# Copenhagen, Denmark

## Comprehensive Municipal Energy Efficiency

## Profile #80


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# Executive Summary

Copenhagen is a leading city in terms of energy efficiency, and like other European leaders profiled by The Results Center, its efforts have been broad and have spanned supply-side efficiency, the aggressive promotion of district heating, energy efficiency initiatives, renewable energy developments, and transportation. Together these efforts are providing a framework for Copenhagen's commitment to carbon dioxide reductions and to decreasing its dependence on foreign energy supplies. In fact, in 1991 Denmark as a whole became self-sufficient in its oil and gas use as compared with 1973 when it imported 100% of its oil.

Copenhagen's largest singular achievement with energy management has been the construction of what will become the largest district heating system in the Western world. This network now supplies 67% of the space heating demands of the City, and when complete in the year 2002 will supply fully 95% of the space heating demands of Copenhagen.

The City of Copenhagen has implemented demand-side management programs using an approach that is based on energy advisory services. This approach underscores the City's commitment to provide its energy customers with appropriate price signals and then to inform its customers that energy efficiency upgrades are in their best interest. Thus the ultimate costs of efficiency are borne by the customers and the total costs of DSM are moved off the utility's balance sheet. Nevertheless, the City projects that these services will provide 265 GWh annually by the year 2005.

Like the City of Oslo, Norway, (See Profile #79) The Copenhagen Lighting Department collects revenues to fund its efficiency efforts through the use of a small surcharge, equal to less than half a percent of the current average kWh rate, applied to every kilowatt-hour sold. These resulting funds have been used to hire skilled energy engineers who prepare detailed energy surveys of the City's largest energy consumers and to support the downtown energy center and its staff, plus various energy efficiency campaigns.

While the overall picture of responsible energy use in Denmark is epitomized by Copenhagen's comprehensive initiatives, the City is plagued by the erosion of savings that challenges energy efficiency initiatives around the world. Despite high prices and a series of factors intended to discourage automobile use, it is nevertheless on the rise in Copenhagen. Similarly, the dramatic influx of waterbeds in Denmark has created a demand for electricity that is greater than the entire country's wind generation capability! Thus the model presented in Copenhagen, which provides for a host of innovative and progressive policies and practices, is complete with challenges and opportunities that will be watched carefully by countries similarly committed to carbon dioxide reductions in the coming years.

### City of Copenhagen, Denmark

**Comprehensive Municipal Energy Efficiency**

| | |
|---|---|
| Utility: | Copenhagen Lighting Department |
| Sectors: | Residential, commercial, & industrial |
| Strategies: | Supply-side efficiency; extensive use of district heating; building and industrial energy efficiency; renewable energy and transportation initiatives |
| Mechanisms: | National carbon dioxide tax; district heating extension; Energy Advisory Services for commercial and industrial accounts; residential information services; grass roots focus on renewable energy and the social aspects of energy use; restrictions on automobile use |
| History: | Energy efficiency initiatives began in 1970s after the oil crises; further emphasis on wise and sustainable energy use related to carbon dioxide reduction commitments in both Denmark and Copenhagen |

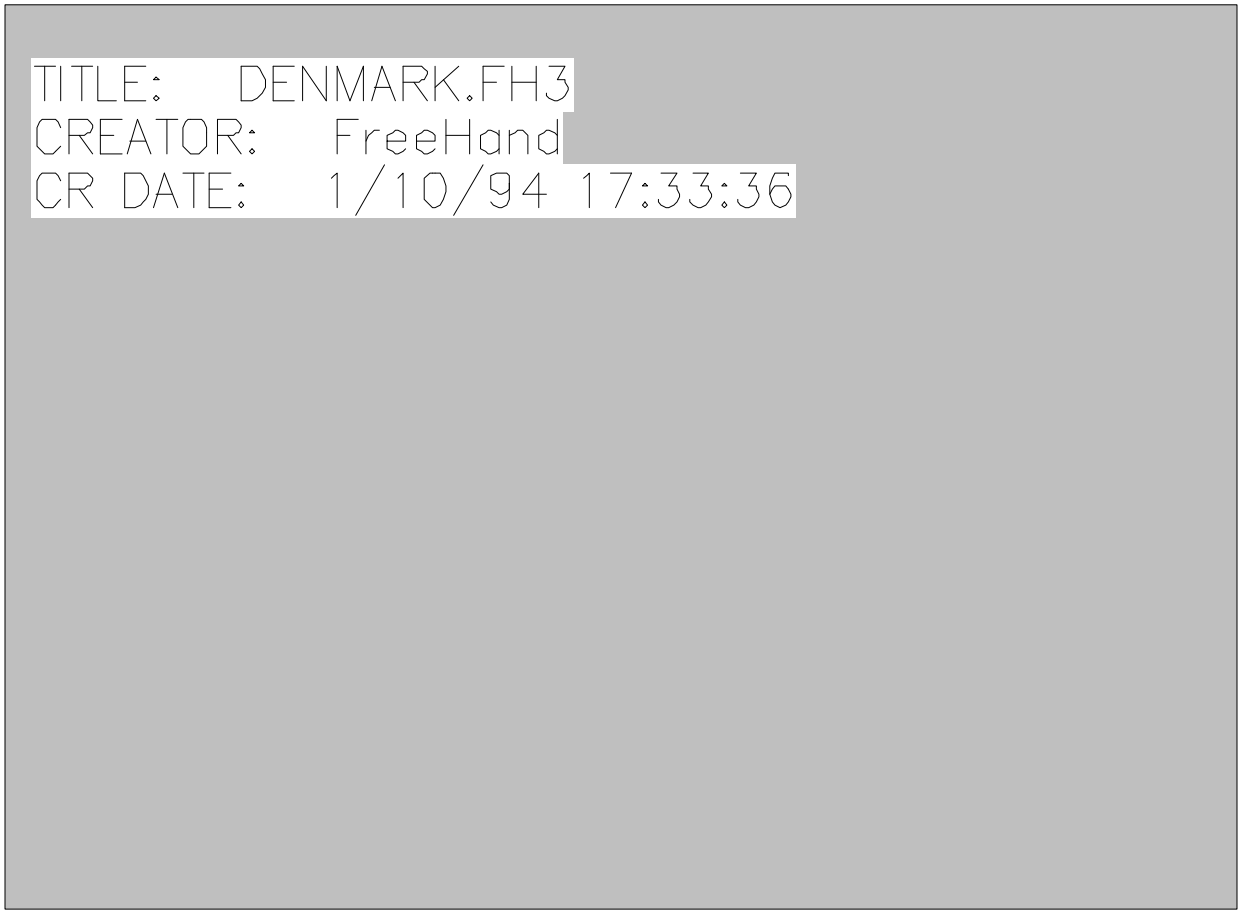
#### Conventions

For the entire 1993 profile series all dollar values have been adjusted to 1990 U.S. dollar levels unless otherwise specified. Inflation and exchange rates were derived from the U.S. Department of Labor's Consumer Price Index and the U.S. Federal Reserve's foreign exchange rates.

*The Results Center* uses three conventions for presenting program savings. **Annual savings** refer to the annualized value of increments of energy and capacity installed in a given year, or what might be best described as the first full-year effect of the measures installed in a given year. **Cumulative savings** represent the savings in a given year for all measures installed to date. **Lifecycle savings** are calculated by multiplying the annual savings by the assumed average measure lifetime. **Caution:** cumulative and lifecycle savings are theoretical values that usually represent only the technical measure lifetimes and are not adjusted for attrition unless specifically stated.


Denmark is a tiny but enchanted country directly north of Germany and south of the border dividing Sweden and Norway and separated from these countries by the narrow Kattegat and Skagerrak straits. On a clear day it's easy to see Sweden where a pair of nuclear plants inscribe the horizon. Denmark has an area of 43,069 square kilometers (16,629 square miles), about the size of the states of Vermont and New Hampshire combined although Denmark's population density is about five times that of the two U.S. states. The country has a population of 5,133,000 of which about 10% live in its capital city of Copenhagen.[R#25]

Denmark is made up of two regions called Sealand and Jutland that are separated by a narrow dividing body of water. Jutland is a peninsula extending north from the European mainland while Sealand is a group of islands located to the east of this peninsula. Directly west of Jutland is the North Sea; east of Sealand is the Baltic Sea. In terms of topography the country is primarily coastal lowlands.[R#13] ☞




Denmark's economy is based in agriculture and an increasingly-important manufacturing sector. Three-quarters of the land is used for agricultural purposes of which two-thirds of the products are exported. The primary agricultural products are meat, dairy, and eggs. However, roughly 66% of Denmark's total exports are manufactured goods including machinery and electrical industrial items, textiles, and ships. Denmark does not have abundant natural resources but has enjoyed stable production from its North Sea oil and gas reserves.[R#14]

The primary unit of currency is the Danish Kroner (DKK), with 100 ore to the Kroner. For the purposes of converting all sums to U.S. 1990 dollars, the 1992 rate of 6.0372 DKK to 1 dollar has been used with all dollars then converted to 1990 as per The Results Center convention. [R#6]

Denmark is ruled by the oldest constitutional monarchy in Europe and was established in 1849. Major Danish territorial possessions include Greenland and the Faroe

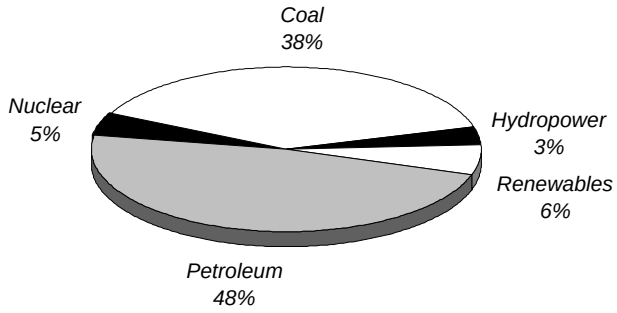
Islands. Denmark is governed by a parliamentary democracy, the foundations for which were established in 1953. The primary language is Danish but many Danes are fluent in Swedish and English as well. Between 20% and 30% of the representatives to the national Parliament are women. Women also make up nearly 45% of the work force with a strong concentration in the textile industry.[R#13,14]

National energy policy is the responsibility of the Ministry of Energy that was created in 1979 from an existing infrastructure in the Ministry of Trade. The Ministry consists of a headquarters staff (the Department), the Danish Energy Agency, and the Riso Research Center. The Department is responsible for advising and assisting the cabinet minister for energy in the preparation of policies. The Agency performs the basic administrative work for the Ministry as well as technical tasks including power plant siting. The Riso Research Center is the research and development component of the Ministry and is primarily focused on renewable and efficient technologies. The Ministry of Housing & Building and the Ministry of the Environment also have energy-related roles.[R#17]

The Danish government has been active in energy issues since the first oil crisis in 1972-1973 when it implemented policies during the 1970s and early 1980s primarily targeted at securing energy supply. Chief among these early efforts was a tax on various forms of energy that remains in force today. This policy focus changed during the late 1980s and in the early 1990s to address environmental concerns, primarily through reduced dependence on oil and coal and increased use of natural gas, cogeneration, and renewable resources.[R#3]

Despite the country's remarkable transition away from imported oil, Denmark is a net energy importer, consuming 854,595 TJ (0.81 quads) of primary energy in 1991 while producing only 432,573 TJ (0.41 quads). Energy consumption is comprised of 432,573 TJ (0.41 quads) of petroleum, 348,168 TJ (0.33 quads) of coal, 31,652 TJ (0.03 quads) of hydroelectricity, and 42,202 TJ (0.04 quads) of nuclear power. Renewable resources such as windpower, biogas, straw combustion, and solar heating accounted for 6% of total energy consumption in 1990. Total electricity consumption in 1992 was approximately 30 TWh/year, or 6 MWh/year/capita.[R#2,3,16]

**1991 DANISH ENERGY CONSUMPTION**




Denmark has significant oil and natural gas capacity from North Sea fields that comprises the bulk of energy production capability. In 1991 the country produced 316,520 TJ (0.3 quads) of crude oil and 126,607 TJ (0.12 quads) of natural gas. Finally, cogeneration from waste incineration is a major source of both power and heat primarily for the widespread use of district heating as discussed later in the text.[R#16] ■

Denmark was hit particularly hard by the first oil crisis in 1973 because imported oil accounted for 93% of energy supply at that time. A similar but smaller shock to the country occurred again in 1979-1980 as a result of the second oil crisis. Thus the Danes made great efforts to reduce their dependence on imported oil, initially moving to greater reliance on coal purchased on the spot market. Ten years later, as environmental quality and specifically carbon dioxide (CO2) mitigation has become an explicit goal of Danish energy policy, Denmark is now in the process of moving away from coal to natural gas, renewable resources, and energy efficiency in all end-uses including transportation. Specifically, the country has enacted a series of policies and supported those policies with a series of fiscal commitments to reduce CO2 emissions from a 1988 baseline by 20% by the year 2005.[R#2,3,4]

#### CURRENT POLICY: ENERGY 2000

A four-part energy strategy titled Energy 2000 was adopted by the Danish national government in April 1990 delineating clear energy and environmental goals. Relative to 1988 levels, the plan calls for reducing gross energy consumption by 15%, increasing natural gas consumption by 170%, doubling renewable energy consumption, reducing coal consumption by 45%, and reducing oil consumption by 40% by 2005. To achieve these goals Energy 2000 contains a four-part strategy based on increased conservation, more use of district heating through cogeneration, increased use of renewable resources, and continued investment in energy research & development. Denmark will be a net exporter of hydrocarbons before the turn of the century if the plan's objectives are fulfilled.[R#3]

#### CONSERVATION

Denmark has implemented a number of programs to improve its energy efficiency and reduce the country's CO2 emissions on a nation-wide basis. For example, the Danish Heat Consultant Scheme (VKO) requires annual heating equipment check-ups for large energy users. The VKO inspection includes a nominal fee for the service that is paid by the user to one of the 700 accredited inspectors of the consumer's choice. There is a corresponding program for small users called The OR Scheme. The Energy 2000 program also requires all state-owned or rented buildings to have energy audits between 1990-1993. Under the Heat Inspection Act all houses that are sold must have an energy consultant audit the building and provide a report of the consumption to the buyer. These national policies, of course, have bolstered efforts in Copenhagen.[R#3,6,9]

One of the earliest efforts to improve building efficiency in Denmark was the development and implementation of National Building Standards in response to the first oil crisis. Standards were radically increased in 1977 (for instance by 100% for insulation requirements) and ratcheted up again in 1982. Revisions taking force in 1993 require that heat demand for buildings is reduced by 25% from 1990 baselines with reductions of 50% of 1990 levels by the year 2000. Standards for fixed ventilation systems and lighting installations in new buildings also take force in 1993.[R#3,6]

Due to significant increases in electricity consumption Denmark has experimented with labeling and standards campaigns for appliances and other electricity-consuming devices. The country has also been active in pushing the European Community to adopt community-wide standards and labeling provisions.[R#3]

### COGENERATION, RENEWABLE RESOURCES, AND RESEARCH & DEVELOPMENT

The Energy 2000 plan stresses the expansion of cogeneration through the continued spread of district heating and the more efficient generation of both power and heat. The plan also calls for greater reliance on alternative generating fuels to reduce greenhouse gas emissions. Straw, biogas, woodchips, and waste are all being used as sources of power, and wind provides a significant portion of the country's electrical capacity, about 400 MW at the time of this writing. Finally, R&D is being pursued on both demand- and supply-side technologies with a focus on cogeneration applications and industrial process improvements.[R#3]

### CARBON TAXES

Denmark's precedent-setting CO2 tax took effect in May 15, 1992 in order to reduce CO2 emissions by 20% by the year 2005 from 1988 levels. To meet this target Denmark has implemented one of the most aggressive CO2 reduction plans of any major industrialized nation to date, including a tax of 100 DKK per ton of CO2 emissions (equivalent to $16.56 in 1992 dollars).[R#3]

The Danish CO2 reduction package passed during the 1991-1992 legislative session is a comprehensive piece of tax legislation that includes eight separate measures. These measures include energy conservation grants and tax refunds for large consumers to mitigate some of the burdens of the carbon tax. For instance, 200 million DKK ($30 million) per year has been earmarked for energy conservation measures in businesses. The same amount was approved for the completion of the district heating network in Denmark, with funding for five years for a total of $166 million (or one billion DKK). Grants were also established to assist with the cost of hooking up to district heating networks, especially difficult for the older housing stock.[R#4]

Fuels used to generate electricity are not subject to the CO2 tax because electricity is taxed under the energy tax structure. The electricty tax is based on the emissions from coal generation with an assumed thermal efficiency of 35%. The Danish government believed that this end-use approach was more equitable than taxing generating fuels.[R#4]

### DANISH UTILITY STRUCTURE AND REGULATION

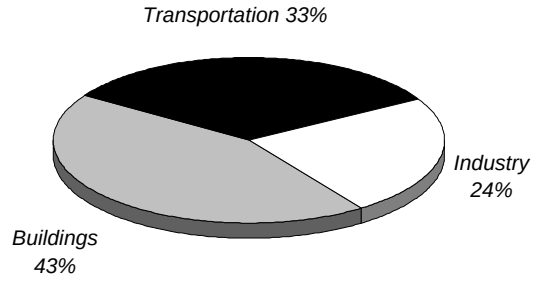
The Danish electric utility industry is primarily divided into separate generation and distribution companies with some notable exceptions including the Copenhagen Lighting Department. There are two major power generation and marketing agencies, ELSAM and ELKRAFT, serving Jutland and Sealand respectively. Under these are ten regional power generation and transmission companies that sell to 106 local distribution companies who reach a total of 2.8 million customers.[R#2]

Utilities in Denmark are regulated by the Electricity Price Commission whose members are appointed by the Minister of Energy and who are guided by the Electricity Supply Act of 1976. One of the recent regulatory reforms underway in Denmark, as in Germany (See Profiles #77,78), is integrated resource planning (IRP). Both ELSAM and ELKRAFT are currently conducting a comprehensive IRP project funded by the European Community, and the Copenhagen Lighting Department recently commissioned Synergic Resources Corporation, an American-based consulting firm, to do an IRP analysis as well. Thus utilities in Denmark seem poised for demand-side management to become institutionalized in Denmark, borrowing planning tools and econometric models from North America to engage and economically justify increased energy efficiency investments. ■

## CITY OVERVIEW

Copenhagen is the capital of Denmark and the country's largest city. Its population is just under a half a million (494,000) though a total of more than 1,300,000 people live in the greater metropolitan area. The City is located on the eastern coast of Sealand directly across a narrow strait from Malmo, Sweden. The City was founded over 825 years ago by Bishop Absalon and became the capital of Denmark in 1416.

**1989 ENERGY CONSUMPTION BY SECTOR**



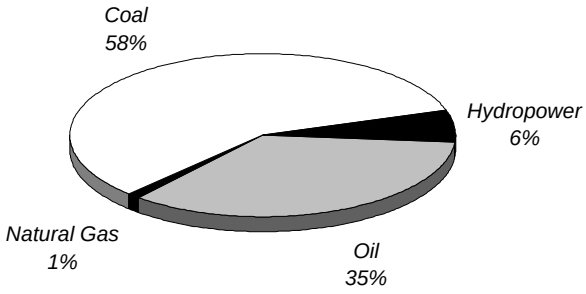

Copenhagen has been a center for commerce and transportation for centuries not only for Denmark but for much of Scandinavia and the Baltic region. Its ship-building industry remains an important economic force today and has had an impressive maritime history. While Copenhagen's local economy has shifted towards an increased reliance on manufacturing, the City remains an important center for traditional activities such as fishing and sales of agricultural products.[R#13]

Additionally, Copenhagen serves as the historic and cultural center of Denmark. As the national capital it is home to important historical monuments such as the Christiansborg Castle and cultural sites including the Royal Theater. Tourism is an important ingredient in the local economy as Copenhagen boasts attractions including many castles as well as the Tivoli Gardens, a 150-year old amusement park which the singer Michael Jackson wanted to buy after his first visit there just a few years ago![R#13]

Copenhagen is governed by a City Council and has an Energy Department which is responsible for overseeing the utility operations and other energy-related issues such as building code enforcement, building permits, and energy use in public buildings.[R#12]

The City and the surrounding municipalities that make up the Greater Copenhagen Council developed the 1988 Regional Heating Plan to coordinate heating as well as planning for other energy end-uses. The 1988 plan includes provisions that closely mirror national actions such as the increased use of cogeneration, natural gas, and renewable resources for electricity generation to reduce pollution and mitigate carbon dioxide emissions. Local energy consumption also closely mirrors the national picture. In 1989, industrial energy use accounted for 23.6% of energy use, transportation 32.5%, and buildings 43.9%.[R#12]

**1988 ENERGY CONSUMPTION BY PRIMARY FUEL**



| *LIGHTING DEPARTMENT 1992 STATISTICS* | | |
|---|---|---|
| Number of Electric Customers | 350,000 | |
| Number of Employees | 2,055 | |
| Generating Capacity | 883 | MW |
| Peak Demand | 485 | MW |
| Electricity Sales | 2,495 | GWh |
| District Heating Sales | 4,528 | GWh |
| Average Electric Rates | 28.2 | ¢/kWh |
| Natural Gas Sales | 2,190 | mmcf |

The Copenhagen Lighting Department (Kobenhavns Belysningsvaesen, KB, or the Lighting Department) is a municipally-owned utility serving the City of Copenhagen and the surrounding metropolitan area. While the utility is not regulated per se, the City's Agency for Environmental Protection plays a significant role in assuring safe utility operations. According to one of our hosts, the environmental department and the utility "battle all the time," but these disputes rarely reach the press headlines as the two municipal agencies prefer to work out their differences behind closed doors.[R#18,19]

## UTILITY OVERVIEW

The Copenhagen Lighting Department is the second biggest utility in Denmark and unlike most Danish utilities it produces and distributes power and provides natural gas and district heating to its customers. The Lighting Department has 2,055 employees.[R#1,11]

**Electricity:** The Lighting Department serves 350,000 electricity consumers and provided them with 2,494.7 GWh in 1992. To provide this service the Lighting Department owns three combined heat and power (CHP or co-generation) facilities including the newly-renovated Amager Power Station, the Svanemolle Power Station, and H.C. Orsted plant, plus two garbage incineration plants, the Amagerforbraending waste incineration plant located next to the Amager plant and the Lynetten incinerator.

In summer the district heating demand drops off dramatically and the only thermal energy required is for domestic hot water heating, a fraction of the thermal energy used for winter space heating. In fact the amount of thermal energy required for domestic hot water heating can be provided through the district heating system by burning garbage, a resource that isn't seasonally dependent! As such there is no way that the utility can efficiently run its base load power plants, so it employs another clever strategy.

Copenhagen Lighting Department now buys the bulk of its summer electricity from Sweden where it taps into excess Swedish nuclear capacity. (While Danes have voted against construction of nuclear power plants, few realize that they are buying nuclear power in the summer.) KB also buys Danish sources of renewable resources in the summer. Then in September of each year, the utility fires up its own plants again taking advantage of the maximum energy value of each unit of fuel it consumes.[R#1,19,24]

One of the major policy initiatives facing the utility is the conversion from coal to natural gas. Of course not too many years ago the City as a whole had been through a massive conversion from oil to coal. Now the tides have turned and the Lighting Department converted the Svanemolle power station from coal to natural gas in 1986 to reduce carbon emissions. A new 60 MW combined-cycle gas turbine is currently being installed at Svanemolle at the cost of approximately $73 million.

The H.C. Orsted power plant will also be converted to natural gas by 1994 at a cost of $23 million. These ☞

changes will make natural gas the primary fuel for electricity generation thereby eliminating the use of coal for power generation in Copenhagen. The conversion is expected to triple natural gas consumption to 300 million cubic meters (10,594 million cubic feet) per year.[R#1,5]

Denmark, as discussed early, does have its own gas reserves in the North Sea but burning coal in power plants is currently cheaper. KB buys coal on the open world market from Venezuela, Colombia, United States, Australia, China, Russia, Canada, Poland and other producers.[R#24]

The utility is actively purchasing renewable capacity in the form of wind power from within and outside its service territory. The utility owns and operates a wind turbine which produced 0.2 GWh last year and it is also attempting to build three windmills with a combined capacity of 600 kW.

**Natural Gas:** Gas for Copenhagen is produced at the Sunby and Nokken Gas works. The Lighting Department and the municipality of Frederiksberg own the facilities jointly and KB manages their operations. In 1992, the facilities produced 83.3 million cubic meters (2,942 million cubic feet) of gas of which 15.7 million cubic meters (554 million cubic feet) went to Frederiksberg and the remainder to Copenhagen. KB's gas sales in 1992 reached 62 million cubic meters (2,190 million cubic feet), about 8.8 million cubic meters (311 million cubic feet) less than 1991. This reduction was attributed to mild weather and the expanded use of district heating. Natural gas is primarily used for cooking and although heating applications remain they are expected to substantially decrease due to the effect of the national carbon dioxide reduction strategy.[R#1]

While urban air quality and then concerns about supply of imported oil have been driving factors for efficiency in Copenhagen in the past, reducing the City's contribution to global carbon dioxide buildup is now the primary driving force for energy management initiatives in Denmark and in Copenhagen.

Since 1990, Copenhagen has been a participant in the Urban CO2 Reduction Project, a consortium of fourteen medium to large European and North American cities committed to reducing their CO2 emissions by 10-20% from 1988 baselines over a ten-year period through joint commitment and by sharing information on their efficiency activities. This initiative is managed under the auspices of the International Council for Local Environmental Initiatives (ICLEI) based in Toronto, Canada and was spurred on by the United Nations in response to the lack of international action at the national level.[R#5]

The efficiency initiatives in Copenhagen, like those in the other European cities profiled by The Results Center (see Profiles #76,77,78,79), do not follow the traditional North American demand-side management framework. Instead, they are broad and more complex including parallel emphases on supply-side efficiency, closely-associated district heating, building and industrial energy efficiency, the development of renewable energy sources, and transportation initiatives. While this profile will focus on the more conventional DSM programs, let's begin with a review of Copenhagen Light Department's supply-side efficiency initiatives and then move to district heating. In the following sections we'll take a close look at the more conventional energy efficiency programs, renewables, and transportation initiatives. ■

## SUPPLY-SIDE EFFICIENCY

Like many European cities a fundamental basis for energy efficiency is at the power plant. As discussed in Profile #77 of Hannover, Germany, the typical North American power plant is 30-35% efficient. In Europe, on the other hand, power plants provide multiple outputs and have efficiencies that exceed 90%! In fact, The Results Center has found a rivalry of sorts between cities and between power plants' chief engineers keen on outdoing each other in terms of plant efficiencies. Capturing the maximum value from every unit of energy consumed is a often overlooked aspect of utility energy management initiatives. Not so in Copenhagen!

Copenhagen's three baseload power plant combined for electricity generation of 2,362 GWh in 1992 at an average thermal efficiency of 73%. The refurbished Unit 3 at the Amager plant (that we toured with its chief engineer) had a remarkable monthly efficiency in January 1993 — when its thermal and electric demands were most closely matched — of 90%. It was just slightly outdone by its sister plant to the south which operated in the same month with an efficiency of 90.5%. Note that without the district heating component of the Amager plant, its maximum efficiency could only be 42%. Copenhagen Lighting Department estimates that its system operates year-round with an average efficiency of the fuel that it uses of 70-80%.[R#24]

The thermal efficiency of the power and heat generation process is of course the major aspect of supply-side efficiency, but the engineers at the power plants are also concerned about their own waste management. The plants use fluidized-bed technology for efficiency and to reduce emissions. In fact the resulting flyash is combined with calcium to make plaster which has been sold to industry for sheetrock production. Since the Danish and European housing market is currently depressed, thus limiting the number of housing starts, the flyash is now used to produce cement and asphalt for roads.[R#19,24]

## DISTRICT HEATING

The second major initiative taken in Copenhagen has been the construction of a massive district heating network that its engineers claim will be the largest system in the West. (Seoul, South Korea will shortly have the largest district heating system in the East!) District heating, while new to Copenhagen, is not new to Denmark. In fact district heating is a Danish tradition. The first DHS in Denmark was installed and operational in the 1920s and then activity surrounding DHS dramatically increased in the 1950s. As of 1992 there were 330 district heating networks in Denmark providing approximately 37% of the country's total heat supply for space heating.[R#3]

Heat and electricity production have been a major source of pollution in Copenhagen for many years. Until the 1950s much of the central heating was fueled by coal and coke thereby generating large quantities of soot. Central heating plants then switched to oil to mitigate the air pollution but in the process created a new and nasty pollutant: sulphur dioxide. The oil crises in the 1970s gave the City the impetus to increase its efforts to extend the district heating system and power the system through alternative fuels, notably coal that could be purchased on the world market without the threat of cartel control and thus dramatic price volatility, not to mention scarcity. Thus coal-fired district heating provided Copenhagen an opportunity to address the dual goals of increasing energy efficiency and reducing dependence on foreign oil.[R#12]

Adoption of the 1988 Regional Heating Plan emphasized the need to expand the district heating network while at the same time reducing overall energy consumption and thus pollution. As a result Copenhagen now has an extensive district heating system that provides space heating to residential and some commercial customers. Fully 61% of total building square footage in the City ☞

is currently served by the district heating system providing roughly two-thirds of Copenhagen's total heating requirements. The remaining third consists primarily of older housing without central heating systems and some oil-fired heating. Furthermore, it is currently prohibited to install electric heating in new buildings and new regulations have limited the application of gas heating as well.

Power for the system is generated primarily at the Amagerforbraednding and Lynetten waste incineration plants and at the three large peak-load power stations discussed earlier. The oldest sections of the system use steam because the industries that were originally served required this source. Newer sections use hot water thereby reducing the energy losses associated with transmission while providing more electricity for the same amount of combustion at the cogeneration facilities. Further modifications to the distribution system are targeted at converting the use of steam to hot water with the addition of gas-fired mini-heating plants to generate steam for those few remaining customers that require it.[R#8]

The City expects 95% market penetration by 2002 to reduce CO2 emissions per household by 50% over traditional oil heating. Estimates of the total investment necessary to reach market saturation targets are $324.576 million though much of this will be offset in tens of millions of dollars of annual fuel savings. When the district heating system, managed by another agency called the "CTR," is complete in the year 2002, it will fulfill 10% of Denmark's total heating requirement.[R#5,8]

Incentives for continuing the expansion of the network and connecting more large commercial and industrial customers are available under the national CO2 tax package. The introduction of compulsory connection requirements for large customers under the tax package has been augmented by a local requirement to connect all customers to district heating prior to 2003. The passage of the carbon tax package is likely to accelerate the pace of the system's expansion.[R#5,8]

Unlike district heating programs in Germany (see Profile #78 of Saarbrucken, Germany) and Finland, hooking up to Copenhagen's system is now compulsory. Initially there was some financing assistance for residential customers available from the state at the beginning of the system's construction, but now citizens get no help for connecting. Residential customers are typically changing out oil furnaces and as such will reap significant energy savings, thus eliminating the need for additional incentives. ■

The Lighting Department is attempting to secure 265 GWh of annual energy savings from residential, commercial, and industrial demand-side management programs. To finance this level of retrofit activity, the utility with the support of the City has added a surcharge onto every kilowatt hour of electricity sold in the City to all customers. The surcharge, equal to half an ore (a half of a hundredth of a Danish Kroner) or 0.083¢/kWh provides $1,656,397 (10 million DKK) to efficiency each year. Two-thirds of this sum is earmarked for the commercial sector and one-third for the residential sector.[R#20]

Power sells for an average rate in Copenhagen of 1.17 Kroner per kilowatt hour or 28.2¢/kWh. Thus the surcharge of 0.083¢ is a small fraction of the kWh cost borne by consumers. In fact, the surcharge represents on 1/234 of the average kWh rate, or 0.43%. Nevertheless, in Denmark, like the United States, there have been concerns raised by industries regarding rate impacts and the value of utility-sponsored energy efficiency initiatives. Some DSM programs are provided by the Danish government.[R#20,21]

The City and the Lighting Department have realized the magnitude of potential energy savings and thus CO2 reduction from improved energy use in buildings as buildings consume 43.9% of the total energy in the City. As the current building market is saturated and the new construction market is depressed, the great majority of efficiency opportunities are in the retrofit market. Thus the Lighting Department has undertaken a number of programs to reach this market, primarily through its energy advisory services. These DSM programs include a major focus on targeting the 3,500 largest commercial and industrial consumers for substantial efficiency improvements. DSM programs for residential customers provide information and audits through the Energy Advisory Center, a neighborhood retrofit "blitz" program called the Urban Ecology Project (carried out in large part by the City's Environment Department), and the Lighting Department's first time of use rates.[R#1,5,12]

#### ENERGY ADVISORY SERVICE

Energy Advisory Services, not to be confused with simple audit programs in North America, are the primary demand-side management programs at Copenhagen Light Department and are split in two specific divisions, commercial/industrial and residential. (For overall projections of savings anticipated by energy advisory services in the year 2000, see the Advisory Services Energy Projections table page 15) We'll begin with the commercial/industrial component:

Denmark's emphasis on energy advisory services followed on the heels of the Brundtland Commission Report in 1987.[R#30] At that time Denmark produced its own report or Energy Plan that calls for decreasing energy consumption throughout the country by 50%.[R#20,21]

Energy advising then became a project of The Association of Danish Utilities. While there was some resistance to energy advising and teaching customers how to use less electricity and gas, in Copenhagen the Lord Mayor was very keen on the strategy and thus the Copenhagen Lighting Department was free to proceed aggressively with DSM. Danish utilities have assured the Danish government that they will survey all major customers within five years. Of course the energy advisory services are free to large users so this target will quite likely be achieved. Furthermore a new Danish law requires that all public buildings in Denmark invest in energy management, increasing the Lighting Department's workload but opening the door to additional customer-driven and financed savings.[R#20,21]

Copenhagen Lighting Department's Energy Advisory Service is targeted at its 3,500 major energy consumers, defined as users of over 100 MWh per year. Of these, 2,000 customers use half of the total power consumed in the City. The airport is the biggest electricity user followed by the Carlsberg beer brewery.[R#20]

The commercial energy advisory services staff is made up of fourteen professionals of which seven are electrical engineers and seven are energy engineers. There is a special course of study at the Danish Technical University in Lingby for the latter discipline under the auspices of Dr. Jurgen Norgard.[R#5,21,23]

The Energy Advisory Service for commercial and industrial accounts received 66 new "tasks" in 1992 and completed 105 with 187 still outstanding at year's end. By the beginning of 1993 the 14 full-time advisory service employees had reached 320 major customers representing nearly 10% of the target group. Carsten Eriksen, a senior energy advisor, notes that his division is able to produce about 100 energy surveys each year. ☞

Each survey takes a professional staff member approximately three weeks to complete. The end result is a detailed technical report that is 50-100 pages in length and includes the results of an in-depth audit, retrofit strategies, suggested measures, and payback periods for recommended action strategies. While tailored for each large user, the survey reports are prepared on computer discs using a standard format for reporting purposes. [R#5,20,21]

The Energy Advisory Service program currently targets lighting applications, ventilation, pumps and compressors, process improvements, and industry-specific recommendations for bakeries, restaurants, and shops. Planned initiatives include motors, energy-efficient lighting, efficient construction, low-energy and CFC-free refrigerators and freezers, and electric kettles.[R#5]

An additional incentive for an industry to enact the recommendations within the energy surveys is that by doing so they can recoup their CO2 taxes. In order to do so, a new law requires the industry to implement every retrofit measure that has a payback of less than two years as specified in the report.[R#20]

**Time of use rates:** Time of use rates were established in Copenhagen in January 1991 for large electricity consumers. There are three different rates in place designed to influence the customers' decisions on what hours of the day they consume electricity. Although these rates are not yet compulsory, 245 large customers chose to adopt the structure in 1992 and 99 customers with 156 meters signed up for this service in 1991. On January 1994, all large customers will be switched over to the time of use rate to shift as much power as possible from peak periods to off-peak usage.[R#1,28]

#### RESIDENTIAL SERVICES

Residential DSM essentially takes the same form as the commercial and industrial services and is based on the premise that accurate information, coupled with accurate price signals, ought to spur customers' actions on their own behalf. Since it was refurbished in 1989, the Lighting Department has used a showroom called the Energy Advisory Center where six full-time consultants provide comparative information on thousands of appliances on the Danish market as well as information on other residential conservation measures. A database of appliances available in Denmark containing some 1,500 appliances was developed by ten Danish utilities and nicely complements the 500-600 appliances which are displayed in the center complete with comparative data.[R#21]

According to the Center's director, Lene Lund, the Energy Advisory Center has a mission. For years the utility taught its customers how to use more electricity. Now the Center and its staff provide advice on how to use natural gas and district heating to save electricity. The Lighting Department expressed its entire DSM activity slightly differently, stating that it is actually an exercise in "reverse marketing" and teaching its customers "how to buy as little as possible of our gas, electricity, and heat products." Although the Center is advertised in local papers and through utility bill stuffers, most visitors come to the Energy Center when they intend to buy an appliance and want objective information on energy and water saving possibilities. Visitation rose 17.3% in 1992 to 16,200 visitors.[R#1,10,20,21,28]

The Center's focus is on those appliances that use the most electricity in the residential sector: refrigerators and freezers, washing machines, and dishwashers. The Center also provides information on wise water use in cooperation with the water supply company. One of the interesting tips we learned at the Energy Advisory Center is that the use of waterbeds is Denmark is on the rise and is quite alarming in terms of energy magnitude! The Association of Danish Utilities Research Center has found that all of Denmark's windmills combined can't provide enough energy to fulfill the nation's growing water bed energy demand. Electric blanket use as well is problematic and has caused dramatic increases in household electricity consumption.[R#20,21]

The Energy Advisory Center plays a key role in educating Copenhagen's youth about wise energy use. (See Profiles #68,72 for further information on educational curricula programs in North America.) Lene Lund of the Center noted that nearly every student from both public and private schools in the City visits the Center at least once during their elementary schooling, typically at the age of 13-14 years old. The facility includes a demonstration kitchen where rather unconventional cooking classes for students are conducted. Two similar meals are prepared with large meters showing the relative energy intensities of each approach. For instance, two cakes are cooked side-by-side, one in a conventional oven and the other in a microwave oven to show the relative energy efficiency of

| ***Advisory Service Energy Projections*** | *1990 Energy Use (GWh)* | *Technical Savings Potential (%)* | *Projected Savings by 2005 (%)* | *Projected Energy Use Reduction by 2005 (GWh)* | *Projected CO2 Reduction (1,000 tonnes/year)* |
|---|---|---|---|---|---|
| Public Service | 356 | 52 | 17 | 61 | 66 |
| Trades & Services | 911 | 41 | 10 | 91 | 100 |
| Industry | 374 | 45 | 13 | 49 | 54 |
| Residential | 919 | 35 | 7 | 64 | 70 |
| Total | 2,560 | | | 265 | 290 |

the latter option. Lene Lund notes from experience that the students get a kick out of the demonstration and have been particularly keen to sample its output![R#21]

**The mobile meter:** The Energy Advisory Center also provides interested customers with a mobile electric meter that can be taken home to measure the power consumption of various appliances. The meter has been effectively used as part of a campaign called, "Catch an Electricity Thief," and allows users to plug in a refrigerator, for example, and measure its power consumption over whatever time interval they choose. Customers that take advantage of the use of the meter get a nifty refrigerator thermometer and are told that each degree colder they set their refrigerators results in an additional 5% increase in its power consumption. Three-phase meters are also available.[R#20,21,28]

**The urban ecology program:** One of the most intriguing, yet confusing, programs underway in Copenhagen is the Urban Ecology Program. The reason it is intriguing is that it encompasses a wide variety of ecological principles from rainwater collection to urban gardening. The reason that it is confusing is that it appears to be as much of a social redevelopment program as it is an energy efficiency initiative. In fact, the sociological aspects of the program are profound, as if the City is working to recreate a culture in Inner Vesterbro, a portion of the City that seems to have been severely impacted by the removal of the light rail system and other factors. Our guide told us that "the life was sucked out of this community," and that there is a fear in Copenhagen of bad neighborhoods. Thus the project is all part of restoring the life of a community gone sour.

The Inner Vesterbro neighborhood retrofit project will be implemented from 1992 to 2000 at a reported cost of $993.6 million (6 billion DKK). The program has targeted 4,000 apartments with 300,000 square meters of floorspace to implement comprehensive heat, electricity, and water saving measures with a payback of under four years. Demonstrations are also underway in this neighborhood. Sunspaces discussed in the following section on renewable energy forms are being incorporated in some cases, and even rainwater collection is being installed in one multi-family unit.[R#5]

As stated above, the Urban Ecology Project is not just a utility project, in fact the Environment Department seems more involved here than the utility. The City with EC funding is spending large sums on refurbishing neighborhoods to restore culture, at the same time addressing water and energy efficiency, waste management, and social reconstruction. Great efforts are being made to provide at least some modicum of aesthetic character to the social housing developments. Two kinds of work are going on in Inner Vesterbro, new construction but predominantly retrofits of old buildings. In several cases apartments had to be plumbed for bathrooms by raising the flooring in the units. Some other apartments got their first kitchens.

**The Energy Bus:** The Lighting Department co-sponsors an Energy Bus with another utility. The Energy Bus is a 40-square meter moving showroom that is actually a converted tractor-trailer. It is used as a mobile demonstration of efficiency at conferences, fairs, events and "to take efficiency to the streets" in the evening and on weekends. The utility hopes this travelling efficiency resource will spread the message of efficiency throughout its service territory. There has been good experience in Holland with a similar bus.[R#1] ■

Entering Denmark from the south by train, it's hard not to be struck by the number of wind turbines paddling along slowly, adding a calm yet modern touch to quiet Danish rural communities. Denmark's wind capacity, which by early 1990 was already 340 MW, is only exceeded by that of California. (In fact, wind's 2% share of total electricity production gives Denmark the distinction of having the highest percentage contribution of wind of any national electricity mix. Denmark plans to raise this share to 10%.) The contrast between the modern wind turbines and the ancient spires of churches and tidy look of age-old, yet meticulously-maintained barns, is ironic and seems to span time dimensions.

Nearly all of the wind capacity in Denmark produced by the country's 3,300 wind turbines is cooperatively-owned, providing resiliency and sustainability to the Danish energy equation. In fact, more than 100,000 families in Denmark are members of wind energy cooperatives and they have installed 80% of all Danish wind turbines. Denmark now also has installed its first off-shore windpark with 11 turbines of 450 kW each.[R#3,26]

Certainly one of the striking features on the Danish energy horizon is a strong grass roots movement. This movement, which in part grew out of the Danish anti-nuclear movement, pushes for decentralized wind energy and a responsible energy future. Perhaps the grass roots movement best embodies the social orientation that energy planning can take, an orientation that fosters social equity, quality of life, and an integrated approach to energy and environmental planning and policy. Two non-profit organizations have been key players in many initiatives: the Danish Organization for Renewable Energy and the Copenhagen Environment and Energy Office. The latter group has been heavily involved in Copenhagen providing fee educational materials, information, and consultancy services; creating networks; making presentations on case studies and demonstration houses; providing "resource checks" of houses for electricity, energy, water, recycling, etc.; providing exhibitions at fairs, rallies, schools, etc.; teaching courses and seminars; and providing policy input when appropriate and necessary.[R#23,26]

**Avedore Windpower project:** One of the most interesting aspects of the grass roots movement in Copenhagen is the Avedore Windpower project, a windfarm located just ten kilometers (6.2 miles) from the center of Copenhagen along the waterfront in an industrial area. What makes the windfarm so unique is that six of the twelve turbines at the windfarm are owned by 722 individual investors who each invested $3,313 (20,000 DKK) in the windturbines, thus total consumer investment of $2,178,162 (13,150,000 DKK). Each investor will receive $497 (3,000 DKK) per year for a simple payback on their investments of less than seven years. The windfarm began operating in December of 1992 and will produce approximately 7 million kWh annually in combined output from its 12, 300 kW machines.[R#23,26]

Perhaps it is the Dane's keen support of wind energy that best symbolizes the country's long-term orientation regarding environmental and energy awareness. National policy has clearly been influenced by grass roots activism and though initial efforts may have seemed small and insignificant, many grass roots initiatives have grown and become institutionalized. Like the country's preponderance of decentralized and cooperatively-owned wind generation, solar sunspaces cladding the southern exposures of old, innercity apartment complexes tell the story as well.

**Solar additions:** In the urban villages of Copenhagen are many good ideas, one of which is solar additions that have been added onto 3-5 story, multifamily apartment complexes. These sunspaces are about two meters deep and run the width of an apartment and provide warmth through their passive solar design, and have also become quite popular rooms for sometimes cramped apartments. These unusual looking additions represent several themes. First, it is possible to add energy efficiency to old apartments and specifically to take advantage of passive solar energy in Copenhagen in the winter. Second, the rather "funky" initial designs created by some of Copenhagen's most colorful architects are now being institutionalized in new apartment buildings. The newly-built sunspaces add an air of modernity to new apartment complexes and their popularity adds value to apartments, while taking advantage of the sun. Third, energy efficiency is tied with a social agenda. The sun rooms have been heavily used, improving the quality of life in Copenhagen. Some apartment dwellers delighted by the additional area with lots of windows basically moved in,... with electric resistance space heaters, completely defeating the purpose of the additions! This problem has been all but completely rectified through proper education and awareness building. (The Results Center found similar sun spaces being built into new apartment complexes in Hannover, Germany. There architects have paid careful attention to the detail surrounding thermal breaks such that when exterior temperatures are cold the metal-framed sunspaces do not act as cooling fins on the sides of buildings! See Profile #77)

The solar additions were designed and developed partially in response to the City's drive for district heating, perhaps without the necessary precursor of energy efficiency. Solar energy was promoted as one means of taking advantage of potential missed opportunities. While the City was focusing on DHS, grass roots activists reminded policy makers that making apartments more efficient first (including the use of passive solar) made sense, and that then the DHS hookup could be properly sized for the already energy-efficient units. This recommendation was heeded and now brightly-colored murals, three and four stories high, cover insulation that has been added to the exterior walls of apartment buildings without abutting buildings. The huge floral designs add color to the neighborhoods and provide powerful reminders of citizen activism and neighborhood control.

**Copenhagen's planned ecological center:** Finally, Copenhagen is pleased that the European Commission is planning on funding its proposal for a large ecological center in an abandoned meat packing plant built at the turn of the century. The European Commission will provide just under three million dollars (18 million DKK) which the City will be required to match. The utility will be involved in the project as will the Environment Department and the grass roots community. So far the Center has generated lots of creative ideas ranging from an ecological market to a center for arts, music, and the like.

Our guide told us that their greatest challenge will be developing "a heart" for the center, a climate, or a milieu for ecological inspiration. He added that hopefully its meaning and importance will extend from beyond Denmark to throughout Europe, and that it will provide contact information on organizations, companies, seminars and conferences, and so on to become an internationally recognized and used alternative energy center. ■

Danish energy consumption in the transportation sector has actually risen over the past twenty years in stark contrast to energy trends in other sectors. This rise is due primarily to cheaper than predicted energy costs and increasing reliance on automobiles. However, the Brundtland Report called for a 50% reduction in energy consumption attributed to transportation by 2030 and the Danish government has targeted energy and CO2 emission stabilization from transportation before 2005, with reductions of 25% of 1988 levels before 2030. Thus the impetus is in place for policies to reverse Copenhagen's trend of increased automobile dependence through a series of innovative strategies.[R#5]

Despite the abundance of bicycles and a delightful pedestrian mall that extends from the center of town all the way down to the famous Nyhavn Canal (the former stomping grounds of Hans Christian Andersen!), energy consumption in Copenhagen due to transportation is equivalent to 6,432 terajoules (1,805.57 GWh) per year and this level is expected to increase by 25% by the year 2010 primarily as a result of increased driving. Driving

| ***Copenhagen Modal Transportation*** | *Passenger Miles* | | *Energy Consumption* | |
|---|---|---|---|---|
| | *Million Miles* | *Percent* | *TJ* | *Percent* |
| Cars | 1,199 | 58 | 4,175 | 79 |
| Buses | 280 | 13 | 385 | 7 |
| Trains | 419 | 20 | 707 | 14 |
| Bicycles | 180 | 9 | 0 | 0 |
| Total | 2,078 | 100 | 5,267 | 100 |

At first glance, Copenhagen resembles any major city. Cabs scramble around in droves, tires squeaking on cobblestone streets, and pedestrians jam the downtown sidewalks. Then one becomes aware of the bicycles, they are everywhere. At the train station a bicycle rack is hundreds of feet long, in rows three or four deep, carrying thousands of bicycles, and not a space is free. The bikes aren't flashy, they're functional single- and three-speed basic bikes and most remain unlocked. Some newer bikes carry the same style of the Rudge, Raleigh, Schwinn era in North America, and sure they are locked, but for the vast majority of the thousands of cyclists, bicycling is a part of everyday life and not a sport. It's a means of mobility and strongly encouraged in Copenhagen. Bike lanes abound and these are typically on the street (unlike other bike lanes that share pedestrian walks) delineated by painted lines. Biking currently accounts for 9% of total modal transportation in Copenhagen.[R#5]

now accounts for 58% of modal transport in the City. Part of this automobile dependence stems from a decision that many residents of Copenhagen regret to this day. In 1972 Copenhagen's light rail system was ripped out of the streets and sold to Cairo, Egypt.

One of the great new threats to transportation efficiency in Copenhagen, and related urban air quality, is a proposal to build a tunnel from Copenhagen to Sweden. The tunnel would of course have profound effects on the ferry industry by creating a new and expeditious link to Scandinavia. While this is seen as a highly attractive means of increasing trade, some in Copenhagen are concerned not only about the impacts in the City but about

the potential destruction of rail service to Scandinavia if a tunnel allowed freight by truck. The pros and cons to the tunnel are numerous and many environmentalists are calling for a compromise akin to the English Channel crossing whereby auto and trucks are not permitted and the tunnel becomes a rail-only access to the north.[R#18]

While the automobile modal share and trend is disturbing, auto ownership per capita in Copenhagen is half of the rest of Denmark, which in turn is also less dense than neighboring countries. This is a function of several factors. Copenhagen has undertaken a number of initiatives to encourage alternatives to driving. First, the City has enforced higher parking fees, installed parking meters, and enforced stricter restrictions. In the downtown area parking costs $2.48/hour (15 DKK/hour). Gas prices are high as well at $3.26/gallon (5.2 DKK/liter). Many urban neighborhoods have requested speed bumps in the streets to slow down traffic. Danish auto registration fees more than double the sticker price of a car. One of our hosts suggested that the auto registration fee represents a tax value of 150% and noted that the only reason that he has a car, ironically, is that he works for the electric utility in the conservation department! He gets two Kroner for every kilometer he drives on business, and in fairness, he does need a good deal of mobility on the job.[R#19]

In Copenhagen transportation is the responsibility of the Regional Transport Company. This agency has carried out a number of initiatives in conjunction with the City. It has created bike lanes and mass transit lanes and has planned expenditures of $8.28 million in 1992 dollars (50 million DKK) for public facilities and the biking network including a large number of bike racks. On the technology side the Transport Company has employed electric trolley busses with regenerative braking, a process whereby when the brakes are applied energy is regenerated and stored for subsequent acceleration. The Lighting Department is also acting as a consultant to the Transport Company in the demonstration of what is called the Duobus Project. The Duobus employs a new technology whereby direct current from the overhead wire is transformed to alternating current to power the bus.[R#1]

| ***Copenhagen Transportation Annual Energy Consumption*** | *Energy Consumption* | | *CO2 Emissions* | |
|---|---|---|---|---|
| | *TJ* | *Percent* | *Tonnes (x1000)* | *Percent* |
| Cars | 4,175 | 65 | 305 | 62 |
| Buses | 385 | 6 | 29 | 6 |
| Trains | 707 | 11 | 71 | 14 |
| Trucks | 1,156 | 18 | 87 | 18 |
| Total | 6,423 | 100 | 492 | 100 |

Despite the progressive aspects of transportation planning in Copenhagen, the City faces some constraints in attempting further initiatives. Increased bike access has an impact on traffic flow and the number of accidents. Taxes on transportation, such as toll roads or commuter taxes, are tangled in political pressure between the City and the surrounding areas. Finally, the large auto registration fees are viewed by many Danish motorists as a violation of personal freedoms.[R#5] ■

# Copenhagen's $CO_2$ Reduction Strategy

Mitigating CO2 is now the driving force behind energy policy in Denmark in general and Copenhagen in particular. As stated earlier in the text the Danish government has committed to CO2 reductions of 20% of 1988 levels by the year 2005. Copenhagen has also reaffirmed its commitment to this national goal through its participation in the Urban CO2 Reduction Project. It plans to reduce CO2 emissions by 1 to 2% annually over 20 years.

| ***CO2 Reduction Strategies for 2005*** | *Reduced Emissions (Tonnes)* | *Reduced Emissions (%)* |
|---|---|---|
| Power Plant Conversion | 260,000 | 5 |
| District Heating Extension | 570,000 | 11 |
| Energy Advisory Services | 290,000 | 6 |
| Urban Ecology Project | 7,410 | <1 |
| Waste Management | 400,000 | 8 |
| Transportation | (25,000) | (1) |
| Total | 1,502,410 | 30 |

Note: 1988 baseline emissions were 5 million tonnes.

In 1988 the City of Copenhagen was responsible for annual CO2 emissions of approximately 5,000,000 tonnes. To meet its reduction goals, the following strategies are being employed which will have the combined effect of reducing 1988 baseline emissions levels by roughly 30%, or 1,500,000 tonnes of CO2 annually, by the year 2005. Note that the percentages in the accompanying pie chart reflect the percentage of total planned reductions not the percentage of current CO2 emissions.[R#5]

1) Five percent of the City's total CO2 emissions, or 260,000 tonnes, will be reduced through the conversion of Copenhagen's power plants to natural gas.

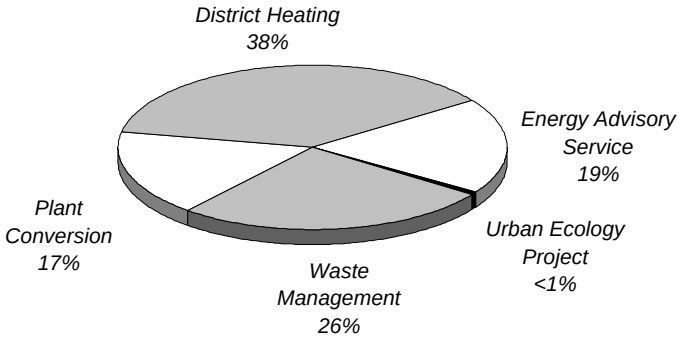
2) Eleven percent, or 570,000 tonnes of CO2 will be reduced by the extension of the district heating system as planned.

3) Six percent, or 290,000 tonnes of CO2, will be reduced per year as a result of the Energy Advisory Service.

4) Less than a percentage point, 7,410 tonnes of CO2 per year, will be reduced as a result of the Urban Ecology Project.

5) Eight percent, or 400,000 tonnes of CO2-equivalent greenhouse gases will be reduced through waste management and incineration programs.

**PERCENTAGE OF TOTAL PLANNED $CO_2$ REDUCTIONS**




6) Copenhagen, however, expects increased emissions of 25,000 tonnes of CO2 in the transportation sector, 5% more than that sector's 1988 emissions, an overall increase in 1988 baseline emission levels of one percent. ■

## LESSONS LEARNED

Naturally with an effort as broad as that carried out in Copenhagen related to energy efficiency and the shift to the sustainable use of energy, there are many lessons learned. Perhaps the most important has to do with district heating, clearly the most significant effort to date to increase the efficiency of fuel use in the City.

District heating in Copenhagen has been driven by a number of factors, not the least of which was the famous Brundtland Report, the result of a United Nations commission on sustainable development. One of the explicit objectives stated in that seminal report concerned "optimum utilization of fuel for the benefit of the environment and human beings." In Copenhagen, despite the natural barriers to construction of a major district heating network in dense, old, and even historic neighborhoods, the City has achieved its goals. The Lighting Department has been able to follow the Brundtland Commission's guidelines, achieved remarkable levels of energy efficiency, and decreased CO2 emissions through the wise use of coal, oil, and garbage burned to provide thermal energy to the now very large district heating system.[R#28]

Another lesson learned in Copenhagen is that despite high prices for fuels and radically high automobile registration fees, consumers seem to be moving to greater and greater levels of energy use. Thus the automobile share in the transport modal split is increasing, a rather disturbing trend, and transport energy use overall is increasing as well supporting the inelasticity of prices and energy consumption for desired end-uses. Wild card end-uses like heated waterbeds also threaten to erode energy savings initiatives. Given these alarming trends, Copenhagen's commitment to CO2 reductions is admirable and will be very challenging to fulfill. Furthermore, given the City's already quite efficient baseline energy use, capturing significant reductions will be that much more challenging. (See Profiles #77,78 for a fuller comparison of relative energy intensities between European and North American cities including Copenhagen.)

Being located in the capital of Denmark has been another important factor in Copenhagen's success to date. The City carries a good deal of influence in national energy planning and initiatives such as CO2 taxes, and at the same time has been and continues to be influenced by the Danish Energy Agency and other relevant government agencies. Furthermore, another factor that is interesting in Copenhagen, as discussed in this profile, is the role that citizen activists have had on national and City energy policies. Thus Copenhagen finds itself in the middle of a top-down, bottom-up planning and evaluations paradigm. Each influence, at each end of the political spectrum, has been important in determining the City's actions and creating a balanced approach to short and long term energy-related concerns. And the result provides another dimension: municipal energy policy that reflects national and international concerns such as foreign oil dependence and global climate change, and at the same time it reflects local issues such as the sociology of urban neighborhoods, aesthetic qualities, and decentralized energy resources.

Most relevant to The Results Center's primary focus, The Copenhagen Lighting Department has concentrated its "DSM" efforts on advisory services with marked success. Supported by the Energy Plan and other pieces of legislation, energy advising is alive and well and effective in Denmark as a whole and also in Copenhagen. The utility has not had to finance energy efficiency or provide direct financial incentives (except in very limited applications) and thus it has been able to shift any burden of DSM program costs, and related concerns about rate impacts, from its own balance sheets to its customers' balance sheets.

Closely related to this last point is the surcharge that is levied on each kilowatt-hour sold in Copenhagen and which is then dedicated to supporting energy efficiency initiatives. This rather straightforward mechanism to fund energy efficiency has worked in Copenhagen (and in Oslo, Norway as well, see Profile #79) and may be replicated in other parts of Europe and North America.

## TRANSFERABILITY

The broad range of energy and resource efficiency initiatives carried out in Copenhagen and underway at this time can certainly be transferred to other parts of Europe and to North America. The country and the City have recognized their contribution to global environmental and energy issues, and have acted responsibly, recognizing that their investments not only carry a social agenda, but also make economic sense in the mid-term and certainly long-term time horizons. ■

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