a strategy earlier this year setting out how Denmark could exploit opportunities within the transport sector of the future. Here it emerges that fuel cells, among other technologies, have the potential to achieve comparable market penetration within the transport sector by 2050. The strategy also shows that in the short term, Denmark has a range of opportunities in markets for technology such as hybrid systems and internal company transport systems. See figure 1.

“The market for trucks alone is enormous. It’s here that the new

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