Photo: Highlight

1.5 Other sectors

1.5.1 Forestry

Around one tenth of Denmark is covered by forest. Of this, approximately one quarter is state forest, while the remainder is municipal forest, privately owned forest, etc. The framework for management of Denmark's forests is set by the Forestry Act, which encompasses all forests. However, a number of provisions only apply to forest that is permanently protected as forest, which comprises 85% of forest acreage in Denmark. These protected forests have to be managed in a diversified manner such that timber production is increased and improved. At the same time, consideration has to be shown for landscape, nature, cultural history, environmental protection and outdoor recreation interests.

In 1994, the Strategy for Sustainable Forestry was adopted. This concluded that compared to international standards, Danish forestry is developing sustainably – not least because the forest area and growing stock have been increasing for 200 years and because the growth is continuing. The political goal is to double the forest area such that 20–25% of the country will be covered by forest in 80–100 years. Forestry is very dependent on the health, stability and economy of the forests, and the sector has faced considerable problems during the 1990s. Several forestal policy initiatives have therefore been implemented to promote sustainable development of the forests in order to safeguard the original types of Danish forest and their flora and fauna.

There are no forests remaining in Denmark that are unaffected by man (primeval forest). Moreover, the forests are more extensively managed and untouched than the agricultural land. As a consequence, many of the wild plants and animals of significance to biological diversity inhabit the forests. Ancient monuments and cultural environments are generally better preserved in the forests than they are on arable land.

The forests serve a number of environmentally protective functions, for example protection of groundwater resources and prevention of soil erosion. In addition, they break the wind, keep down the noise and filter dust and salt from the air. The forests serve as CO_2 sinks, and afforestation increases storage of atmospheric CO_2.

The forests are one of the recreational facilities most utilized by Danes (*see Section 1.5.8*). The public have right of access to virtually all Danish forests – unrestricted access in public forests and access restricted to roads and paths in private forests.

Photo: CDanmark

Trend in forestry

Forestry differs markedly from other forms of rural production because of its long crop rotation times. Total forest acreage has more than doubled over the past just under 120 years, particularly due to growth in conifer acreage (*Figure 1.5.1*). From 1990 to 2000, the total woodland acreage has increased by just under 5% and presently occupies 10% of Denmark. Around 60% of this consists of conifer forest, and 40% of broadleaf forest. The area planted with Christmas trees and ornamental greenery has increased from a negligible share in 1976 to approx. 8% in 2000.

The total area of woodland was 436,000 ha in 2000 compared with 417,000 ha in the 1990 forest survey. Just under half of this increase is attributable to the inclusion of ornamental greenery and Christmas trees on former arable land. By far the majority of the conifer acreage is located in Jutland (81%), while the majority of the broadleaf forest is located on the island part of Denmark (57%).

The proportion of broadleaf forest has increased by 4% between 1990 and 2000, when it comprised 38%. The acreage of oak has increased by 26%, while the acreage of beech has remained constant. The proportion of conifer forest is falling, although the total conifer acreage has not decreased.

Almost a quarter of the regeneration of the forests takes place through self-sowing or planting below the canopy of the existing forests, and the remainder in connection with clear-cutting. Rejuvenation of the existing forests benefits biological diversity in the forests as this causes less disturbance than clear-cutting. The use of these more natural rejuvenation methods seems to be increasing.

The December 1999 hurricane

The worst hurricane of the 20th century hit Denmark on 3 December 1999, causing the greatest windfall ever recorded. The devastation was greatest in southern and western Denmark, where approx. 15,000 ha of forest were lost to windfall. About 3.3 million m^3 of softwood and 400,000 m^3 of hardwood were toppled, corresponding to two years of normal felling volume.

In the hardest hit areas the storm was so severe that virtually all the conifers and many broadleaf trees taller than 10 metres were toppled. Outside the main path of the hurricane, the stands that managed best were those with many broadleaf trees. In the affected areas, the hurricane will influence the annual increment and felling volume for many decades to come. The October storm in 1967 and the November storm in 1981 also caused considerable windfall. It is estimated that a catastrophe of this type strikes Danish forests roughly every 15–20 years.

Felling volume and annual increment

Felling volume has averaged around 2 million m^3 per year over the past 20 years (*Figure 1.5.2*). Approximately 1/3 of this consists of hardwood and 2/3 of softwood. The proportion of timber in

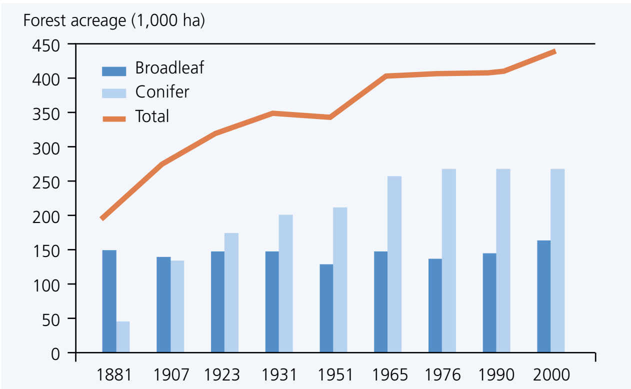


Figure 1.5.1

Trend in forest acreage apportioned by conifer and broadleaf forest.

(Source: Danish Forest and Nature Agency, Statistics Denmark and Danish Forest and Landscape Research Institute, 2001).

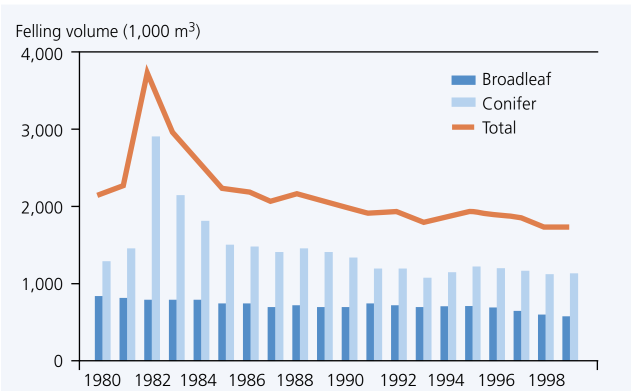


Figure 1.5.2

Felling volume apportioned by tree type for the period 1980–1999. Includes wood chips from 1984 onwards.

(Source: Statistics Denmark, 2001).

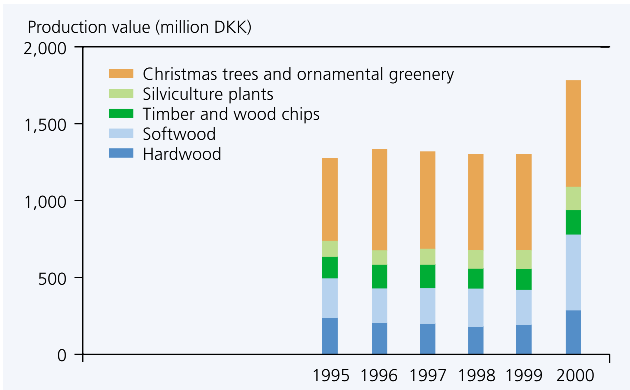


Figure 1.5.3

Forestry production value for the period 1995–2000 calculated as Gross Domestic Product at factor cost.

(Source: Statistics Denmark, 2001).

the fellings has been decreasing, while the proportion of wood for fuel has been increasing. This is due to increased felling of broadleaf species for fuel wood since the beginning of the 1980s as a result of the increasing price of oil. In the case of conifers, it is also due to enhanced production of wood chips for fuel from the mid 1980s. Wood (wood chips, firewood, wood pellets and waste timber) accounts for just over 2% of the Danish energy supply, and comprises about 25% of all renewable energy.

The net annual increment was calculated in 1990 to be 3.2 million m^3 total mass, of which 1.0 million m^3 were hardwood and 2.2 million m^3 were softwood. Compared with the felling volume, and taking into account that part of the wood is left unused on the forest floor after felling, the growing stock is increasing by an estimated 0.5-0.8 m^3 million per year.

Wood consumption in Denmark

Domestic forestal production accounts for just under 30% of the wood consumed in Denmark, with the remainder being imported. Less than 3% of imported wood derives from tropical forests, and the majority of imported wood derives from neighbouring countries – primarily softwood from other Nordic countries.

Total consumption corresponds to 1.5 m^3 of wood per person per year. This is a high figure compared with the average for Western Europe (0.5 m^3), but low compared to that in the other Nordic countries (6.9 m^3). Around half of wood consumption is used to produce paper goods, while the remainder is mainly used in the building materials and furniture industry. Around one third of Danish paper consumption derives from Danish paper factories that use solely recycled paper as the raw material.

Christmas tree production in 2000 amounted to approx. 10 million trees, while production of ornamental greenery amounted to approx. 35,000 tonnes. Of this, approx. 1.5 million Christmas trees and about 10,000 tonnes of ornamental greenery are sold domestically.

Outdoor recreation

The average adult Dane visits a forest approx. 10 times a year (*see Section 1.5.8*). Between 1976/77 and 1993/94, the number of forest visits increased by approx. 25%. The duration of the visits has been falling, however.

Employment and turnover in the forestry and timber sector

Around 2,200 persons work in the Danish forestry sector. In addition, more than 24,000 people work in the timber and paper industry, and an even greater number are indirectly associated with the sector, for example in the furniture industry.

The total production value of Danish forestry is about DKK 0.7 billion per year for timber and about DKK 0.6 billion for Christmas trees and ornamental greenery (*Figure 1.5.3*). Turnover in the Danish timber and paper industry and the furniture industry was approx. DKK 30 billion in 2000. Production of Christmas trees and ornamental greenery is of great significance for the overall economy of the forestry sector, especially for the private forests. Even though Christmas trees and ornamental greenery only account for approx. 8% of total forest acreage, they account for 1/3 of the primary production. A considerable proportion of Christmas tree production takes place on arable land. Hunting is another important source of income for the forestry sector economy.

Silviculture systems

Silviculture systems

The primary form of forestry employed in Denmark is timber forest. With this form of forestry, the forest is renewed by the planting of seedlings, the sowing of seeds or by natural renewal, and is cultivated so as to achieve closed stands of tall-stemmed trees of high quality. Selective felling ensures that the soil remains permanently covered by forest. In contrast, clear-cutting exposes the soil during rejuvenation. At the present time, about 7,700 ha are designated for selective felling.

Natural forest

- Characterized by stands comprised of self-sown forest of Danish trees and shrubs that are of special interest with respect to preservation of the gene pool. A large part of the natural forest area is managed as ordinary diversified timber forest. The area of natural forest is estimated to be approx. 35,000 ha or 8% of the total forest area. Of this 20–30,000 ha are managed as timber forest. The majority of the natural forest is privately owned.

Traditional forestry practices

- 11,000 ha with special nature qualities are now managed by traditional forestry practices, considerably more than the target of 4,000 ha by 2000 stipulated in the Natural Forest Strategy.

Virgin forest

- Held free of all forestry practices and can contain nonindigenous species of tree. Virgin forest can be used as a reference for close-to-natural forestry and is used to ensure and promote the nature value of forests. The objective of a ten-fold increase in virgin forest acreage before 2000 from approx. 500 ha at the beginning of the 1990s has been attained.

Forest drainage

- During the second half of the 19th century, numerous ditches were dug in the Danish forests. Many forest bogs were drained and planted, and the natural flora and fauna declined markedly. The re-establishment of forest meadows and bogs is therefore being promoted at present.

Box 1.5.1

Various silviculture systems.

Impact of forestry on nature and the environment

The natural vegetation in Denmark is broadleaf forest. Due to overexploitation and clearance of forests up through the Middle Ages until 1800, only a minor part of Denmark's modest forest acreage has a long biological continuity and consists of native tree species. The classic managed forestry, which is characterized by homogeneous stand structures and the use of rigorous management practices such as clear-cutting, removal of dead trees and dead wood, intensive soil management, drainage of wetlands and the use of exotic tree species in short rotation, has reduced the extent of the natural habitats of many plants and animals in the forests over the past 20 years.

Cultivation practices

For a forest ecosystem to be in balance in the long term it is necessary that nutrient removal through felling and leaching to the groundwater do not exceed input from the atmosphere and release via weathering of soil minerals. Forest soils naturally become increasingly acidic, a process that can cause problems in the case of the most nutrient-poor soils. The risk of acidification is greatest beneath conifers.

Only small amounts of fertilizer and pesticides are used in forestry, and then primarily in production of Christmas trees and ornamental greenery, in afforestation and in rejuvenation of existing forest (*Figure 1.5.4*). The state forests have reduced pesticide consumption by 78% between 1995 and 1999. Similarly, the fertilization strategy followed by state forests has reduced consumption of commercial fertilizer nitrogen in 1999 to 30% of that in 1995.

The tree species composition in the forests also greatly influences the ecological conditions for the forest plants and animals. The management form is also of major significance for the flora and fauna. In general, the more layered and varied a stand is, the more valuable it is for the flora and fauna. At the same time, biodiversity is far greater in old stands (*see Section 4.3*).

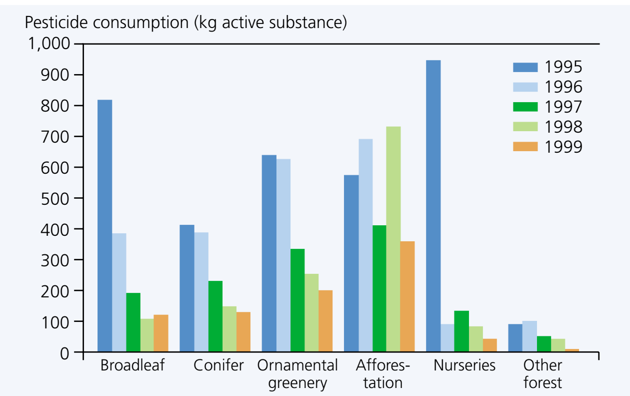
Groundwater

The groundwater beneath our forests is normally considered to be well protected. Groundwater recharge is less beneath forest because the large leaf surface area of the tree crowns enable considerable evaporation to take place. Groundwater recharge is less under conifer forest than under broadleaf forest, partly due to the greater leaf surface area and partly because the needles are not shed in the winter. Around 180,000 ha of forest protect important groundwater resources against contamination.

The amount of nitrogen leaching from forests is usually very small (0.5 kg per ha per year) compared with arable land (approx. 40 kg per ha per year on clayey soils and twice as much

	Private forest		State forest	Total areal	Natural forest strategy
	Management agreements	*Preservation orders*		nationwide in 2000	target nationwide
Virgin forest	1,500 ha	530 ha	4,470 ha	6,500 ha	5,000 ha (in 2000)
Selective felling	1,650 ha	1,400 ha	4,600 ha	7,650 ha	
Grazing forest	870 ha	200 ha	1,800 ha	2,870 ha	4,000 ha (in 2000)
Coppice forest	50 ha	120 ha	180 ha	350 ha	total for selective felling,
Other		70 ha		70 ha	grazing forest and coppice forest

Table 1.5.1
Status in 2000 for implementation of the acreage targets stipulated in the Natural Forest Strategy.



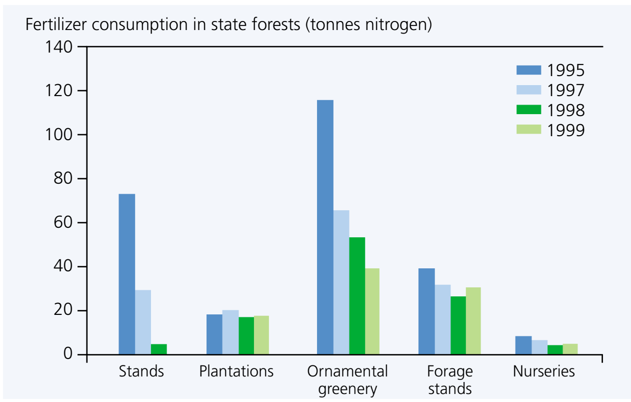


Figure 1.5.4
Pesticide consumption (left) and fertilizer consumption in state forests (right) for the period 1995–1999 apportioned by type of use. (Source: Danish Forest and Nature Agency, 2001).

on sandy soils). Leaching from Christmas tree stands is of the same magnitude as leaching from arable land, however. Following clear-cutting of conifers, nitrogen leaching may reach agricultural levels for a short period. The nitrogen content of the groundwater beneath forest is generally considerably lower than that beneath arable land (*Figure 1.5.5*).

CO_2 storage in forests

Large amounts of carbon are stored in trees. Storage of CO_2 will therefore increase when forest acreage increases. In forests, an average of 600–900 tonnes CO_2 per ha are stored during the lifetime of trees prior to felling. Calculations show that if the forest acreage is doubled evenly over the course of a tree generation, approx. 300 million tonnes CO_2 will be bound in 150 years time, corresponding to permanent storage of 2 million tonnes CO_2 annually or just under 5% of the current Danish annual CO_2 emissions.

Environmental effects of forestry products

The use of wood entails a number of environmental benefits compared to alternatives such as concrete, steel and plastic. Energy consumption during manufacture is less, the wood is a renewable resource, and its use is CO_2 neutral. In addition, wood products can often be reused several times before finally being used as an energy resource in combustion, thereby replacing fossil fuels.

Various initiatives are currently being implemented in the forest certification area in Denmark. One is PEFC (Pan-European Forest Certification), and the other is FSC (Forest Stewardship Council). Certification enables forest owners to document that their forests are managed sustainably, and enables consumers to choose wooden products derived from sustainable forestry. In 2000, 15 retail chains sold FSC-labelled garden furniture made from tropical wood, and the market is expected to increase.

Selected initiatives to create robust forests and enhance biodiversity

Through a number of initiatives, laws and strategies in the forestry area, attempts are being made to concomitantly ensure economic exploitation of forestal production and preservation and development of the intangible value of forests, including their ecological value, according to the requirements for sustainable development of forestry (*Table 1.5.2*). The initiatives are partly motivated by international agreements and action plans on sustainable forestry.

The objectives include doubling of the forest area. This objective may seem ambitious, but the forest area has doubled twice over the past two centuries from approx. 3% when the duty to preserve forests was introduced in 1805, to approx. 10% at the present time. The outlook for forestry is described later in this chapter (*see Section 1.7*).

Consideration for sustainability and safeguarding of biodiversity in the forests also necessitates the preservation of stable and diverse forests. Attempts are made to promote this through protection of biotopes in the forests, among other means through the Strategy for Sustainable Forestry, the Natural Forest Strategy and the Biodiversity and Gene Pool Strategy, as well as the EU Habitats Directive (*Table 1.5.2*). The improvements in the conditions for biodiversity and sustainable forestry are a key argument for conversion to near-natural forestry.

In April 2001, guidelines were published for a set of voluntary management principles for sustainable forestry at property level. The principles aim to promote forestry that supports natural forest processes while concomitantly combining and taking into account a number of social, ecological and economic considerations.

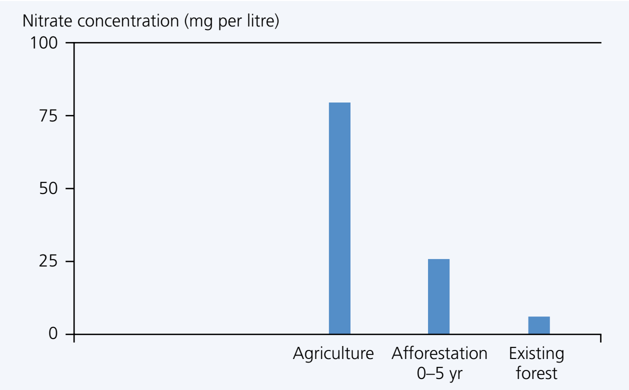


Figure 1.5.5
Nitrate concentration in soil water (75–100 cm depth) for various types of land use. Average for points in the grid net for the period 1986–1993. (Source: Callesen et al. 1999).

Photo: NERI/Britta Munter

The subsidy schemes for private forest owners were revised with effect from 1998. The latest revisions have placed greater emphasis on nature conservation in the subsidy schemes. The total subsidy budget for 2000 was approx. DKK 180 million. Of this, subsidies for afforestation accounted for the major share (approx. DKK 130 million). In the years since 1989, when the Danish Parliament passed a resolution to double the forest acreage within one tree generation, the objective of afforestation has changed considerably.

Whereas it used to be viewed mainly as a tool to curb overproduction in the agricultural sector, it is now viewed as a tool to facilitate protection of nature and the environment and satisfy outdoor recreation interests. Afforestation is carried out both publicly and privately.

Important objectives for the new forest are to ensure biodiversity and environmental protection, with special emphasis on protection of the groundwater resources and on the opportunities for outdoor recreation. In addition, great importance is accorded to the interaction between the forests and the local landscape and the local cultural environments, as well as to the value of wood production.

Management of the state forests is subject to a number of guidelines in order to be able to better ensure and promote society's wishes regarding the forests' diverse functions. Examples are protection of the groundwater, phase-out of pesticides, limiting fertilizer use, preservation of a greater number of dying trees and dead wood, increased use of native species (from 40% today to 55% in 2080), no new stands consisting of only a single tree species, consideration for outdoor recreation, and specific environmental requirements to and guidelines for the use of machines.

Table 1.5.2
Strategies, action plans, laws, and objectives in the forestry area.

Strategy, action plan, law	Objective and description
Target of doubling the forest area (1989)	The target is to double the forest area within one tree generation (80–100 years) from 10% to 25% of the area of the country. During the 1990s, approx. 21,000 ha of new forest have been planted.
Strategy for Danish natural forests and other forest types worthy of preservation (Natural Forest Strategy) (1992)	**The Natural Forest Strategy** is to be implemented over a 50-year period in three phases: • **Safeguarding** original forest, oak coppice, grazing forest, coppice forest and primeval-like forest • **By the year 2000:** Ensuring the existence of at least 5,000 ha of virgin forest, 4,000 ha of forest managed by traditional forestry practices, and the identification of special areas where forest biodiversity is to be preserved. • **By the year 2040:** Ensuring the existence of at least 40,000 ha of original forest, virgin forest and forest managed by traditional forestry practices.
Strategy for Sustainable Forestry (1994)	**Forestry** shall meet the social, economic, ecological, cultural and spiritual needs of present and future generations. Among other things, consideration is to be given to increasing and improving timber production. Danish forestry is generally sustainable measured after these criteria. The stands exhibiting health and stability problems are to be made more varied and stable.
Strategy for the Preservation of Tree and Shrub Biodiversity and Gene Pools (1992)	**The Biodiversity and Gene Pool Strategy** concerns the tree and shrub species used as cultivated plants in Danish forests and landscapes. The objective is to preserve genetic variation. 1,800 ha have to be designated before the year 2004. So far, areas have been designated in state forests.
Forestry Act of 1989 with amendments of 1996	**The Forestry Act** of 1989 aims to protect and increase the forest area while concomitantly improving forestry's stability, productivity and property structure. The 1996 amendment requires forestry to be sound and diverse and emphasizes the intangible and ecological values of forests as a consequence of national and international strategies. The objective is to be achieved through a number of new subsidy schemes aimed at improving the stability of forests, improving their long-term productivity and health, supporting the biological diversity of forests and contributing to the establishment of new forests.
Product Development Scheme for Forestry and the Timber Industry (1998)	**The Product Development Scheme** supports the development of new products and production processes. Subsidies are given to forestry to improve the efficiency of felling and transport, to develop new types of machine, to reduce consumption of pesticides and to improve the working environment, as well as for other environment-friendly and economic improvements of forestry. Subsidies are also given to the timber industry.
Windfall Support Scheme (2000)	The Act has two elements – an insurance scheme that provides forest owners with compensation for forests destroyed by future windfall, and a subsidy scheme that provides help to plant robust new forest after the 3 December 1999 hurricane and future windfall events.

1.5.2 Fishery

Man predominantly affects fish stocks through fishery, but also through nutrient loading and resultant eutrophication, changes in the plant and animal communities and hence changes in the habitat conditions and food resource for fish. In addition, pollution by hazardous substances, including heavy metals and hormone-like substances, can have unwanted effects on fish. Activities such as exploration and extraction of raw materials, oil and gas as well as construction activities can have local effects, in particular causing disturbance.

Fishery affects the fish stocks and other stocks directly through overexploitation and by-catch of non-target species. Biological conditions are also affected by heavy towed fishing gears, which impact upon the benthic communities. Gillnets can lead to unwanted by-catch of porpoise and seals. Some types of fishery consume considerable energy, e.g. fishery with heavy fishing gears such as otter trawls and fishery far from Denmark.

Freshwater and saltwater fish farms use large amounts of feed and ancillary substances such as antibiotics. Organic matter and nutrients are discharged from the fish farms.

Trend in the fishery sector

Fishery has always played a major role in Danish society. In some local communities fishery is still an important factor, and the export of fish and fish products contributes both to employment and to the overall economy.

In 2000, the Danish fishing fleet consisted of just under 4,200 vessels, of which around 60% were small boats of less than 5 gross registered tonnes (GRT). The small vessels are mainly used in net, line and ground net fishery. The net vessels accounted for approx. 75% of the vessels, but only just under 15% of the gross registered tonnage. The large vessels were engaged in trawling and seining. It is the major vessels that account for the majority of the catch. During the 1990s, the number of fishing vessels larger than 5 GRT fell by around 1,000 (*Figure 1.5.6*). During the same period the number of very large vessels increased, and the total tonnage therefore only fell slightly. In 1999, just over 6,400 persons were engaged in fishery from Danish fishing vessels, while the total number of persons employed in the fishing industry was around 7,300. Over the past 30 years the number of fishermen has been halved, while the total catch has remained roughly constant.

Catches by Danish fishermen increased from just under 0.1 million tonnes in 1930 to around 2 million tonnes in the 1970s, whereafter they fell to around 1.4 million tonnes at the end of the 1990s. The increase was due to both an increase in human consumption fishery and a marked increase in industrial fishery from 1960 onwards.

Many years ago, Danish fishery was mainly coastal fishery. Today the majority of the catch is made far from the Danish harbours, however. From 1930 to the present day the catch in the inner marine waters has increased approx. four-fold, while that in the outer marine waters has increased 30-fold (*Figure 1.5.7*). This trend has been driven by the larger vessels with greater engine power and other types of fishing gear, among other things otter trawls. The trend has also resulted in a very high energy consumption per kg harvested fish.

Fish for human consumption

In 2000, Danish fishermen landed fish and shellfish for human consumption worth DKK 2.3 billion. Of this, cod, plaice, herring, lobster and shrimp were the most important. From the weight point of view, the most important species were herring (111,000 tonnes) and

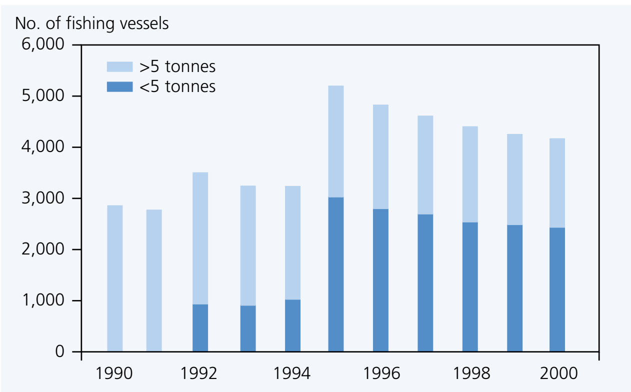


Figure 1.5.6

Trend in size composition of the Danish fishing fleet. The calculation method was changed to include more small vessels in 1995.
(Source: Danish Fisheries Directorate, 2001).

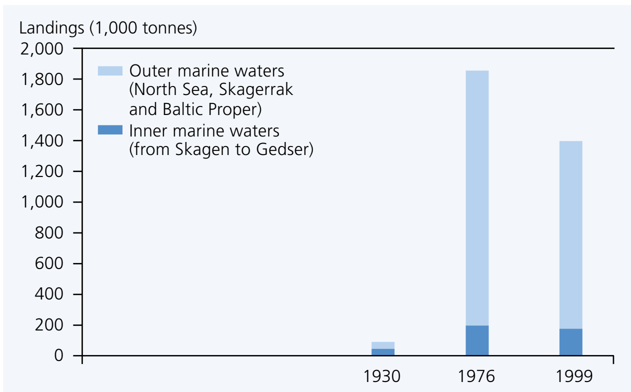


Figure 1.5.7

Landings by Danish fishermen apportioned by outer and inner marine waters.
(Source: Based on "Danmarks Natur", 1980 and Danish Fisheries Directorate, 2000).

cod (60,000 tonnes). In 1999, Danish fishermen harvested 244,000 tonnes of fish (excluding shellfish) for human consumption (*Figure 1.5.8*). In addition, foreign fishermen landed 202,000 tonnes of consumption fish in Danish harbours. Half of these fishermen were from other EU countries and half from countries outside the EU, with Norway as the main country. In addition, 254,000 tonnes of whole saltwater fish were imported for the Danish consumption fish processing industry.

The supply of fish for human consumption in Denmark is thus 700,000 tonnes per year. Of this the majority is exported, namely just under 500,000 tonnes. Half of the exports consist of unprocessed fish, and half of processed fish in the form of filets and smoked or conserved fish. On average, each Dane consumes approx. 20 kg fish annually, corresponding to 100,000 tonnes.

Total landings of fish and shellfish by Danish fishermen have fallen from just under 500,000 tonnes to around 350,000 tonnes, while landings by foreign fishermen have concomitantly increased by a third to around 200,000 tonnes (*Figure 1.5.9*).

Industrial fishery

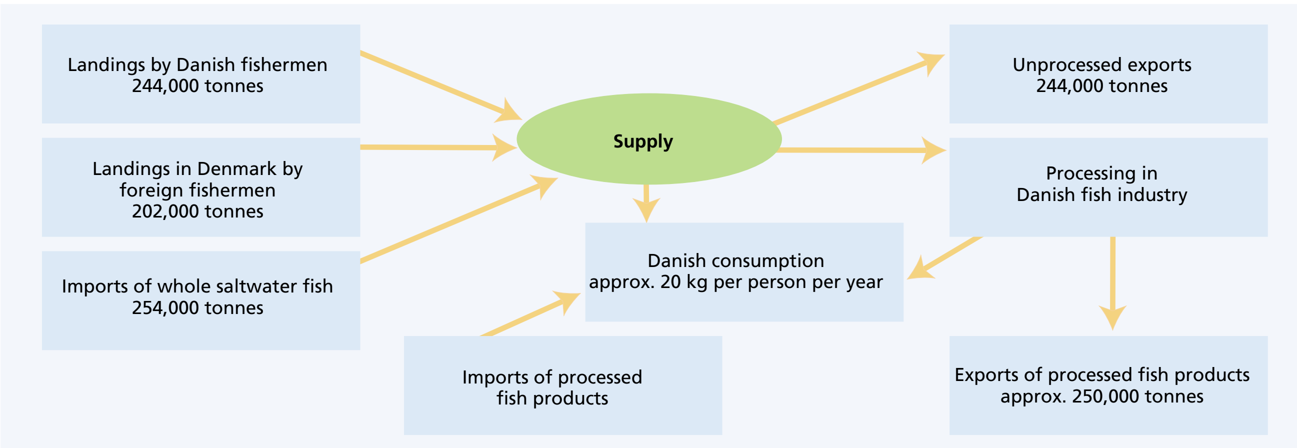
Landings from industrial fishery are around three-fold greater than landings from consumption fishery. The value of Danish industrial landings only amounted to DKK 1.2 billion in 1999 and 0.7 billion in 2000 as compared with DKK 2.3 billion for consumption fishery. Industrial fishery is primarily based on four species: Sandeel, sprat, Norway pout and blue whiting. Of these, sandeel accounts for more than half of the catch in terms of weight and value. Almost 2/3 of all Danish landings from industrial fishery derive from the central part of the North Sea and are mainly caught by the relatively large vessels that are almost 100% dependent on industrial fishery. Annual industrial landings fluctuated between 1.2 and 1.6 million tonnes during the 1990s (*Figure 1.5.10*). In addition to the approx. 1 million tonnes of industrial fish landed by Danish fishermen, foreign fishermen landed a further 200,000 tonnes of industrial fish in Danish harbours.

The industrial fish are processed to fishmeal, which is used as feed in livestock farming and aquaculture, and to fish oil, which is primarily used in the food industry.

Figure 1.5.8

Mass flow of fish for human consumption (excluding crustaceans and molluscs) in 1999.

(Source: Based on data in Danish Fisheries Directorate, 2000).



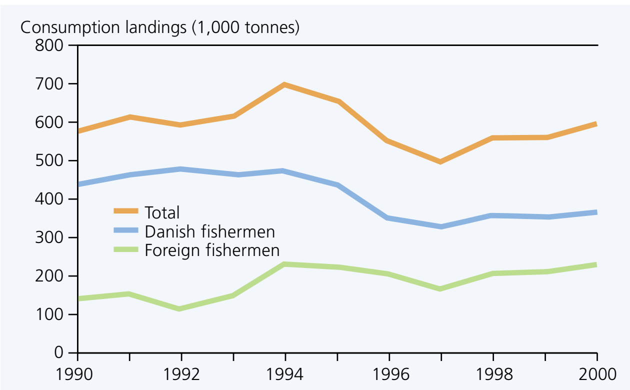


Figure 1.5.9

Landings of fish, crustaceans and molluscs for human consumption for the period 1990–2000.

(Source: Danish Fisheries Directorate, 2001).

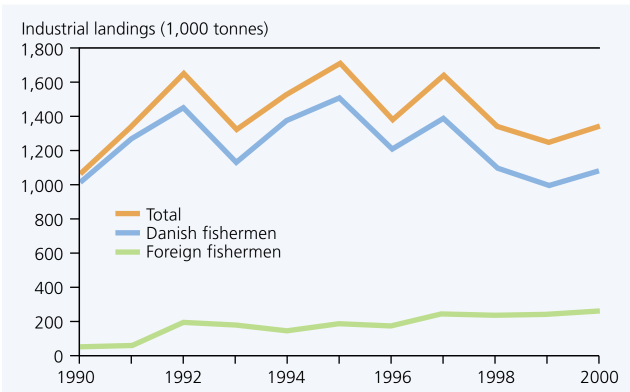


Figure 1.5.10

Landings of industrial fish species for the period 1990–2000.

(Source: Danish Fisheries Directorate, 2001).

Aquaculture (freshwater and saltwater fish farming)

The annual production value of Danish aquaculture is about DKK 0.8 billion, and the majority of the production is exported. The sector employs approx. 1,000 persons.

In 2000, there were 391 freshwater fish farms and land-based saltwater fish farms in operation (predominantly freshwater). Total production was 33,000 tonnes, roughly the same as throughout the 1990s (*Figure 1.5.11*). Approximately half of the production takes place in Ringkøbing and Ribe counties, while the remainder is distributed between the other five counties in Jutland.

In 2000, 27 marine fish farms were in operation together encompassing 266 cages. Annual production amounted to just over 7,000 tonnes (*Figure 1.5.11*). The majority of the cages are located in the Little Belt, the northern Belt Sea, the waters north of Lolland and in the Great Belt.

Recreational fishery

It is estimated that there are more than 350,000 anglers in Denmark, of which 140,500 purchased a fishing licence in 1999. The licence income amounts to around DKK 30 million and is used for fishery management. In 1999, there were 33,600 registered recreational fishermen.

Catches

Of the 250 or so species of fish found in Danish marine waters, approx. 45 are commercially exploited. Total annual international landings from the North Sea, the Skagerrak and the Kattegat amounted to around 1 million tonnes until the Second World War. Thereafter the catch increased to around 3 million tonnes in the period from the early 1960s to the present time, primarily due to a marked increase in herring fishery and subsequently due to major industrial fishery, which has increased to comprise around half of the total catch (*Figure 1.5.12*).

The herring stock collapsed in the 1970s, and landings fell to a low level at the end of the 1970s. The landings increased again up to 1987, thereafter to fall during the period 1987–1995. In recent years, herring landings have decreased considerably. Cod landings have decreased continuously since the beginning of the 1980s, and plaice since 1990.

Total annual international landings from the Baltic Sea have increased from 0.5 million tonnes in the late 1960s to between 0.8 and 1 million tonnes over the past 30 years (*Figure 1.5.13*). Herring has been the most important species during the whole period, while cod fishery increased until 1985, thereafter to decrease sharply until 1993. Industrial fishery for sprat has been growing steeply throughout the 1990s.

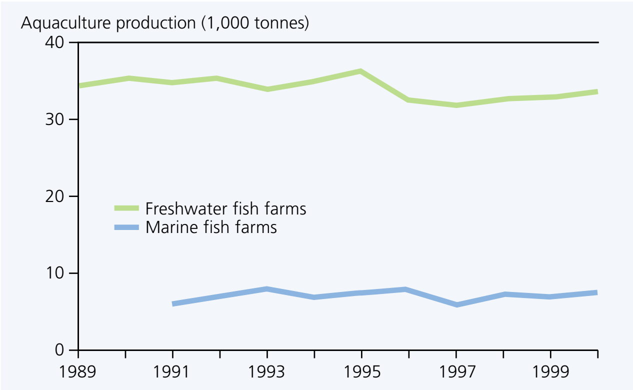


Figure 1.5.11
Trend in production by freshwater and marine fish farms for the period 1989–2000. (Source: Danish Fisheries Directorate, 2001).

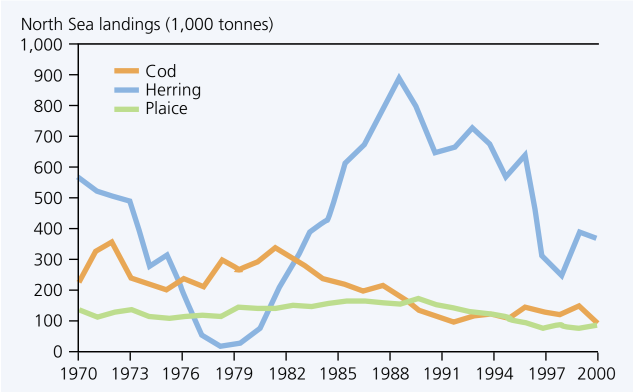


Figure 1.5.12
Trend in landings of herring, cod and plaice from the North Sea, the Skagerrak and the Kattegat for the period 1970–1999 (1,000 tonnes). (Source: ICES, 2000).

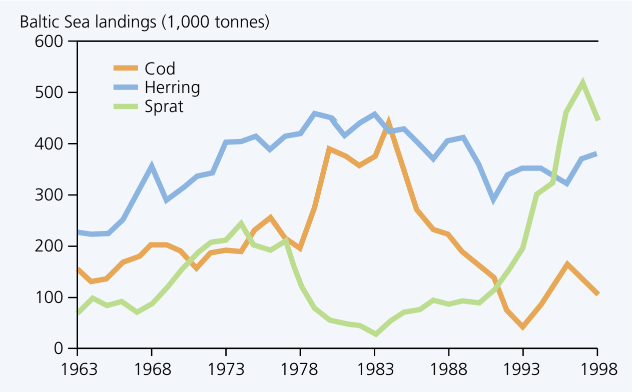


Figure 1.5.13
Trend in landings of important species from the Baltic Sea for the period 1963–1998. (Source: ICES, 2000).

Overexploitation

Fishery is responsible for additional mortality of both target and non-target species. The effect is a reduction in the average age of the fish stock and a reduced biomass. The majority of fish stocks can tolerate a relatively high fishing mortality without this causing a reduction in production by the stock. However, fishing mortality can be so great that the spawning stock biomass, i.e. the amount of sexually mature fish, is reduced to such a low level that insufficient eggs and larvae are produced to maintain the stock. In serious cases, this can lead to collapse of the stock.

The International Council for Exploration of the Sea (ICES) assesses the status of the most important commercially exploited fish and shellfish species each year. In making the assessment, ICES employs two reference points:

- **Spawning Stock Biomass**
  If the spawning stock biomass falls below a level where an insufficient amount of eggs and larvae are produced to maintain the stock, the stock is considered to be outside safe biological limits
- **Fishing mortality**
  If fishing mortality is so great that it will bring the stock outside safe biological limits in the medium term, the fishery is non-sustainable.

A large proportion of the commercially important fish and shellfish populations are outside safe biological limits, and in many cases the fishery is non-sustainable in the long term (*Table 1.5.3*). With the majority of stocks that are outside safe biological limits, ICES recommends an effective reduction in fishing mortality. However, in many cases the recommendations of the international fisheries commissions have not been followed. This applies, for example, to EU Common Fisheries Policy and hence to Danish fishery. With certain stocks, the total allowable catches (TACs) have been set higher than recommended by the scientific advisors.

The development of the cod stock has been particularly negative. The North Sea-Skagerrak and eastern Baltic stocks are at risk of collapse if fishery continues unchanged (*Figure 1.5.14*). In 2000, international efforts were initiated to develop a restoration plan to ensure that the Baltic and North Sea cod stocks can be restored to a level that is within safe biological limits, and to ensure that fishery is sustainable. The TACs for cod have been reduced considerably, and an area of the North Sea was closed for cod fishery for part of 2001.

Compared with fishing pressure on human consumption species, fishing pressure on industrial species is less severe. Both sandeel and Norway pout are within safe biological limits.

By-catches and discards

The fish stocks are also affected by by-catch, irrespective of whether the fish are discarded or landed. Discards include fish that do not meet minimum landing sizes, fish that are protected, for example because the TACs have been exceeded, and fish that are generally protected. The extent of by-catch can vary considerably depending on the species and fishery technology. With human consumption fishery it is around 10–25% of the target species catch. ICES estimates that the total annual discards in the North Sea amount to 500,000 to 800,000 tonnes of fish, corresponding to about twice Danish consumption fishery. Industrial fishery can entail large by-catches, especially of herring. During the 1990s, the fishery has been modified to reduce the by-catch of herring.

No. of fish stocks assessed by ICES in 2000

Marine water	Within safe biological limits	Outside or harvested outside safe biological limits	Stock could not be assessed
North Sea	3	9	3
Skagerrak and Kattegat	3	3	5
Baltic Sea	0	4	7

Table 1.5.3
Number of fish stocks assessed by ICES as being within or outside safe biological limits.
(Source: ICES, 2000).

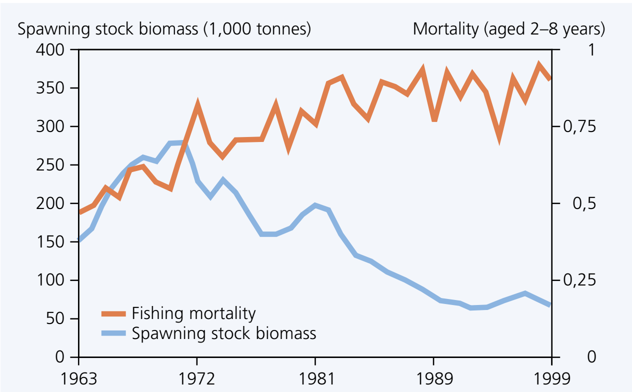


Figure 1.5.14
Cod spawning stock biomass and fishing mortality in the North Sea and the Skagerrak for the period 1963–1999. Fishing mortality is measured as the proportion of cod aged 2 years and older harvested in the course of the year.
(Source: ICES, 2000).

Discards can be reduced considerably by making fishery more selective. It can be expected that technical measures such as larger mesh sizes and sorting panels on fishing gears will be able to reduce unwanted by-catches and hence reduce discards.

Physical impact of fishing gears on the seabed

Desmeral active gear – especially beam trawls – and other fishing gear that is towed along the seabed can severely impact on the benthic plant and animal communities. Beam trawls are predominantly used in flatfish fisheries in the North Sea, where heavy iron chains in front of the trawl plough the upper layer of the seabed. Over the years the beam trawls have become larger and the chains heavier, and the impact on the benthic plants and animals have become correspondingly more severe. Dutch studies have shown that for each kilogram of saleable fish landed by a beam trawler, an average of 10 kg of non-saleable fish and 6 kg of other benthic animals are killed.

The combined area affected by trawling is considerable. In the North Sea, trawling thus affects an area of 429,000 km^2. Around 70% of the area is trawled less than once per year, while 10% is trawled two or more times a year. The distribution is far from even in that certain areas of seabed are trawled up to 400 times a year. One of the effects of trawling is that benthic invertebrates and fish with a slow reproductive cycle become rarer.

Indirect effects of fishery

Fishery naturally competes with the marine predators, and it cannot be excluded that fishery can reduce the food resource locally. Sandeel fishery in the North Sea has therefore been closed in an area on the east coast of Great Britain on a trial basis in an attempt to enhance and safeguard the food resource for the kittiwake, a three-toed gull that breeds on the Scottish coasts.

Fishery in the North Sea and the Baltic Sea has changed the size composition of the fish stocks. The number of large fish and hence large predators has decreased, and the fish stocks presently consist of a relatively greater proportion of small fish than previously. For example, the high level of sprat fishery in the Baltic Sea during the 1990s could explain why the cod stock has declined markedly. It must also be expected that fishery favours species with a short life cycle at the cost of species with a long life cycle.

Fishery affects marine mammals such as the porpoise and seal both by catching these animals in nets and through competition for their food resource.

Conversely, marine mammals and sea birds compete with fishermen for the fish. Porpoise, seals and cormorants thus consume up to 200,000 tonnes of fish per year. This can influence the development of the fish stocks in the inner marine waters. In general, fishery is directed at larger and older fish than those that serve as food for sea birds and marine mammals. However, cormorants and to some extent seals use the ground nets and gillnets as a "pantry" and can thereby cause considerable nuisance to both ground net and gillnet fishermen.

It is estimated that Danish fishery alone costs the lives of 5–7,000 porpoise each year, which is more than the population can sustain. The porpoise drown when they become entangled in nets. The calculated by-catches by Danish and foreign fishermen correspond to 1.9–3.8% of the population. In 1995, the Scientific Committee of the International Whaling Commission recommended that the annual by-catch should never exceed 2% of the population, and that a by-catch rate of over 1% gives cause for concern for the population's sustainability. Research is currently being carried out on porpoise behaviour, and methods are being tested to hinder porpoise from becoming entangled in fishing nets. Examples of such methods are the use of passive acoustic reflectors and pingers that are activated by the cetaceans' sonar activity, and which scare away the animals.

Energy consumption in fishery

Beam trawling and industrial fishery are the main energy consumers within the fishery sector. The large trawls require considerable engine power, and considerable energy is required to drag the trawl along the seabed. Dutch studies have calculated the energy consumption for fish harvested with beam trawls to be up to 3 litres of diesel oil per kilogram fish (*Figure 1.5.15*).

Environmental impact of aquaculture

The total feed consumption by freshwater fish farms has fallen from more than 43,000 tonnes in 1989 to 31,014 tonnes in 1999. During the same period, production has fallen slightly from just over 35,000 tonnes to 33,000 tonnes. Thus the feed is utilized more efficiently today, and less goes to waste. Feed utilization has also improved in the land-based saltwater fish farms.

Over the past 10–15 years, discharges of organic matter and nutrients from aquaculture have decreased markedly despite production having remained fairly constant. In the case of freshwater fish farms, discharges of organic matter and nitrogen have been halved, while discharges of phosphorus have decreased by 60%. In the case of marine fish farms the specific discharge of nitrogen has fallen from 97 kg N per tonne fish produced to just under 50 kg N since 1987. Correspondingly, specific phosphorus discharge has fallen from about 14 kg P per tonne fish produced to approx. 5 kg P. The decrease is primarily attributable to marked improvement in the quality of the feed,

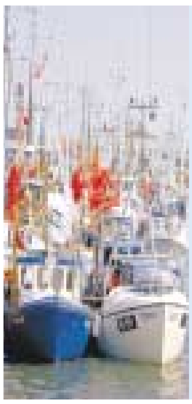


Photo: CDanmark

although optimization of feeding techniques has also contributed to the decrease.

The freshwater fish farms utilize various ancillary substances, including about 100,000 litres of formalin and 10 tonnes of copper sulphate. Consumption of antibiotics by both freshwater fish farms and land-based saltwater fish farms was between 0.8 and 2.5 tonnes per year during the period 1995 to 1999.

The environmental impacts of aquaculture are mainly restricted to the vicinity of the farms, e.g. downstream of freshwater fish farms and the seabed around marine fish farms, which, in the worst cases, can become eradicated of all life. In 1999, watercourse quality was detrimentally affected at a third of the fish farms investigated, in 7% of cases severely so. Since 1989, the quality of the watercourses downstream of the fish farms has improved considerably. Thus whereas only 15% of the reaches downstream of the fish farms met the quality objectives set for them in 1989, the quality objectives are now met in more than half. It should be noted, though, that the quality objectives are not met upstream of 40% of the fish farms.

Selected initiatives to reduce the impact of fishery and aquaculture

Fishery is dependent on the fish stocks functioning as a renewable natural resource. Sustainable fishery that helps to safeguard the marine fish stocks and ecosystem will also help to ensure the future development of the sector. The majority of Danish fishery and the fish stocks to which it has access are not only dependent on Danish efforts to ensure sustainable exploitation of the sea's resources, but also on the efforts of other countries. The environmental impact on the marine environment is thus a highly transboundary issue. An effective policy therefore has to be based on concerted international cooperation.

Fishery is regulated through the EU Common Fisheries Policy and a number of international agreements, among others for the various marine waters. The overall objective of fisheries policy is to ensure sustainable use of fish resources taking into account the consequences for the marine ecosystem and the societal significance of the fishery sector.

In accordance with a number of international agreements, efforts are to be made nationally and via the EU Common Fisheries Policy (CFP) to develop and apply an ecosystem approach to enhance integration between fishery and the environment. In addition, the precautionary principle is to be more widely incorporated into fisheries management. This principle was used for the first time by the EU Council of Ministers in 1999 when setting the TACs for a number of stocks. The significance of these measures is confirmed by the EU Commission in the Green Paper on future fisheries policy and in the conclusions of the April 2001 Council of Ministers on integration of environmental considerations and sustainable development into the CFP. Both will be incorporated in the 2002 revision of the EU CFP.

As part of national implementation of the CFP, several initiatives have been implemented to reduce fishing pressure, for example restrictions on when and where fishing may be carried out, on fishing gear and on engine power. In addition, the total capacity of the Danish fishing fleet has been reduced considerably. This has increased profitability among the fishermen who have remained in the industry.

The implementation of a ban on the discard of fish that can be landed lawfully is intended both to reduce pressure on the fish stocks and to increase the societal value of the Danish catch potential. With regard to reducing fishing pressure, priority is accorded to the development of selective, more gentle fishing gears, thereby better avoiding unintended by-catches and unwanted impacts on the seabed, the natural flora and fauna and the ecosystem as a whole.

In May 2001, the Government published an action plan for marine fish farms, "Mariculture 2001". The main initiatives are:

- Tightening of the various parameters, including the feed quotients and feed nutrient content, stipulated in the Statutory Order on mariculture.
- Stipulation of planning requirements (Regional Plan and EIA).
- Revocation of the official notice of 27 February 1996 recommending a moratorium on new mariculture installations. The notice had been sent to the Counties because phosphorus discharges were approaching the ceiling of 54 tonnes set by the Ministry. There is now more "room" for expansion, however, and the notice can therefore be revoked with the proviso that the Ministry can intervene again if the total permitted discharges once again approach the target ceiling.

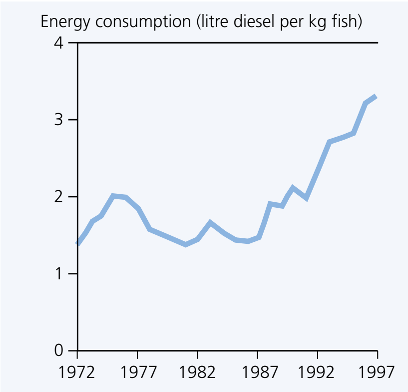


Figure 1.5.15
Energy consumption per kg fish harvested by beam trawl.
(Source: RIVM, 2000).

1.5.3 Raw materials extraction

Everything from large structures such as buildings and roads to smaller objects such as glasses, plates and a large number of everyday products are manufactured from sand, stone, clay or other Danish raw materials. These solid raw materials derive from the upper parts of the subsoil and are excavated from depths down to 30–40 metres.

The resources in the upper subsoil on land belong to the landowner while those in the seabed belong to the State. Extraction of these solid raw materials is regulated by the Raw Materials Act. Permits are usually valid for 10 years. The resources of solid raw materials are non-renewable and shall therefore be exploited considerately. The Act sets the framework for extraction while taking into account the consequences for nature and the environment as well as overall resource availability.

Raw materials extraction on land affects nature and the environment in a number of ways. Landscape profiles and geological formations become altered. In addition, the groundwater can be affected, thereby affecting both water quality and the water supply. Finally, problems can arise with dust and extra traffic, especially in inhabited areas. Extraction from the seabed can affect the bottom topography, depth conditions and the composition of the surface sediments both inside and outside the extraction area.

Extraction and use of solid raw materials

The amount of raw materials extracted in 1999 totalled 47.9 million m^3, corresponding to 9 m^3 per inhabitant. Of the total, 35 million m^3 were extracted on land, and 12.9 million m^3 offshore. By far the majority of the total extraction was accounted for by sand, gravel and stones, followed by limestone and chalk (*Table 1.5.4*).

The overwhelming majority of the raw materials are used in Denmark in the construction sector and for the production of building materials.

The materials extracted from the seabed are largely used as high-quality materials, for example in the manufacture of concrete and in construction projects. A considerable amount is used each year for beach nourishment along the west coast of Jutland. In the 1990s, large amounts of materials were extracted for use in construction of the fixed links across the Great Belt and the Øresund.

Over the past 15 years, raw materials extraction on land has varied between

Table 1.5.4
Raw materials extraction in Denmark in 1999.
(Source: Statistics Denmark, 2000).

Location	Apportionment by type of raw material	Most important uses
Raw materials extraction on land 35 million m^3	Sand, gravel and stones 28.4 million m^3	18.3 million m^3 for construction and road materials 7.9 million m^3 for concrete aggregates 1.1 million m^3 for asphalt materials 1.1 million m^3 for other and unknown uses
	Limestone and chalk 3.3 million m^3	2.2 million m^3 for cement 0.5 million m^3 for agricultural and fodder lime 0.3 million m^3 for paper filler and industrial lime 0.3 million m^3 for flue gas filters and quicklime
	Clay 0.8 million m^3	0.8 million m^3 for bricks and tiles
	Glass sand 0.28 m^3	0.14 million m^3 for concrete, casting and sandblowing sand 0.14 million m^3 for filter sand and other uses
	Granite 0.18 million m^3 Modelling clay and bentonite 0.35 million m^3 Moler 0.20 million m^3 Peat and peat moss 0.25 million m^3 Other raw materials (especially soil) 1.2 million m^3	
Raw materials extraction from the sea floor 12.9 million m^3	Sand, gravel and stones 12.0 million m^3	7.0 million m^3 for expansion of Aarhus harbour 3.0 million m^3 from the seabed for beach nourishment along the west coast of Jutland
	Other 0.8 million m^3	Surplus material from building and construction projects, e.g. the Øresund Bridge

25 and 35 million m^3 per year, mainly due to variation in extraction of sand, gravel and stone (*Figure 1.5.16*). In contrast, the amount of limestone and other raw materials extracted has remained relatively constant. After a relatively low level at the beginning of the 1990s, raw materials extraction increased from 1993 onwards, largely due to construction of the two fixed links, road construction and increasing housing construction.

The amount of raw materials extracted offshore has been increasing over the past 15 years (*Figure 1.5.16*). It was particularly high at the beginning of the 1990s due to construction of the fixed links across the Great Belt and later the Øresund, and more recently in connection with expansion of Aarhus harbour.

The value of raw materials extraction is approx. DKK 4 billion per year. The Danish raw materials industry employs a total of just over 2,000 persons and mainly consists of small and medium-size enterprises. In recent decades, the trend in the raw materials industry has been towards a decrease in the number of enterprises and foreign purchases of Danish raw materials companies.

Impact on nature and the landscape

The general understanding is that there is abundant sand, gravel, stone, clay, limestone and chalk, and that shortages will not arise within the near future. However, numerous local shortages of these raw materials already exist, especially shortages of raw materials of high quality. Exhaustion of local resources increases the need for transport of raw materials.

Extraction of solid raw materials on land affects large areas – approx. five km^2 every year – and results in the disappearance of large or smaller parts of the original landscape and its geological narrative value. Extraction is usually carried out on arable land. Excavation work rapidly creates new conditions for life on barren gravel surfaces, quarry slopes and stone heaps for new species of flora and fauna. If the excavations leave behind quarry lakes, a varied flora and fauna rapidly arise.

The Raw Materials Act stipulates that disused quarries have to be landscaped so that they do not become overgrown with thicket or forest. This typically encompasses evening out the quarry faces, laying out layers of humus and topsoil, soil treatment and planting. The majority of sites are restored for agricultural use. In many cases, part of the quarry site is preserved as natural countryside – especially in the case of quarry lakes. In the vicinity of large urban communities the sites are often converted to recreational purposes.

Raw materials extraction at sea

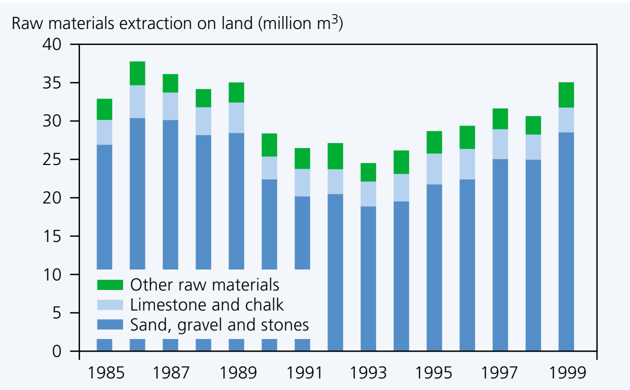
In the past, raw materials could be freely extracted at sea except in coastal areas and in areas where extraction was prohibited. Due to implementation of the Raw Materials Act in 1997, the permission of the Danish Forest and Nature Agency is now required, and extraction has to be carried out in delimited areas following an environmental assessment.

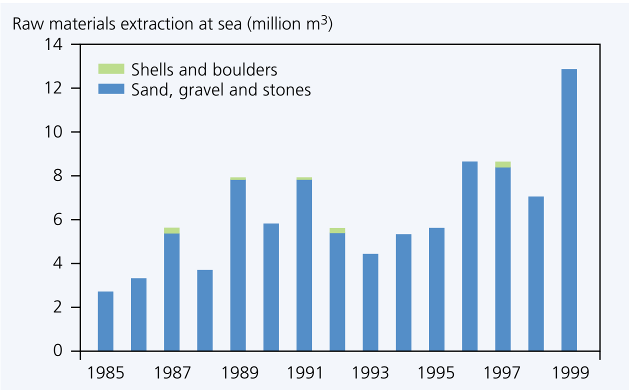
Offshore extraction of raw materials is carried out at approx. 150 designated extraction zones in Danish marine waters. The total area is approx. 1,000 km^2. Less than 1% of this is affected by actual extraction, however, either because extraction only takes place in a minor part of large areas, or because the areas are only used periodically to supply local needs.

Extraction is normally undertaken at depths ranging from 6 to 20-25 metres. Extraction removes the flora and fauna where suction is carried out, and causes changes in the bottom conditions. Extraction can also lead to resuspension of fine particles in the water column. This reduces light penetration, and the particles subsequently settle on the seabed again inside and outside the extraction area. The plant community and spawning grounds for certain species of fish, e.g. herring and sandeel, can be destroyed by the changed conditions at the seabed.

Extraction of boulders directly affects habitat conditions for plants and animals that live on hard seabed by removing the substrate to which they adhere. A conservative estimate for the major con-

Figure 1.5.16
Trend in raw materials extraction on land (left) and from the seabed (right) for the period 1985–1999.
(Source: Statistics Denmark, 2000)





struction periods in the 1960s is that boulder extraction in Danish marine waters has removed 15 km² of hard seabed. During that period, extraction of boulders was predominantly carried out at water depths of less than 10 metres, with hole-forming stone reefs being the preferred source. This type of habitat is presently very rare. At present, boulder extraction is only carried out at 18 designated sites with a combined area of 101 km². A maximum total quota of 15,500 m³ has been set for each area. The quota for boulder extraction is regularly reduced. Marine boulders may only be used for special tasks where boulders from the sea have previously been used. Moreover, every individual task has to be authorized by the Danish Forest and Nature Agency. When major boulder extraction work is to be carried out, environmental impact assessments have to be made.

The outlook

The deposits presently exploited for raw materials extraction in Denmark were formed over a period of 250 million years. The raw materials are being excavated rapidly – more than 35 million m³ per year, corresponding to a lorry load per person. It is the best quality materials closest to the surface that are extracted. It is predicted that in some generations' time, problems will arise with the supply of raw materials of the same high quality as presently available.

It is necessary to work towards a more "sustainable" use of the raw materials. Among other things this will necessitate efforts in the following areas: Reduce production waste, increase processing and recycling of raw materials and increase the proportion of alternative raw materials.

1.5.4 Building and construction

The building and construction sector accounts for some of the largest and most important material flows in Denmark. The sector thus consumes the majority of raw materials produced domestically and a large part of the imported materials. Extraction of raw materials, manufacture of building materials and transport and use of these products have a number of different impacts on health and the environment. In addition, around one fourth of the total Danish waste production derives from demolition of buildings and structures.

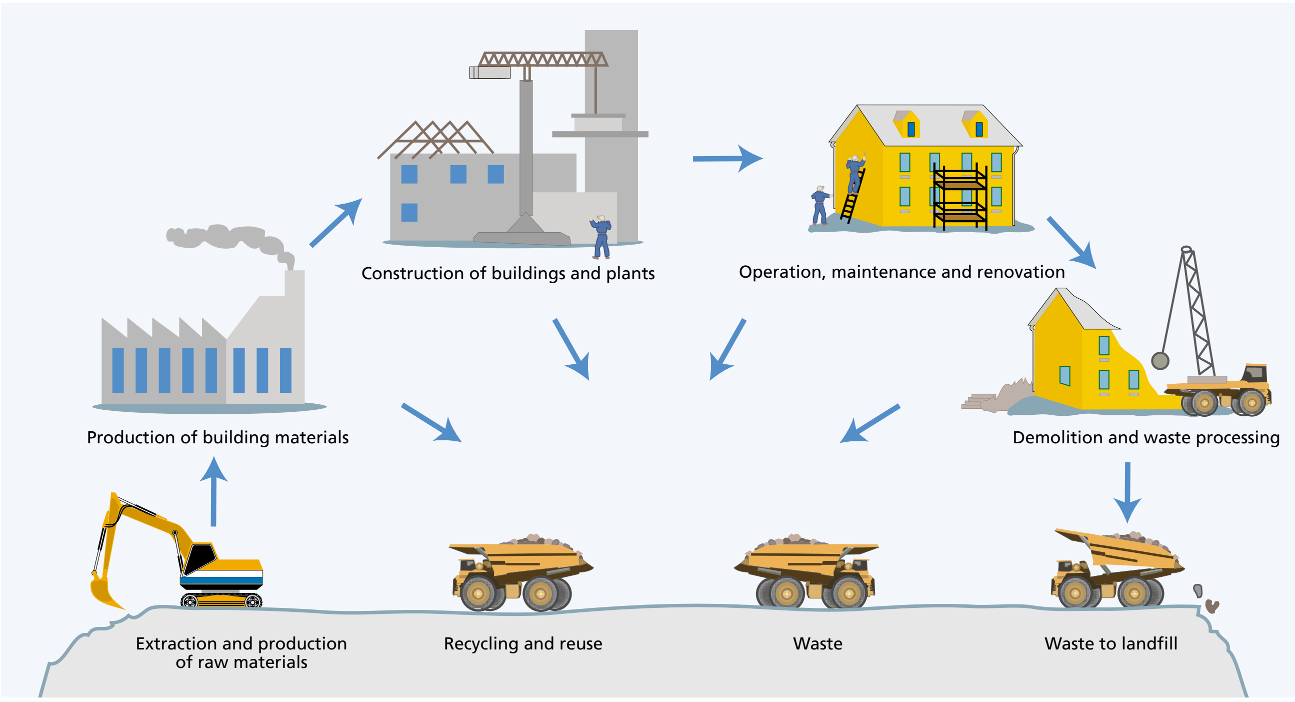
The main environmental impacts in connection with the building and construction sector are:

- Extraction and use of raw materials (minerals, metals, wood, etc.)
- Environmental impacts and energy consumption associated with the manufacture and transport of building materials
- Environmental and health effects in all phases of the life cycle of hazardous substances
- Large amounts of waste.

In addition, the environment is affected during the operation phase, e.g. through consumption of energy and water (*see Section 1.5.6 and 1.5.7*).

Figure 1.5.17

The building sector life cycle.



Trend in the building and construction sector

The building and construction sector can be subdivided into development, repair and maintenance, and construction. The activities in the building and construction sector are highly coupled to the state of the market and therefore vary during the course of time, especially activities in connection with new building. Activity was greatest during the period 1964–1980 when the sector accounted for 10% of total employment and gross value added. During the 1980s, this fell to 6%. During the 1990s, the sector accounted for 6% of employment and just over 4% of gross value added (*Figure 1.5.18*).

The number of new houses has fallen from more than 30,000 per year in the 1960s and 1970s to under 20,000 per year in the period after 1992. Employment has fallen from 179,000 in 1970 to 114,000 in 2000.

During the second half of the 1990s, expenditure on traffic infrastructure totalled DKK 14–16 billion annually. Of this, just under half was used on the road network – approx. DKK 4 billion for operation and maintenance, and approx. DKK 3 billion for road construction. A further DKK 1 billion was spent on the railroad network. During the 1990s, DKK 2–4 billion have been spent annually on major construction projects (the fixed links over the Great Belt and the Øresund, Copenhagen airport and the Metro in Copenhagen).

Consumption of materials

A very considerable proportion of Danish consumption of raw materials is accounted for by building and construction activities. The raw materials used in by far the greatest amounts are minerals, metals and timber. In addition, large amounts of oil-based products are used, e.g. asphalt and plastic products.

The building and construction sector consumes more than 90% of all the raw materials produced domestically. Of this, one third is used for building, and two thirds for construction. Raw materials consumption for new buildings generally amounts to 1.1 tonnes per m^2, of which 70% is accounted for by concrete, mortar, gypsum, etc., 15% by sand, gravel and stone aggregates, and 9% by bricks, tiles and clinker. During the 1990s, consumption of building materials in Denmark amounted to 6–9 million tonnes annually.

The building and construction sector uses considerable amounts of metals, especially copper, zinc and aluminium. The copper is primarily used by the installation branches, including pipes and pipe fittings, roofing and flushing, cables, etc. The majority of the zinc is used in connection with the galvanization of construction steel, pipes, etc.

Copper and zinc are relatively scarce resources. Mining and manufacture of the metals from ore usually generate large amounts of waste and consume considerable energy. It is therefore necessary to recycle the materials as much as possible and in some cases to replace them with more environment-friendly materials.

The building and construction sector accounts for a considerable proportion of total wood consumption – up to 60–75% of the total amount of cut timber and board materials. The majority consists of Nordic softwood (*see Section 1.5.1*). Up through the 1990s there has been considerable growth in the construction of wooden houses.

Since the 1950s, the consumption of various types of plastic in the building and construction sector has grown markedly, for instance within the electrical and sanitation areas and in connection with doors, windows, profiles, etc. The use of plastic has also introduced a large number of new substances that are potentially harmful to health and the environment.

PVC and PE are the most commonly used types of plastic for building. Around 35,000 tonnes of hard PVC (1995 figure) are consumed annually in building materials, of which about 25,000 tonnes are used for various types of pipe (e.g. drain pipes, electrical pipes, guttering), 5,000 tonnes for window frames and just over 2,000 tonnes each for roofing and flooring.

PVC is a hard material. Plasticizers are therefore added to it to make PVC plastic pliable and flexible. In some cases, PVC plastic contains as much as 60% plasticizer. The most commonly used plasticizers are the phthalates. Phthalates are generally considered to be undesirable due to their effects on health and the environment. Some phthalates have been shown to interfere with fecundity in experimental animals and to cause hormonal disturbances. Stabilizers and pigments containing heavy metals have also been added.

Photo: Highlight

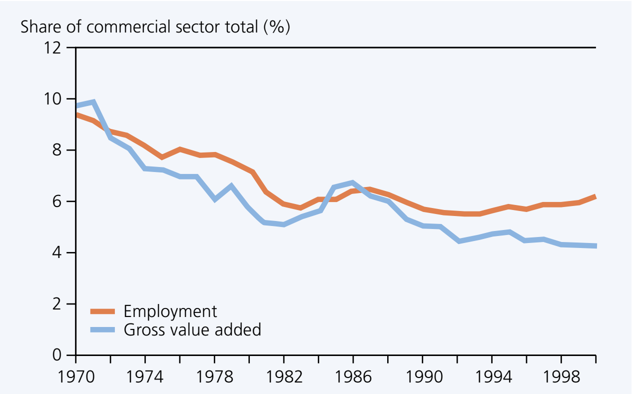


Figure 1.5.18
The building and construction sector's share of total employment and gross value added for the period 1970–1999.
(Source: Statistics Denmark, 2001).

When PVC came into focus in Denmark at the end of the 1980s, it was primarily because chlorine is released from PVC upon combustion. As a consequence, hydrochloric acid is formed in the atmosphere, thereby entailing the potential danger of acid precipitation. Lime is added during flue gas abatement, thereby generating a waste product that contains heavy metals and hence has to be deposited as hazardous waste. Incineration of 1 kg PVC generates between 1 and 2 kg of waste residue.

Chemicals and hazardous substances

The building and construction sector is one of the sectors that uses the greatest number of different chemical products – just over 6,000 different products out of approx. 40,000 registered products. In 1999, the State Building Research Institute carried out a study of problematic substances in building materials (*Table 1.5.5*). The main materials containing problematic substances were impregnated wood, paint, adhesives and sealants. In 1996, around 90,000 tonnes of paint were used, of which half contained organic solvents. In addition, just over 50,000 tonnes of adhesive, filler and sealant were used.

There are also reasons for concern about the large amounts of chemical substances present in the existing buildings and structures, and which eventually end up as waste. It is possible to reduce the environmental impacts by reducing consumption or improving the production and use of these materials. In the long term, though, the greatest improvements are obtained by completely replacing these materials with other environment-friendly alternatives.

Wood preservation

The softwoods pine and spruce are the types of wood used in the greatest amounts for building in Denmark. They have only a limited natural durablilty when permanently exposed to humidity, and especially when in contact with the soil. Thus much of the wood used is treated with chemical wood preservatives, either through industrial wood impregnation (vacuum or pressure impregnation) or by surface coating (wood preservatives).

In Denmark, around 250,000 m^3 (approx. 120,000 tonnes) of pressure-impregnated wood is utilized each year. It is mainly used in constructions where the wood is exposed to biodegradation, for example for playground equipment, carports, fences, wall facing, harbour structures, etc. It is estimated that about 3 million tonnes of impregnated wood have accumulated in Denmark over the past 50 years due to the use of such wood.

Many of the impregnation agents developed contain active substances that are harmful to health or the environment. Examples are the chemical substances that contain the metals chromium, copper, tin or the formerly (in Denmark) approved arsenic oxides. Some of the tar products used in the past (creosote, etc.) also contain many substances harmful to health or the environment.

Consumption of wood preservatives containing arsenic and chromium has declined markedly over the past 10–15 years due to a total ban on the use of arsenic, including arsenic-treated wood, and a ban on the impregnation of wood with chromium based agents in Denmark.

However, much of the hazardous substance and heavy metal content is still present in the wood when it ends up as waste for incineration or landfill. Moreover, although now banned, arsenic and creosote may be present in old impregnated wood. Following incineration or landfill, the hazardous substances in the wood can enter the environment. It is also important to avoid burning impregnated wood in home wood burning stoves and open-hearth fires.

Table 1.5.5
Overview of hazardous substances in building materials that have or in future could have effects on human health and the environment. (Source: Krogh, 1999).

Type of substance	Substance/substance group	Building materials
Metals	Arsenic	Impregnated timber
	Lead and lead compounds	Flashing, cables, PVC
	Cadmium	Pigments, solder
	Chromium compounds	Impregnated timber
	Tin compounds	Vacuum-impregnated timber
	Nickel	Locks
	Copper compounds	Impregnated timber
Persistent substances	Polychlorinated biphenyls	Sealants
	Phthalates	Sealants, plastic
Solvents		Paint, impregnation oils
Biocides	Fungicides	Sealants, paints
	Preservatives	Sealants, paints
Monomers	Isocyanates	Foam sealants
	Epoxy compounds	Epoxy adhesives
	Phenol	Two-component adhesives
	Formaldehyde	Two-component adhesives

Energy consumption for building

Energy consumption for the construction of traditional buildings (incl. transport and manufacture of building materials) accounts for 10–15% of the total energy consumption during the buildings' life cycle, or approx. 3% of the total energy consumption in Denmark.

The manufacture of a number of building materials entails a relatively high energy consumption. The main examples are cement, bricks and tiles, metals, asphalt, mineral fibres and plastic. By recycling some of these materials and products it is possible to save on energy consumption for the production of new building materials.

Transport of building materials

Transport of the large amounts of building materials and of soil and waste poses a significant environmental problem. The many heavy loads of materials and soil also cause considerable wear of the road network. Transport of sand, gravel, stone and soil, etc. alone accounts for one fifth of total freight transport by lorry in Denmark.

Waste and recycling

In 2000, building and construction waste amounted to 3.2 million tonnes, corresponding to 24% of all the waste generated in Denmark. The following fractions are sorted from building waste for recycling: Concrete (31%), asphalt (17%) and stone and earth (15%).

The amount of waste generated by the building and construction sector varies depending on the level of activity in the sector and increased by 41% between 1994 and 1997, whereafter the waste volume has decreased slightly (*Figure 1.5.19*). Overall, the amount of waste has increased by 32% over the period 1994–2000.

Around 90% of the building and construction sector waste was recycled in 2000, while 2% was incinerated, and 8% was disposed of by landfill. During the period 1994–2000, the proportion of building waste recycled has increased by six percentage points, and the proportion sent to landfill has decreased correspondingly. The high percentage of recycling is due to the fact that the waste levy is not charged on waste that is recycled.

Selected initiatives to reduce the environmental impact

A number of initiatives have been implemented to reduce the environmental impact of the building and construction sector. For example, concerted efforts are being made to considerably reduce fluorocarbon emissions from brick and tile works, and a branch-specific computer-based environmental management system with an accompanying environmental handbook has been developed for the asphalt branch to facilitate the introduction of environmental management in the enterprises.

The target for 2004 in the waste action plan "Waste 21" is to maintain the high level of recycling of building and construction waste and to enhance sorting of hazardous waste fractions, e.g. PVC, impregnated wood and electrical/electronic products. Finally, environmentally sound design is to be enhanced in connection with building and construction projects.

In 2000, a product panel was established within the building and construction area. The panel is comprised of a large number of representatives from within the sector and has the task of promoting the development of a cleaner building sector. The panel has drawn up an action plan "Action Plan for Sustainable Development of the Danish Building Sector". Based on the Action Plan, the panel will initiate a number of initiatives. The Action Plan identifies three main areas that are to be implemented in parallel:

- Demand for environmental consideration is to be stimulated. The main responsibility lies with the authorities, who will have to implement legislation, and with developers, who are to carry out branch campaigns.
- The ability to incorporate environmental consideration in the building sector is to be enhanced, among other means through research and product development.
- Close, coordinated interaction between all the actors involved in the building sector.

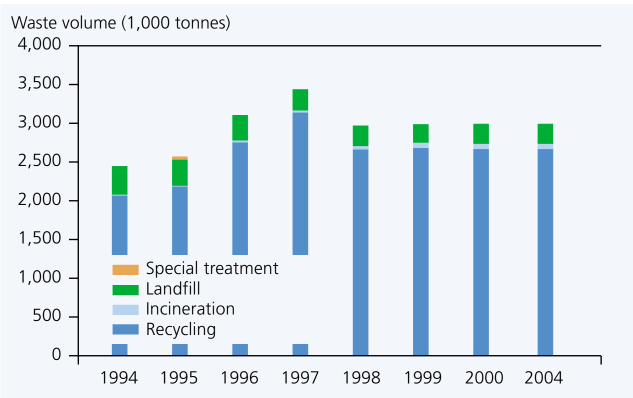


Figure 1.5.19
Building and construction waste apportioned by treatment for the period 1994–2000 together with the target for 2004.
The figure is constructed such that the total waste volume in 2004 corresponds to that in 2000. This should not be taken to represent a forecast of the future trend in waste volumes.
(Source: Danish Environmental Protection Agency, 2001).

1.5.5 Industry

Industry holds a key position in relation to many environmental problems. Environmental regulation of industry since the 1970s has yielded good results with regard to reducing emissions to the air and the aquatic environment and impact on the local environment. Industry still faces considerable challenges, however, for example, to develop cleaner products, limit the use of hazardous substances in products and production processes, to reduce energy and resource consumption and to reduce waste generation.

Different sectors of industry affect the environment in different ways. The most important sectors of industry as regards energy consumption, water consumption, use of unwanted substances and emissions to the air (*Table 1.5.6*) are:

- In 1999, the food, drink and tobacco industry accounted for 26% of industry's energy consumption, followed by the stone, clay and glass industry (23%), the metal processing industry (14%) and the chemical industry (13%).
- The food, drink and tobacco industry and the chemical industry accounted for the majority of industrial water consumption (just over 40% each).
- The greatest consumers of unwanted chemical substances were the machinery industry, the electronics and metal processing industries (28%, 24% and 18%, respectively) due to the large amounts of copper they use, followed by the chemical industry (8%).
- Most CO_2 was emitted from the stone, clay and glass industry (30%), followed by the food, drink and tobacco industry (26%) and the refined petroleum products industry.
- Industrial consumption of organic solvents was a major source of emissions of volatile organic compounds (VOCs). VOC emissions mainly derive from industrial processes, in particular in the food, drink and tobacco industry, the wood industry, the furniture industry and the iron and metal industries. Furthermore, considerable VOC emissions derive from vehicle repair shops.

In 1997, the food, drink and tobacco industry was the largest, accounting for about 18% of both employment and gross value added (*Table 1.5.6*). This was followed by the machinery industry (15%) and by the chemical industry, the paper and printing industry, the metal manufacturing and processing industry and the electronics industry, each of which accounted for about 10% of gross value added.

Table 1.5.6

Percentage of total employment and gross value added (GVA) accounted for by the main sectors of industry. Figures are also given for resource consumption, use of unwanted substances and emissions of CO_2 and VOCs for the main branches responsible. (Source: Statistics Denmark and National Environmental Research Institute, 2001).

Line of industry	Employment		GVA	Energy consumption	Water consumption	Consumption of unwanted substances*	Emissions of CO_2	Emissions of VOC
	Number	%	%	%	%	%	%	
	1997	1997	1997	1999				
Food, drink and tobacco industry	80,051	18.0	17.6	26.0	44		26	xx
Machinery industry	68,026	15.3	14.8			28		xx
Paper and printing industry	51,770	11.6	10.6		4			
Metal manufacturing and processing	49,639	11.1	10.3	14.0		18		xx
Electronics industry	42,980	9.6	10.1			24		xx
Furniture and other industry	32,959	7.4	6.1			7		xx
Chemical industry	26,307	5.9	11,6	13.0	41 **	8		
Rubber and plastics industry	20,596	4.6	4.9		2			
Transport equipment industry	20,248	4.5	3.1					
Stone, clay and glass industry, etc.	19,566	4.4	4.7	23.0		7	30	
Textiles, clothing and leather industry	17,228	3.9	3.3		2			
Wood and wood products industry	15,720	3.5	2.8			4		xx
Refined petroleum products industry, etc.	807	0.2	0.3				18	

GVA: Gross value added; VOC emissions: The branches mainly responsible are indicated by xx

* cf. the Danish EPA's List of Unwanted Substances (see Section 1.6)

** Approx. 80% of water consumption in the chemical industry is seawater used for cooling

Trends in industry

Industry's share of total employment fell from 26% to 19% between 1966 and the mid 1980s (*Figure 1.5.20*). Over the past 15 years, the percentage of total employment has only decreased slightly, and was about 17% in 1999. Altogether, just under 450,000 persons were employed in industry at the end of the 1990s. Industry's share of gross value added has fallen from around 19% before 1980 to approx. 17% today (*Figure 1.5.20*).

The sector profile of Danish industry has not changed radically over the past 10–20 years. Thus the food, drink and tobacco industry was also the dominant one in the 1980s.

Over the past 20 years, employment and gross value added have decreased markedly in the textiles, clothing and leather industry, in the stone, clay and glass industry, in the paper and printing industry and in the transport equipment industry (*Table 1.5.7*). Conversely, gross value added has increased markedly in the chemical industry, the electronics industry and the rubber and plastics industry. For example, expressed in fixed prices, gross value added has more than doubled in the chemical industry and the electronics industry from 1980 to the present day. In the other industries, employment has remained relatively constant, while gross value added in fixed prices has increased by about 25%.

Environmental impact and resource consumption

Industry's direct or indirect resource consumption and environmental impact are primarily related to raw materials consumption for production, energy and water consumption for production processes, emissions to the air and the aquatic environment, and waste generation. Some of the environmental impacts are common for many of the industrial sectors, e.g. the environmental impacts associated with energy consumption.

In industry, raw materials are processed into semi-manufactured goods and thereafter final goods and products (*Figure 1.5.21*).

In the food, drink and tobacco industry, for example, abattoirs, fishmeal factories, dairies, oil and margarine factories, sugar factories and breweries, the input of raw materials (agricultural

Table 1.5.7

Percentage change in employment and gross value added (1995 prices) for the main sectors of industry between 1980 and 1997.

(Source: Statistics Denmark, 2000).

	Employment	Gross value added
Textiles, clothing and leather industry	-56.8	-29.3
Stone, clay and glass industry, etc.	-32.2	-16.0
Transport equipment industry	-22.3	-11.6
Food, drink and tobacco industry	-15.8	12.3
Paper and printing industry	-11.5	-12.1
Electronics industry	-4.2	112.2
Machinery industry	-1.9	12.6
Furniture and other industry	3.5	28.5
Metal manufacturing and processing	4.6	39.5
Refined petroleum products industry, etc.	8.2	-48.1
Wood and wood products industry	16.7	41.9
Rubber and plastics industry	27.1	53.9
Chemical industry	32.1	138.0
Industry, total	**-9.4**	**122.0**

Photo: Highlight

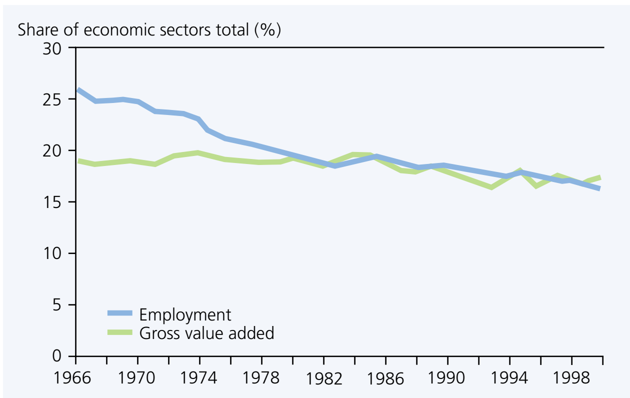


Figure 1.5.20

Industry's share of total employment and gross value added for the period 1966–1999.

(Source: Statistics Denmark, 2000).

produce and fish) is considerable. Energy consumption is often high, for example for refrigeration, as is water consumption, and large amounts of wastewater are produced that often contain much oxygen-consuming organic matter.

The wood and paper industry, e.g. saw mills and paper factories, process Danish and foreign wood to wooden goods as well as to cardboard and paper. The wooden goods are further processed in the building materials and furniture industries, while paper goods are used in the printing industry and for packaging and housekeeping products. The Danish paper industry is based on recycled paper, and new paper is produced abroad, primarily in Sweden, Finland and Germany. Production of paper used to entail considerable consumption of water and discharge of organic matter and hazardous substances to the aquatic environment. However, as a result of the implementation of cleaner technology in Danish factories and in many of the countries we import from, the environmental impacts have been considerably reduced.

The building materials industry encompasses among other things cement and concrete factories, brick and tile works, and flooring, window and kitchen element manufacturers. These use large amounts of raw materials such as sand and lime, wood and plastic that end up as final products in the form of building materials such as concrete panels, bricks, rafters and windows. The environmental impacts include a high energy consumption, emissions of CO_2 and the use of hazardous substances, including wood impregnation agents and PVC (*see Section 1.5.4*).

Nowadays, much of the textiles and leather goods used in Denmark are manufactured at spinning mills, dye works and tanneries abroad. The manufacture of clothing and footwear is mainly carried out in countries where labour is relatively cheap. Dye works and tanneries can produce considerable amounts of wastewater, which may contain heavy metals, especially at the low-technology factories, while the production at the more advanced factories is carried out in sealed systems.

The two Danish refineries process some of the oil from the Danish oil fields to various petroleum products, especially fuels. Petrochemical works in the neighbouring countries use oil to produce plastic materials and granulates. These are further processed in the Danish rubber and plastics industry to packaging, building materials and medical items. The oil companies also supply bitumen, which is combined with sand and gravel to produce asphalt.

The Danish chemical industry is highly specialized with relatively little activity in primary chemical production. Most of the industrially manufactured chemicals and compounds used in Denmark are imported, some of which are further processed in the Danish chemical industry.

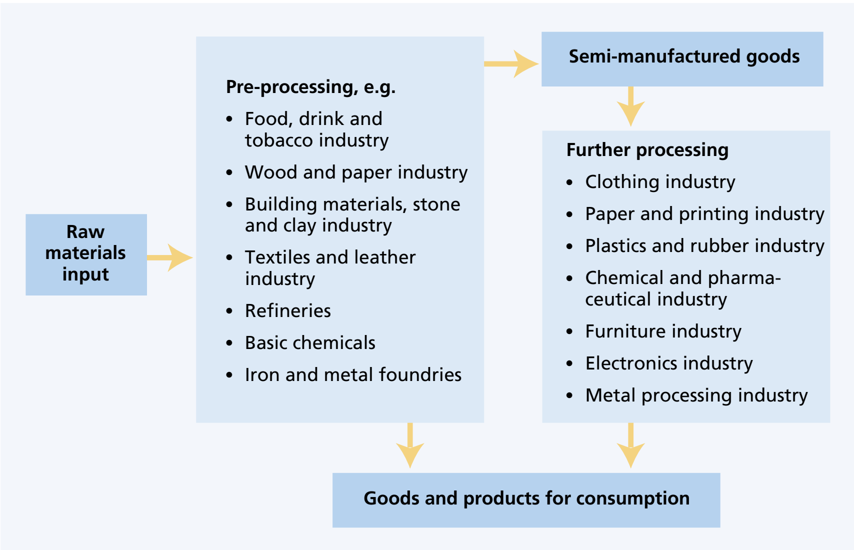
Compared with nearby countries, the primary iron and metal industry in Denmark is relatively small, the main plants being the steelworks "Stålvalseværket" and a few iron and metal foundries. Considerable processing of metal goods takes place in the Danish machine and conveyance industry (e.g. shipyards).

Over the past 10–20 years, a number of industries in the first links of the processing chain have disappeared in Denmark or have receded considerably. The first stages of the manufacturing process used to – and to some extent still do – entail high consumption of ancillary materials such as energy, for example for melting or cooling metal, as well as high consumption of water and production of wastewater. In addition, it is usually the first stages in the manufacturing process that cause the largest emissions to the air and aquatic environment, and which generate the most waste.

When assessing the environmental impacts of industry and of the products we use in Denmark, the focus of attention should not only be on the environmental impacts of industry in Denmark, but also on the impacts that take place during processing abroad, for example in dye works, tanneries, paper factories, fertilizer factories, the basic chemical industry and metal foundries. Little is presently known about the environmental impacts abroad of the products that we import.

Figure 1.5.21

Material flows in industry.



Energy consumption

In 2000, the manufacturing industry accounted for 18% of total energy consumption in Denmark. The climate-corrected energy consumption in the manufacturing industry has remained roughly constant over the past 20 years, although at a slightly lower level after the energy crisis in 1981 and during the economic recession around 1990 (*Figure 1.5.22*). Relative to 1990, energy consumption was 7% higher in 2000.

The composition of energy consumption in the manufacturing industry has changed markedly since 1980. The proportion of oil has fallen from 62% to 22% today, while electricity consumption has increased from 17% to 30%, and natural gas now accounts for 29% of the consumption.

In 1999, the food, drink and tobacco industry accounted for 26% of industrial energy consumption, followed by the stone, clay and glass industry (23%), the metal processing industry (14%) and the chemical industry (13%). The stone, clay and glass industry uses about five times as much energy per gross value added as the remainder of industry (*Figure 1.5.23*). Only minor changes in energy efficiency have taken place in the various sectors of industry over the past 10 years.

Soil contamination from industry

Altogether, there are approx. 14,000 contaminated sites in Denmark (*see Section 4.4*), of which around one fifth are former industrial sites. The iron and machinery industry together with the asphalt industry and electroplating factories are the main sources of the contamination. Some of the largest contamination incidents were caused by the chemical industry, for example the factory complex "Proms Kemiske Industri" in southeastern Zealand. The use of chemicals by industry is described in *Section 1.6*.

Emissions to the air

Industrial energy consumption and some of the production processes lead to the emission of various harmful substances to the atmosphere (*Figure 1.5.24*).

Industrial CO_2 emissions from in-house energy production have remained fairly constant over the past 20 years at 5–6 million tonnes annually corresponding to 8–10% of Denmark's total CO_2 emissions (*Figure 1.5.25*). To this should be added just over 1 million tonnes CO_2 from the manufacture of cement. Around one third of the energy consumption by the manufacturing industry is supplied in the form of electricity and district heating. If the associated CO_2 emissions are added, industry accounts for 12–15% of Danish CO_2 emissions.

Industrial emissions of sulphur dioxide (SO_2) and nitrogen oxides (NO_x) mainly derive from in-house energy production and comprise 15% and 7%, respectively, of the total emissions. To this must be added emissions related to industrial consumption of electricity and district heating. NO_x emissions have remained almost constant since 1985, whereas SO_2 emissions have decreased markedly by over 80% (*Figure 1.5.26*). This is attributable to the use of low-sulphur fuels and to a lesser extent to the introduction of flue gas desulphurization.

Industry is an important source of emissions of volatile organic compounds (VOCs). The use of organic solvents accounts for 27% of the total Danish emissions. A large part of this derives from industrial processes, primarily in the food, drink and tobacco industry, the wood industry, the furniture industry, the iron and metal industry and vehicle repair shops.

In order to reduce the high level of VOC emissions, the Minister for the Environment made an agreement with

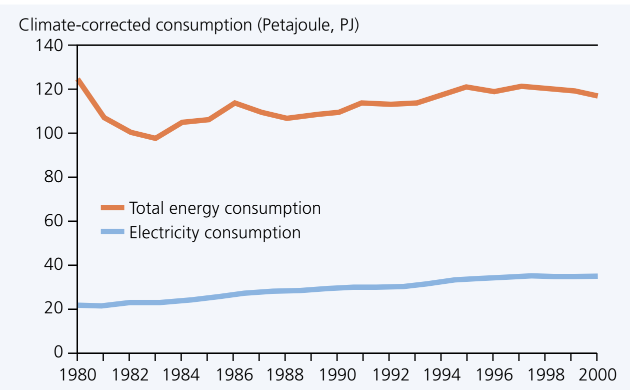


Figure 1.5.22

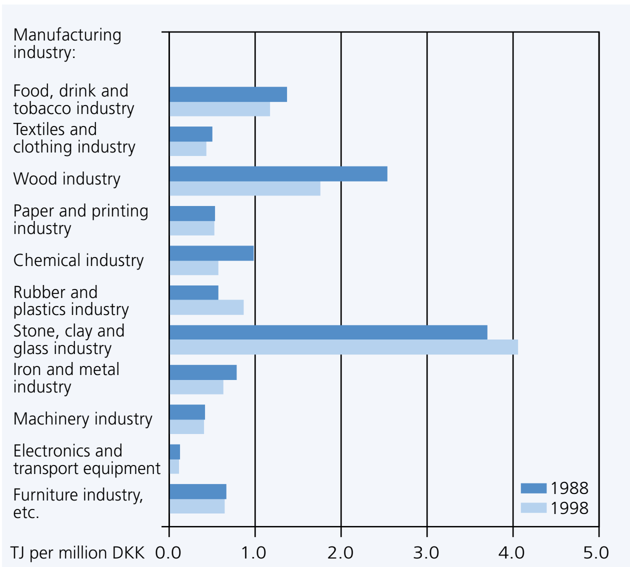
Energy and electricity consumption in the manufacturing industry for the period 1980–2000.

(Source: Danish Energy Agency, 2001).

Figure 1.5.23

Energy intensity, i.e. energy consumption per gross value added, in the industrial sectors in 1988 and 1998.

(Source: Danish Energy Agency, 1999).



the majority of industry in 1995 to reduce the emissions by 40% by the year 2000 relative to the 1988 level. This was to be achieved through the introduction of new and cleaner technology in industry and through a greater switch to production of water-based paints, printing inks, etc. within the paint and varnish industry. In 2001, the EU Directive on VOCs will be implemented in Denmark. The Directive encompasses approx. 20 branches, all of which will be subjected to stricter limit values for emissions of VOCs so that industrial emissions of VOCs will continue to decrease in the coming years.

A number of the substances that industry uses for the manufacture of such items as foam plastics, refrigerators and fire extinguishers deplete the ozone layer, e.g. CFCs. Emission of these substances can occur both during manufacture of the products and during their use and disposal. At the international level the substances are regulated by the Montreal Protocol, which requires the signatory countries to phase out these substances. Over the past 15 years, use of the most potent ozone-depleting substances (CFCs, tetrachloroethane, 1,1,1-trichloroethane, halons and methyl bromide) has been almost completely phased out in Denmark (*Figure 1.5.28*). Internationally, the phase-out has been successful too.

The HCFCs, which are much less harmful to the ozone layer, have not yet been completely phased out in Denmark or internationally. In 1999, just over 2,000 tonnes of HCFCs were used as a refrigerant and in insulation foam for refrigerators and freezers.

Industrial gasses that are used as a refrigerant and foaming agent (HFCs), refrigerant (PFCs) and as an insulator in high-voltage circuit breakers and for noise-proofing windows (SF_6) are potent greenhouse gasses. However, the three industrial gasses only account for less than 1% of total greenhouse gas emissions.

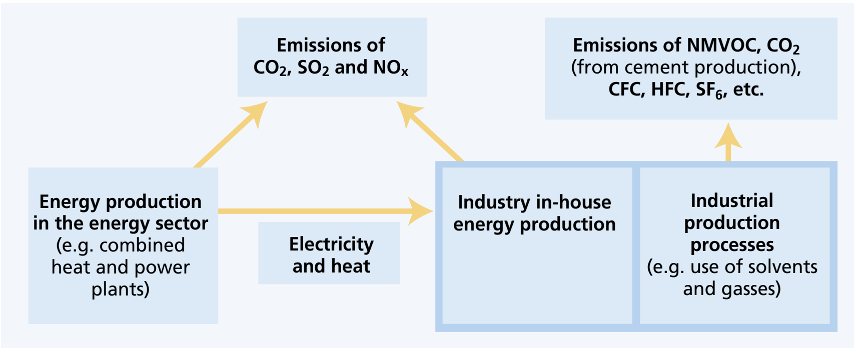


Figure 1.5.24

Emissions to air by industry.

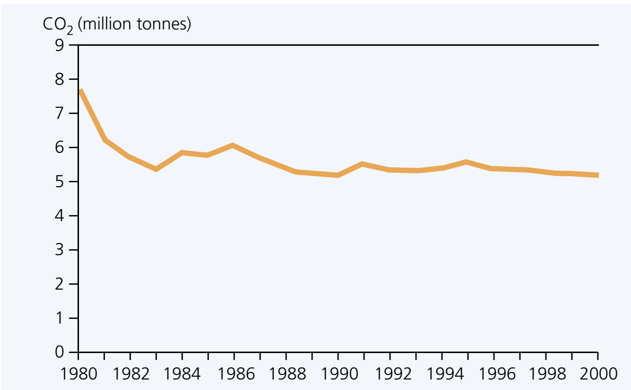


Figure 1.5.25

CO_2 emissions from in-house energy production by the manufacturing industry for the period 1980–2000.

(Source: Danish Energy Agency, 2001).

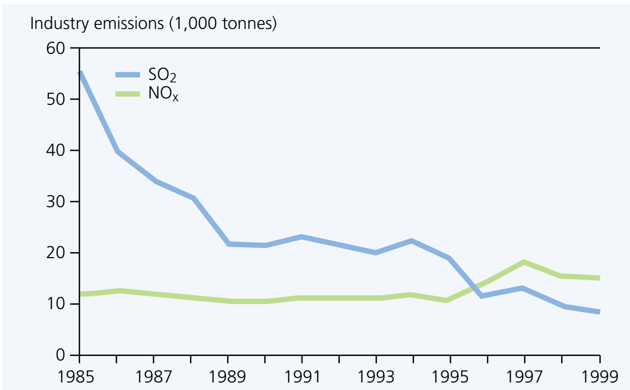


Figure 1.5.26

Industrial sector emissions of SO_2 and NO_x. The increase in NO_x emissions after 1995 is due to improvements in the method of calculation.

(Source: National Environmental Research Institute, 2000).

Water consumption

Industrial water consumption accounts for around one quarter of total water consumption in Denmark and decreased by about 15% during the 1990s.

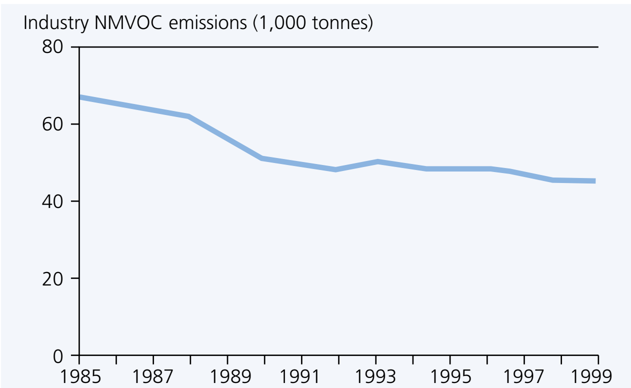
Consumption by businesses and institutions of water from public waterworks amounted to around 180 million m^3 in the 1980s, thereafter decreasing to 136 million m^3 by 1999 (*Figure 1.5.29*). Water abstraction by industries, etc. with their own waterworks has varied between 80 and 100 million m^3 during the 1990s.

At the beginning of the 1990s, an analysis was made of industrial water consumption by sector and type of use. The food, drink and tobacco industry and the chemical industry were the two main branches, each accounting for just over 40% of industry's total water consumption. Just over 80% of the water used by the chemical industry was seawater for cooling and hence did not impact on the groundwater resource. Apart from these industries, the textile dying plants and the paper and cardboard factories also consumed considerable amounts of water. Within the food, drink and tobacco industry the major water consumer was the drinks industry, although abattoirs, dairies, the fish processing industry, sugar factories and oil mills and margarine factories also consumed considerable amounts of water.

Over the past 10–20 years, many industrial enterprises have invested in cleaner technology in order to reduce water consumption. For example, the amount of water consumed to produce a litre of beer, slaughter a pig, manufacture a kilogram of paper and produce a cubic metre of glass wool has decreased markedly (*Figure 1.5.30*). The water saving has mainly been achieved by recycling the water and through improved production processes, and has also resulted in savings on chemicals and process energy (for example to heat the water) and has markedly reduced the amount of wastewater. Since 1989, for example, water consumption by pig abattoirs is estimated to have decreased by 60%, and wastewater discharges by 40%.

Figure 1.5.27 (upper)
Emissions of NMVOCs by industry. The agreement on a 40% reduction in 2000 relative to 1988 only encompasses part of industry.
(Source: National Environmental Research Institute, 2000).

Figure 1.5.28 (lower)
Consumption of ozone-depleting substances in Denmark expressed in terms of ozone-depleting potentials (ODP).
(Source: Danish Environmental Protection Agency, 2001).



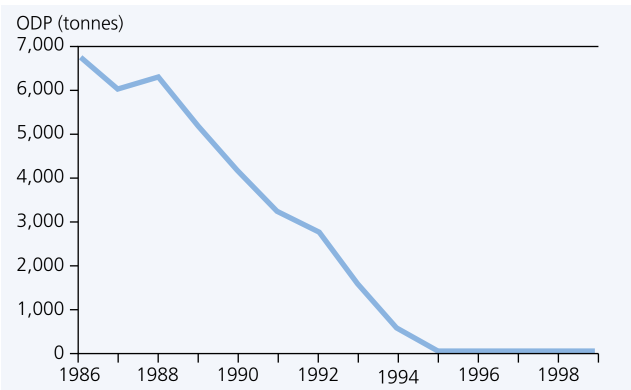
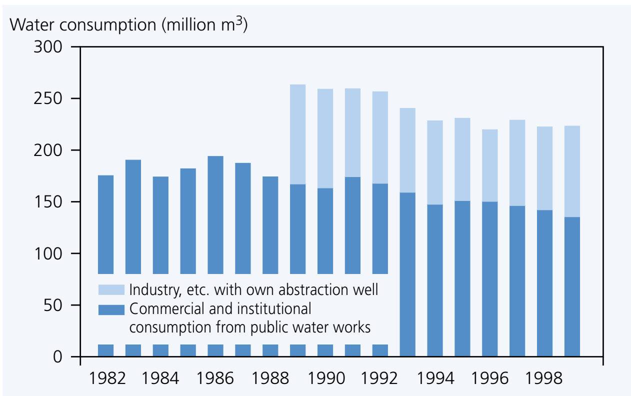


Figure 1.5.29
Trend in water consumption by businesses and institutions apportioned by water from public waterworks and by industries with their own abstraction wells for the period 1982–1999. In addition to industry, the category "Industry, etc. with own abstraction well" also encompasses remedial abstraction and major construction projects. For example, construction work on the Metro in Copenhagen accounted for 7.6% of total water abstraction in 1999. Taken together, water table lowering and remedial abstraction accounted for 17% of water abstraction that year.
(Source: Geological Survey of Denmark and Greenland, 2001 and Statistics Denmark, 2000).



Discharges to the aquatic environment

Industrial production processes involving cleaning and rinsing result in wastewater discharges. The majority of industrial enterprises are connected to the sewerage system, and the wastewater is led to the municipal wastewater treatment plants. Wastewater from industry comprises 41% of the water volume led to the treatment plants. In addition, around 100 enterprises have their own treatment plant and a separate industrial outfall.

Due to improved wastewater treatment, the amounts of pollutants discharged via both the municipal treatment plants and separate industrial outfalls have decreased markedly over the past 15 years (*see Section 3.2*). Discharges of organic matter, phosphorus and nitrogen now only amount to a tenth of the discharges in the late 1980s.

Industrial processes generate wastewater containing heavy metals and hazardous substances. Among other things, heavy metals are discharged from dye works, from pesticide factories and metal processing factories, while hazardous substances are discharged from various chemical enterprises. Improved production processes involving closed systems and improved treatment at the treatment plants have now considerably reduced the discharges of heavy metals and hazardous substances to the aquatic environment (*see Section 3.9*).

Waste

In 2000, waste generation by industry amounted to 2.95 million tonnes, corresponding to 22% of the total waste generated in Denmark. Between 1994 and 2000, waste production by the manufacturing industry increased by 28%.

In 2000, 64% of the waste generated by industry was recycled, 15% was incinerated and 21% was disposed of by landfill (*Figure 1.5.31*). Over the period 1994 to 2000, the proportion of the waste incinerated or recycled has increased, while the proportion disposed of by landfill has decreased from 36% to 21%.

Selected initiatives to reduce the environmental impact

Several initiatives are currently being implemented to reduce the environmental impact of industry, for example, green levies and taxes, ecolabels and voluntary agreements, which are market-based instruments that can help reduce environmental impact and promote cleaner technology and competence. Overall, it is important to make strategies and measures work together. At the same time, the efforts are being internationalized, including the cooperation within the EU.

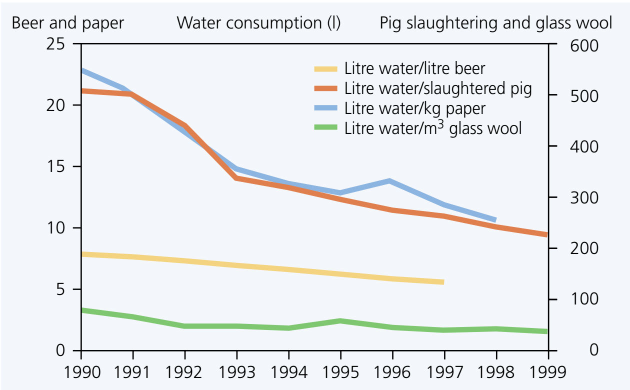


Figure 1.5.30

Trend in water consumption per product for four selected products. (Source: Based on data in the Green Accounts of the companies Carlsberg, Dalum Papir Ltd, Danish Crown and Isover Ltd).

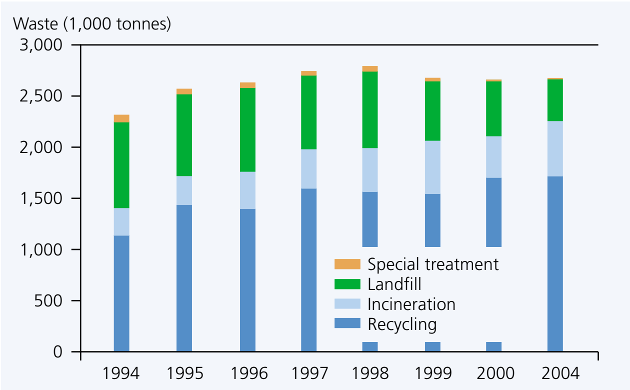


Figure 1.5.31

Manufacturing industry waste apportioned by treatment for the period 1994–2000 together with the target for 2004. The figure is constructed such that the total waste volume in 2004 corresponds to that in 2000. This should not be taken to represent a forecast of the future trend in waste volumes.

(Source: Danish Environmental Protection Agency, 2001).

The Danish environmental approval system dating from 1974 requires that all polluting enterprises must have an environmental approval. Through implementation of the EU IPPC Directive in 1999, the scheme has now been made European such that a common procedure now exists for imposing minimum requirements on polluting enterprises in Europe with the possibility to adjust these requirements in the light of technological development. When approving an enterprise, emission requirements have to be imposed corresponding to the levels attainable using the best available technique (BAT), and the approvals have to be revised a minimum of every tenth year.

In 1995, it became obligatory for a number of industrial enterprises to publish green accounts providing information about environmental impacts and describing environmental conditions. As a consequence, approx. 40% of the enterprises have achieved environmental improvements, and approx. 50% have benefited economically through savings on resources, etc.

Active efforts are being made to promote and develop environmental management in Danish enterprises with the aim of integrating environmental aspects in company decision-making processes and day-to-day operations. Thus a number of industry-specific environmental management tools have been developed to facilitate the implementation of environmental management in the individual enterprises. In recent years the focus has widened from the more technical aspects to encompass financial aspects and the life cycle perspective.

Enterprises and authorities can also obtain support for environmental management, green procurement and the build-up of environmental competence. As evidence of documented environmental management systems, over 500 enterprises are ISO 14001-certified, and more than 160 are EMAS-registered (*Figure 1.5.32*).

The Government's business strategy ".dk21" incorporates the 2001 Green Business Strategy, which emphasizes three areas:

- Well-functioning green markets for goods and services
- Integration of environmental considerations in company business procedures in order to develop market-oriented environmental strategies
- Organizational development.

Finally, innovation and development can support the position of Danish enterprises in a green market. The target is to support a development whereby the enterprises can make a profit by contributing to a green market.

The National Strategy for Sustainable Development published in June 2001 emphasizes the importance of incorporating consideration for the environment in all phases from production to consumption to disposal. At the same time, the market forces in combination with new market-oriented instruments, voluntary initiatives and regulations are to help reduce the environmental impact.

In general, too much industrial waste is disposed of by landfill. The target stipulated in the waste action plan "Waste 21" is that 65% of industrial waste should be recycled, and no more than 15% disposed of by landfill. Among other means, this is to be attained by promoting recycling via consultancy schemes for industrial waste and by promoting the development and knowledge of new recycling technologies.

The recyclable and hazardous fractions of waste must be separated properly. For example, industry shall separate paper and cardboard, plastic, electrical and electronic products and impregnated wood. An official set of guidelines concerning hazardous waste is being prepared in which the regulations for collection and treatment are specified. In addition, a project has been initiated to investigate the possibility of increasing the recycling of hazardous waste through the imposition of a waste levy.

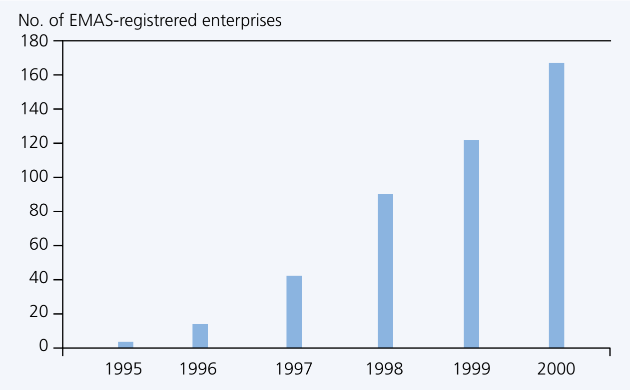


Figure 1.5.32
EMAS-registered enterprises in Denmark for the period 1995–2000.
(Source: Danish Environmental Protection Agency, 2001)

1.5.6 Private and public service

The service sector consists of a number of diverse enterprises related by the fact that they all produce services. Together they account for 71% of the economic activity in Denmark. In the statistics, the service sector is generally subdivided into four main branches:

- Trade, hotel and restaurant enterprises
- Transport enterprises, post and telecommunication
- Financial enterprises and business services
- Public and personal services.

The public sector consists of public administration and service and all public enterprises.

The service sector's direct or indirect resource consumption and environmental impact are primarily related to the sector's energy consumption, waste generation and general consumption of products.

Some parts of the sector entail activities and environmental impacts that are described under other sectors of society. For example, the environmental impact of transport enterprises are described under the section on transport (*see Section 1.4*), and that of hotels and restaurants is described in the section on tourism and outdoor recreation (*see Section 1.5.8*).

Trends in the service sectors

Over the past few decades, Denmark has developed from an agricultural and industrial society to a society in which services dominate. Since 1960, the share of employment accounted for by the services has increased from less than half to more than two thirds. The increase is most pronounced for public services, where the share of total employment has more than tripled such that as much as one third of all employees now work in the public services. Today around 970,000 persons are employed in the private sector, and 940,000 in the public sector (*Figure 1.5.33*). One of the main reasons for this is that the percentage of working women has increased such that many of the functions previously carried out at home (e.g. taking care of children and the elderly) are now carried out by the public sector.

Since 1993, the public sector has accounted for around 31% of gross value added each year. The number of employees in public administration and service increased markedly during the 1970s. The trend stagnated at the beginning of the 1980s, and the share has since remained relatively constant at around one third of all employees.

The service sector's buildings, e.g. hospitals, child-care centres, nursing homes, schools, shopping centres, offices and shops cover a very large area. The total floor space is just under 80 million m^2, of which offices, trade and storage account for just over 50 million m^2, while schools, hospitals, child-care centres, etc. account for 25 million m^3. Over the past 15 years, the total floor space of buildings has increased by 28%.

The public sector as a major consumer

Consumption of goods by the service sector causes environmental problems such as resource consumption and indirect environmental problems associated with the production of the goods. The State, Counties and Municipalities are major consumers, together purchasing goods and services worth around DKK 140 billion each year. For several years, the goal has been to make public procurement greener. The public sector has to lead the way and stimulate green demands, thereby promoting the development and sale of greener products.

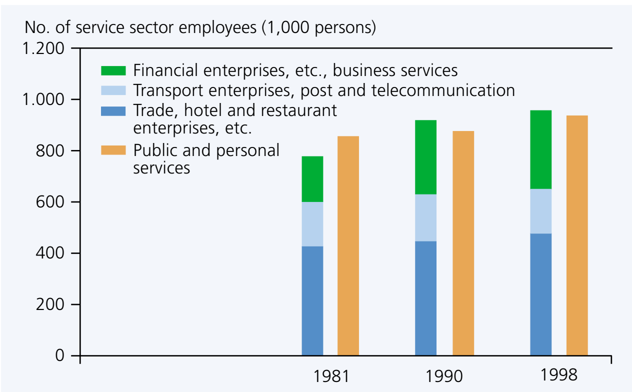


Figure 1.5.33
Number of service sector employees in 1981, 1990 and 1998.
(Source: Statistics Denmark, 1999).

A new survey carried out by the Danish EPA in 2000 (*Figure 1.5.34*) showed that:

- Two out of three state institutions, eleven out of thirteen Counties and just over half of the Municipalities are either in the process of drawing up a written green procurement policy or already have done so.
- The majority state that they often, nearly always or always stipulate green requirements when purchasing goods. Green requirements are stipulated slightly less frequently when purchasing services than when purchasing goods.
- The percentage of purchases assessed as being green varies somewhat. The state institutions assessed that around half of all purchases were green, while the figure was 25% among the Counties and slightly less among the Municipalities.
- The survey further indicates that when obtaining information about environmental aspects of goods, the public institutions particularly use the official ecolabels and energy labels. A little less importance is accorded to the information provided by the suppliers.

Energy consumption

Energy consumption by the service sector is approx. half that by industry. The final climate-corrected energy consumption in 2000 corresponds to 12% of total energy consumption in Denmark. However, to this should be added the energy consumed to produce the products used in the service sector. Over the past 20 years, energy consumption has remained roughly constant (*Figure 1.5.35*). Between 1988 and 1999, the activity (gross value added) in the service sector increased by 24%, while energy consumption only increased by 6%. Thus energy consumption and economic activity in the service sector have been decoupled to some extent.

Since the start of the 1980s, oil consumption in private services, trade and public services has been decreasing markedly, while consumption of electricity, district heating and natural gas has been increasing. Space heating now accounts for around 60% of the energy consumption. Relative to 1980, energy consumption for this purpose has decreased by 20%.

Private services, trade and public services account for 42%, 28% and 30%, respectively, of energy consumption by the trade and service sector. Relative to 1990, energy consumption for private services and trade has increased by 12% and 2%, respectively, while energy consumption by the public services has decreased by 8%.

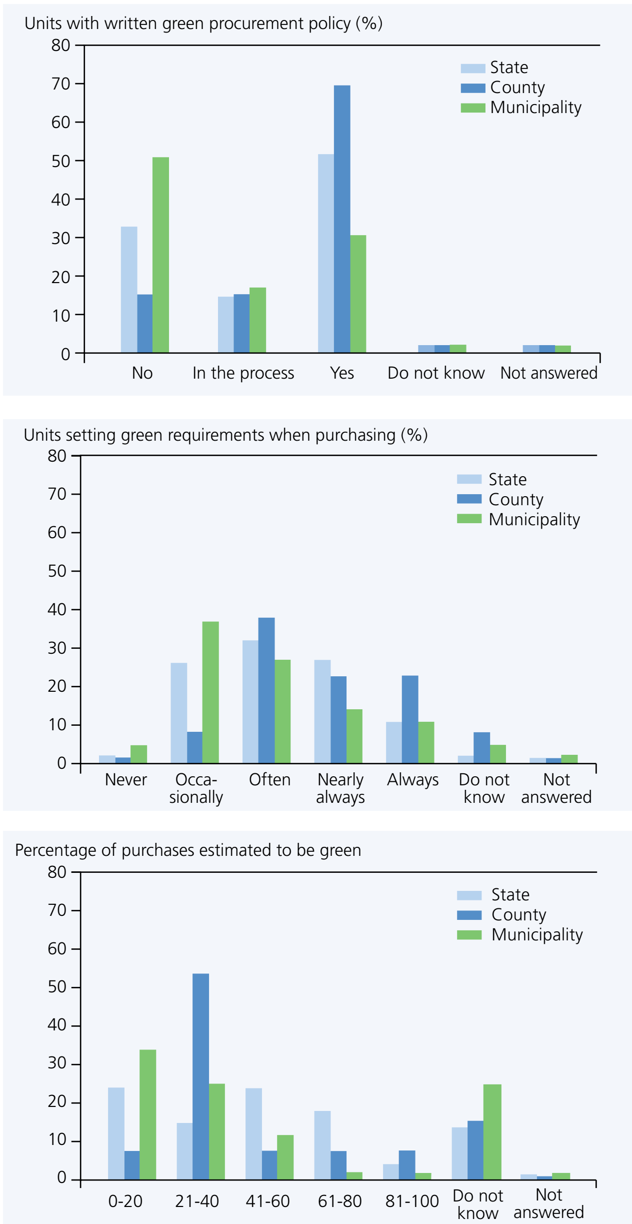


Figure 1.5.34
Green procurement status among state institutions, Counties and Municipalities.
Upper:
Status regarding written green procurement policy
Centre:
Status regarding green requirements to suppliers
Lower:
Percentage of purchases estimated to be green.
(Source: Danish Environmental Protection Agency, 2001)

During the 1990s, the state has implemented several initiatives to reduce energy consumption. Between 1995 and 1999, total energy consumption by state institutions decreased by just over 6%, while total CO_2 emissions from energy consumption decreased by 20% over the 5-year period.

Consumption of heat by state institutions fell by just over 9% during the 5-year period 1995–1999, while electricity consumption increased by 2%. Measured per square metre, however, heat and electricity consumption decreased by 14% and 4%, respectively.

Transport

The service sectors give rise to traffic, both commuting by employees and transport to and from the services by customers, patients and other users. To this should be added freight transport in connection with distribution of goods to the trade enterprises. The sector accounts for a large part of the 2.5 million business journeys. Just over half are domestic, while 1.2 million are journeys abroad. In Denmark, just under 2/3 of the business journeys are made by car, 18% by train and 11% by aircraft. Of the journeys abroad, 4/5 are carried out by aircraft.

New information technology

The National Environmental Research Institute (NERI) has premises at two locations in Jutland (Silkeborg and Kalø) and one on Zealand near Roskilde. NERI members of staff make many journeys to internal meetings on NERI premises and to meetings with other parts of the Ministry of the Environment and other collaborators.

In summer 2000, NERI purchased three sets of video conferencing equipment for the three NERI premises. During the first half-year the system was in operation, 56 video conferences were held. Of these, 13 were with participants from other institutions, while 43 were internal meetings between NERI premises. Compared with corresponding meetings held in the traditional manner, these video conferences are estimated to have saved between 62,000 and 94,000 passenger-kilometres. To this must be added the travelling time saved by the participants.

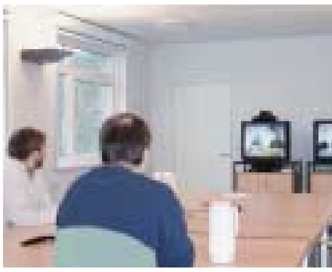


Photo: NERI

Box 1.5.2
New information technology can reduce the number of journeys to meetings.

Waste generation by institutions, trade and offices

The amount of waste generated by institutions, trade and offices has increased from just over 0.8 million tonnes in 1997 to 1.5 million tonnes in 2000, corresponding to 9% of all the waste generated in Denmark. The waste fraction to be incinerated comprised just over half of the waste, followed by separated paper and cardboard, which comprised just under a quarter.

In 2000, 40% of the waste was recycled, 46% was incinerated and 14% was disposed of by landfill (*Figure 1.5.36*). Relative to 1994, the amount of waste recycled has increased by 9%, while the amount disposed of by landfill has decreased by 9%.

The target stipulated for the service sector in the Waste Action Plan “Waste 21” that half of the waste should be recycled by 2004, is still some way from being achieved.

Figure 1.5.35
Energy and electricity consumption in the trade and service sectors for the period 1980–2000.
(Source: Danish Energy Agency, 2001).

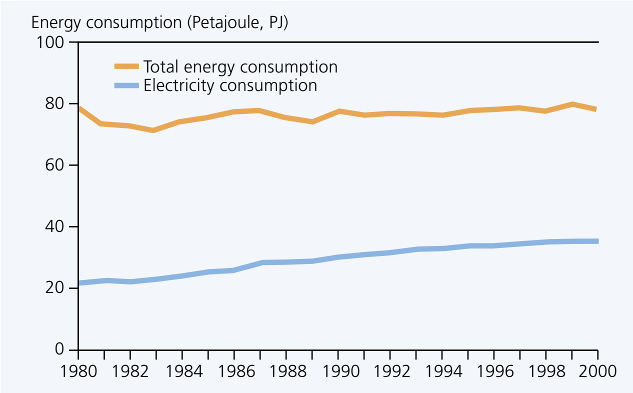
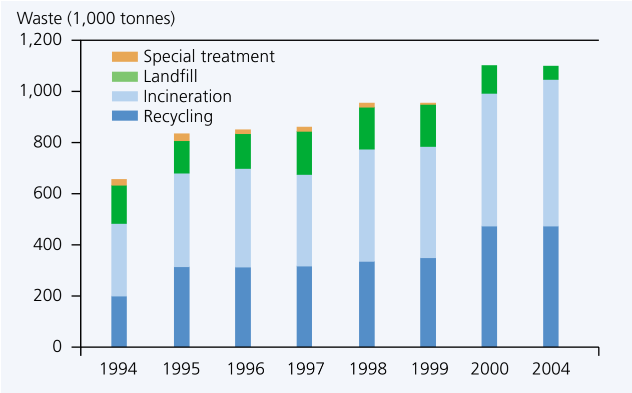


Figure 1.5.36
Institutional, trade and office waste apportioned by treatment for the period 1994–2000 together with the target for 2004. The figure is constructed such that the total waste volume in 2004 corresponds to that in 2000. This should not be taken to represent a forecast of the future trend in waste volumes.
(Source: Danish Environmental Protection Agency, 2001).



Selected initiatives to reduce the environmental impact

Under the Danish EPA's Programme for Cleaner Products, efforts have been initiated to describe the environmental impact of the service sector in order to identify priority areas and recommend new initiatives. This work is expected to be completed by the end of 2001. In addition, a project has been carried out with a retail outlet chain to develop tools to help purchasers buy green retail trade products, and a trial has been carried out to provide comprehensive consumer information via the retail trade. Both initiatives are expected to be extended to other interested retail outlet chains once the results are available.

In addition, the retail trade plays a decisive role in the dissemination of ecolabelled goods. Finally, it is expected that the Government's "Green Business Strategy" will be implemented in concrete consumer information initiatives through the retail trade.

In 1998, an agreement was made between the Minister for the Environment and Energy and the municipal organizations concerning green public procurement in the Municipalities and Counties. The parties involved agree to work towards the introduction of green procurement in all Municipalities and Counties. The Danish EPA has drawn up a number of tools to support green public procurement.

The Waste Action Plan "Waste 21" contains a number of initiatives aimed at enhancing recycling and ensuring that waste containing hazardous substances is separated out for separate treatment. The most recent Statutory Order on Waste that entered into force in June 2000, contains the following initiatives:

- The recycling of cardboard and paper and plastic from the service sector is to be enhanced
- Hazardous waste fractions such as batteries, tires, PVC, electrical and electronic products and refrigerators/freezers are to be separated for special disposal.

1.5.7 Households

The household sector accounts for more than half of all Danish consumption of goods and services. Our individual consumption is one of the main ways in which we affect the environment. The diet, the home, the means of transport and the consumption of household chemicals all play a role.

Food consumption accounts for over one third of the average family's consumption of resources and discharges to the environment. The next third of the environmental impact is due to energy consumption for space heating, electricity and transport, while the final third is accounted for by clothing, hygiene, health care, cleaning and leisure activities.

The direct impacts of households on the environment and nature encompass:

- Resource consumption in the form of materials for products and consumption of energy and water
- Discharges of hazardous substances and waste to the environment
- Land use for homes and transport infrastructure.

The indirect impacts of households on the environment encompass:

- Effects of the extraction of raw materials and the production of foods
- The manufacture of products and management of waste in other sectors.

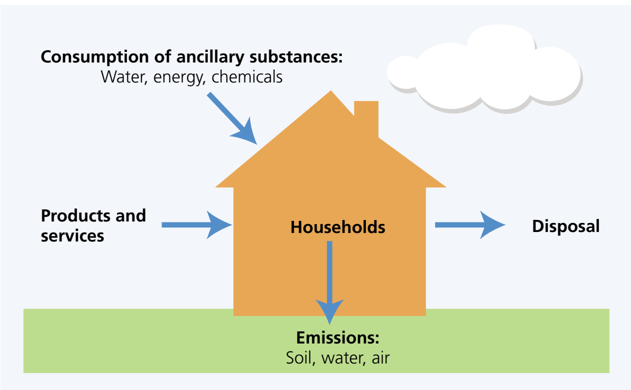


Figure 1.5.37
Household resource consumption and environmental pressures.

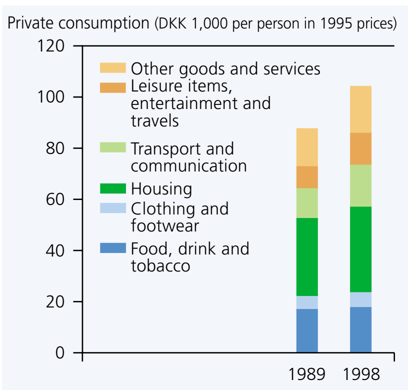


Figure 1.5.38
Value of household consumption in 1989 and 1998 (in 1995 prices) apportioned by main consumption items.
(Source: Statistics Denmark, 2000).

Main trends of significance to the environment

Whereas there were just under 1.5 million households and approx. 4.6 million inhabitants in Denmark in 1960, there are now 2.4 million households and 5.3 million inhabitants. The number of persons per household has fallen from around 3 to 2.2 persons today. Despite the fact that fewer people inhabit each house, the average size of houses has increased from 106 m^2 in 1981 to 109 m^3 today. The greater number of households results in greater consumption as each individual household has its own resource consumption with its own refrigerator, deep freezer, TV, furniture, etc.

Increased consumption

As mentioned above, our homes are becoming increasingly larger, we are consuming more meat, we are transporting ourselves further, we are travelling further on holiday, and we are purchasing more clothes and a greater number of appliances. Consumption of goods and services by Danish households accounts for just over half of the total domestic demand. In 1999, private consumption thus amounted to DKK 600 billion. Over the past 10 years, per capita expenditure on private consumption has increased by 19% (*Figure 1.5.38*).

In 1997, the average disposable household income was about DKK 229,000 (after deduction of income taxes and interest on mortgages and other loans). Of this, DKK 209,000 was spent on consumption, DKK 14,000 on savings (including pension and mortgage capital repayments), and the final DKK 6,000 on such things as trade union fees and gifts to charities. The largest consumer item was housing.

Increasing number of appliances

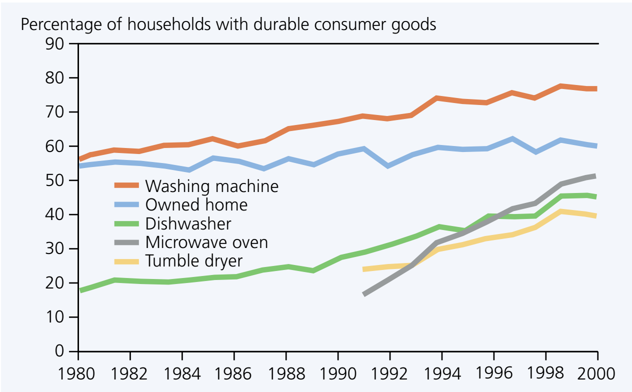
Today, the majority of Danish households own a refrigerator, deep freezer, washing machine, TV, video recorder and CD player (*Figure 1.5.39*). Many households also have a microwave oven and a dishwasher, and there are now around 350 cars per 1,000 inhabitants. Computers and mobile telephones made their entry into Danish homes in the 1990s, and more than 2/3 of Danish households now have home computers and mobile telephones.

Energy consumption

In 2000, household energy consumption (excluding transport) accounted for almost 30% of total Danish final energy consumption. Of this, 85% was for space heating, and 15% for electrical appliances, etc. Energy consumption was relatively low in very warm years such as 1989–90 and 2000, and high in the unusually cold year 1996 (*Figure 1.5.40*). Compared with 1990, the climate-corrected energy consumption has grown by 1%. This increase should be seen in the light of a 7.5% increase in the number of households.

The virtually constant total energy consumption hides considerable changes in its composition. Thus, consumption of heating oil has fallen to a third over the past 20 years due to conversion to district heating and natural gas. District heating now accounts for 35% of total household energy consumption, while oil and natural gas each account for 15–20%.

Expressed per square metre, energy consumption for heating has fallen by 26% between 1980 and 2000. The decrease is attributable partly to improve-



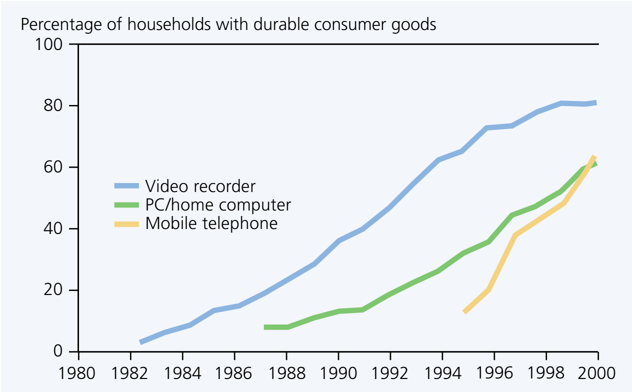


Figure 1.5.39

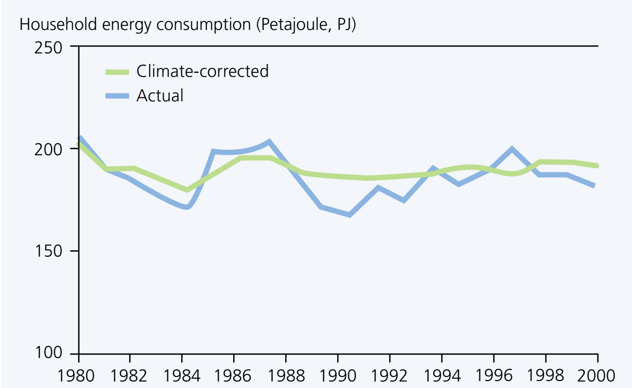
Trends in household possession of durable consumer goods.

(Source: Statistics Denmark, 2001).

Figure 1.5.40

Trend in household energy consumption for the period 1980–2000.

(Source: Danish Energy Agency, 2001).



ments in home insulation and partly to the replacement of old oil-fired furnaces by more effective natural gas furnaces and district heating installations. In addition, energy consumption for heating is generally less for new dwellings than for existing dwellings.

Electricity consumption comprises 20% of total household energy consumption. Up to 1992, electricity consumption increased each year. Thereafter the increase became more moderate, and has now been replaced by stagnation.

Even though the number of electrical appliances in homes has increased markedly during the 1990s, electricity consumption has stagnated, mainly due to a significant improvement in appliance average specific electricity consumption (kWh per year) during the same period (*Figure 1.5.41*). For example, a new deep freezer uses 22% less electricity than a 1990 model.

Greenhouse gas emissions

More than 95% of household greenhouse gas emissions consist of CO_2 derived from household energy consumption. Household final energy consumption (heating and electricity) leads to the emission of 5.1 million tonnes CO_2 each year. To this should be added household transport, other consumer goods and the disposal of waste, which result in considerable emissions in other sectors.

CO_2 emissions from households, including CO_2 emissions from electricity generation and district heating, account for about 25% of Denmark's total CO_2 emissions. Since 1980, however, CO_2 emissions have fallen by a third (*Figure 1.5.42*) due to changes in fuel composition and more effective energy production.

Transport

During the period from the mid 1980s to 1994, the number of cars per 1,000 inhabitants remained roughly constant at 310 cars. During the last half of the 1990s, the number of cars has increased markedly and is now around 350 cars per 1,000 inhabitants. The proportion of households owning a car has increased from 54% in 1991 to 59% in 1999. An average Dane from a household without a car transports himself 22 km daily, while people from households with a car transport themselves 42 km daily.

Water

Since 1989, household water consumption has fallen by a quarter (*Figure 1.5.43; see also Section 3.3*), in part due to the fact that the price of water (including wastewater disposal) has more than doubled since 1988. In 1999, the total price of one cubic metre of water was DKK 30. Of this, around half is the wastewater disposal charge while the remainder covers levies, VAT and the actual cost of supplying the water.

Since adoption of the 1987 Action Plan on the Aquatic Environment, the municipal wastewater treatment plants have been considerably upgraded, and discharges from households have fallen markedly (*see Section 3.2*). For example, the amount of phosphorus discharged is now only 20% of that discharged at the end of the 1980s. Other hazardous substances are also retained to some extent in the wastewater treatment plants.

Consumption of chemicals

An average household uses more than 50 kg of household chemicals per year. This largely consists of cleaning agents and detergents, but also of other chemicals such as paints, varnishes and wood protection products, car care products and pesticides/fertilizer for the garden. As regards harmfulness to the aquatic environment, some of the worst household chemicals are textile detergents, shampoo and toilet cleaners.

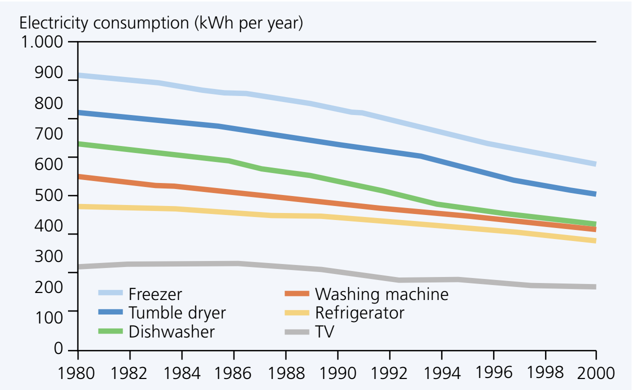


Figure 1.5.41

Trends in electricity consumption for the most common household electrical appliances.

(Source: Danish Energy Agency, 2001).

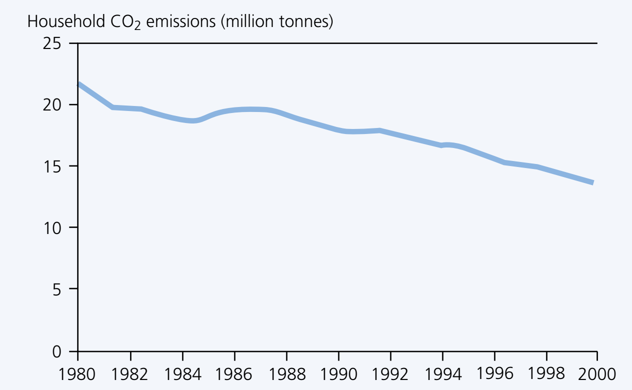


Figure 1.5.42

Trend in household CO_2 emissions, including the household share of CO_2 emissions from electricity production and district heating.

(Source: Danish Energy Agency, 2001).

Waste and recycling

In 2000, households generated 3.1 million tonnes of waste, corresponding to 24% of the total amount of waste generated in Denmark (*Table 1.5.8*). Of this, 1.7 million tonnes (54%) was domestic waste. The remainder consisted of 0.73 million tonnes of bulky waste, 0.52 million tonnes of garden waste and 0.16 million tonnes of other waste.

Between 1994 and 2000, the total amount of household waste increased by 20% from 2.58 million tonnes to 3.1 million tonnes. The amount of domestic waste remained relatively constant during that period, with the increase in the total waste volume being mainly due to a marked increase in the amount of garden waste and an increase in the amount of bulky waste. The largest household waste fraction is combustible waste (65%), while 15% is garden waste and less than 1% is hazardous waste.

Domestic waste consists of paper, glass and organic food waste, etc. In 2000, 81% of domestic waste was incinerated, 14% was recycled and 5% was disposed of by landfill. Between 1994 and 2000, the proportion of domestic waste disposed of by landfill decreased by 9 percentage points, while the proportion incinerated increased by 7 percentage points (*Figure 1.5.44*).

Household waste production							
	1994	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Household waste, total	2.58	2.61	2.77	2.78	2.80	2.96	3.08
• Domestic waste	1.66	1.63	1.66	1.62	1.70	1.67	1.68
• Bulky waste	0.61	0.62	0.64	0.59	0.58	0.67	0.73
• Garden waste	0.29	0.33	0.40	0.44	0.44	0.46	0.52
• Other	0.02	0.04	0.07	0.13	0.08	0.16	0.16

Table 1.5.8
Trend in household waste generation for the period 1994–2000 (million tonnes).
(Source: Danish Environmental Protection Agency, 2001).

In order to attain the "Waste 21" target of an average recycling percentage of 30% by 2004, the following initiatives will be implemented:

- Enhanced separation and collection of glass, paper, cardboard and plastic packaging for recycling
- Enhanced recycling of organic matter. Whereas only 4% of organic waste is presently used in biogass plants, the target is for 7% of organic domestic waste to be recycled by the year 2004.

Of the 0.73 million tonnes of bulky waste generated in 2000, 48% was incinerated, 36% was disposed of by landfill, and 16% was recycled. Between 1994 and 2000, the proportion of bulky waste disposed of by landfill decreased by 11 percentage points. The proportion incinerated increased by 8 percentage points, while the proportion recycled increased by 3 percentage points. In order to attain the target of 25% recycling in 2004, a number of initiatives have been implemented concerning cardboard, electronic products, impregnated wood, PVC-containing waste, etc.

The amount of garden waste collected has increased by 81% since 1994. The majority of garden waste is composted and recycled.

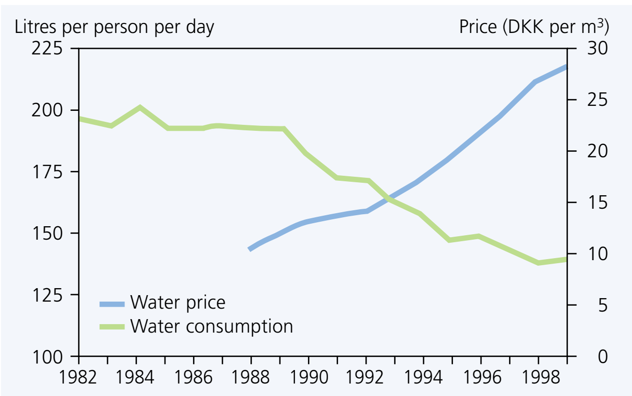


Figure 1.5.43
Trend in household water consumption and the price of drinking water (including wastewater treatment).
(Source: Statistics Denmark and Danish Environmental Protection Agency, 2000).

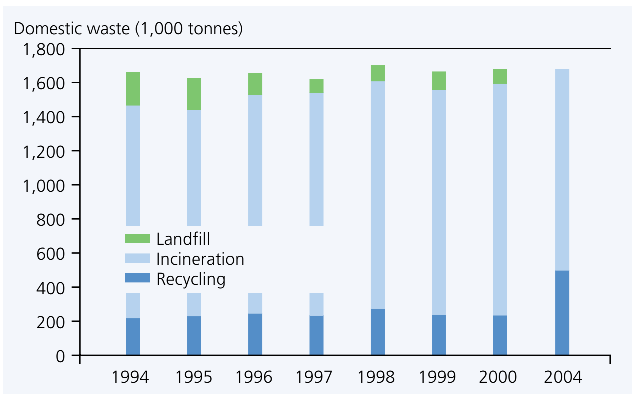
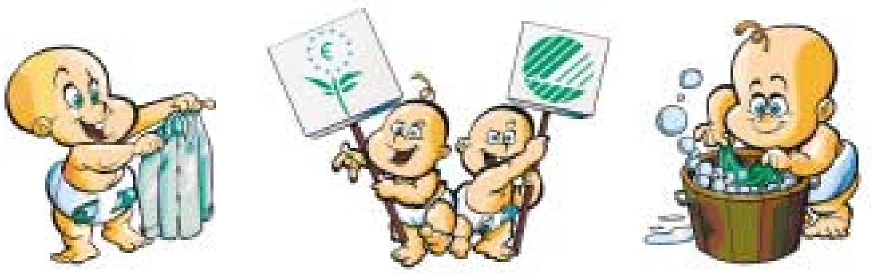


Figure 1.5.44
Domestic waste apportioned by treatment for the period 1994–2000 together with the target for 2004. The figure is constructed such that the total waste volume in 2004 corresponds to that in 2000. This should not be taken to represent a forecast of the future trend in waste volumes.
(Source: Danish Environmental Protection Agency, 2001).

Selected initiatives to reduce the environmental impact

Efforts are being made to ensure an increased supply of greener products and services as well as to ensure that consumers are able to base their purchasing decisions on sufficient and relevant information. Households are to have access to sufficient and relevant information to enable them to assess and choose the goods that have least impact on the environment. Ecolabels such as the Nordic Swan and the EU Flower provide consumers with quick and simple guidance (*Box 1.5.3*). A major information campaign was carried out in 2001 concerning ecolabels, especially in connection with textiles and textile detergents. The Danish EPA is also carrying out other information campaigns concerning hypochlorite and pressure-impregnated wood.

As a considerable proportion of household waste consists of various types of packaging, a new packaging levy was introduced in 1999 to encourage producers and consumers to reduce the consumption of packaging and hence the amount of waste, as



Ecolabelling

Two official ecolabels are in use in Denmark: The Nordic Swan and the EU Flower. Before a product can be given an ecolabel, it has to live up to a number of criteria collated in a criteria set for each product group. The criteria sets are based on the impacts during the products' life cycle, i.e. raw materials, production processes, product use and disposal. The criteria sets also include requirements as to product quality. The criteria are updated every third year, so ecolabelling is a process that regularly imposes stricter requirements on products and production processes. At the end of 2000, more than 2,500 Swan or Flower ecolabelled trademarks within 33 product groups were on the market. It is estimated that turnover of ecolabelled products amounted to just over DKK 2 billion in 2000.

Consumer awareness of ecolabels has been measured before and after a major ecolabel campaign. Before the campaign, only 4% of consumers knew that the EU Flower is an ecolabel. After the ecolabel campaign in spring 2001, knowledge of the ecolabel among the campaign's target group – women – has increased to 26%. Knowledge of the Swan ecolabel among the target group has increased from 26% to 46%.

Confidence in the ecolabels is high. Two out of three consumers believe that it is environmentally beneficial to choose an ecolabelled product rather than one that is not ecolabelled. Finally, the campaign evaluation shows that the campaign has also increased the number of consumers who purchase ecolabelled products. The number of consumers who state that they have purchased ecolabelled products within the preceding six months has thus increased from 32% to 38%.

The fact that demand for ecolabelled products is on the increase provides enterprises with an added incentive to use ecolabels. In recent years the number of ecolabelled products on the Danish market has increased markedly, and Denmark is well positioned among both the Nordic countries and the EU as regards the number of ecolabelled products and manufacturers who meet the ecolabel requirements (*Figure 1.5.45*).

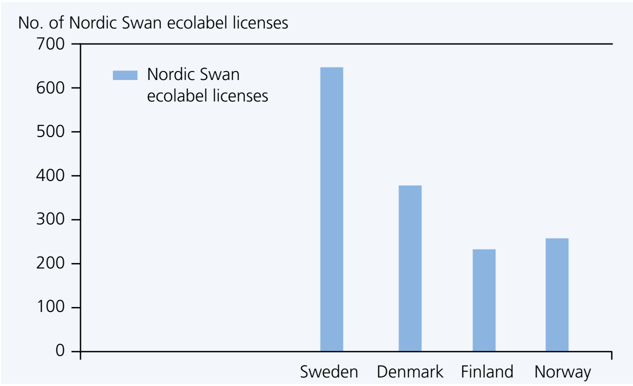
NORDISK MILJØMÆRKNING

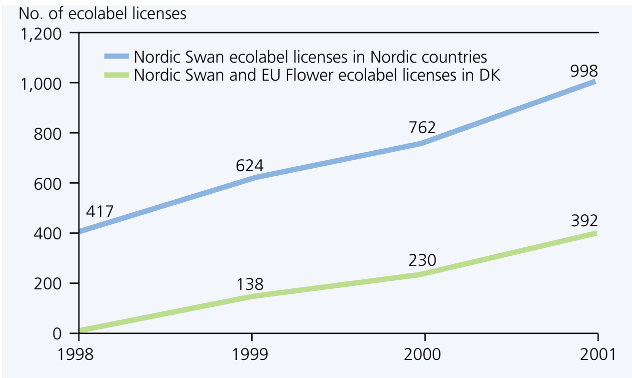
Box 1.5.3
The Nordic "Swan" and the EU "Flower".

well as to promote more environment-friendly packaging. In addition, recycling of paper and cardboard from households is to be doubled by 2004 through more effective collection schemes. The existing schemes for glass are to be made more efficient, and a system for recycling of bottles is to be continued. A greater proportion of organic waste is to be recycled too. Full-scale experiments will be initiated concerning the collection and biogassification of the organic fraction of domestic waste.

The recycling of bulky waste is also to be enhanced through improved separation, and separate schemes are to be established for collection of hazardous fractions such as electrical and electronic products, impregnated wood and PVC. The collection of hazardous waste is to be enhanced through the dissemination of information to households.

Figure 1.5.45
(Left) Number of Swan ecolabel licenses issued in Denmark and the other participants in the Nordic Swan ecolabel scheme.
(Right) Trend in the number of ecolabelled products in the Nordic countries.
(Source: Ecolabelling Denmark, 2001).





Energy labelling

Energy labelling is a tool increasingly being used to arouse consumer awareness concerning energy consumption. Energy labelling provides information about products in order to promote demand for and sales of energy-efficient products.

The EU energy label is an obligatory scheme for labelling household electrical appliances. In 1995, an energy labelling scheme was introduced for refrigerators and freezers. Since then, labelling has also been implemented for washing machines, tumble dryers, dishwashers and light sources. The appliances are divided into categories according to their energy efficiency (from A to G, where A is the most efficient). In addition, the energy label provides relevant technical information, e.g. washing and spinning capacity, water consumption, etc. The energy labels have affected consumption. For example, sales of the most energy-efficient refrigerators and freezers have increased markedly.

Consumer electronics can be labelled with the "Energy Arrow", which is a label given to appliances that meet certain specific energy efficiency requirements. Approximately 25% of the appliances on the market can obtain the label. At present, the Energy Arrow can be given to TVs and video recorders, but products such as hi-fi systems and components, DVD players and office equipment (PCs, monitors, printers, etc.) are expected to be encompassed by the scheme during 2001.

The House Labelling Scheme is a compulsory national labelling scheme. The label provides information about energy and water consumption and must be available as part of the basis for house purchase decisions. An authorized energy consultant must calculate the annual expenses for electricity, heat and water and draw up an energy label, energy plan and documentation for the house. The energy plan specifies what energy saving measures are worthwhile implementing. In addition, there is a voluntary energy label for windows and window panes.

Box 1.5.4
Energy labels

1.5.8 Tourism and outdoor recreation

Tourism and outdoor recreation have a number of impacts on nature and the environment, including effects on landscapes and nature caused by structures such as holiday centres, summer cottage districts and roads. Tourism also contributes to society's general consumption of resources, e.g. energy and water, and generation of wastewater and waste. In return, both outdoor recreation and tourism contribute to the welfare of the population and are of increasing importance for the economy as a whole.

Many different activities together comprise outdoor recreation. In Denmark, outdoor recreation is usually unorganized. Nearly the whole population regularly visits parks, forests and beaches, etc. Outdoor recreation enhances quality of life and health, and the opportunity for outdoor experiences is normally considered to be an expression of welfare.

Trends within tourism and outdoor recreation

Danish tourism contributes significantly to turnover and value added in Danish society. Turnover in tourism thus amounted to DKK 44.6 billion in 1999, while value added amounted to DKK 27.2 billion. Tourism thereby accounted for approx. 3% of the national value added.

In 2000, there were 42.2 million registered tourist bed-nights in Denmark. To this should be added the many unregistered bed-nights, among others in borrowed or owned summer cottages. The largest proportion of the registered bed-nights – just over 15 million – was accounted for by summer cottages, while hotels and holiday centres accounted for 13 million bed-nights, and camping grounds for 11 million bed-nights (*Figure 1.5.46*). In addition, there are around 1 million registered bed-nights per year at youth hostels and 1.5 million at marinas. Danish tourists accounted for 42% of the registered tourist bed-nights in 2000, while the foreign tourists are primarily German (38%) and to a lesser extent Swedish (6%), Norwegian (5%) and Dutch (3%).

Following marked growth during the period 1989 to 1992, the number of bed-nights stabilized at around 43–44 million until 1998, thereafter falling to just over 42 million in 2000 (*Figure 1.5.46*). At the same time, employment in the sector has fallen over the past five years from 72,000 to 70,000 full-time employees, while turnover has increased.

Tourism is often concentrated in sparsely populated areas of great natural value. Coastal tourism accounts for 69% of the registered tourist bed-nights, especially along the west coast of Jutland, but also to a lesser extent along the east coast of Jutland. Southern Funen, the islands south of Funen, Lolland and Falster, and Bornholm are also well visited. On Zealand, bed-night density is highest in Odsherred and the coast of northern Zealand, as well

Figure 1.5.47

Density of tourist overnight capacity (summer cottages, camping grounds, hotels, holiday centres and youth hostels) at municipal level in 1999. (Source: Danish Forest and Landscape Research Institute, Topic Centre for Outdoor Recreation and Tourism, 2001).

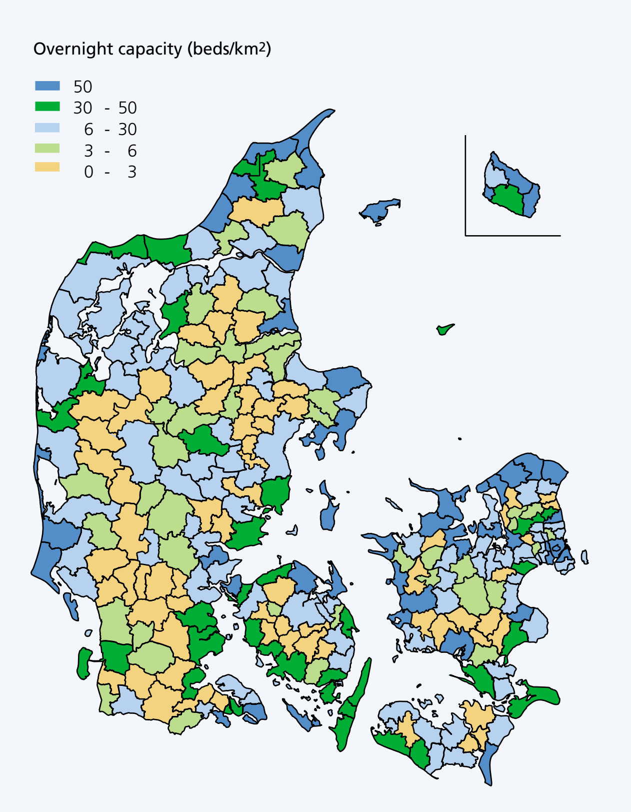
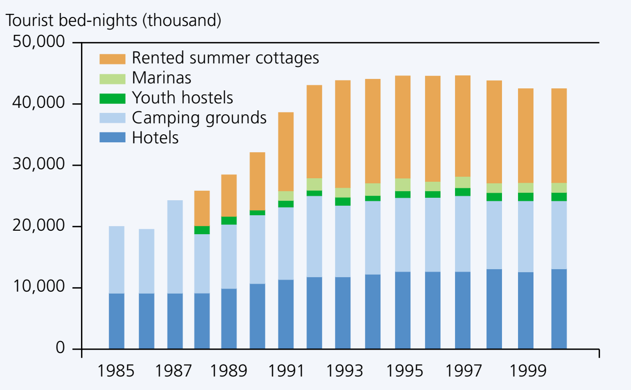


Figure 1.5.46

Trend in the number of registered tourist bed-nights for the period 1985–2000. Note that a new category for pleasure boats (marinas) was added in 1991, and that from 1990 onwards the category "Rented summer cottages" encompasses the whole year. (Source: Statistics Denmark, 2001).



as in Copenhagen. Unregistered tourist bed-nights – for example in owned summer cottages – tend to be near the coast.

The density of tourist bed-night capacity (both registered and owner-user) is greatest in the municipalities of Greater Copenhagen, northwest Zealand, the Mols Bjerge area, Bornholm, northern Jutland, parts of western Jutland and on a few of the islands (*Figure 1.5.47*).

Over the period 1987 to 1999, the number of long (at least 5 days) holiday journeys by Danes increased from 3.8 million in 1987 to just under 5 million in 1996, thereafter falling to 4.4 million in 1999 (*Figure 1.5.48*). Three million of these holidays were held abroad and 1.4 million in Denmark.

There are presently just under 200,000 summer cottages in Denmark, of which approx. 97% are located in the 180 coastal municipalities. Around 15% of the coastal protection zone is presently built-up or reserved for new summer cottages and other holiday and recreational facilities (*see Section 4.2*). The increase in the number of summer cottages was greatest in the 1960s and 1970s. Over the past 15 years, the number of summer cottages has increased by 7% from 186,000 to 199,000 (*Figure 1.5.49*).

The increase is due both to the conversion of existing buildings to summer cottage status and to the construction of new summer cottages. In 1999 and 2000, for example, the number of summer cottages increased by 1,723, of which 739 were newly-built summer cottages. In addition, the summer cottages have become larger. Thus, the number of summer cottages exceeding 100 m^2 has increased by just over 60% from 13,600 in 1986 to 22,000 in 2001. Over the past 10–20 years, a large number of luxury summer cottages have been built with swimming pools, saunas, Jacuzzis, etc.

Surveys show that 96% of all adults visit the countryside at least once a year, while 75% have done so within the preceding 14 days. The forests and beaches are the most popular excursion destinations. Just over 90% of adults visit both types of countryside for a short or longer visit at least once a year. The number of visits to forests increased by 25% between 1977 and 1994. Danes typically visit a forest 10 times a year, thus resulting in around 50 million forest visits annually. Two thirds of the trips are made to the forest nearest home, which is interesting in view of the fact that many new forests are to be planted in the coming years, and that some of these forests are to be located near the towns.

The beaches receive approx. 36 million visits per year, while bogs receive approx. 8 million, ancient monuments approx. 6 million and heaths approx. 5 million. As visitors often visit several types of nature during the same trip, these add up to 75 million visits to the countryside in all – excluding visits by foreign tourists.

The Nature Guide Scheme, which started in 1986 with 14 nature guides, has grown considerably and encompassed 250 trained nature guides in 2000. The nature guidance is increasingly directed at children and young people. Around 700,000 people participate each year in around 200,000 activities (*Figure 1.5.50*).

Figure 1.5.48

Trend in number of holiday journeys by persons aged 16 and older. The figures are based on random sample surveys. Holiday journeys are here defined as journeys lasting at least 5 days, i.e. at least 4 nights away from home.

(Source: Statistics Denmark, 2001).

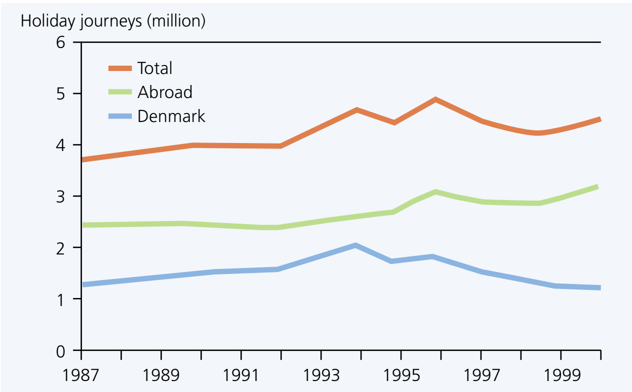
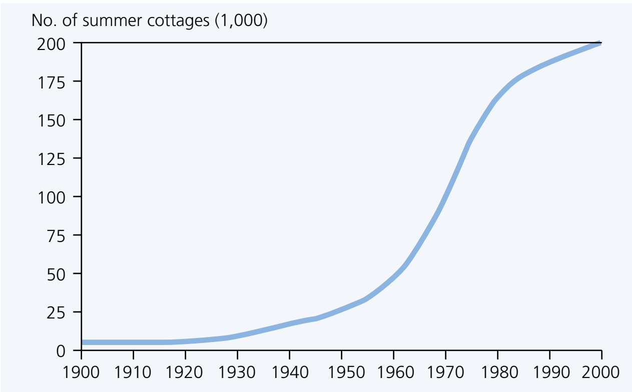


Figure 1.5.49

Trend in the number of summer cottages for the period 1900–2000.

(Source: Danish Forest and Landscape Research Institute, Topic Centre for Outdoor Recreation and Tourism, 2001).



Environmental impact of tourism

Tourist facilities such as holiday centres, summer cottage districts and amusement parks particularly affect the landscape, although the many tourists also affect the nature. The increase in tourism has led to increased use of natural areas, particularly along the coasts. Through environmental and spatial planning legislation, Denmark has generally avoided a number of unfortunate consequences of tourism development and has preserved the naturalness of the countryside and hence its attraction value for tourism. A number of small urban communities and local areas of natural countryside are affected by extensive tourism development, however.

The countryside in Denmark is generally very resilient towards ordinary forms of outdoor recreation and tourism. Nevertheless, outdoor recreation and tourism can cause local problems of wear and tear and disturb the fauna. For example, there are still problems with wear in the vulnerable dune areas along the west coast of Jutland. It can therefore be necessary to enhance efforts locally, for example in the form of new footpaths to avoid wear on nature and to create opportunities for a greater number of qualitative experiences. A controversial problem is motoring and parking on some of the beaches in western Jutland.

Energy consumption for space heating in connection with tourism is generally low as a large part of the tourism takes place during the summer. However, the summer cottages are increasingly being used in the spring and autumn months, which means that energy consumption increases.

Electricity consumption by summer cottages has increased by 35% between 1986 and 1995 compared with an overall increase of 18%. The majority of summer cottages are heated by wood-burning stoves or electric radiators, and many summer cottages are less well insulated than permanent residences and therefore relatively more energy-demanding. The luxury summer cottages with swimming pools and Jacuzzis can be even more energy-demanding, especially those that are rented out all year round.

The greatest environmental impacts of hotels and restaurants result from the consumption of energy. Most of the energy is used in the kitchens and hotel rooms, including the mini-bars. Ventilation alone accounts for 15–20% of energy consumption by hotels and restaurants.

Around 37% of passenger transport in Denmark is related to trips between home and leisure activities, of which a large part is associated with tourism and outdoor recreation. Nearly all tourists in Denmark use cars as the primary mode of transport. On some road stretches, especially in the coastal areas, daytime traffic in July is double the annual average. The traffic concentrates in the peak season and around summer cottage check-in days.

Nearly 2.6 million adult Danes travelled abroad one or more times in 1999. Around 3/4 of all holiday and business journeys in Denmark are carried out by car, 15–20% by train or bus and 5–10% by domestic flight (*Figure 1.5.51*). For journeys abroad, aircraft is the most important mode of transport. Half of all holiday journeys abroad are made by aircraft, while 13–31% are made by car and only 3% by train.

Water consumption by tourists is seasonal and geographically concentrated in the coastal zone, where the groundwater resources can be locally limited, especially on the smaller islands. The consumption of water per

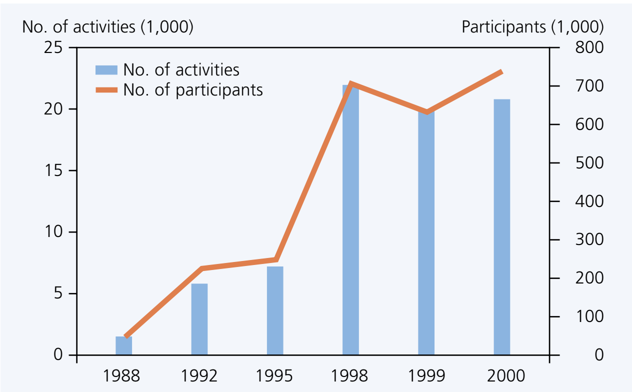


Figure 1.5.50

Nature guidance: Number of activities and number of participants for the period 1988–2000.

(Source: Danish Forest and Nature Agency, 2001).

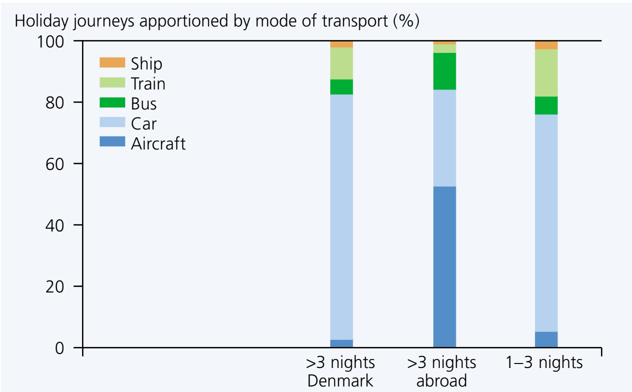


Figure 1.5.51

Holiday journeys in 1999 apportioned by mode of transport.

(Source: Statistics Denmark, 2000).

Environmental impact of holidays abroad

Tourism is one of the largest and most rapidly growing commercial sectors world-wide. Since the 1960s, there has been a marked increase in holiday and business journeys abroad by Danes. We travel abroad more frequently and increasingly far.

Many Danish holiday journeys are to the Mediterranean coast, especially Greece, France and Spain. In 1999, 220 million international tourists visited the Mediterranean area, 84% of whom came from other European countries, especially from northwestern Europe. Projections indicate that the number of tourists in the Mediterranean area may increase to 350 million by 2020.

Buildings and infrastructure related to tourism (hotels, holiday flats, airports, roads, golf courses and amusement parks) have severely affected the vulnerable coastal and marine ecosystems in the Mediterranean area. For example, 3/4 of the dunes have disappeared along the coast from Spain to Sicily due to urban development, especially that related to tourism.

In many of the tourist districts, the water resources are sparse. During the summer months the tourist invasion causes water consumption to increase considerably. For example, whereas a town dweller in Spain uses about 250 litres of water per day, the average tourist uses 440 litres, increasing to the double if swimming pools and golf courses are present. Periodic water shortages already occur in many areas and will increase with increasing tourism.

Large amounts of wastewater are discharged into the Mediterranean annually, often after little or no treatment. Part of the wastewater derives from tourism. In some areas, water quality and the ecosystems are markedly affected by the discharges. Tourists also produce considerable waste that is disposed of by landfill.

Photo: CDanmark

Box 1.5.5
Environmental impact
of holidays abroad

summer cottage is somewhat greater than by permanent residences, especially by the luxury summer cottages with swimming pools. While the majority of permanent residences are connected to the sewerage system and treatment plants, many summer cottages are not and thus contribute to nutrient loading of our water bodies. Bathing centres and golf courses consume considerable amounts of water, and use chemicals to safeguard the quality of the water in the swimming pools.

As summer cottages are only used for part of the year, waste generation is estimated to be approx. 30% of that in corresponding permanent residences. Restaurants generate large amounts of organic waste. In fast-food outlets, the widespread use of disposable packaging causes associated waste problems.

Selected initiatives to reduce the environmental impact

During the 1990s, Danish tourism experienced many initiatives in the environmental area. The "Blue Flag" for beaches and marinas was introduced in Denmark and the remainder of Europe. Since 1994, hotels, conference centres and youth hostels have been able to obtain the "Green Key" eco-label, which more than 100 enterprises now use. In 1999, the scheme was extended to include camping grounds and holiday homes, etc. In recent years, the major chains and hotel groups have launched their own environmental programmes.

Nowadays it is even possible for whole destinations to achieve an eco-label under the concept Destination 21, which implements the Agenda 21 principles on a large scale. So far, two of seven pilot destinations have attained Destination 21 labelling. Studies in the Haderslev-Vojens area indicate considerable interest in sustainability and environmental initiatives within tourism among both tourists and local inhabitants.

Environmental measures for domestic tourism

Blue Flag
Beaches and marinas flying the familiar Blue Flag are to be found throughout Europe. The Blue Flag guarantees that the beaches are tidy and the water is clean, and that there are toilet facilities and information about the environmental efforts, etc. Marinas also have to provide reception facilities for waste oil from the boats as well as for the general waste. Moreover, both the beaches and the marinas have to be operated in accordance with environmental management principles.

The Green Key
This is an ecolabel that can be granted to hotels, youth hostels, camping grounds, holiday homes, etc. More than 100 Danish enterprises have the Green Key, thereby indicating that they live up to a number of requirements concerning energy consumption, water consumption, waste management, use of chemicals and implementation of environmental management, etc.

Destination 21
Well-defined tourist localities wishing to focus on sustainability can receive the status of Destination 21. A Destination 21 could for example involve cooperation between some municipalities who market themselves to tourists jointly. In such localities, consideration must be shown for environmental sustainability and for the social and economic integration of tourism in the local community. At a destination 21, at least 20% of tourism-related enterprises must meet specific requirements in the three elements of sustainability.

Environment 2100
The Association of the Hotel, Restaurant and Tourism Industry in Denmark (HORESTA) has developed a toolbox that provides inspiration and assistance for environmental work in hotel, restaurant and tourism enterprises. The toolbox consists of theme booklets covering such aspects as environmental management, environmental indicators, electricity and heat, waste, water consumption, foods, cleaning, hazardous substances, etc. The material was developed and published in 2000 with the financial support of the Danish EPA, the Danish Energy Agency and the Danish Agency for Development of Trade and Industry. As a consequence, the enterprises in the industry are now better able to work with environmental aspects in a systematic and goal-oriented manner.

Box 1.5.6
Environmental measures
for domestic tourism

1.5.9 Waste

Society's many activities – both private consumption and production of goods and services – generate waste. Economic activity in society and the volume of waste generated are linked. For example, while it is environmentally beneficial to replace our old refrigerators with newer, more energy-efficient models, the old models then become waste, which has harmful effects on the environment.

Waste is an expression of wastage of resources in society. It is therefore important that we create as little waste as possible, while at the same time ensuring that the waste that is unavoidably generated contains as few hazardous substances as possible and is treated in the most environmentally benign manner possible. The overall objective of "Waste 21", the Government's waste action plan for the period 1998–2004, is to stabilize the total waste volume in 2004, whereafter it is to be reduced as a step towards sustainable development.

Waste generation and management in the individual sectors is described in the preceding sections concerning the building and construction sector, industry, private and public service and households.

Trends in waste generation

Overall, 13.0 million tonnes of waste were generated in 2000 (*Table 1.5.9 and Figure 1.5.52*). The societal activities generating the most waste were households, building and construction, and manufacturing, each of which generated around 3 million tonnes of waste. Institutions, trade and offices and coal-fired power plants each generated around 1 million tonnes of waste. Wastewater treatment plants generated around 1.5 million tonnes of sewage sludge.

The amount of waste increased by 16% between 1994 and 1996, whereafter it fell by about 5% to 1999. In 1996, the amount of residual products from coal-fired power plants was especially large due to large exports of electricity to Sweden and Norway. Between 1999 and 2000, the amount of waste increased again by 7%.

Considering the whole period 1994 to 2000, the amount of waste has increased by 17%. This is due both to a real increase in the amount of waste as well as to improved reporting to the ISAG Information System for Waste and Recycling.

Apart from the coal-fired power stations, the amount of waste from all commercial and public sources has increased over the period 1994–2000. The amount of waste generated by the households has also increased due to enhanced collection of garden waste and bulky waste. The amount of domestic waste has remained virtually unchanged.

Waste management in 2000

In 2000, 8.5 million tonnes of waste corresponding to 65% of the total was recycled (*Figure 1.5.52*), while 24% was incinerated and 11% was disposed of by landfill. Between 1994 and 2000, the proportion of waste recycled increased from 56% to 65%, while the proportion incinerated increased from 20% to 24% and the proportion disposed of by landfill decreased from 23% to 11%. The percentage of waste recycled is greatest for residual products from the coal-fired power plants and for building and construction waste (approx. 90% in each case).

The overall target for waste disposal in 2004 stipulated in "Waste 21" – that 64% should be recycled, 24% incinerated and 12% disposed of by landfill – was already attained in 2000 (*Figure 1.5.52*). This is partly attributable to the ban on the disposal of combustible waste by landfill that entered into force on 1 January 1997.

Selected initiatives to reduce the environmental impact

In May 1999, the Government published its waste action plan "Waste 21". This sets the overall framework for Danish waste policy until the year 2004. Waste 21 contains a broad range of initiatives together intended to ensure that the waste management targets are attained by 2004. Implementation of Waste 21 is in full swing. Among other things, this entails revision of the Statutory Order on Waste. Initiatives to enhance recycling and source separation of hazardous waste fractions in the individual sectors are described in the preceding sections.

Based on the results of a series of workshops with representatives from consumers, the service sector, industry and the building and construction sector, a discussion paper on future waste prevention initiatives was published in autumn 2000. In addition, a conference on waste prevention was held in November 2000.

New regulations on waste

The Statutory Order on Waste contains new provisions concerning municipal waste management planning, data submission to the ISAG Information System for Waste and Recycling, recycling of paper, and the collection of PVC and impregnated wood. In addition, the Statutory Order is accompanied by two guidelines, one of which concerns waste management planning, while the other concerns collection of paper from private households.

The Statutory Order on the import and export of waste has been amended and now specifies that it is no longer permitted to export waste for disposal unless suitable treatment plants are not available in Denmark.

Figure 1.5.52

All Danish waste apportioned by treatment for the period 1994–2000 together with the target for 2004. The figure is constructed such that the total waste volume in 2004 corresponds to that in 2000. This should not be taken to represent a forecast of the future trend in waste volumes. (Source: Danish Environmental Protection Agency, 2001).

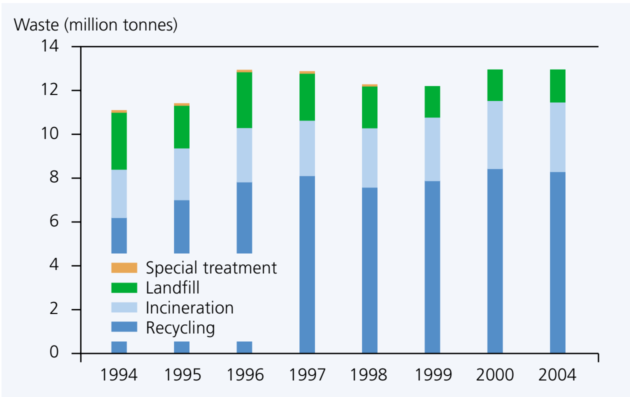


Table 1.5.9

Total waste generation in Denmark for the period 1994–2000 apportioned by source. Values are thousand tonnes. Note that household waste is also shown subdivided by type, and that the yearly totals therefore exclude these 4 figures. (Danish Environmental Protection Agency, 2001).

Source of waste	1994	1995	1996	1997	1998	1999	2000	% change 94–1999
Household waste, total	2,575	2,610	2,767	2,776	2,796	2,963	3,084	20
• Domestic waste	1,662	1,628	1,655	1,621	1,702	1,665	1,676	01
• Bulky waste	606	610	639	588	572	670	730	21
• Garden waste	286	326	401	443	438	464	519	81
• Other	21	38	72	125	83	160	158	656
Institutions/trade and offices	656	834	851	861	955	955	1,119	71
Manufacturing, etc.	2,309	2,563	2,632	2,736	2,783	2,653	2,948	28
Building and construction	2,433	2,559	3,088	3,427	2,962	2,968	3,223	32
Wastewater treatment plants	1,156	1,195	1,212	1,248	1,251	1,379	1,476	28
Slag, fly ash, etc. (coal)	1,962	1,699	2,332	1,775	1,469	1,299	1,176	-40
Other	14	6	30	34	18	15	5	-61
Total	11,105	11,466	12,912	12,857	12,233	12,233	13,031	17

Enhanced recycling of waste

The Statutory Order on Waste requires the Municipalities to enhance the collection of paper and cardboard for recycling. The municipal collection schemes for households have to be improved so as to increase the number of types of waste paper collected. Self-delivery schemes are to be supplemented by collection-at-source schemes if the municipalities' collection schemes in general do not meet the requirement of 40% recycling of the total potentially recyclable paper and cardboard in 2001 and 55% in 2002. In addition, self-delivery collection schemes have to be established for other types of paper and cardboard.

Enhanced quality of waste management

Regulations have been adopted for the management of electronic waste aimed at ensuring enhanced recycling of resources from electrical and electronic products. Electronic waste is to be prevented from entering the incineration waste stream, and the waste fraction that cannot be recycled is to be disposed of in an environmentally sound manner. Greater attention has been focused on the scrapping of cars, and a scrapping premium payable to car owners has been introduced. In addition, a certification scheme has been introduced for enterprises that work with vehicle waste so as to ensure that it is disposed of in an environmentally sound manner.

In June 1999, a PVC strategy was published. Among other things, this strategy describes the problems associated with the use of PVC and stipulates guidelines for dealing with the waste problem caused by the former use of PVC. In addition, it aims to prevent problems with future use of PVC. The new regulations in the Statutory Order on Waste also contain requirements on the separation of PVC-containing waste and impregnated wood. In future, non-recyclable PVC and impregnated wood have to be disposed of by landfill. The PVC that can be recycled has to be separated for recycling.

The regulations concerning batteries have been tightened. Among other things, the use of mercury in batteries has been banned.

Incineration of waste

Between 1996 and 2000, the amount of waste incinerated increased from 2.5 million tonnes to 3.1 million tonnes. Of this, 1.8 million tonnes derived from households. The capacity at the 31 waste incineration plants in Denmark was calculated to be 2.7 million tonnes in 1999, an increase of 0.25 million tonnes relative to 1996. In 1999, 64% of all waste disposed of by incineration was incinerated at combined heat and power plants, and 36% at heating plants. In 1997, the corresponding figures were 57% and 43%.

Pollution from the incineration plants has to be limited to the greatest extent possible. It is therefore important to ensure that problematic substances and products do not end up in the incineration waste stream. As mentioned, Waste 21 thus includes initiatives concerning batteries, electronic products, impregnated wood and PVC. Waste incineration remains the main source of dioxin pollution. Considerable efforts have already been made to reduce dioxin emissions from incineration plants. The newest plants are equipped with a dioxin filter. As a consequence, dioxin is removed at 1/5 of the total incineration capacity.

The new EU Directive on incineration of household and industrial waste strictly regulates emissions from the plants such that the emission of substances harmful to health is minimized. In June 2000, the Minister for Environment and Energy and the Association of County Councils in Denmark urged the County Councils – which are the supervisory authorities responsible for the incineration plants – to help hasten the establishment of dioxin removal so that the plants would already comply with the EU requirements on dioxin emissions by the end of 2004.

Waste disposal by landfill

In 2001, new regulations on the disposal of waste by landfill were adopted through an amendment of the Environmental Protection Act and the publication of a number of new Statutory Orders. The legislative changes entail that all existing landfills have to be reevaluated. In this connection, it is expected that a number of the existing landfills – predominantly those approved before 1997 – will be closed down or required to implement remedial measures. This will reduce the risk of groundwater contamination in particular. Requirements will also be imposed concerning the collection of landfill gasses, thereby reducing the emission of the greenhouse gas methane to the atmosphere.

Regulations requiring improved knowledge of the properties of waste will improve the extent to which landfilling can be planned so as to ensure that different types of waste with different properties are deposited separately.

1.6 Chemicals – consumption and occurrence

1.6.1 Introduction

Consumption of chemicals is attracting increasing attention in Denmark. Efforts to reduce consumption have been enhanced through the 1980s and 1990s, but new chemicals and new chemical products are continually being introduced on the market and the number of product types in which chemicals are being used is increasing. In 1999, Denmark therefore drew up a strategy for the chemicals area in order to strengthen efforts to reduce consumption of chemicals with harmful effects on health and the environment.

There are a large number of chemical substances on the market, and knowledge of their effects on the environment and health is very limited. We are often exposed to several substances at the same time, which makes it difficult to assess the effects of chemical substances since the different substances can interact, thereby changing the effect of the individual substance. The existing knowledge of such combination effects is very limited. Moreover, it is difficult to determine the overall environmental impact of chemicals since this is not only attributable to point-source loading, i.e. the direct discharges from enterprises to the air, aquatic environment or soil, but also to diffuse loading of the environment. The latter is due to the fact that chemical substances are constituents or impurities of a number of goods and products that circulate in society and are released during use or disposal of the products. The environmental impact is thus highly correlated with activities that occur before and after the manufacturing processes, during processing of the raw materials, during use of the products and upon disposal of them.

The development of chemical substances has had many beneficial effects – better and cheaper products, easier working processes, etc. Many of the goods that are used in a modern society can only be produced through the use of chemical substances. However, the large number of existing substances, the development of new substances and our inadequate knowledge of their effects on the environment and health are now considered to be one of the most serious environmental problems of our time.

Photo: NERI/Jørgen Aagaard Axelsen

1.6.2 Consumption of chemical substances

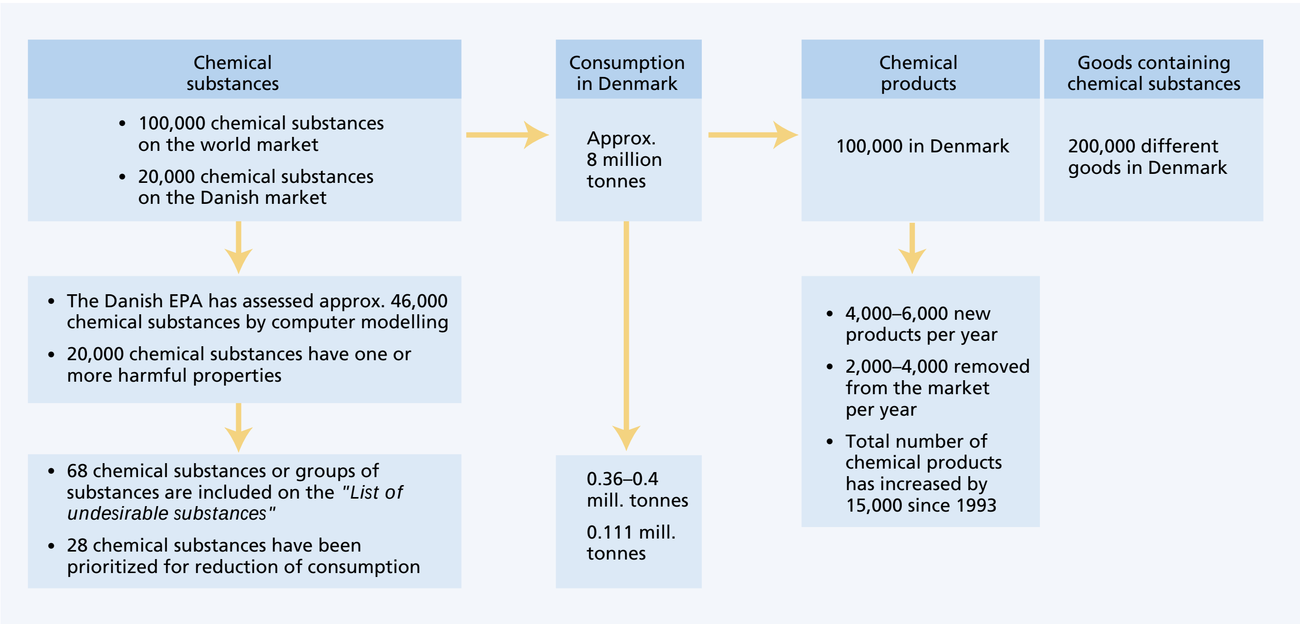
Consumption of chemical substances has increased markedly in recent times. Thus global production of organic chemical substances has grown from 7 million tonnes in 1950 to 250 million tonnes in 1997. This is comprised by approx. 100,000 different chemical substances, of which approx. 1,500 account for 95% of world production.

In Denmark, there are around 20,000 chemical substances on the market. These are found in approx. 100,000 different chemical products, which in turn are used in the manufacture of approx. 200,000 different industrial goods (*Figure 1.6.1*). The total consumption of chemical substances and products for industrial purposes, i.e. excluding production in Denmark and imports of finished goods, amounts to around 8 million tonnes per year. The value of the turnover by the Danish chemical industry is DKK 38 billion, corresponding to just under 10% of total industrial turnover in Denmark. Chemicals manufacturing in Denmark is very limited compared with the remainder of Europe and only accounts for 1.3% of total European chemicals production. The majority of the chemical substan-ces and products used in Denmark are imported from abroad.

The number of newly notified chemical substances has only increased slightly in Denmark in recent years, while the number of chemical products has increased much more markedly. Since 1982, the authorities in Denmark have required that all hazardous chemicals and products used commercially must be notified to the Danish Products Register administered jointly by the Danish Working Environment Service and the Danish EPA. Notifiable chemicals and chemicals approved by the Danish EPA (pesticides, cosmetics, etc.) are entered into the Register. Thus approx. 40 chemical substances have been notified per year over the past 5 years, and a total of 514 chemicals have been added to the Register since 1982. The number of newly notified chemical products has totalled between 4,000 and 6,000 a year in recent years. The actual growth is somewhat less as some of the previously notified products have been discontinued such that annual net growth has only averaged approx. 2,000 products over the past 5 years. In total, the number of chemical products has increased by approx. 15,000 since 1993.

A number of chemical substances and products cause undesirable effects on the environment and health, and the Danish EPA has therefore drawn up a list of the chemical substances considered to have problematic effects. The list encompasses approx. 1,400 substances and is designated the "Effects List". Chemical substances on this list that are used in quantities exceeding 100 tonnes per year. A number of substances that the Danish EPA considers to be especially problematic or whose use Denmark is committed to reduce pursuant to international agreements are collated on an official list entitled "List of Undesirable Substances". The list

Figure 1.6.1
Overview of the use of chemical substances and products.



currently encompasses 68 chemical substances or substance groups, including a number of metals, organic solvents, industrial greenhouse gasses – substances that are persistent and/or suspected of having oestrogen-like effects. Both lists are regularly revised in the light of new knowledge.

The List of Undesirable Substances is not to be considered an actual prohibition list, but rather as an advisory list to enterprises, product developers, purchasers, etc. indicating those substances whose use should be ceased or reduced in the short or long term. The substances have been prioritized, and initial efforts will focus on 28 of the 68 substances. The difference between the Effects List and the List of Undesirable Substances thus does not lie in how hazardous the substances are, but rather in the quantities used (*Figure 1.6.1*).

Cleaning agents, toiletries and paints/varnishes are the three most frequently occurring chemical product groups (*Figure 1.6.2*). The situation has changed since the last analysis in 1995, when the three most frequently occurring product groups were cleaning agents, paints/varnishes and binding agents, while toiletries only held seventh place.

The top scorers among the industrial branches that have registered chemical products are the chemical industry followed by the building and construction industry and the iron and metals industry (*Figure 1.6.3*). This too represents a shift compared with the previous analysis, at which time the top scorers were the iron and metals industry followed by the chemical industry. The shift is relative, though, in that the total number of products in both the chemical industry and the iron and metals industry has been decreasing. One area where the notification of chemical substances has been growing markedly is the food, drink and tobacco industry.

The figures for the distribution of chemical substances among the product types and branches provide an impression of where the chemicals are used. To what extent they also reflect the distribution of undesirable substances is unknown, however. From 2000 onwards, Statistics Denmark will draw up an annual inventory of the consumption of the chemical substances encompassed by the List of Undesirable Substances. Statistics Denmark's data on total purchases by Danish industry of substances on the Danish EPA's List of Undesirable Substances represent the first estimates of the total amounts used. The estimates solely encompass actual purchases of undesirable substances by industry and hence are not fully comprehensive since chemical substances imported in finished goods, etc. are not included.

Photo: Carsten Andersen

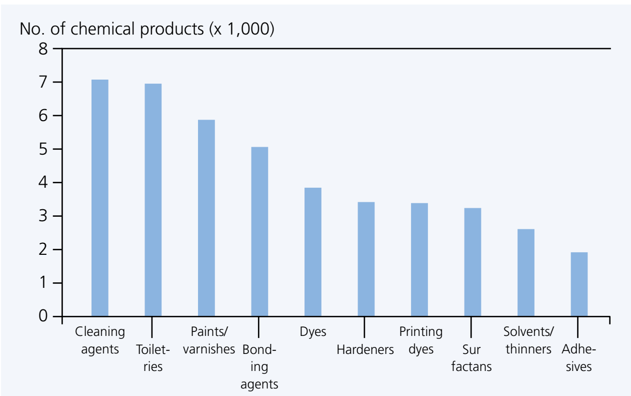


Figure 1.6.2

Chemical products in use apportioned by area of use.

(Source: Danish Products Register, 1999).

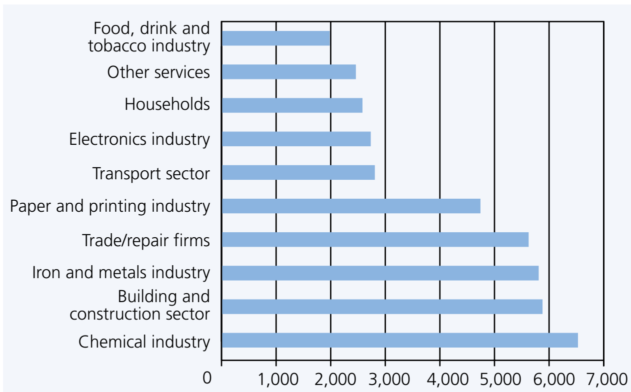


Figure 1.6.3

Registered chemical products apportioned by branch.

(Source: Danish Products Register, 1999).

On a weight basis, the majority of industry's purchases of undesirable substances consist of metals, with by far the largest part being accounted for by copper (*Figure 1.6.4*). Hypochlorites, chlorites and hypobromites are the group of non-metals purchased in the greatest amounts, followed by formaldehyde and phenol. Consumption of undesirable chemical substances is greatest in the iron and metals industry (*Figure 1.6.5*). Within the iron and metals industry, it is the machinery and electronics branches that account for the largest part of purchases of undesirable chemical substances, thus reflecting the fact that these two branches use large amounts of copper. The chemical industry accounts for 8% of total consumption of undesirable substances.

1.6.3 Dispersal and occurrence of chemical substances in the environment

The marked growth in the production and use of chemical substances since the 1950s has resulted in the dispersal of chemical substances in the environment. The chemicals produced by the chemical industry circulate either directly or via the product streams of other manufacturing sectors to the consumer, eventually ending up in the environment. Alternatively, the chemical substances are spread to the environment via direct industrial discharges to the air, water and soil. Once the chemical substances have dispersed into the environment, they continue to circulate. At the same time, they affect the biological cycle and in some cases end up in the drinking water and in certain foods, and can thereby affect our health (*Figure 1.6.6*).

Some substances degrade to harmless degradation products, whereas others are persistent and accumulate in the environment. Some substances and/or degradation products have acute toxic effects at a given concentration that cease when the substance disappears. With other substances, their effect is permanent, e.g. carcinogenic, mutagenic, etc. With yet other substances their effect is enhanced by the interaction of several substances such that it can be difficult to fully determine the cause-effect relationship between emission, concentration levels and effects.

Photo: NERI/Patrik Fauser

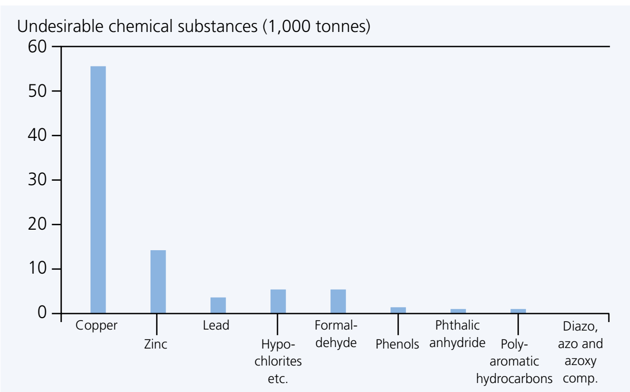


Figure 1.6.4

Industrial purchases of undesirable chemical substances in 1997. (Source: Statistics Denmark, 1999).

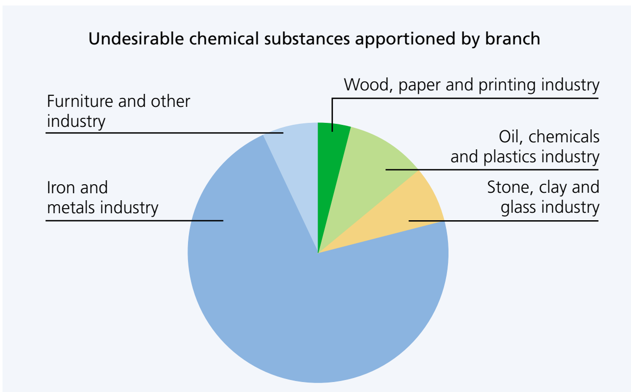


Figure 1.6.5

Industrial purchases of undesirable chemical substances apportioned by branch in 1997. (Source: Statistics Denmark, 1999).

In Denmark, special attention is accorded to the persistent chemical substances and the substances that have permanent effects. The persistent substances are often those that can accumulate in biological systems and end up in our foods. Attention regarding undesirable substances has traditionally focused on heavy metals and the persistent organochlorines such as dioxin, PCB (polychlorinated biphenyls) and compounds that were previously widely used as pesticides, e.g. DDT. In recent years, however, it has been increasingly acknowledged that other chemical substances also circulate in the environment in concentrations that have undesirable effects on the environment and health. Examples include phthalates and brominated flame retardants, which are suspected of causing hormonal disturbances.

The occurrence of persistent substances in the environment changes relatively slowly during the course of time, and the substances are detectable in the environment long after restrictions have been placed on their use. The substances continue to circulate via the products that are already on the market, and the amounts that are already present in the environment. The trend in the occurrence of PCB in grey seals illustrates this (*Figure 1.6.7*). There is some delay from the time a new substance is placed on the market until effects are detected in the environment, the causes have been determined, and measures have been taken to remedy the problem. The PCBs are a group of several hundred chemical substances that are persistent and accumulate up the food chain.

PCB has been widely used as an insulator in condensers and transformers for exactly the reason that they are so stable. In addition, PCB has been used as a flame retardant in hydraulic systems and as an additive in paints, printing ink, refrigerants and cutting oil, as well as a plasticizer in plastic. PCB has been in industrial use since the 1930s. The first observations of effects were recorded at the beginning of the 1960s, when pathological changes were detected in grey seals. In the mid 1960s, PCB was detected in the environment, and the first restrictions on its use followed in the mid 1970s. In the mid 1980s and mid 1990s, further restrictions were imposed. Nowadays there are only a few existing products containing PCBs, and these may be used until the end of their lifetime.

Photo: CDanmark

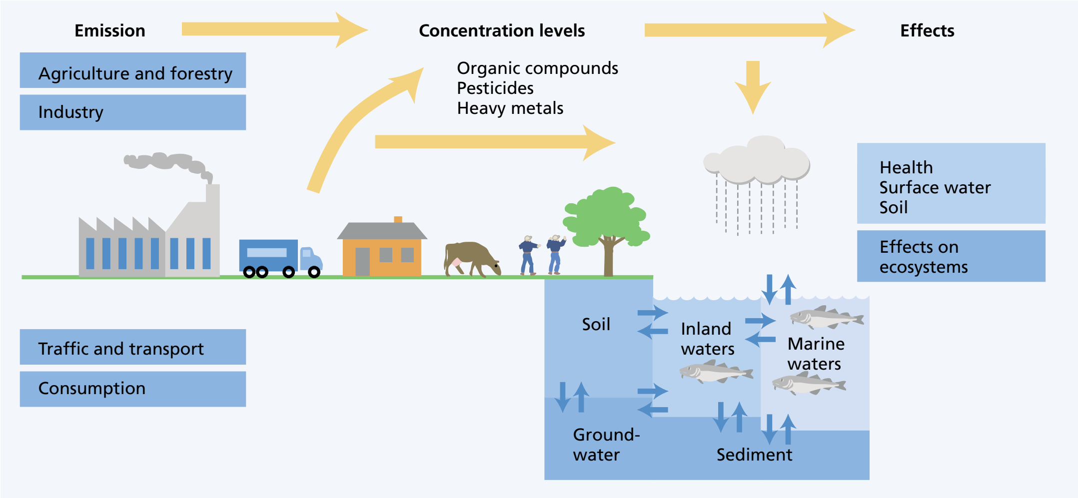


Figure 1.6.6
Circulation of chemical substances in the environment.

It has also become apparent that the persistent chemical substances can be transported over long distances. This means that chemicals from industry and pesticides from agriculture and market gardens that are used in some parts of the world can reappear in places where they have never been used. This global dispersal is one of the newer problems adding to the effects of the increasing consumption of chemicals. One of the main means by which chemical substances can disperse throughout the world is the so-called "Grasshopper effect" (*Figure 1.6.8*). This term reflects how chemical substances "hop" from place to place by a repeated process of evaporation, transport and deposition. The transport follows simple physico-chemical rules with the most important driving forces being temperature differences such that the substances constantly move from warmer to colder places. The majority of substances thus eventually end up in the Arctic regions (*see Section 3.8*).

Denmark is not alone in its concern about the persistent and bioaccumulating substances. A global agreement signed in Stockholm in May 2001 thus commits the nations of the world to a convention banning the future production and use of 10 persistent organic pollutants (POPs: Chloridane, dieldrine, endrin, heptachlor, hexachlorobenzene, mirex, toxaphene, PCD and DDT). In addition, the convention strives to prevent, reduce and if possible eliminate emissions of two POP by-products (dioxins and furans).

The status and trends concerning actual emissions of chemical substances and their occurrence and possible effects in the environment are described in the relevant chapters/sections of this report (*Table 1.6.1*).

Table 1.6.1 Summary of the descriptions of the state and trend in emission, occurrence and effects of chemical substances included in this report indicating the relevant section numbers.

Topic	Heavy metals	Hazardous organic compounds	Pesticides
Consumption and content in products	3.6.2, 4.4	1.3, 1.5, 3.6	1.2, 1.5.1, 4.5
Wastewater and sewage sludge	3.2, 3.6.2, 4.4	3.2, 3.6.2, 4.4	
Atmospheric emissions and deposition	2.3, 3.6.2, 4.4		
Discharge to the aquatic environment	3.6.2	3.6.2	
Discharge to and concentration in soil	4.4	1.5.5, 4.4, 5.3	
Concentration in air	2.3		2.3
Concentration in groundwater and drinking water	3.3	3.3	3.3, 4.5, 5.6
Occurrence in watercourses, lakes and ponds		3.6.2	4.5
Impact on mussels and fish	3.6.2	3.6.2	
Impact on arable land fauna and flora			4.5
Impact on human health	5.6	5.6	5.6

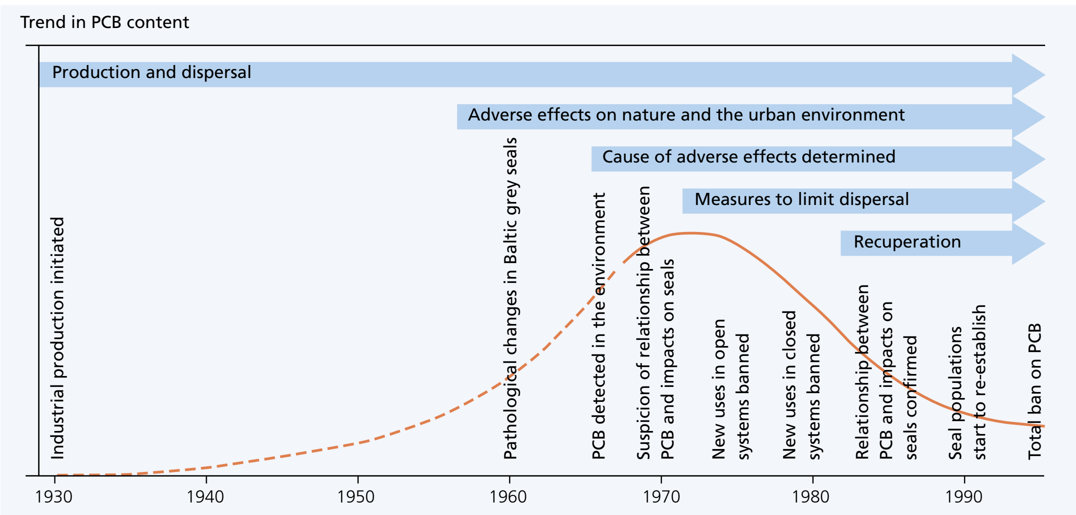


Figure 1.6.7 Trend in PCB content of grey seals from the inner Danish marine waters. (Source: Fromberg, 2001).

1.6.4 Regulation of chemical substances and products

Regulation of chemical substances in Denmark centres around the environmental legislation and the Chemical Substances and Products Act. The current efforts in the chemicals area are based on a substance-oriented strategy concentrating on assessment of each individual substance or group of related substances. The assessment is used as the basis for a classification of the substances relative to their effects on the environment and health, for setting limit values for emissions to the environment, and as the basis for decisions on restrictions.

The overall objective of the current Danish chemicals strategy is to limit the consumption of harmful chemicals to the greatest extent possible and to ensure that the manufacture, use and disposal of chemical substances does not have unacceptable effects on the environment and humans (*Box 1.6.1*).

Within certain areas, the current efforts encompass restrictions on the use of specific substances through a complete or partial ban. The efforts have concentrated on heavy metals, e.g. lead, mercury and cadmium, surface coating products, phthalates in PVC, ozone-depleting substances and certain organic compounds such as PCP (pentachlorophenol).

Regulation of chemical substances is optimal if cause-effect relationships between the occurrence of the substances in the environment and their effects on the environment and human health are fully understood. These relationships are very complex, however, and it is therefore necessary to take into account the uncertainty in our understanding in order to enable decisions on regulation of problematic substances despite this uncertainty. An important tool for managing this uncertainty is the precautionary principle (*Box 1.6.2*). The principle recently served as the basis for restricting the use of phthalates in Denmark.

Regulation of the chemicals area is predominantly an EU responsibility because it is of great significance for the free movement of goods.

A factor of great importance is the current focus on the chemicals area in the EU, including the EU White Paper outlining a strategy for chemical policy published in February 2001 and currently being considered by the Council of Ministers.

Photo: NERI/Ole Lund Jensen

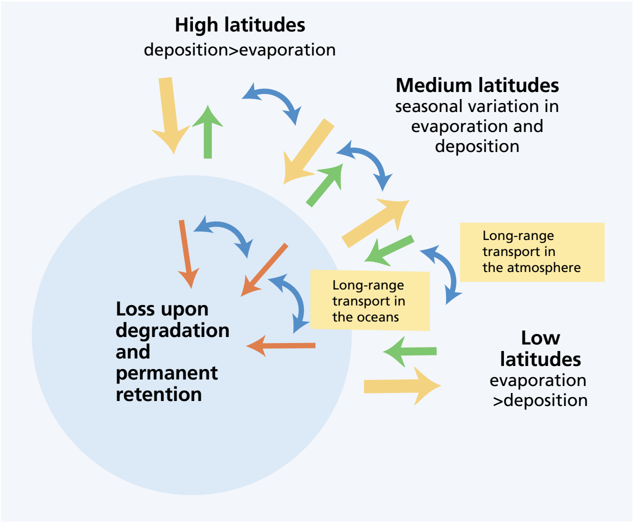


Figure 1.6.8
"Grasshopper effect"
– dispersal mechanism for persistent pollutants.

Box 1.6.1

Main elements in Denmark's strategy in the chemicals area.

Danish chemicals – main elements

- **Limit consumption of hazardous substances**
  Measures: Prohibitions, taxes, voluntary agreements, etc. – based on the "List of Undesirable Substances".

- **Greater responsibility to the manufacturers, more information to the consumers**
  Initiatives: Influence the EU system to amend the chemicals directives such that manufacturers are required to present data on the effects of the substances placed on the market, as well as to intensify information activities and draw up fact sheets.

- **Concerted actions concerning global chemicals regulation**
  Initiatives: Promote the participation of developing countries in the work on international conventions and focus their attention on the chemicals area through development aid.

Box 1.6.2

Description of the precautionary principle

The precautionary priciple

- The precautionary principle is a tool that can serve as the basis for intervention when environmental pressures entail unacceptable risks for human health and/ or the environment in cases where the relationship between the emission and effect has not been fully clarified. The unacceptable risks can for example be permanent effects such as impairment of fertility. The intention behind the precautionary principle is to ensure a high level of protection.

- The precautionary principle is incorporated in a number of international conventions and declarations. It was introduced in 1987 in the London Declaration concerning protection of the North Sea against pollution by chemical substances. The idea behind the precautionary principle was also incorporated in the 1992 Rio Declaration under the title "The Precautionary Approach". At the EU Summit Meeting in Nice in December 2000, the heads of state and government adopted a resolution on the precautionary principle that commits EU institutions to integrate the precautionary principle in all policy areas and international agreements where relevant.

- The Danish chemicals strategy emphasizes that use of the precautionary principle should be extended. Examples of uses of the precautionary principle in Denmark are the action plans to reduce and phase-out the use of phthalates in soft plastics and to regulate the use of phthalates in children's articles and toys.

Photo: 2. maj/Sonja Iskov

1.7 Societal trends in Denmark

1.7.1 Demographic and economic trends

The population of Denmark is increasing, and has grown by nearly 200,000 in the past 10 years (*Figure 1.7.1*). Population growth was especially rapid from 1994 to 1996, when net immigration and the birth rate were relatively high. Net immigration and natural population growth are currently of the same magnitude, approx. 8,000 to 10,000 per year, yielding total growth of about 15,000 to 20,000 per year.

The age distribution of the population is changing. The post-war generation, which dominated the distribution as youths in the 1960s, is now in its fifties (*Figure 1.7.2*). The age distribution was characterized by an overrepresentation of children in 1960 and by adults 25–55 years old in 2000. The projected age distribution for 2040 is more even, with nearly the same number of elderly people (60–75 years) as children. A record number of elderly people is projected for 2040. There are currently about 35,000 people aged 75 years, and this number is expected to nearly double in 2040.

Women's life expectancy is currently higher than that of men. This difference is projected to even out to some extent in 2040, however, thereby equalizing the number of elderly men and women (*Figure 1.7.2*). As elderly people consume less on average than adults of working age, this trend towards an older population could lead to a fall in consumption. On the other hand, elderly people have high average wealth, and pension savings are increasing. Moreover, the elderly of 2040 will have lived a life characterized by higher consumption than present-day elderly people. There is thus no overall sign that consumption will decline as a result of the expected demographic changes.

Photo: FotoDisc

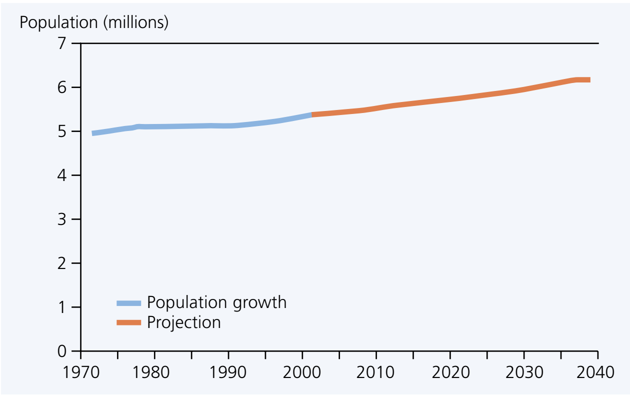


Figure 1.7.1
Growth in the Danish population from 1970 to 2000 and projection up to 2040.
(Source: Statistics Denmark, 2000).

Denmark's economy was characterized by a low growth rate from the mid-1980s until 1993. At that time an economic boom started and the gross domestic product (GDP) increased by up to 6% annually. The boom has lasted since 1993, with average annual growth rates of 2–3%. The latest economic projections predict increasing GDP growth up to the year 2010 in continuation of the economic trend that has characterized the Danish economy since 1993. The growth rate in the next decade is expected to be somewhat lower than in the period 1993–2000, however.

Both production and consumption have increased rapidly since 1993 (*Figure 1.7.3*). The increase in consumption from 1993 to 2000 was five-fold greater than could be expected from population growth. The pattern of consumption has shifted to lower spending on food and housing and higher spending on transport (including telecommunication) and leisure (including child care). The projection for the period until 2010 is that the increase in consumption of nondurable goods and housing costs will continue unchanged, while expenditure on transport is expected to remain constant from 2001 to 2003 and then to increase at the same rate as during the period 1993–2000 (*Figure 1.7.4*).

The distribution of production apportioned by sector shows that the increase from 1993 to 2000 was greatest in the private service sector (including trade and financial services) (*Figure 1.7.5*). Public services have also grown, but less than private services. Industrial production has increased, but at a slower rate than the private service sector, while the production value of the agricultural and energy extraction sectors was nearly constant during the latest 10-year period. The building and construction sector stagnated in the early 1990s, but activity increased by almost 20% from 1994 to 1998.

Transport increased steadily from the mid 1990s. The projection for the period until 2010 shows unmitigated growth in private services, an unchanged increase in industrial production and slight increases (less than 1% per year) for public services and agriculture. The value added for energy extraction is expected to be constant from 2001 to 2010. The level of building and construction activity is expected to be relatively low in 2001–2002, thereafter to increase steadily by about 1.5% per year.

The trend towards growth in servic-

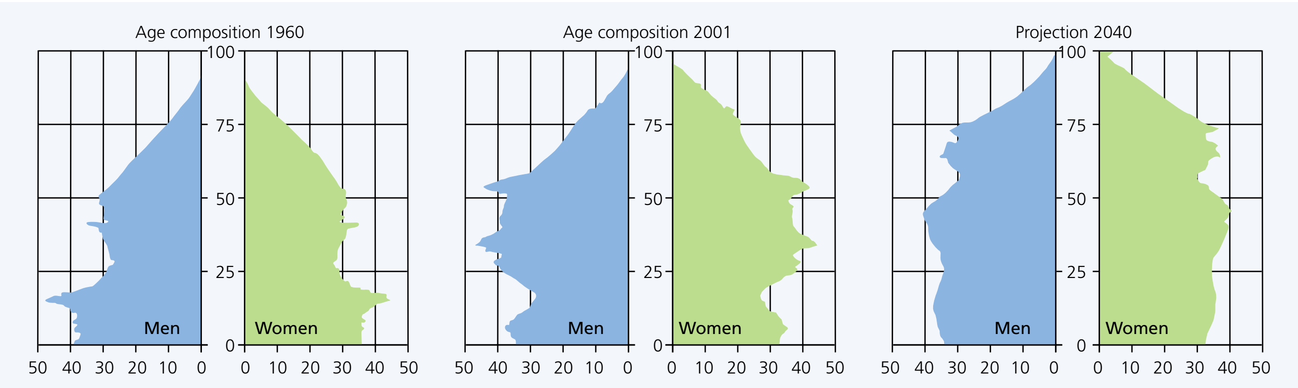


Figure 1.7.2

Age composition of the population in 1960, 2001 and 2040 (in 1,000 persons).
(Source: Statistics Denmark, 2001).

es and decline in production sectors (industry, agriculture and energy) as a proportion of the total economy will tend to reduce the environmental impact of overall economic activity. Transport is still increasing, though, especially car transport. Some of the reduced environmental impact of production will thus be counteracted by increased motoring to obtain services. In this respect, increasing use of Internet technology could have a positive effect on the environment. The proportion of households connected to the Internet increased from approx. 5% in 1996 to approx. 55% in 2001.

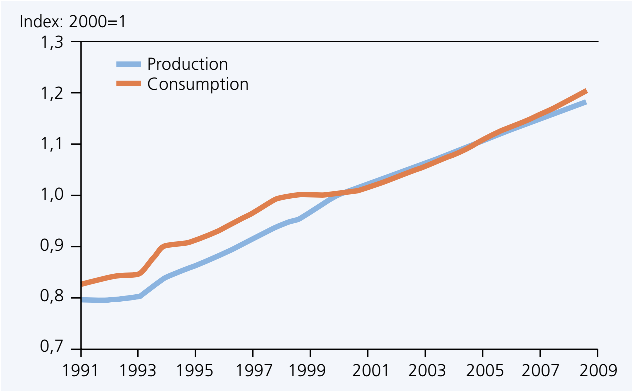


Figure 1.7.3

Trend in production and consumption over the period 1991–2010 in fixed 1995 prices relative to the year 2000.

(Source: Statistics Denmark, 2000; Ministry of Finance, 2001).

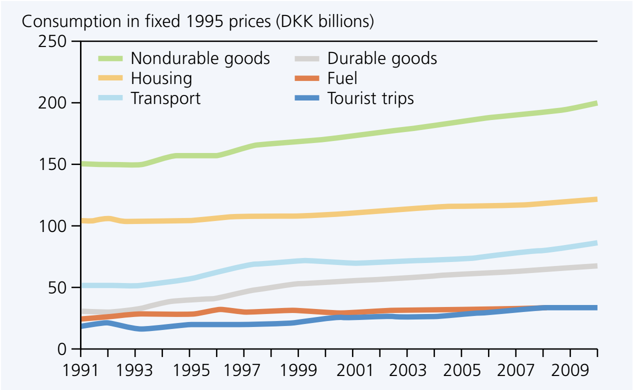


Figure 1.7.4

Trend in private consumption over the period 1991–2010 in fixed 1995 prices.

(Source: Statistics Denmark, 2000; Ministry of Finance, 2001).

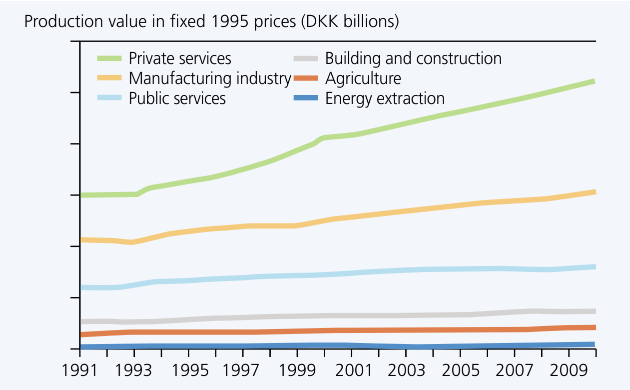


Figure 1.7.5

Trend in production value of the various business sectors over the period 1991–2010 in fixed 1995 prices.

(Source: Statistics Denmark, 2000; Ministry of Finance, 2001).

Photo: CDanmark

1.7.2 Theme – Outlook

Introduction

Assessments of societal trends and their environmental impact are in great demand among politicians and administrators who want a basis for policy formulation, and among environmental organizations and citizens who would like to know more about what the future will bring. When one has assessed the current state of the environment, the logical question is: What is the outlook?

Projections of Danish economic trends are available at the national level. In addition, more detailed analyses are available for some sectors of the economy. Methods have been developed that allow extremely detailed quantitative projections for some sectors. With other sectors, it is not possible to make predictions other than expert assessments. This may be because the conditions are relatively complex, or because the need has not been sufficiently great to warrant development of the necessary methods. Numerous projection models are available for the agricultural, energy and transport sectors, but the outlook for the industry and service sectors, for example, can only be described very generally at the national level.

Apart from the fact that there is considerable difference in how detailed the outlooks are for the various sectors, there is also considerable difference in the extent to which the impact of a sector on nature and the environment can be predicted. The relationship between the activities in a given sector and its environmental impact needs not only to be recognized, but also to be understood as specific and quantifiable relationships.

For example, it is known that agriculture influences nature, and the nutrient and pesticide loads are known. However, there are currently no known equations or direct relationships between, for example, the trend in agriculture and the change in the state of nature.

Photo: NERI/Anna Bodil Hald

Projections can be made in many different ways. Some are forecasts that use more or less well-known relationships or models to project trends year by year. One example is population forecasts, which are based on knowledge of the preceding demographic trends. The forecast can be said to describe the most likely trend.

Others are projections that use a given starting point and various assumptions about future events to predict potential future trends. One example is projections of energy consumption which, based on models for trends in economic sectors, their energy consumption and several assumptions on technological change and politically determined changes (such as levies), describe the current best estimate of trends in energy consumption over a number of years and the expected environmental impact. Such projections may include alternative courses of events called scenarios.

Finally, there are the future scenarios which, based on a given situation – for example the present – move directly to another situation – for example one in which a specific policy has been implemented or a change in society has occurred. An example of this could be that one has a known situation, e.g. that the population of Denmark is approx. 5 million, and wants to know what the impact on the environment would be if the population doubled in size. In contrast to population forecasting, the focus here is not on the cause of the change in population, but rather on the changes in the environment and nature resulting from a population increase.

Every outlook has a starting point, also timewise, and the results are often a comparison of various scenarios and trends. For example, one year can be compared with a later year, or a trend can be compared with one or more other trends. Scenarios are compared using a baseline projection including known facts like politically adopted action plans and other initiatives. The alternative scenarios can then be used to analyse ideas and proposals for change. Other types of scenario analysis similarly use a starting point or reference enabling the effect of a precise initiative or change to be assessed without being confounded by changes in other factors. The section below on agriculture compares, for example, a baseline projection and three alternative scenarios for the future. Another example describes the effect of an agricultural reform by comparing a reference scenario (the status quo without reform) with a scenario in which the reform is implemented.

This section describes current projections and scenarios for some environmentally important sectors: Agriculture, forestry, energy, industry, transport and waste. They should be viewed as the current possibilities for making consistent projections of trends for an economic sector and its impact on nature and the environment. These are examples, and hence do not represent a comprehensive review of all future impacts on the environment and nature.

Agriculture

Predicting trends in agriculture is very complicated because agriculture is both a highly regulated sector influenced by political changes at the EU and global levels and an independent industry in which the farmers' actual behaviour plays an important role. This section describes two different types of outlook:

1 A scenario describing the consequences for Denmark of the EU Common Agricultural Policy reform within the framework of Agenda 2000
2 A projection of the trend in Danish agriculture for the period until 2012 with three alternative scenarios

The two projections are not directly comparable. The starting point for one of them is the agricultural conditions for a specific year with the Agenda 2000 reform then being assessed on the basis that all other things remain equal. The other describes, based on a projection for agriculture until 2012, the trends in the relevant environmental impacts (in this case greenhouse gas emissions) and how additional initiatives to reduce pollution from agriculture can contribute to fulfilling Denmark's greenhouse gas emission targets. Both assessments take into account the effects of Action Plan on the Aquatic Environment II (*see Section 3.8*).


Photo: CDanmark

The Agenda 2000 scenario

The Agenda 2000 scenario pertains to changes in the framework conditions for agriculture. On 25 March 1999, the EU Heads of Government entered into an agreement reforming the Common Agricultural Policy within the framework of Agenda 2000 – the so-called Agenda 2000 reform. From the economic point of view, the reform is expected to result in behavioural changes affecting the agricultural sector economy, the economy as a whole and the environment. The scenario analysed is a combination of Agenda 2000 and Action Plan on the Aquatic Environment II, and assumes that both plans are fully implemented.

The Agenda 2000 reform includes both reductions in price support and compensation in the form of area payments and direct payments for livestock (*Table 1.7.1*) and support schemes related to environmental policy and rural development policy. The latter are not included in the Agenda 2000 scenario. The scenario is based on the conditions pertaining to the agricultural sector in 1995 corrected for the measures in Action Plan on the Aquatic Environment II. This reference scenario can then be compared with the effect of implementation of the parts of the Agenda 2000 reform being analysed. The effects on agriculture were analysed using the Econometric Sector Model for Evaluating Resource Application and Land-use in Danish Agriculture (ESMERALDA) developed by the Danish Institute of Agricultural and Fisheries Economics.

The changed market conditions will result in changes in both plant cultivation and livestock farming. The most important changes in land use are associated with the fall in cereal prices, which will result in a decrease in winter cereal acreage and an increase in spring cereal acreage (*Figure 1.7.6*). Part of the price fall will be compensated for by increasing area payments for cereals. This will increase the acreage of cereals for whole-crop harvesting, which is included under the category of "Grass and green fodder under crop rotation". Conversely, it will reduce the acreage of permanent pasture. Other changes in land use are minor. Total agricultural acreage is assumed to be unchanged relative to the reference scenario.

Changing the support will not change cattle production. In contrast, calculations show that pig production will increase by 2% due to the lower feed costs resulting from the fall in cereal prices. The increase in pig production is based on the assumption that the price of pork will decline by 3% as a result of the lower costs of feed. This assumption is based on previous experience with the relationship between feed costs and pork prices, but is subject to uncertainty.

Table 1.7.1
Market schemes encompassed by the Agenda 2000 reform of EU Common Agricultural Policy. (Source: Andersen et al., 2000).

Crop schemes	Livestock schemes
• 15% reduction in the intervention price for cereals	• 20% decrease in the beef price
• Increase in the area payment for cereals by DKK 351 per hectare	• 15% decrease in the milk price
• Decrease in the area payment for peas by DKK 234 per hectare	• Increase in the suckler cow premium by DKK 800 annually
• Decrease in the area payment for rape by DKK 1,247 per hectare	• Increase in the special premium for steers by DKK 500 annually (max. two premiums per animal)
• Decrease in the set-aside payment by DKK 228 per hectare	• Introduction of a milk quota premium of DKK 0.15 per kg milk quota (DKK 1,100 per dairy cow)
	• Introduction of a slaughter premium for cattle of DKK 600 per slaughtered animal
	• Introduction of additional payments in the cattle sector to a total value of DKK 350 million annually

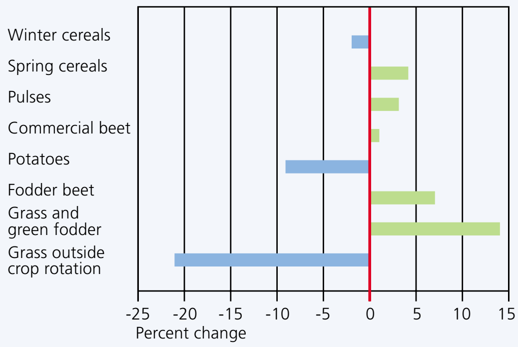


Figure 1.7.6
Percentage change in land use in the Agenda 2000 scenario relative to the reference scenario. (Source: Andersen et al., 2000).

The fall in prices for cereals, beef/veal and milk in the Agenda 2000 scenario and the assumed indirect reduction in pork prices will reduce the production value by DKK 4.6 billion or 9% relative to the reference scenario. The declining production value will be partly offset by the increasing revenue from area payments of DKK 0.4 billion and direct payments for livestock of DKK 1.7 billion. Since much of livestock feed consists of cereals, the agricultural sector's feed costs will decrease. Changes in plant cultivation will also entail changes in the consumption of fertilizer, chemicals, etc. In total, costs will be reduced by DKK 0.7 billion. Overall, the Agenda 2000 scenario will reduce the Danish agricultural sector gross domestic product at factor cost by DKK 1.8 million (6%) relative to the reference scenario.

As mentioned, the Agenda 2000 scenario does not take into account any change in agricultural trends from 1995 onwards apart from that resulting from Action Plan on the Aquatic Environment II. Thus the fact that a decline in the number of cattle is expected (see below) is not in conflict with the fact that the Agenda 2000 scenario predicts a neutral effect on cattle production – factors other than the Agenda 2000 reform are responsible for the decline in the number of cattle.

Environmental impacts of the Agenda 2000 scenario

The environmental consequences are assessed on the basis of several key parameters: Nitrogen loading of the marine waters and the resultant effects on oxygen concentrations, the emission of greenhouse gasses and the risk of pesticide leaching. This list of environmental problems associated with agriculture is not complete, however. For example, problems with phosphate leaching, the effects on nature and nitrate contamination of the groundwater are not included because methods or models able to predict the effects of these parameters at the national level are not yet available (*Box 1.7.1*).

The reduction in cereal prices entails a 9% reduction in nitrogen consumption per hectare for cereal crops relative to the reference scenario. For the other crops, for which the prices are unchanged, the intensity of nitrogen application will remain unchanged. The effect on the intensity of pesticide application will be limited to cereal fields, where the reduction will be slightly less than 20%. For the other crops, the pesticide consumption per hectare is unchanged. The change in the intensity of pesticide application can result from opposing trends. The declining application of nitrogen often leads to reduced use of plant growth regulators and fungicides. In contrast, the use of herbicides increases as a result of increasing competition from weeds when the cereals become less robust.

Environmental models used

The NP model is used to describe the nitrogen loading of the marine environment from arable land. The model also estimates ammonia emissions from agricultural sources and the contribution of agriculture to the deposition of NH_X-N. These inputs comprise agriculture's share of the total nitrogen load. To calculate the total load it is therefore necessary to add the other sources. Since the Agenda 2000 reform will not change the input from other sources, they can be considered as background loading. The NP model plays a special role in the agricultural model complex because of its geographically distributed data for land use, livestock farming and fertilizer consumption.

The Hav90 model is used to investigate environmental effects on the inner Danish marine waters. The model calculates the changes in oxygen conditions in response to reductions in nitrogen loading of these marine waters. Since the Hav90 model requires knowledge about the total input of nitrogen, input from the other sources, including foreign sources, is included.

Agricultural emissions of the greenhouse gasses CH_4 and N_2O are calculated using a simple greenhouse gas module in which CH_4 emissions are determined from the size and composition of the livestock herd, and N_2O emissions are determined from the nitrogen turnover in agriculture and the acreage of humic soil.

The pesticide load is determined solely on the basis of the risk of leaching from the root zone. Leaching is calculated from land use and pesticide consumption for each type of crop, and is based on partial ranking of the individual active substances relative to one another using a so-called Hasse diagram technique.

Box 1.7.1
Environmental models used for assessing the impact of agriculture on the Danish environment and nature.

The environmental consequences of the Agenda 2000 scenario relative to the reference scenario are minor in all the areas assessed. It should be remembered, though, that the environmental support measures are not included in the Agenda 2000 scenario as it solely deals with the effects of the market schemes encompassed by the Agenda 2000 reform. In addition, considerable uncertainty is associated with the fall in the prices of cereals and pork, both of which influence the environmental effects.

Nitrogen deposition on the terrestrial environment will increase less than 1% relative to the reference scenario. Ammonia emissions will grow as a result of increasing pig production, but the reduced fertilization intensity for cereal crops will reduce emissions from the crops by nearly the same amount. Since the resulting increase in emissions is minor, and since only part of the emissions are deposited on land, the effect on deposition is very small. In addition, only part of the nitrogen deposition derives from agricultural activities in Denmark (*see Section 2.4*). The nitrogen deposition caused by Danish agriculture would have to fall markedly to cause any noticeable change in total deposition. The limited change in nitrogen deposition also means that there will be no regional redistribution of nitrogen deposition.

The effect of the Agenda 2000 scenario on nitrogen loading of Danish marine waters from agricultural sources relative to the reference scenario is also limited – a 2–3% reduction attributable to the declining fertilization intensity for cereal crops and a resultant reduction in nitrogen leaching and hence of nitrogen runoff to the sea. The effect of this is reduced, however, by the change in crop mix and increasing production of pig manure. The regionalized and specialized nature of agricultural production in Denmark means that the reduction in nitrogen loading is not proportional in the respective marine waters. Nitrogen loading of the Skagerrak from agricultural sources decreases by only 1.5% in the Agenda 2000 scenario, whereas that of the southern Belt Sea is reduced by just over 4% (*Figure 1.7.7*).

The effects on the oxygen concentration in Danish marine waters are negligible. This is due to the fact that Danish agriculture is not the only source of the nitrogen load. Thus wastewater treatment plants, separate industrial discharges, freshwater fish farms, sparsely built-up areas and nitrogen runoff from neighbouring countries also contribute, as does atmospheric deposition. Since all these inputs are kept unchanged in the Agenda 2000 scenario, and since the reduction in nitrogen loading from agricultural sources is small, the effect on the oxygen concentration is also small.

The Agenda 2000 scenario reduces the emission of nitrous oxide (N_2O) and methane (CH_4) by just over 1% relative to the reference scenario. The reduction is presently attributable to declining use of commercial fertilizer, which again is caused by the reduced fertilization intensity in cereal crops. The increase in pig farming will influence emissions of both CH_4 and N_2O, but the changes are too small to play any decisive role.

The change in pesticide loading of the aquatic environment is too small to enable the effects of the Agenda 2000 scenario to be determined with any certainty. That the effect is limited is due to the fact that the change in crop mix will increase the risk of leaching of pesticides, whereas the reduction in the intensity of pesticide application for cereal crops will reduce the risk.

The environmental impacts of the part of the Agenda 2000 reform investigated in the Agenda 2000 scenario were marginal, in part because the changes in agricultural production are relatively small, but especially because the effects of the changes predicted to some extent counteract each other.

Photo: Danish Institute of Agricultural Sciences/Henney Rasmussen

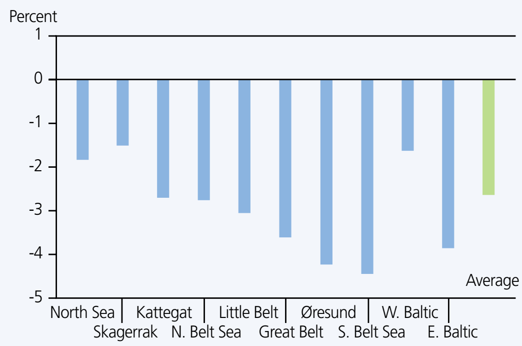


Figure 1.7.7
Percentage change in nitrogen loading of Danish marine waters from agricultural sources in the Agenda 2000 scenario relative to the reference scenario. (Source: Andersen et al., 2000).

Projections for agriculture up to the year 2010

As a basis for determining greenhouse gas emissions from Danish agriculture, a conservative projection taking into account the consequences of Action Plan on the Aquatic Environment II and the Agenda 2000 reform has been made using 1999 as the starting point for both livestock and land use (1997/1998 for the crop mix, though).

The number of cattle is expected to decrease by 1.8% per year, corresponding to the changes during the period 1990–1999. This will reduce the total dairy herd by 116,000 head in 2010. The number of slaughter pigs is expected to increase by 1.5% annually, which will increase the total number from 22.8 million in 2000 to more than 26 million in 2010. It is assumed that total cultivated acreage will decrease by 0.3% per year, among other reasons due to the expected increase in set-aside acreage. In addition, 17,430 ha will be reassigned for afforestation. It is also assumed that 220,000 ha will be cultivated organically in 2010. The land used for conventional agriculture will thus decrease by nearly 22% by 2010. The crop mix is assumed to be determined in part by the Agenda 2000 reform. Relative to the crop mix in 1997/1998, this entails a partial shift from winter cereals to spring cereals and a shift towards less acreage of grass, fodder beet and pulses and more of cereals.

This does not entirely correspond to the change in plant cultivation predicted by the Agenda 2000 scenario (*Figure 1.7.6*), however, partly because the starting-points for the comparisons are not the same (1995 versus 1997/1998 for agriculture), and partly because the projection for 2010 includes the previously mentioned expected structural changes in agriculture from 1999 to 2010.

Environmental impacts of agricultural trends up to the year 2010

The environmental impacts of agricultural production in the period up to 2010 are described in terms of emissions of greenhouse gasses and ammonia. Agriculture accounts for approx. 18% of Denmark's total emissions of greenhouse gasses. Of agricultural emissions, crop farming accounts for the largest proportion, followed by livestock farming, with the smallest proportion deriving from energy consumption, i.e. CO_2 emissions from diesel oil, oil, etc. (*Figure 1.7.8*). The various emissions have all been converted into CO_2 equivalents to enable comparison. For example, the emission of 1 kg of CH_4 contributes as much to the greenhouse effect as the emission of 21 kg of CO_2, and CH_4 is therefore a more potent greenhouse gas than CO_2. N_2O is an even more potent greenhouse gas and therefore contributes relatively more than CH_4 to agricultural emissions of greenhouse gasses than CH_4. The CH_4 emissions derive from livestock farming, while N_2O is released during metabolism of nitrogen on arable land and is therefore closely related to the nitrogen input.

The projections of ammonia and greenhouse gas emissions were made for three separate years: 1999, 2003 and 2010 (*Figures 1.7.9 and 1.7.10*). In addition to the general projections of agricultural conditions, the measures in Action Plan on the Aquatic Environment II are assumed to be implemented from 2003.

According to the baseline projection, greenhouse gas emissions will decrease until 2003 and thereafter remain virtually unchanged. This is because no initiatives to reduce CH_4 and N_2O emissions are included other than those in Action Plan on the Aquatic Environment II, which will be fully implemented in 2003. The slight fall after 2003 is attributable to the reduction in the

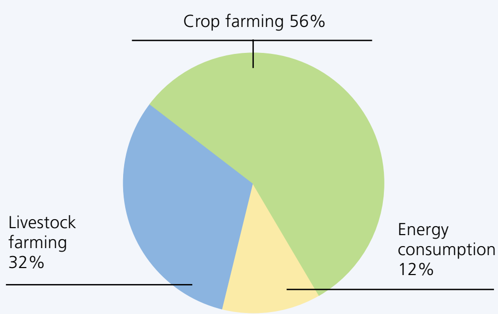


Figure 1.7.8
Source apportionment of agricultural greenhouse gas emissions in 1999 based on emissions expressed in terms of CO_2 equivalents.
(Olesen et al., 2001a).

Photo: Danish Institute of Agricultural Sciences/Henney Rasmussen area of arable land and a decrease in the cattle herd. The baseline projection for ammonia emissions shows a decline until 2003, again mainly resulting from the effects of Action Plan on the Aquatic Environment II, while the increase from 2003 to 2010 is due to the growing number of pigs.

Based on an assessment of the best opportunities to reduce emissions in agriculture, and especially on an assessment of where existing knowledge allows reasonably certain analysis, three measures (scenarios) have been selected and the reduction in emissions of greenhouse gasses and the costs of implementing the measures have been calculated. The measures analysed are:

1 Reduction in CH_4 emissions by changing dairy cow feed
2 Reduction in ammonia volatilization
3 Cultivation of energy crops.

The first measure entails changing the composition of concentrated feed for dairy cows by increasing the content of vegetable fat in the feed. This reduces CH_4 excretion by the dairy cows. The second measure focuses on reducing ammonia volatilization through changes in handling and storage of manure and through cessation of ammonia treatment of straw. Reducing ammonia emissions indirectly affects agricultural N_2O emissions since ammonia deposition leads to N_2O emission from arable land. The last measure entails replacing traditional cereals with energy crops (elephant grass, 50% harvested in the spring and 50% in the autumn), which is subsequently used as a CO_2-neutral fuel in energy production. These three initiatives are unchanged from year to year, whereas the effects are expected to differ because agricultural conditions change from year to year. The second measure decisively affects ammonia emissions and is therefore shown together with the baseline projection for ammonia (*Figure 1.7.10*).

Changing the composition of dairy cow feed leads to the greatest reduction in greenhouse gas emissions, followed by the cultivation of energy crops, whereas the ammonia measures only have a marginal effect (*Figure 1.7.9*). If all three measures are implemented together, emissions will be reduced by 980 million kg of CO_2 equivalents relative to 1999 and by approx. 890 million kg of CO_2 equivalents relative to the baseline projection for 2010.

The measures to reduce ammonia emissions will yield an approx. 12–13% decrease in 2003 and 2010. The reduction caused by the measures investigated is of the same order of magnitude as that resulting from Action Plan on the Aquatic Environment II (*see Section 3.8*).

The reduction measured in CO_2 equivalents, the costs of the initiatives (in welfare economics terms) and the cost-effectiveness ratio (cost in DKK per kg of CO_2 emission reduction) were calculated and compared with the results for selected measures in other sectors (*Table 1.7.2*). The economic costs are presented only for the first two agricultural measures (changing the composition of feed and reducing ammonia volatilization). This is due to the fact that in order to take advantage of the increased cultivation of energy crops it is necessary to increase biofuel utilization capacity at power plants. The measure is related to other measures in the energy sector and cannot be considered solely as an agricultural measure.

The potential of the various measures to reduce greenhouse gas emissions varies considerably, and it will thus be necessary to combine several measures to achieve Denmark's target of a 21% reduction in greenhouse gas emissions by 2012, corresponding to a reduction of approx. 15 million tonnes of CO_2 equivalents.

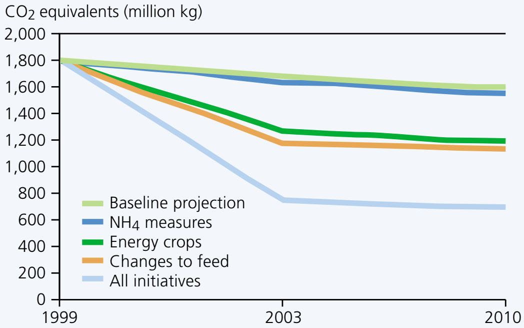


Figure 1.7.9

Projections of agricultural greenhouse gas emissions for different reduction initiatives.

(Source: Calculated on the basis of Olesen et al., 2001a).

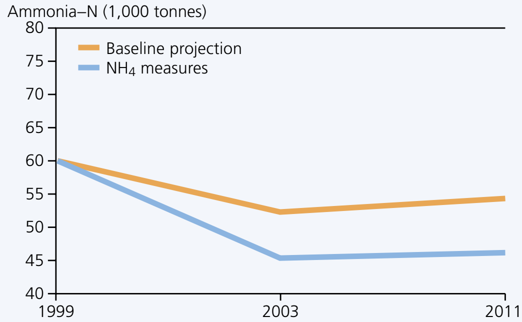


Figure 1.7.10

Projections of agricultural ammonia emissions for the baseline scenario and the initiative to reduce ammonia volatilization.

(Source: Calculated on the basis of Olesen et al., 2001).

The cost per unit reduction in CO_2 equivalent (mitigation cost) varies considerably among the measures. For example, introduction of norms for circulation pumps will actually save money since the most cost-effective technology available is not currently being used. In contrast, increasing the tax on fuel entails the highest mitigation cost, i.e. DKK 3.5 per kg of CO_2 equivalent. This calculation does not account for all the costs in a welfare economics assessment, as only the direct costs are included. Potential indirect benefits of the measures have not been included since they could not be determined for all measures. Indirect benefits will be of great significance for several of the measures. For example, afforestation would provide considerable public benefits in the form of recreational opportunities. Increasing fuel taxes is an example where the main benefit from the welfare economics point of view is the reduction in air pollution, and where the reduction in CO_2 emissions presented here is of less importance and is seen as a complementary effect. The analyses of the individual measures are nevertheless consistent and comparable.

Summary

The scenario for the trend in agriculture shows that the market schemes being implemented under the EU Agenda 2000 reform have relatively little inherent effect on the environmental impact of Danish agriculture, partly because the changes are expected to be relatively minor as a whole and partly because the resultant environmental impact on the parameters investigated (nitrogen runoff, pesticide loading and greenhouse gas emissions) are opposing, and hence to some extent therefore counterbalance each another.

The projection for 2010 entails a more than 20% decrease in the area of conventionally farmed arable land. The acreage used for extensive cultivation, forests and wetlands is expected to increase – trends that will benefit nature. Nitrogen consumption is expected to decline up to 2003, as will leaching of nitrate and emission of greenhouse gasses and ammonia. Thereafter, ammonia emissions will increase slightly due to an increase in the number of pigs. Emissions of greenhouse gasses will not increase after 2003, since the major sources of agricultural emissions – cattle farming and fertilizer application – are not expected to increase.

Forestry

The target of doubling Denmark's forested area within a tree generation derives from 1989.

Afforestation is carried out through state programmes as well as through subsidized planting in the private sector. Meeting the target will necessitate planting an average of 4,000 to 5,000 ha of forest per year. Between 2000 to 2006, only approx. 3,300 ha of new state forest and 9,600 ha of subsidized private forest are expected to be planted. At present, therefore, it seems unlikely that the afforestation target will be met.

The new forests predominantly consist of broadleaf woodland, partly because of the higher subsidies for broadleaf species and partly because of the requirement that all small projects must consist of broadleaf trees. Within conifers, the future growth in land planted with ornamental greenery is expected to stagnate due to falling real prices since 1997 (stricter quality requirements to producers and falling prices). Land cultivated with nordmann fir for Christmas tree production is expected to be under the greatest pressure. The state Windfall Support Scheme of 2000, which supports the reforestation of areas devastated by windfall after the hurricane on 3 December 1999, will enhance the pro-

	Emission reduction (million kg CO_2)	Welfare economics cost (DKK million)	Cost-efficiency ratio (DKK/kg CO_2)
Agriculture			
Changes to dairy cow feed	433	233	0.5
Ammonia initiatives	34	60	1.9
Other sectors			
Afforestation	26	10	0.4
Expansion of offshore wind farms	2,108	672	0.3
Expansion of biofuel capacity	233	140	0.6
Norms for small circulation pumps	78	-31	-0.4
Electricity tax on private trade and service sector	364	36	0.1
Increased fuel taxes	313	1,083	3.5

Table 1.7.2
Projected effects (in CO_2 equivalents), costs and cost-effectiveness ratio in 2010 for selected initiatives to reduce agricultural emissions of greenhouse gasses.
(Source: Olesen et al., 2001b; Schou and Birr-Pedersen, 2001; Danish Energy Agency, 2001a).

portion of forested land with mixed tree species. The purpose of mixing trees of different species is to establish robust, sustainable forests with a high nature content.

The economic incentives for afforestation for non-productive purposes will need to be developed further to promote a shift in forestry operations in the direction of natural forests. The Natural Forest Strategy aims to ensure the existence by 2040 of 40,000 ha of virgin forest, original forest and forest managed by traditional forestry practices. Much of this will continue to be managed as ordinary diversified timber forest, though.

The consumption of fuel wood in wood chip-fired combined heat and power plants is increasing. The future distribution of this increasing consumption between imports and domestic production is unknown, however. The long-term national consumption is expected to be about 400,000 tonnes of wood chips per year. Felling volume in 2020 is expected to total about 3.1 million m^3 of growing stock because of afforestation. In comparison, the felling volume has averaged 2 million m^3 per year for the past 20 years.

A 1995 Food and Agricultural Organization projection indicates that wood consumption in Denmark will increase by 50% up to 2020. The increase depends on such factors as the level of building starts, the use of biomass for energy production and the proportion of paper that is recycled. The level of building starts is highly dependent on the state of the market and is currently expected to stagnate in the coming years.

Awareness is increasing of the overall environmental consequences of various forestal production and management forms. Key initiatives are therefore being implemented in Denmark concerning forest certification (Pan-European Forest Certification (PEFC) and Forest Stewardship Council (FSC) schemes, *see Section 1.5.1*). In Sweden, half the forested area is already FSC certified, and more than 21.5 million ha of forest have been FSC certified world-wide. The International Organization for Standardization (ISO) has published an international standard for implementing life cycle assessment (ISO 14040) that can be applied to environmental assessment of Christmas tree production methods. In the long term, it is hoped that cooperation can be established between the various certification schemes, thereby rendering them more transparent to consumers. Support for FSC certification has increased dramatically on the world market. In the first 2 months of 2001, 331 companies were certified – representing an increase of 30%. Certification of wood from Danish forests is expected to increase substantially.

Energy

Energy projections up to the year 2012

Energy consumption and energy-related emissions of CO_2 and of the six greenhouse gasses have been projected until 2012 based on Ministry of Finance estimates of future economic development in Denmark, International Energy Agency estimates of future energy prices, and the expectation of continuing technology-driven improvements in energy efficiency. The energy consumed by the transport sector is estimated using a Ministry of Transport projection. It should be noted that projected energy consumption is based on numerous assumptions, each of which is uncertain, and the result is also therefore subject to considerable uncertainty. The present projection is a baseline projection assuming no new initiatives, and hence should not be confused with an actual forecast.

Final energy consumption (climate-corrected) is expected to decrease transiently in 2000–2002, among other things due to expectations that high oil prices in 2000–2001 will limit consumption (*Figure 1.7.11*). Except for the transport sector and private trade and services, energy consumption is expected to remain stable up to the year 2012 due to the expected higher energy prices than in the 1990s and a series of measures that are expected to limit energy consumption,

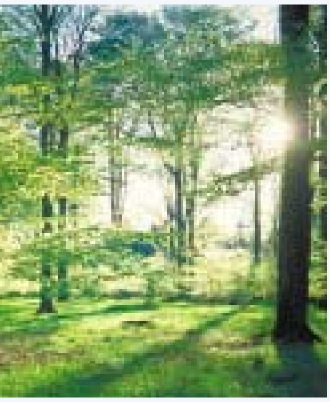
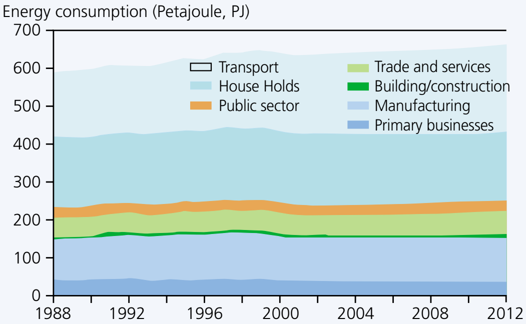


Photo: CDanmark

Figure 1.7.11

Projected energy consumption apportioned by sector. (Source: Danish Energy Agency, 2001b).



especially among households and manufacturing sectors. The most important measures include efforts to conserve electricity, natural gas and heat, subsidies for business investment in energy efficiency and the increases in energy taxes adopted in 1998.

The efficiency of the power supply sector is expected to continue to improve, thereby reducing fuel consumption by power plants and district heating plants. Among other means, this will be achieved by continued expansion of district heating and wind turbines and a shift from coal to natural gas as a fuel. Coal consumption is expected to decline in the next few years to the benefit of renewable energy, especially wind power *(Figure 1.7.12)*. The consumption of oil-based types of energy is highly transport-related and is therefore expected to increase slightly despite a reduction in the number of oil-heated homes. In the future, subsidies for renewable energy will be partly shifted from direct subsidies to so-called green certificates (*see Section 1.3.2*). The changes in the power supply structure also include increasing use of biomass in combined heat and power plants and a shift from oil to natural gas and district heating among consumers. All these changes will contribute to a reduction in CO_2 emissions.

The environmental impact of energy production

The future emissions of CO_2 and of the six greenhouse gasses encompassed by the Kyoto Protocol (CO_2, CH_4, N_2O, perfluorocarbons (PFCs), hydrofluorocarbons (HFCs) and sodium hexafluoride (SF_6)) can be compared with Denmark's national targets for 2005 and the target of the Kyoto Protocol for 2008–2012 (*Figure 1.7.13*).

From this it seems that there is a possibility that the national targets for 2005 will be attained with the initiatives already adopted, primarily because wind turbines are being expanded rapidly and because final energy consumption is expected to remain stable over the next few years. This projection is subject to great uncertainty, though. In relation to the Kyoto target, in contrast, there seems to be a shortfall of 1.8 million tonnes of CO_2 equivalents (2.4%). Thus, additional measures are needed to achieve this target. This comparison of the target of the Kyoto Protocol and Denmark's greenhouse gas emissions in 2008–2012 is based on a correction of the base year 1990 for electricity imports and entails that the quotas set for power plant CO_2 emissions after 2003 correspond to the domestic electricity consumption. The current quota scheme expires at the end of 2003. Before the end of 2001, political discussions must be conducted on continuing the power companies' CO_2 quota scheme. Assuming that the quota scheme is not extended, the shortfall would be 15 million tonnes of CO_2 (19%) in 2008–2012.

Denmark's benchmark of reducing CO_2 emissions by 50% in 2030 relative to 1990 will require more extensive intervention, including both reducing final energy consumption and additional promotion of renewable energy and cleaner fuels. It seems that transport will account for more than one third of Denmark's total CO_2 emissions as early as 2012, and achieving the 2030 target without changing transport volume or technology may be difficult.

Figure 1.7.12

Gross energy consumption apportioned by fuel type. (Source: Danish Energy Agency, 2001b).

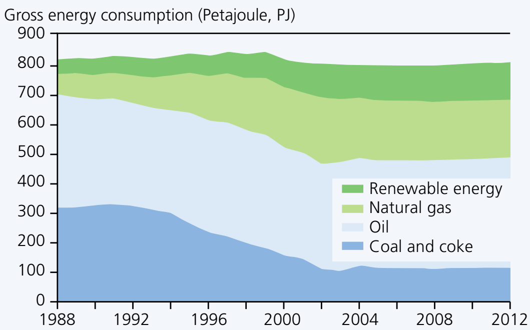


Figure 1.7.13

Historic and projected greenhouse gas emissions compared with existing reduction targets. In contrast to emissions of the six greenhouse gasses, CO_2 emissions are corrected for net electricity exports and encompass international air traffic. (Source: Danish Energy Agency, 2001b).

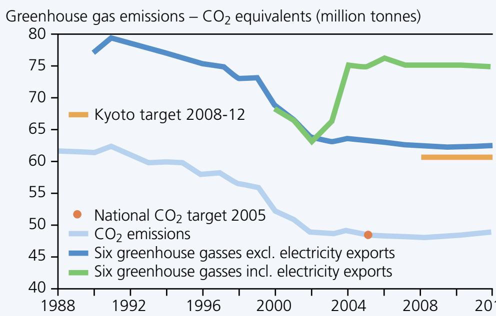


Photo: NERI/Britta Munter

Industry

Trends

The traditional industrial society is developing into a service and information society. The increasing globalization of trade, investment and information exchange is an important factor that will contribute to influencing development in the coming decades together with technological development and the increasing demand for consumer goods. Among other things, the expected economic growth and structural development towards a service and information society will increase demand, especially within electronics, information technology, the environmental industry and services associated with the sale of products.

Production within traditional manufacturing industry will generally shift towards the production of goods requiring greater input of knowledge. Further, small companies will tend to merge, and large companies will tend to form larger national and international networks to maintain their position given the stiffer competition. Technological development is an important driving force changing the environmental impact of manufacturing industry. Technological development was previously often considered as a cause of the environmental impacts, whereas today it is viewed as one of the main means of decoupling economic growth and environmental impact.

Efforts to ameliorate the environmental problems caused by industry are changing direction, both with respect to the focus of the efforts and the nature of the regulatory instruments used. Since the 1970s, regulation has mainly targeted direct emissions from production processes, whereas in recent years attention has focused on the environmental effects of the goods produced during their entire life cycle, i.e. from extraction of the raw materials to the manufacture and use of the products until they end in the waste streams. The emphasis on reducing the local and regional environmental effects has thereby been broadened to also include their global environmental effects since environmental effects can be considered to follow the product, irrespective of whether it is produced in Denmark or elsewhere.

Companies will in future tend to highlight one or more environmental benefits of their products to achieve a competitive advantage on the market. The graphics industry is a good example of how environmental performance has become a competitive parameter and is currently considerably over-represented as regards, for example, production of ecolabelled products. The number of ecolabelled products is generally growing rapidly (*see Section 1.5.7*). For example, the textiles industry placed a large selection of ecolabelled textiles on the market in spring 2001.

The environmental impacts of the production processes themselves have been continually reduced despite the increasing total consumption of resources and goods. These efforts have been further strengthened by the EU IPPC (Integrated Pollution Prevention and Control) Directive, which was implemented in Denmark in 1999 (*see Section 1.5.5*).

Despite the efforts made so far, some types of pollution have increased along with the increase in production and consumption. For example, the amount of waste has increased proportionally to economic growth, and the use of hazardous chemicals comprises an increasing problem. Moreover, the current trend can be paradoxical in that it involves the development of production using the cleanest possible technology and consumption of cleaner products, while at the same time the production and consumption can be environmentally detrimental in extent and nature. This problem must be included in the assessment of environmental impact and be reflected in the overall efforts to reduce industry's environmental impact.

The greatest environmental problems of the future will probably be associated with general resource consumption in society and with the use and disposal of environmentally detrimental products.

The aim is that the transformation to the global knowledge economy should take into account consideration for sustainable development. For industry, this means that economic development must proceed without corresponding growth in environmental impact, energy consumption and waste generation. Denmark's new business strategy ".dk21" establishes the framework for such development (*see Section 1.5.5*).

Resource efficiency – energy

Denmark has succeeded in decoupling growth in energy consumption and growth in the manufacturing industry. Since 1993, gross value added has increased more rapidly than energy consumption. The latest projections of economic growth show an increase in gross value added of 2–3% per year over the next 2 years and thereafter growth of 1.5% annually until 2010. Nevertheless, energy consumption is expected to be stable in the next 2 years (*Figure 1.7.14*). Growth in the manufacturing industry is expected to be slightly lower than that of general economic growth at just under 2% for the next 2 years. This reflects the expected structural change towards the expansion of private services.

The final energy consumption in the manufacturing industry increased until 1995 and, after 2 years of stagnation, declined up to the year 1999. The fall in energy consumption is primarily attributable to the effects of a package of environmental taxes for 1996–

2002 comprising taxes on CO_2 emissions and energy consumption. Energy consumption is expected to continue to decrease until 2002 and then remain fairly stable until 2012. The increase in energy consumption was decoupled from economic growth as early as 1993 such that gross value added increased more rapidly than energy consumption.

Energy efficiency also increased from 1993 to 1999, and this trend is predicted to continue until 2012 (*Figure 1.7.14*). This increase is real, i.e. the energy used to produce a given value added has decreased during the period. This effect is even greater than the figures show directly since there has been a concomitant structural change towards more energy-intensive sectors, which tends to increase energy consumption.

The increase in energy efficiency has been greatest in some of the energy-intensive industrial sectors, i.e. extraction of raw materials and the metals, and chemical industries. In contrast, energy efficiency has remained virtually unchanged in most of the less energy-intensive industries such as textiles, paper and machinery. The increase in energy efficiency is particularly attributable to the package of environmental taxes for the period 1996–2002. Part of the revenue from these taxes is returned to industry in the form of subsidies, which are primarily used to promote energy-efficient technology and to disseminate energy management in industry through development, demonstration and information projects. Since 1 January 2000, a subsidy fund of DKK 175 million per year has been available to promote energy conservation in industry.

Nearly all of industry's CO_2 emissions are related to energy consumption. The manufacture of cement and bricks and emissions of organic solvents also contribute to Danish CO_2 emissions, however. Industrial emissions of CO_2 are expected to change minimally in the period up to 2012 (*Figure 1.7.14*). The energy-related CO_2 emissions are expected to remain constant based on the expected trend in energy consumption. The process-related emissions are expected to decrease slightly as a result of the reduced use of organic solvents. In contrast, cement production achieved maximum production capacity as early as 1995, and emissions from this are therefore expected to remain constant until 2012.

Industrial chemicals
– a change of direction is on the way

Over the past 10 years, the number of newly registered chemical substances in Denmark has only risen slightly, whereas the number of chemical products registered has grown about 50 times as much (*see Section 1.6*).

The consumption of chemicals is generally increasing, and the current figure for Denmark is about 12 million tonnes of chemicals per year in industry, agriculture and households. Although efforts in the chemicals area have been enhanced through the 1980s and 1990s, industrial use of chemicals in manufacturing and in products is still relatively weakly regulated and industry has virtually free access to use existing substances without prior risk assessment. There is thus no parallel to the regulation of, for example, agricultural use of pesticides.

The overall aim of Denmark's new strategy on chemicals (*see Section 1.6*) is to limit the consumption of hazardous chemicals to the greatest extent possible and to ensure that the manufacture, use and disposal of chemical substances do not result in unacceptable effects on the environment and humans. The framework for Denmark's chemicals strategy is being developed, and one of the conclusions of this work is that a change of direction is needed – the previous strategy of focusing efforts on regulating individual substances based on risk assessment is slow and costly and has proven inadequate. It is thus recommended to shift the focus from individual substances and recipients to enterprises as part of a network and to products in a life cycle perspective. The idea is to activate producers, suppliers and consumers, increase transparency concerning the use of chemicals by enterprises, promote dematerialization (increasing resource efficiency) and strengthen use of the precautionary principle (*see Section 1.6*). Further, it is considered important to clearly state government policy on the future use of chemicals so as to enable industry to make long-term investments.

The EU is developing a strategy for a future chemicals policy. A key part of this is to change the burden of proof making industry responsible for proving that chemical substances are safe to use before they can be placed on the market. In future, new and existing

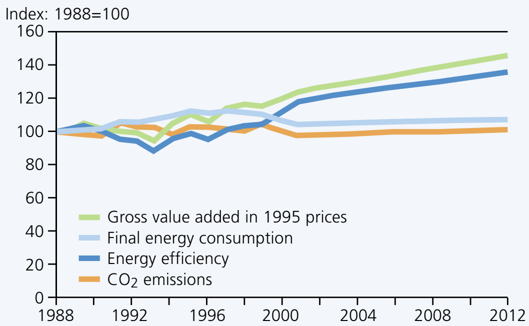


Figure 1.7.14

Historic and projected trends in gross value added, final energy consumption, energy efficiency and CO_2 emissions in the manufacturing industry.

(Source: Danish Energy Agency, 2001b).

chemical substances will be processed in a system that details the data required before a substance can be placed on the market. An authorization system will be established for the most hazardous substances such that they may only be placed on the market for specific uses and in accordance with special permits. New directives will soon be adopted in this area to establish the specific guidelines.

Transport

Both passenger and freight transport have increased throughout almost the whole of the 20th century and are expected to continue to increase in the coming decades, especially road and air traffic.

Road transport dominates transport as a whole. Economic growth has historically resulted in a growing number of cars and increasing road traffic. The Danish Road Directorate projects that growth in car traffic will continue to follow economic growth in the future, but that the rate of increase will decline. Thus, annual growth in the number of cars, which averaged about 25,000 per year over the past 10 years, is expected to decrease to an average of 7,000 cars per year over the next 10 years, among other reasons due to the 1998 tax reform, which increased the price of petrol. Growth in car traffic, which has been around 3.4% per year since 1988, is also expected to slow. Traffic growth up to 2010 is thus expected to average about 1.6% per year. It is thus assumed that some decoupling will take place between economic growth (which is expected to be about 2% per year) and transport, mostly because prices will increase.

Lorry transport and especially van transport are also expected to increase. In contrast, other modes of transport (bus, rail and ship) are not expected to increase substantially in the long term depending on such factors as investments and changes in prices and fares.

All other things being equal, road transport is thus expected to become even more dominant. Domestic air traffic, which declined markedly after the opening of the Great Belt Fixed Link, is expected to increase even more rapidly than road transport. International air traffic is also expected to grow strongly. Within the EU alone, air traffic measured in passenger-kilometres has increased by 50% over the past 10 years.

The environmental impact of transport

The future impact of transport on nature and humans differs among the various environmental problems, e.g. climate change, air pollution, noise, etc. With some problems, the impact will increase relative to the present level – in others it will decline even though the volume of transport increases. These differences are due to the fact that the opportunities to reduce the individual environmental impacts differ markedly, and that environmental changes in transport systems and transport behaviour can take a long time. In some cases technological solutions can markedly reduce environmental impacts, an example being vehicular emissions of NO_X and hydrocarbons. In other cases, practical or economic barriers prevent the problems from being solved fully using technical means, an example being CO_2 emissions, noise, the urban environment, disturbance of natural ecosystems and road deaths – at least as the situation is at present.

The future trends in environmental problems associated with transport will depend on the initiatives implemented to regulate or limit traffic and to introduce more environmentally sound technology. The overall goal, both in Denmark and internationally, is to achieve sustainable development in the transport area. Denmark's national strategy for sustainable development from 2001 designates some important environmental priorities within the transport area:

- Growth in the impact of transport on the environment and human health should be decoupled from economic growth
- Health, environment and safety considerations should be integrated into transport policy
- The transport sector should contribute to reducing negative impacts, especially related to greenhouse gas emissions, air pollution harmful to human health, traffic noise, road safety and disturbance in plant and animal habitats.

In addition, a number of specific environmental targets have been set for development of the transport sector in Denmark. These targets can be considered as steps on the way to more sustainable transport. In May 2001, the OECD Environment Ministers adopted the "OECD Environmental Strategy for the First Decade of the 21st Century". This strategy refers to the OECD "Guidelines on Environmentally Sustainable Transport" which will be included in the continuing work of formulating the Danish strategy for sustainable development. Issues of importance for future development in the transport area are:

- Whether the demand for transport will continue to increase at the same rate as economic growth, or whether the two can be decoupled
- Whether technical solutions to the most important environmental problems can be developed and implemented at a sufficiently fast pace
- Whether the population's lifestyles, the development of the urban structure and the organization of business will be based on increasingly transport-intensive solutions, or whether alternative models will gain ground.

Projections of the trend in transport sector emissions of NO_X and CO_2 from 1988 to 2030 (*Figures 1.7.15 and 1.7.16*) are based on forecasts of energy consumption by the transport sector prepared in connection with Denmark's action plan for reducing transport sector CO_2 emissions. For NO_X, emissions for the individual modes of transport are calculated on the basis of the same projection. The expected baseline projection given the measures already adopted is compared with Denmark's applicable targets and benchmarks. The baseline projections include the effect of all adopted requirements and agreements regarding emissions from the various means of transport, including the EURO IV standards for motor vehicle emissions that will enter into force from 2006 onwards, as well as the agreement between the EU and automobile manufacturers on reducing CO_2 emissions from new cars.

The emissions of NO_X are projected to decrease very steeply, largely due to the impact of increasingly stricter standards for motor vehicles, especially cars, but also lorries and vans. In about 2020, the effect will flatten out when the vehicle fleet has largely been replaced. Thus, the trends in road transport volume and in NO_X emissions will be decoupled. The specific targets for reducing transport sector NO_X emissions are 40% from 1988 to 2000 and 60% by 2010. The target for 2000 is unlikely to be achieved, whereas it should be possible to achieve the target for 2010 (*Figure 1.7.15*). A similar trend is expected for hydrocarbon emissions, but the reduction will be even greater and it seems that all applicable targets can be achieved.

CO_2 emissions are directly linked to trends in transport and energy consumption, and the trend is therefore less positive than for NO_X. Since 1988, emissions have increased by about 20%, and further growth can be expected in the future (*Figure 1.7.16*). The projected long-term trend if no new measures are adopted (the baseline projection) flattens out in about 2005–2010, largely because the projection takes into account the new EU agreement with the automobile industry in Europe, Japan and South Korea on achieving average emissions for new cars of 140 g of CO_2 per km. According to information provided by the European automobile industry, the CO_2 emitted by new cars fell by nearly 3% in 2000, thereby bringing the trend on course towards the agreed target.

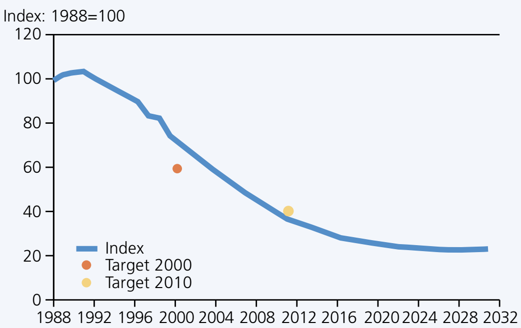


Figure 1.7.15

Historic trend in indexed transport sector NO_x emissions and projected trend taking into account the adopted reduction measures. The projection is based on forecasts of energy consumption by the transport sector. Off-road transport, military transport and international transport are omitted. (Source: Danish Energy Agency, 2001b; Danish Road Directorate, 2000, supplemented with NERI's current assessment of the trend in transport emission factors).

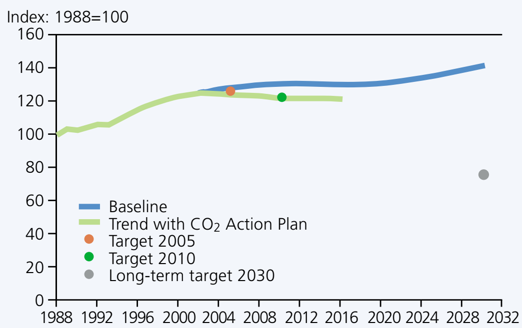


Figure 1.7.16

Historic trend in indexed transport sector CO_2 emissions and projected trends for a baseline scenario taking into account the adopted reduction measures and for a scenario including implementation of the CO_2 Action Plan. Current and long-term targets are indicated. Note: The projections are based on the same assumptions as in Figure 1.7.15. Off-road transport, military transport and international transport are omitted. The targets are described in Section 1.4. (Ministry of Transport, 2001).

An action plan stipulating targets for Danish transport sector CO_2 emissions and proposals for specific initiatives and instruments was adopted in April 2001 (*see Section 1.4*). The baseline projection combined with the implementation of the CO_2 action plan (*Figure 1.7.16*) is expected to ensure attainment of the target of stabilizing emissions by 2005 at the 2003 level and of reducing emissions by 7% in 2010 relative to the baseline projection. However, emissions are expected to increase in the long term if additional initiatives are not adopted. Denmark's benchmark of reducing CO_2 emissions by 25% in 2030 relative to 1988 will require more extensive intervention, including changes to transport volume and technology.

Transport also influences the environment and human health, especially in urban areas. Denmark has adopted specific targets for particulate emissions and noise from transport. Calculations show that it will probably be possible to achieve the target of a 50% reduction in the total amount of particulates in towns in 2010. Attention is expected to increasingly focus on the fine particles, which are the most harmful to human health (*see Section 2.3*).

The World Health Organization (WHO) has adopted air quality guidelines with limit values for numerous harmful pollutants, including fine particles. The EU has adopted binding limit values that will apply from 2005 and 2010. Model calculations show that ambient air quality in towns will improve in the future, especially as a result of reduced vehicular emissions. The calculations show, however, that some of the WHO limit values could be exceeded along busy urban streets in Denmark (*Table 1.7.3*). The EU limit values, in contrast, will probably be complied with. However, it is uncertain whether the limit value for particulates in 2010 can be complied with.

The target for noise is that no more than 50,000 homes should be exposed to noise nuisance by 2010. The Danish Environmental Protection Agency expects that attainment of this target will require additional initiatives beyond those already planned. An action plan on noise is being drawn up (*see Sections 5.3 and 5.4*).

Photo: 2. maj/Sonja Iskov

Table 1.7.3
Measured and calculated nitrogen dioxide (NO_2), benzene and ozone concentrations in the ambient air at the major traffic artery Jagtvej in Copenhagen compared with various limit values and standards. (Source: Jensen et al., 2000).

Status	**NO_2**	**Benzene**	**Ozone**
	(µg/m³)	**(µg/m³)**	**(µg/m³)**
1995 observed	52	17.0	29.8
2000 calculated	44	5.2	32.8
2005 calculated	33	2.9	36.6
2010 calculated	23	2.1	39.9
2015 calculated	20	1.9	41.4
2020 calculated	18	1.8	42.3
EU limit value	40	5.0	-
WHO guidelines	40	0.17	-
Danish EPA air quality standard	**15–20**	**0.13–0.25**	**-**

Waste

Waste generation is affected by economic activity. Growth creates increased demand for goods and services. Increased production and consumption increase the waste volume if this is not limited by corresponding technological development.

Waste volumes and waste disposal can be projected using a waste model linked to the macroeconomic model ADAM based on the latest projections for the economy and energy. The model assumes that waste generation follows the trend in economic growth, but takes into account known or expected changes in public behaviour (such as increased sorting at source), new technologies or political initiatives that influence waste volumes.

The environmental effects of waste generation depend not only on the volume of waste but also on the type of waste and the treatment method used. The trend in the total waste generation therefore has to be related to the waste treatment method in order to be able to determine the environmental impact of the waste. In addition to recycling, the main methods of waste treatment are:

- Landfill, which can lead to emission of the greenhouse gas methane and result in hazardous substances leaching to groundwater and contamination of surface waters.
- Incineration, which contributes to air pollution and generates slag, which can be reused in road construction, etc. and fly ash, which must be deposited. Incineration of waste is one of the means of producing energy without using oil, coal or natural gas, and is therefore CO_2-neutral.

Waste 21, Denmark's new action plan on waste, sets a number of targets for waste treatment in the period up to 2004. Many of the initiatives in Waste 21 are related to increased sorting of certain waste fractions with the aim of shifting the waste from incineration to recycling. Another equally important target of Waste 21 is stabilization of the total waste volume.

A baseline projection of the waste volume based solely on the latest projections for the economy and energy predicts a 27% increase in the total waste volume from 2000 to 2020, equivalent to an increase from 13 million tonnes in 2000 to 16.5 million tonnes in 2020.

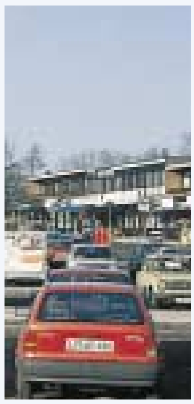


Photo: NERI/Jes Fenger

Photo: Highlight

In comparison, the economic projection predicts a 43% increase in production and a 53% increase in consumption. The model thus predicts that waste volumes will increase more slowly than growth in the economy as a whole. The most important reasons for this slower increase in waste volumes are the declining coal consumption by power plants and the expected low growth in the building and construction sector.

The baseline projection predicts a stronger increase in the amount of combustible and non-combustible waste than in the recyclable fractions such as "paper and cardboard", "glass" and "plastic". This means that the proportion of waste destined for recycling will decrease from 64.8% in 2000 to 62.5% in 2020. Correspondingly, the proportion incinerated will increase from 24.0% in 2000 to 26.4% in 2020. The proportion disposed of by landfill will remain almost constant at about 11%.

A Waste 21 scenario has been prepared on the basis of the baseline projection. This scenario integrates the initiatives in Waste 21 on increased sorting and recycling of the fractions "paper and cardboard", "glass", "plastic" and "organic waste" for the years 2000–2004. No additional assumptions have been made on increased sorting for the period 2004–2020. The results for this period are therefore solely based on the projected economic growth. The Waste 21 scenario does not include initiatives aimed at reducing the total waste volume, since a strategy for this is not expected to be ready until 2002.

Comparison of the Waste 21 scenario with the baseline projection shows a reduction in the mixed waste fraction "combustible" and an increase in the recycled fractions "paper and cardboard", "glass" and "plastic" (*Figure 1.7.17*). The proportion of waste incinerated in 2020 decreases from 26.4% to 24.6%, while the proportion recycled increases from 62.5% to 64.4%.

The Waste 21 Action Plan thus counteracts the declining proportion of recycled waste predicted by the baseline projection such that the proportion treated by the different methods will be largely the same in 2000 and 2020 (*Figure 1.7.18*).

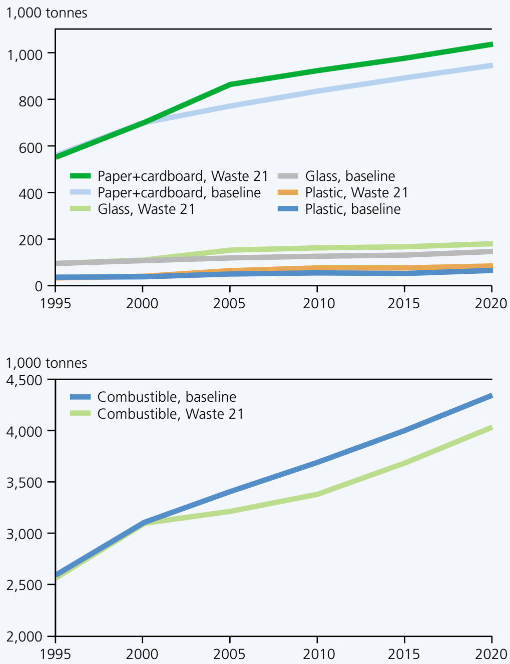


Figure 1.7.17

Comparison of the projected trend in waste volume of selected waste fractions (above) and combustible waste (below) for the baseline scenario and the Waste 21 scenario. (Source: Danish Environmental Protection Agency, 2001).

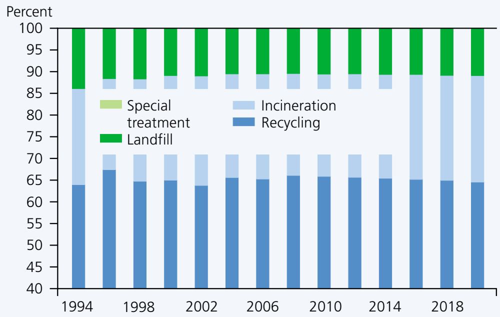


Figure 1.7.18

Projected trend in waste treatment method for the Waste 21 scenario.

(Source: Danish Environmental Protection Agency, 2001).