5. Economic analysis

The present section summarizes the results of the economic part of the Article 5 characterization and analysis for Odense River Basin (COWI, in press). This has to include a projection for societal development in the basin in relation to water use as well as provide an economic basis for the subsequent assessment of possible measures in the programme of measures for the basin. As a consequence, the economic part of the Article 5 characterization and analysis will to some extent consist of a number of descriptive data aimed at facilitating subsequent analysis.

In carrying out the economic analysis it has become clear that much of the information needed is not immediately available. To obtain a broad picture of the water use in a basin such as Odense River Basin, the analysis has to be based on relatively rough estimates of many central indicators.

According to the WFD, the term "water use" is to be understood in its widest sense. In addition to encompassing water abstraction/water consumption, wastewater discharge and water management, water use also has to encompass activities within the household, industrial and agricultural sectors of significance for the chemical and ecological status of the water.

Conversely, the use of water for recreational purposes is not encompassed by "water use" in the Article 5 characterization and analysis. However, the recreational value of water (bathing, angling, etc.) can be included in connection with the economic assessments in the programme of measures.

5.1 Aim of the economic part of the Article 5 characterization and analysis

The economic part of the Article 5 characterization and analysis has the following primary aims:

- Assessment of the economic significance of water use
- Analysis of trends in activities within the basin, including water consumption, wastewater treatment, production conditions, etc. up to 2015
- Assessment of the current recovery of costs in the water sector.

The main aim of all three elements is to contribute in the economic area to the assessment of how water use will develop and hence whether further measures will be needed in order to attain the long-term objectives for water quality.

5.2 Assessment of the economic significance of water use

The economic significance of water use is difficult to measure. From the economic point of view it can generally be argued that consumers will demand a service until the price corresponds to the marginal benefit of the consumption, i.e. an enterprise will use water until the production value added for the last m^3 of water purchased corresponds to the price of that m^3.

Another example could be watercourse maintenance, which primarily serves to drain farmland. This service is largely and has traditionally been publicly financed. In this case demand will not be determined by the price of the service, but alone by the farmer's expectation of obtaining an additional profit from the drained land. In addition to the direct costs of the drainage, moreover, this also includes the indirect costs to society of enhanced pressure on the environment resulting from drainage.

In practice, the expenses for water and water-related services are relatively low in relation to other production costs or in relation to household incomes. At the same time water is a vital necessity or a necessary production factor in many contexts, and the value of the different water uses is therefore significantly higher than the expenses that can be calculated from the actual price and amount.

As no actual studies of the total value of the individual water uses are immediately available, proper measurement of the value of the water is not possible. The significance of the water can only be described using different indicators. The indicators used here are:

- Total expenses apportioned by different types of water use and the administration of these
- Expenses seen in relation to production value added or income.

The analysis is based on subdivision into the following sectors: Households, industry, agricul-

Table 5.1
Trend in demand for water and abstraction volume of groundwater and surface water in Odense River Basin. Intake of seawater from Odense Fjord for cooling by Fynsværket CPH plant is not included.
Source: COWI (in press).

10^3 m^3	1997	1998	1999	2000	2001
Households – waterworks water	11 538	10 841	10 578	10 639	10 209
Industry – waterworks water	3 070	2 885	2 815	2 831	2 716
Farms and market gardens – waterworks water	2 829	2 658	2 594	2 609	2 503
Institutions and services – waterworks water	2 588	2 432	2 373	2 387	2 290
Households – own plant	1 433	1 433	1 433	1 433	1 433
Industry – own plant	2 637	2 772	3 035	3 085	2 864
Farms and market gardens – own plant for irrigation	3 667	2 566	2 336	2 878	2 462
Total	27 763	25 587	25 163	25 861	24 478

ture and the public sector. By way of introduction, the recent trend in demand for abstracted water is presented.

It is important to emphasize that calculated figures for expenses, etc. are often based on estimates and hence are subject to some uncertainty. The figures therefore primarily present a picture of the order of magnitude for the individual water uses.

5.2.1 Trend in water demand

The trend in the amount of water abstracted is illustrated in Table 5.1 apportioned by type of abstraction and consumer. The amounts encompass both groundwater and surface water. Groundwater accounts for 95% of the water abstracted in the basin. Abstraction of surface water is primarily accounted for by industrial plants.

The demand for water has been decreasing for many years, and hence also over the last few years. It is mainly consumption of waterworks water that has decreased. The figure for abstraction by single plants is an estimate as far as concerns households, and the precise trend is therefore unknown. As regards industrial single plants, there is no clear trend; the same applies to abstraction for irrigation. As far as concerns irrigation, annual fluctuations in precipitation must play some role in determining water needs.

Table 5.2
Production value and gross value added for the business sectors in Odense River Basin in 2001 (rounded values). Source: Statistics Denmark and own calculations.

DKK million (2001 prices)	Production value	Gross value added
Agriculture and market gardens	2 800	1 700
Industry and services	80 050	40 700
Industry	29 800	11 200
Services	50 250	29 500
Total	82 850	42 400

5.2.2 Economic significance of the commercial sectors

In the following sections the expenses associated with the different water uses are examined for the three main sectors: Households, industry/services and agriculture/market gardens. For the two commercial sectors, the expenses are related to each sector's total production value.

The production value is a measure of the turnover in the sector. Relating the expenses for the water uses to the production value thus gives an impression of the significance of the different water uses as production factors. Deducting the expenses for raw materials and intermediate products from the production value yields the value added, which is the value created by the primary production factors soil, manpower and capital. Production values and gross value added for the commercial sectors are shown in Table 5.2.

The figures are based on values for gross value added in Fyn County, down-scaled to Odense River Basin on the basis of population size. The production value is calculated on the basis of a national mean for the relationship between production value and gross value added.

The service sector, which also includes the public sector, is the largest sector, followed by industry, with agriculture and market gardening being the smallest. The real significance of the individual sectors is difficult to measure completely using these indicators, though, for example because agriculture supplies a large number of manufacturing industries.

	Total	Per capita	Per m³	Percentage
	DKK million/yr	DKK/yr	DKK/yr	
Water charge	80	320	7	23%
Wastewater disposal charge	140	580	12	40%
Total service charges	**220**	**900**	**19**	**63%**
Water levy	60	230	5	17%
VAT	70	280	6	20%
Total taxes	**130**	**510**	**11**	**37%**
Total expenditure	**350**	**1 410**	**30**	**100%**

Table 5.3
Overview of household expenses for water and wastewater disposal in Odense River Basin in 2001.
Source: COWI (in press).

5.2.3 Households

Households consume drinking water, discharge wastewater and use the water bodies in the basin for a number of recreational purposes. From the value point of view, it is possible to determine household sector expenses for drinking water and for wastewater disposal and treatment.

The main groups of household expenses associated with water use are summarized in Table 5.3. A number of the taxes that have to be paid are included here in order to be able to assess the size of the total costs.

The expenses for consumption of drinking water are calculated on the basis of a distribution of the total production costs in relation to the household sector's share of the consumption. The expenses for drinking water also include a charge to cover groundwater mapping by the Counties. The household sector's contribution to this mapping is expected to amount to approx. DKK 2 million.

Expenses have not been calculated for actual pollution-limiting measures to protect the groundwater, measures that are part of the current planning of the future groundwater protection initiatives.

With respect to wastewater, there are no immediately available calculations of the amount discharged apportioned by consumer groups. This expense is therefore estimated as households pay for disposal of the same amount of wastewater as their water consumption.

The expenses for wastewater include part of the wastewater levy, which is determined by actual discharges of BOD_5, N and P. The levy is included as part of the cost of the actual service as the households have no direct influence on the size of the levy. No figures are available of the size of the wastewater levy for Odense River Basin.

Based on the combined national proceeds and the proportion of the population inhabiting the basin, the levy can be estimated at just over DKK 10 million. Of this the households pay just under half.

The table shows that household expenses for wastewater disposal comprise almost two thirds of the expenses for the actual services. To this must be added the specific tax on water consumption of DKK 5/m³ which, together with VAT, comprises one third of the total costs.

If the calculated costs per m³ are compared with water fees it should be noted, for example,

	Unit	Expenditure in % of income	
		Income (pre-tax)	Income (disposable)
Service charges	%	0.7%	1.0%
Taxes (levy and VAT)	%	0.4%	0.6%
Total expenditure	%	1.0%	1.6%
Total income for all households	DKK million	33 750	21 940
Average per capita income	DKK thousand	136	88

Table 5.4
Percentage of household income used on water and wastewater disposal.
Source: COWI (in press).

that the meter charge helps cover the costs, and that the variable part of the fee for drinking water will be less than that stated in the table. The cost of one m^3 of water is typically DKK 4–6.

These expenses can be compared with household income in order to provide an impression of how much households spend on water and wastewater disposal. Out of its total income, an average household pays only approx 1% for water and wastewater services, including taxes. If the cost is related to disposable income, i.e. income after tax, the percentage is somewhat higher (see Table 5.4).

5.2.4 Industry/services

Like the households, industry/services use drinking water and have to dispose of their wastewater. A small number of enterprises in the basin have their own water supply, and a couple of them have their own wastewater outfall. To this should be added Fynsværket Combined Heat and Power plant, which uses large amounts of fjord water as cooling water to cool down steam from the turbines. This heated water is subsequently led out into the lower reach of the River Odense.

In addition to the above-mentioned expenses, a minor fee for the protection of the groundwater against soil contamination is included. In this respect, a rough estimate has been made of the expenses for remediating contaminated sites that are paid by members of the public. This cost has been ascribed to industry/services, even though a minor share might be defrayed by households.

Expenses incurred by industry/services for water and wastewater disposal are summarized in Table 5.5. These expenses are placed in relation to the industry/services production value. This measure is an attempt to determine the proportion of the sectors' total production costs comprised by water and wastewater services, and hence how important water use is as a production factor.

It should be noted that industry's expenses for complying with various discharge criteria are not included. Such expenses are not calculated in Denmark as they are often process-integrated, and it is thus quite random how much is ascribed to environmental requirements and what is operation-related improvements in production.

The relative expenses for industry alone are somewhat higher since water and wastewater together account for approx. 0.6% of the production value, as compared with 0.1% for the service sectors alone.

5.2.5 Agriculture/market gardens

Agriculture is a central sector in the analysis of the existing water use in that it accounts for the greatest proportion of nutrient loading of surface waters and groundwater in the basin. The environmental pressure is an unintentional side effect of the intensive production. The calculations of agricultural expenses associated with water use include an estimate of the annual expenses associated with pollution-limiting activities. First and foremost, these encompass expenses associated with the implementation of the nationwide Action Plan on the Aquatic Environment II.

Agriculture uses water as a necessary input to both livestock and crop production. The sector primarily uses water abstracted from the public waterworks in livestock production. Field irrigation is primarily based on individual abstraction wells, and accounts for approx. 50% of combined

Table 5.5
Industrial and service sector expenses for water and wastewater disposal (excluding Fynsværket CHP plant expenses for cooling water, cf. text).
Source:
COWI (in press).

	Expenditure (DKK million)	Expenditure in % of production value	Percentage
Water consumption	54	0.07	25
Wastewater	158	0.20	72
Other expenses	6	0.01	3
Total expenditure	218	0.27	100

Table 5.6
Agricultural and market gardening sector expenses associated with water use in 2001 (excluding expenses for drainage and dyke associations, cf. text).
Source:
COWI (in press).

	Expenditure (DKK million)	Expenditure in % of production value	Percentage
Water consumption	34	1.2	60
Household wastewater	2	0.1	4
Agro-environmental measures (APAE II)	8	0.3	15
Pesticides levy	12	0.4	21
Total expenditure	56	2.0	100

water consumption by agriculture and market gardens in Odense River Basin.

In addition, drainage measures have been or are being carried out in the form of the drying-out of wetlands, watercourse regulation, drainage and watercourse maintenance in order to optimize agricultural production and maximize the size of the area suitable for cultivation. At the same time, these measures enhance pressure on the environment due to a reduction in the natural self-purification capacity of the soil. Expenses for these drainage measures are paid for by agriculture with respect to wetland drainage (pump and dyke associations), and by the Counties and Municipalities with respect to watercourse maintenance. In 2003, the expenses for the operation and maintenance of 11 private pump and dike associations are calculated to be approx. DKK 1.3 million incl. VAT. To this should be added indirect expenses for society as a consequence of the increased pressure on the environment, for example increased wastewater treatment.

Expenses associated with wastewater are estimated on the basis of just under 2 000 farms in the basin. The latter are assumed to be connected to an emptying scheme for sewage sludge from the individual mechanical treatment facilities, while at the same time paying the wastewater levy of DKK 3.8 per m^3. These expenses each correspond to approx. DKK 1 million per year. The expenses for the pesticide tax have been calculated from the proportion of arable land in Odense River Basin relative to that in Fyn County as a whole and the total tax proceeds.

Estimated water use expenses for agriculture/market gardens are shown in Table 5.6 and expressed relative to production value.

Agriculture's own expenses for their agri-environmental measures account for just under 15% of the sector's total expenses immediately related to water use in Odense River Basin. Expenses for environment-related green taxes (tax on pesticides) account for 21% of the total expenses.

Relatively, the expenses for water use comprise a higher proportion of agriculture/market garden production value than is the case with industry/services. The percentage is still relatively small, though.

5.2.6 The public sector

The State, Counties and Municipalities undertake a large number of tasks in connection with management of the water bodies of Odense River Basin. An overview of the total expenses is given in Table 5.7 subdivided by two types of task as well as by type of authority. The first of the two groups of task is planning, supervision and monitoring, while the other is construction, operation and maintenance. The latter group encompasses expenses for watercourse maintenance, subsidies and support for the establishment of wetlands, ESAs, organic farming, etc.

	State	Fyn County	Municipalities	Total
Planning, environmental supervision and monitoring	3 900	27 800	3 800	35 3500
Environmental construction, operation and maintenance	13 200	5 700	2 800	21 700
Total	17 100	33 500	6 600	57 200

Table 5.7 Overview of public sector expenses associated with the management of water bodies in Odense River Basin in 2001 (DKK thousand). Source: COWI (in press).

Fyn County accounts for almost 60% of the public sector expenses for water management in the basin. Monitoring and registration of the groundwater resources comprise the largest item of expenditure, accounting for nearly DKK 12 million per year. Planning and monitoring of surface waters is the second largest item, accounting for just over DKK 7 million per year, while watercourse maintenance accounts for approx. DKK 4 million per year.

5.2.7 Cost-effectiveness

The next phase of the implementation of the Directive entails the assessment of possible measures to help meet the WFD's objectives for water bodies in Odense River Basin. Based among other things on the above-mentioned expenses for different sectors, however, it is possible to estimate the cost per unit nitrogen reduction from both municipal wastewater treatment plants and agricultural sources (see Table 5.8).

With the measures directed at agriculture, the average cost per unit N reduction varies from approx. DKK 5 per kg N for such measures as the

	Cost-effectiveness
	DKK/kg N
Additional N reduction from municipal WWTPs[1]	73
Average cost of agricultural measures[2]	23

Table 5.8 Cost-effectiveness of measures to reduce nitrogen loading. Source: 1) BERNET Regional Action Plan – Fyn County . 2) Action Plan on the Aquatic Environment II – Midterm evaluation.

establishment of wetlands or increased requirements for the utilization of the nitrogen content of manure, to more than DKK 146 per kg N for the establishment of organic holdings. The latter type of measure also entails other positive environmental effects in addition to the reduction in nitrogen loading, however.

The great difference in the cost per kg N reduction illustrates the need for and the benefit of assessing the cost-effectiveness of alternative measures.

Apart from the above-mentioned types of measure, the cost-effectiveness assessments will also have to include environmental measures such as changed watercourse maintenance. This measure will encompass both cost savings in the form of reduced maintenance work and expenses in the form of reduced agricultural yield. Other measures affecting drainage of floodplain soils also have to be included in a cost-effectiveness analysis.

5.3 Trends in water use

In order to be able to assess the future environmental pressures in the basin it is relevant to determine whether there are economic trends that might affect the possibilities for attaining the environmental objectives established. The following section briefly discusses the trends in the water use by the individual sectors.

5.3.1 Trend in water consumption

Water consumption is an essential indicator of water use. A projection of water consumption up to 2015 based on the trend in water consumption over the past few years is shown in Figure 5.1.

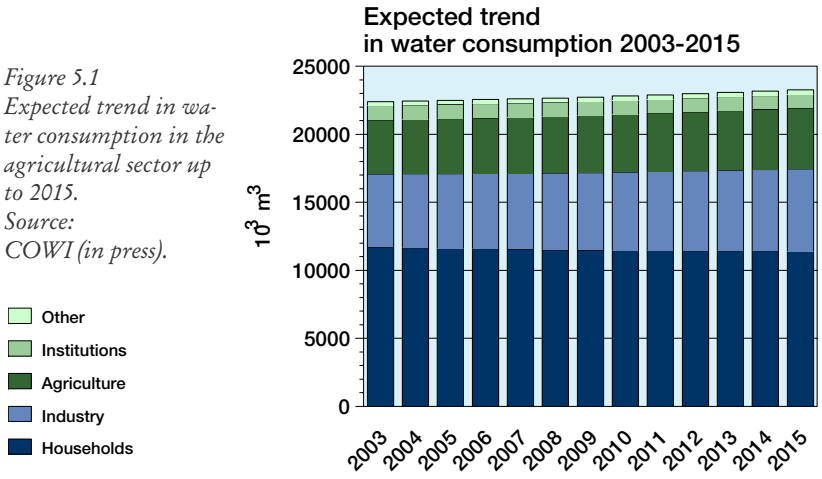

Figure 5.1
Expected trend in water consumption in the agricultural sector up to 2015.
Source:
COWI (in press).

The fall in water consumption over the last few years is expected to cease as a result of slightly increasing demand for water over the period. Thus a slight increase in demand is expected in industry and agriculture, whereas household consumption is expected to continue to fall as a result of the ongoing water saving campaigns. Various analyses of the susceptibility of this result to changes in the assumptions show, moreover, that it is unlikely that any major changes in water consumption will occur.

Thus there is nothing in either household behaviour or in the expected development in the industrial and service sectors that can be expected to lead to substantial changes in water consumption in Odense River Basin during the period up to 2015.

5.3.2 Trend for households

With respect to households, a slight fall in water consumption is expected. Even though continued economic growth and ensuing wealth can draw in the direction of increasing water consumption, this will be counteracted by increasing drinking water prices. Increasing expenses to combat groundwater contamination will entail increasing prices.

As regards wastewater, pollution from sparsely built-up areas will be reduced. Approx 10% of the households in the basin are not connected to the sewerage system.

Discharges from all sources connected to the sewerage system, and hence to the treatment plants, are only expected to be reduced marginally. The wastewater treatment plants in the basin more than meet the current requirements concerning removal of organic matter, nitrogen and phosphorus.

5.3.3 Trend for industry/services

As with households, no substantial changes are expected for industry/services as regards water consumption or wastewater discharges. The only major change would be if the use of surface water from Odense Fjord for cooling by Fynsværket CHP plant were changed. A proposal for a solution to this problem already exists. The expenses for solving Fynsværket CHP plant's cooling water problems by separating the River Odense and the cooling water canal are estimated to DKK 10 million. Consumption of cooling water by the plant is not included in Figure 5.1 as this solely encompasses fresh water.

5.3.4 Trend for agriculture/market gardens

Of absolute central importance for expectations regarding future water use is the trend in the agricultural sector. Currently, a number of analyses are being undertaken in the sector with the aim of determining how agricultural production conditions will develop. For instance, these analyses will look into whether the trend towards increasing pig herds seen in recent years will continue, and will encompass an assessment of the environmental effects of Action Plan of the Aquatic Environment II in Odense River Basin. The trend in climate is also to be incorporated in the analyses. Not until these analyses have been completed will it be possible to make an actual projection of loading in the basin.

5.3.5 Other trends

With regard to future conditions it should be mentioned that the implementation of measures directed at stormwater discharges are expected.

5.4 Cost recovery

The assessment of the degree of cost recovery depends on which cost elements are included. The following section summarizes the degree of cost recovery for the actual obligatory supply services in relation to the direct production costs associated with these services.

In addition to the direct production costs and the administrative costs, the cost recovery could also be assessed in relation to the environmental and resource-related expenses that result from current water use in its broadest sense.

The production of drinking water can be considered to entail two types of environmental and resource-related costs: If groundwater abstraction is greater than groundwater recharge due to precipitation, the resource will diminish, leading to increased costs for the future drinking water supply. The second type of cost is that associated with the effects on the natural habitats if abstraction results in reduced water flow in the basin's watercourses. No data are available that render an assessment of these costs possible.

Leaching of nitrogen and phosphorus is one of the chief environmental problems facing the water bodies in the basin. Agriculture is the primary source together with discharges from sparsely built-up areas. As with the above-mentioned conditions, no data are available that can clarify the environmental costs.

The current work on planning measures to protect the groundwater and implementation of the WFD both aim to reduce pollution and other undesirable pressures on the aquatic environment. The introduction of green taxes or levies in order to recover the environmental and resource-related costs that water use imposes on the aquatic environment must be considered as a regulatory instrument to attain the Directive's objectives.

5.4.1 Assessment of the degree of cost recovery

Common national regulations for the price-setting of water and wastewater apply in Denmark. The principles entail full cost recovery for obligatory supply services such that all costs in connection with obligatory supply services have to be recovered in accordance with the "polluter pays principle".

All water and wastewater services supplied within Odense River Basin are thus subject to full cost recovery. It is not possible to assess the extent of any possible cross-subsidizing between consumer groups. In most cases, identical prices apply to every one. However, this could be tantamount to some sort of subsidy. If the real distribution costs are less per m^3 for consumers with a very high consumption, they should pay less per m^3. That is also what happens to a certain extent, but it has not been possible to assess it more closely.

In the wastewater area it is possible for the individual Municipality to stipulate special charges depending on the pollutant content of the wastewater.

With respect to industry and in relation to the Odense Fjord, an example of the application of a special form of the "polluter pays principle" can be mentioned. In this case, Fynsværket CHP plant paid DKK 50 million to Odense Municipality at the beginning of the 1990s as a charge for compensatory wastewater treatment to take account of the plant's heat effect on Odense Fjord.

Cost recovery can also be assessed in relation to recovery of the administrative and management-related services that are primarily taken care of by the public sector. To the extent these services are caused and rendered necessary by the different water uses, it could be argued that they ought to be covered by the uses.

The total public expenses are roughly estimated at approx. DKK 57 million per year. Income from the tax on mains water and from the pesti-

cide tax is estimated at approx. DKK 75 million per year. To this should be added the charge to cover the groundwater mapping (which is included in the price of drinking water) amounting to approx. DKK 4–5 million per year. All in all, this represents more than the cost recovery. However, there is no connection between the management activities and the green taxes in that the public administration is primarily financed through general taxes and charges.

The above-mentioned expenses for water use do not include expenses for measures to protect the groundwater, measures that are being implemented as part of the ongoing work on planning groundwater protection initiatives. The expenses in question include compensation to agriculture in connection with use restrictions on arable land. In principle, these expenses should be paid by the individual waterworks' consumers or be financed by existing EU support schemes.

Of other water uses there is, for instance, agricultural use of watercourses, etc. for drainage of the fields, a use that is not currently encompassed by cost recovery. Moreover, the expenses for nature restoration, including watercourse restoration and establishment of wetlands are not encompassed by cost recovery as these measures are paid by the State, County and Municipalities.

The County and the Municipalities in the basin hold expenses for watercourse maintenance of DKK 3.9 and DKK 2.4 million, respectively, in total around DKK 6.3 million annually. By refraining from weed cutting, etc. a number of fields will be flooded occasionally, thereby hindering their cultivation. On the other hand the drainage measures enhance pressure on the environment from agricultural production, which might eventually need to be compensated for by expensive environmental measures.

No calculations are available of how great the production losses would be if watercourse maintenance and part of the drainage and the such like were not undertaken.

5.4.2 Incentive structure in the price-setting mechanism of the current tariffs

The current consumer taxes comprise an incentive to reduce consumption and discharges, which correspond to the expenses for production of water and disposal of wastewater. For households, the green tax of DKK 5 per m^3 is a further incentive to reduce water consumption. This tax almost doubles the price of water.

The wastewater levy paid by the individual treatment plants depends on the amount of organic matter, nitrogen and phosphorus discharged and comprises a considerable incentive to reduce the discharges. That discharges from wastewater treatment plants more than meet current treatment requirements is probably due in part to the levy.

In addition to the question of further incentives to reduce pollution and environmental pressures through taxes and charges, the Danish Competition Authority has posed the question as to whether the statutory requirement that supply companies in the water area should "rest in themselves" ensures the lowest price for the consumer and a sufficient incentive to improve efficiency.

5.5 Environment-related subsidies

Environment-related subsidies are presently only included in the Article 5 characterization and analysis to a limited extent.

According to Statistics Denmark, environment-related subsidies can be subdivided into environmental subsidies and pollution-related subsidies.

Environmental subsidies encompass product subsidies and other production subsidies with running transfers from public management and service to enterprises and households. The environment-related subsidies are subdivided in the same way as the taxes depending on whether they are related to pollution, energy, transport or resources. It should be noted that what is involved here is subsidies that are assumed to have a beneficial effect on the environment by influencing production and consumption.

The pollution-related subsidies encompass renovation and combustion, area payments and set-aside, other EU schemes, subsidies for fish management, including stocking, subsidies for environmental management and environmental audit, etc. in enterprises, and subsidies for industrial exploitation of environmental technology.