PÖYRY

PROJECT REPORT

CO_2 emissions in eco-societies

July 2009

CONTENT

INTRODUCTION

The aim of this project has been to calculate the annual CO_2 emission level for an average eco-citizen to compare this with the Danish average.
In 2007 the Danish Ministry of Climate and Energy launched a campaign called "1 ton less" (1 ton mindre) which requests each individual Dane to reduce its personal CO_2 emission. As a lead in this campaign, the Ministry established a web-based CO_2 calculator which calculates the individual's CO_2 emissions and indicates saving potentials.[1]

Pöyry AS has been part of the campaign and actually developed the calculations of the Ministry of Climate and Energy's CO_2 calculator. Therefore, the described project is based on the calculator and its background data. The calculator provides all data related to the average Danish CO_2 emissions.
In order to calculate the eco-citizen's average CO_2 emissions, a questionnaire has been sent out to 92 households (196 persons) in three eco-societies in Denmark: Munksøgaard, Hjortshøj and Svanholm. Based on this, we developed the profile for a typical "eco-citizen" and calculated the CO_2 emissions with the help of the Ministry of Climate and Energy's CO_2 calculator (questionnaire, see annex 1). However, because the three eco-societies indicate very different starting conditions, all calculations are also made for each eco-society itself.

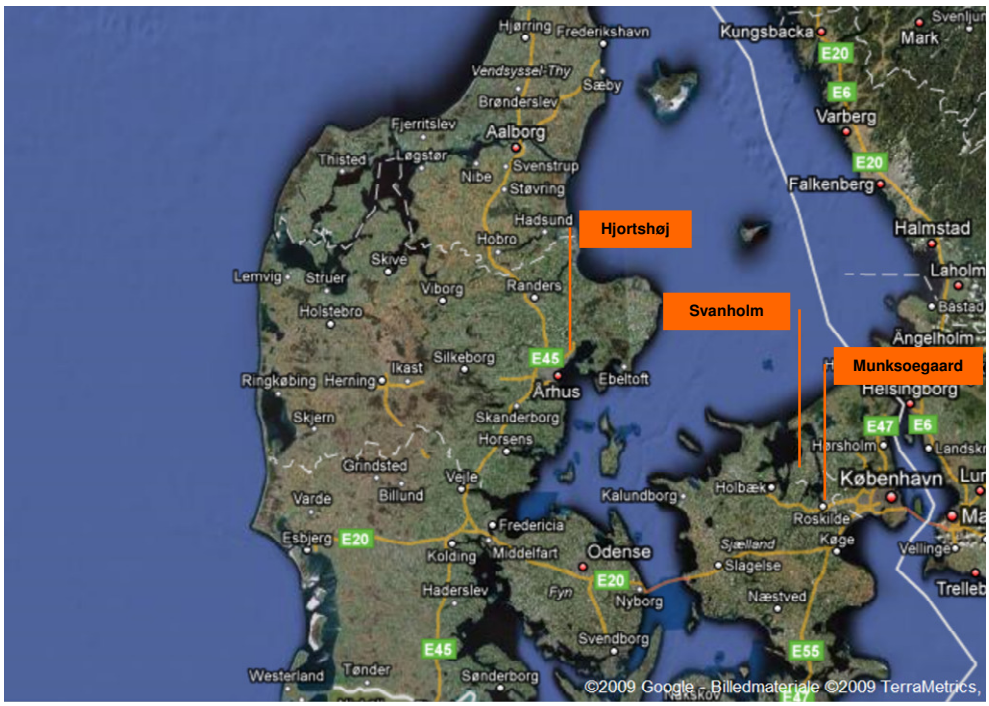

Figure 1: Location of the project's eco-societies

It needs to be mentioned that the collected data material (questionnaires of the eco-societies) has been collected in a very short time period. The interpretation of the data involves a lot of uncertainties. Sometimes, it is not clear if answers refer to a household or an individual person. Also some inconsistency has been discovered among the data. The individual figures do never add up to the eco-society's overall consumption figures given additionally. Anyway,

[1] www.1tonmindre.dk

in our analysis, once the overall data was looking consistent and realistic, we have taken that data first, before using the individuals' data. We have tried to interpret the data as good as we could. Averages are first calculated for each single eco-society and then for the three societies together. Since the three different societies indicate very different data, which complicates the calculation of an average, all calculated averages are presenting weighted average in regard to the number of people living in each society.
Energy consumption figures include agriculture once the eco-society does farm its own food products. Therefore, the energy consumption figures for an average eco-citizen might be relatively high compared to the Danish average from the Ministry of Climate and Energy's CO_2 calculator which includes energy consumption for farming within the CO_2 factors of the good consumption section.

Moreover, transport is the section which indicates highest uncertainties in relation to the collected data material. The reason for this is that the used questionnaire does ask very detailed on distances for each transport mode. Unfortunately it is not always clear, if people answered on an individual basis or for the whole household/family. This is very important for flight trips since a single flight could mean a huge difference in a person's annual CO_2 emission level.

This project only calculates CO_2 emissions. It does not consider other greenhouse gases than CO_2.

RESULTS

An average Danish citizen emits 6.2 tons CO_2 per year due to its direct electricity and heat consumption, the purchase of food and non-food products and its transportation.
Hereby, the main emission sources are all direct energy consuming activities. 32 % of its total annual CO_2 emissions derive from transportation, 26% from its heat consumption and 15 % from electricity use. However, 24% of the total annual emissions stem from the consumption of goods. Only 3% of the annual emissions derive from fresh water consumption.

Hereby it has to be emphasized on that the calculated emission levels only refer to direct CO_2 emissions arising in Denmark. Other GHGs as well as emissions emitted outside Denmark are not included. In regard to emissions deriving from good consumption it has not been considered the overall life-cycle of a product. Instead, emissions are only accounted for until a product reaches the private household.

The below figure indicates the Danish average CO_2 emission level:

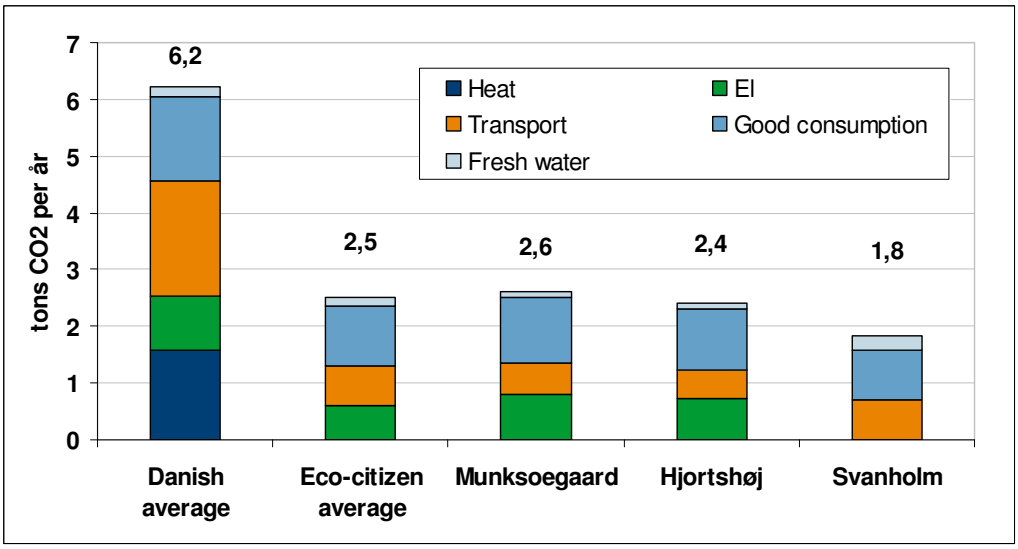

Figure 2: Average CO_2 emissions for a Danish citizen compared with citizens from the different eco societies

In comparison, an average eco-citizen does emit about 3.7 tons CO_2 less than the Danish average. This is mainly due to the renewable heat production, all investigated eco societies applied. Using bio-energy as a heating source results in an emission level of zero. This means, the overall annual emission level of an eco-citizen is already reduced by about 1.6 tons per year only due to heating. The average heat consumption of an eco-citizen is 1825 kWh per year. Comparing with the Danish average of about 5967 kWh, an average eco-citizen is about 4140 kWh lower.

Moreover, an eco-citizen has lower annual CO_2 emissions related to electricity use. Even though, for one eco-society (Svanholm) the average electricity consumption of an eco-citizen is about the same as the average electricity use in Denmark, the weighted average of all eco-societies indicates with 1309 kWh per year a lower el-consumption than the average electricity use in Denmark (1673 kWh). Additionally, the eco-societies produce some of there electricity on their own by renewable sources. This more than offsets the high electricity consumption in Svanholm which is mainly due to their own food farming activities.

Table 1: Average CO_2 emissions for heat, electricity, transport, good consumption and fresh water use, Danish average compared with citizens from the different eco societies

in tons CO_2 per year	Heat	El	Transport	Good consumption	Fresh water	**Total**
Danish average	1.59	0.95	2.02	1.49	0.17	**6.22**
Munksoegaard	0	0.81	0.55	1.16	0.09	2.61
Hjortshøj	0	0.72	0.52	1.07	0.10	2.41
Svanholm	0	0.00	0.71	0.87	0.26	1.84
Eco-citizen average *(weigthed)*	0	0.60	0.70	1.06	0.15	**2.51**

In good consumption, due to own farming and the higher share in organic and eco-labelled products and higher shares of recycling an eco-citizen has slightly lower average emissions (by 0.4 tons per year) than the Danish average.
Annual emission levels due to transportation for an eco-citizen are less than half of the emissions from the Danish average. Very few people in eco-societies have their own car, car sharing is a concept used very much and also public transport, which has usually lower emission factors than private cars, is used more often. Also the number of average flights is less for an eco-citizen compared to an average Dane.

CALCULATIONS AND DATA INPUT

Total emissions from energy and good consumption have been calculated with the help of the CO_2 calculator of the Ministry of Climate and Energy. The input data has been based on the average values from the questionnaires of each eco-society. Hence, it has always been done four different calculations, one for each eco-society plus one for the overall eco-societies' weighted average.

The Ministry's CO_2-Calculator starts by plugging in some basic information regarding the housing condition. In general, for an eco-citizen the used information regarding the type of housing is difficult to reveal in average figures. Therefore we have usually chosen to use the information which fits the majority of the people in the survey.

By the questionnaire, the eco-societies indicated that the majority's type of housing is a terraced house of 90 square meters with 2.4 persons.
The chosen "postal code" (postnummer) has been defined for each of the societies. The postal code decides the carbon factor of electricity and district heating. The eco-societies however produce their own heat and are not connected to district heating. In regard to electricity, there are two societies located east of the Great Belt. Therefore they are given the same postal code. And the coefficient of electricity which applies to the most citizens will be used for both of the societies.
As the primary heating system, a "Central heating, wood/straw /tiled stove" is chosen because this category captures the fact that a society mainly is heated by biomass.

The average eco-citizen is chosen not to have a summer house.

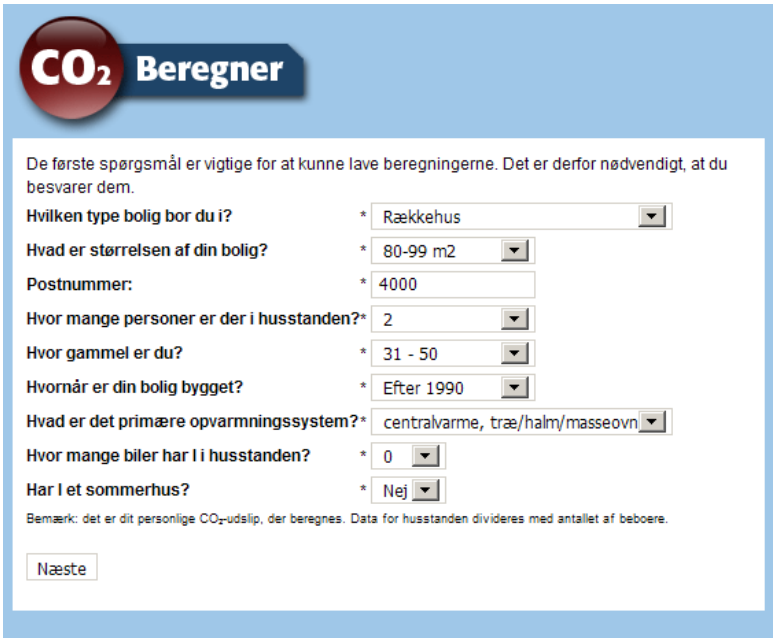

Figure 3: Housing conditions; Data input in the CO_2 calculator of the Energy and Climate Ministry

On the basis of the basic information shown above the type of emissions for an average eco-citizen is calculated and compared with the average of a Danish citizen.

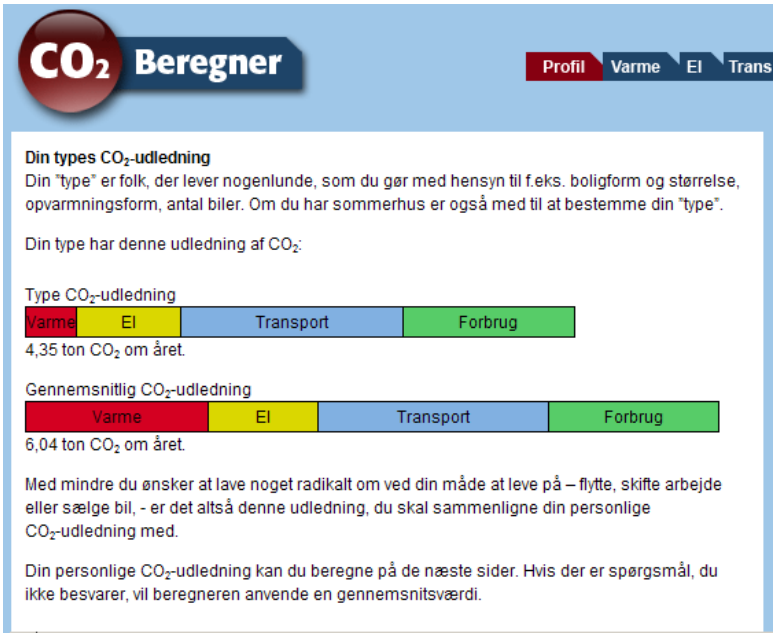

Figure 4: The average eco-citizen emission profile; results from the CO_2 calculator of the Energy and Climate Ministry

In the following calculations of emissions related to energy, good consumption, waste and fresh water use it is assumed that the input data for the housing conditions are the same for each single eco-society.

ENERGY AND TRANSPORT EMISSIONS

Emissions from energy consumption and transportation have been calculated with the help of the CO_2 calculator of the Ministry of Climate and Energy. The input data has been based on the average values from the eco-citizens in each eco-society as well as for the overall weighted average.

Heating

In the CO_2-Calculator biomass is given an emission factor of 0. Thus the size of the heat-/fuel consumption does not affect the total CO_2 emissions for each citizen. Given the information collected in the survey the average heating consumption per household is 4455 kWh which amounts to 1.68 m^3 of wood (given that 0,000378 m^3 of wood is assumed to produce 1 kWh). In average an eco-citizen uses 1825 kWh per person[2] annually for heating purposes.

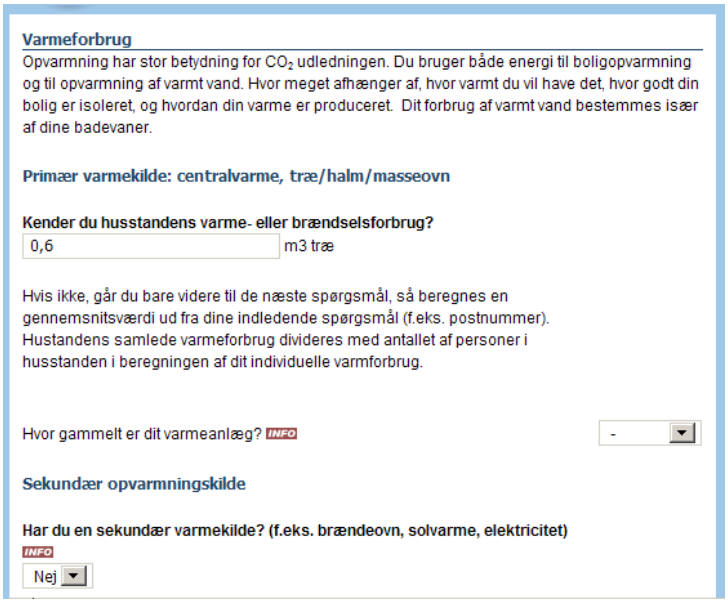

Figure 5: Heating consumption; Data input in the CO_2 calculator of the Energy and Climate Ministry

Due to lack of information we do not know the age of the heating systems. However, this will have no effect when biomass is the energy source used for heating.
It is assumed that an average eco-citizen does not have a secondary heating system.

[2] Svanholm: 3413 kWh/år, Munksoegaard: 1438 kWh/år, Hjortshøj: 1084 kWh/år

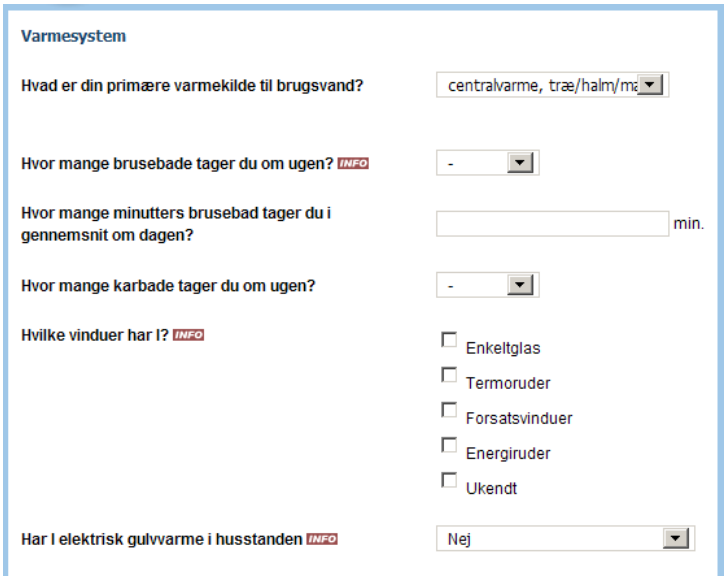

Figure 6: Heating information; Data input in the CO_2 calculator of the Energy and Climate Ministry

Given the data in the survey we cannot say much in general about warm water heating. Therefore it is assumed that the primary source of heating is the same as for space heating. There is no information regarding habits of bathing but still as long as biomass is the source of energy neither this nor the type of windows affects the emissions from a citizen. Based on the survey we conclude that an average eco-citizen does not have electric floor heating.

Given the information above the average CO_2-emission from heat consumption is found to be zero for an eco-citizen.

Electricity

It has been quite complicated to calculate the electricity consumption of an average eco-citizen. Mainly because the eco-societies' conditions vary so much and the societies' own production of renewable electricity differs. Svanholm informs they are self-sufficient with electricity. The supply comes from an own windmill. Power from windmills has a carbon factor of zero therefore Svanholm's electricity consumption cannot be typed into the CO_2-Calculator due to the fact that it would assume the average electricity grid factor for Denmark. So, in the CO_2 calculator, the average electricity consumption per household in Svanholm is set to zero. Furthermore, Munksoegaard uses photovoltaic to produce 640 kWh per year. This consumption has been subtracted from the society's total electricity consumption before typed into the CO_2 calculator. To find the average electricity consumption of an overall average eco-citizen we took a weighted average of the three societies.
The final average is 1309 kWh. Hereby, Svanholm has on average 1667 kWh per year and person, Munksoegaard shows 1243 kWh og Hjortshøj 1116 kWh/year and person.

Figure 7: Electricity consumption; Data input in the CO_2 calculator of the Energy and Climate Ministry

Some of the inhabitants in the societies prepare their meals using electricity while others use gas. Therefore we have chosen a combination in the CO_2-Calculator.
We have received no further information regarding electricity consumption and habits. All following questions regarding electricity consumption in the Ministry's CO_2 calculator are therefore not answered. In the calculator's calculations then, it will assume the Danish average values.

It is assumed that an average eco-citizen does not have a solar cell plant.
On the basis of the information regarding electricity the emissions from electricity consumption of an average eco-citizen is 0.6 ton CO_2.[3]

When it comes to transportation it should be noted that the calculations contains substantial uncertainties especially due to the fact that it is uncertain whether the person who has filled out the survey describes her own transportation habits or the household as a hole. Unless the respondent has made the specific note that the answer treats the entire household it is assumed to be strictly personally.

Transport

From the results of the survey it is difficult to say that a typical eco-citizen only uses one source of transportation because most of the answers reveal a combination of different kinds of transportation. The average daily distance of transportation is estimated at 24 km. Munksoegaard has 27 km per person and year and Hjortshøj indicates 16 km per year. Svanholm indicates 621 GWh/year for the whole societies' transport energy consumption. This figure cannot be used at all. Hence the above average only regards the two other eco-

[3] Svanholm: 0 ton/year, Hjortshøj: 0.72 tons/year and Munksoegaard: 0.81 tons/year

societies. Moreover, this applies to the following description of all values regarding transportation in the below text.

Figure 8: Daily transportation; Data input in the CO_2 calculator of the Energy and Climate Ministry

The average distance driven by eco-citizens in cars, they do not own, is 1,968 km per year.[4]

Figure 9: Transportation by car; Data input in the CO_2 calculator of the Energy and Climate Ministry

On the basis of the survey it has been found that an eco-citizen travels 3,987 km by public transportation per year and takes 1.03 trips in Europe and 0.15 travels overseas per year by plain.[5]

It should be noted that the data regarding air travelling are attached with big uncertainties. From the survey it seems as many have misunderstood the questions regarding air travel. For example in the question: "How many travels by plain do you undertake per year?" many have

[4] Munksoegaard: 1448 km per year, Svanholm: n.a. , Hjortshøj: 2650 km per year
[5] Svanholm: n.a.; Hjortshøj: 4037 km per year, 0.7 flights in EU, 0.1 flight overseas; and Munksoegaard: 3949 km per year, 1 flight in EU, 0.21 flight overseas

answered the total number of trips by plain. The following three questions regarding domestic European and overseas air travelling it seems as if many has answered how many trips the conduct in general and not only by plain. We therefore have been forced not to interpret on the results and this can be a source of possible erroneous conclusions.

Figure 10: Transportation by public transport; Data input in the CO_2 calculator of the Energy and Climate Ministry

On the basis of the input above an eco-citizen has been found to emit 0.7 ton of CO_2 due to transportation.[6]

Figure 11: Emissions for transportation; Data input in the CO_2 calculator of the Energy and Climate Ministry

[6] Svanholm: 0.71 tons per year; Hjortshøj: 0.52 tons per year ; and Munksoegaard: 0.55 tons per year

GOOD CONSUMPTION

In general, CO_2 calculations are based on a lot of assumptions. However, plausible assumptions were very much dependent on the general availability of data.

The lack of data on average consumption data, emission levels and CO_2 factors of consumption goods has been a challenge. Especially in this section, the calculations are based on very rough and general assumptions because specific product related information and data could be hardly found. This is the reason why we tried to relate and base this project's calculation on the Ministry of Climate and Energy's calculator as much as we could. Additionally, we had to add some specific calculations referring to organic product use and own production of food products, since these things were not considered by the Ministry's calculator.

CO_2 emissions per average Danish person per year, linked to the consumption of all goods, has been 1.49 ton CO_2 in the year 2005.[7] The calculation for the individual emissions of an eco-citizen's good consumption is based on the above Danish average. However, due to the higher share of organic products, the consumption of eco-labelled products and the own production of food, an eco-citizen's CO_2 emissions due to good consumption is reduced. The calculations will show the difference of an average citizen and an eco-citizen and will deduct these from the overall average consumption figure.

Table 2: Danish average consumption data for different goods

in 1000 tonnes CO_2/a	Total	Per person
Food	1962.2	365.53
Drinks	429.16	79.94
Tobacco	61.55	11.46
Clothing	303	56.44
Housing and rentals	880.18	163.96
Furniture, furnishings, carpets etc.	194.84	36.29
Household textiles	47.69	8.88
Major household appliances and repairs	51.97	9.68
household utensils	173.46	32.31
Medical products, appliances and equipment	150.49	28.03
Transport and Vehicles etc.	531.53	99.02
Communications	430.54	80.21
Other major durables for recreation and culture	1796.56	334.68
Accommodation and Home services	751.03	139.91
Insurance and financial services	280.44	52.24
Total	**8044.64**	**1498.63**

Source: CO_2 calculator of the Danish Climate and Energy Ministry

The above figures are based on data from Statistics Denmark (Danmarks Statistik) about direct emissions of the Danish goods consumption. Besides the emissions in Denmark consuming a product often causes emissions outside Denmark. Statistics Denmark also indicates the "global" emissions of Danish demand in goods. In this case, an average Dane

[7] Source: The Energy Ministriy's CO_2 calculator

would emit about 2.38 tons of CO_2 per year, counted all direct and indirect CO_2 emissions of Danish good consumption into account.[8] Here, the making up of global emissions (given as the direct and indirect emissions in Denmark and abroad) is besides the emissions in Denmark also the emissions which would have been in Denmark if Danish companies had produced all imported final goods for private consumption. Furthermore the figures of global emissions in Denmark encompass the emissions from imported inputs used in the Danish production.
The figures are based on the assumption that the same production technology is used in Denmark and abroad. In some cases this leads to an underestimation of the emissions from some imported products there have been produced at a less energy efficient facility or in a more CO_2 intensive economy. But in the same time the global emissions are overestimated due to for example imported electricity from hydropower. The making up takes all indirect effects into account. In other words al the emissions there stems from the entire process of creating inputs into the production and goods and services for private consumption

However emissions from international transportation between the country of origin and Denmark are not taken into account. It is important to note that transportation of goods by for example a ship, a single good only accounts for a very small part of the ships CO_2-emissions due to the huge number of goods being shipped. Adding this emission to the entire amount of emissions attach to producing the product will only give a marginal increase.

In this project, due to the fact that the calculated emission level of an eco-citizen is supposed to be compared with the Danish average deriving from the Energy and Climate Ministry's CO_2 calculator, we only looked at direct emissions within Denmark.

Food

A Dane consumes on average 640 kg food per year resulting in a CO_2 emission level of 0.4 tons per year.[9]

We assume, concluding from the questionnaires, that an eco-citizen produces about 30% (Svanholm: 62%; Hjortshøj: 25%; and Munksoegaard:7.5%) of its vegetables, fruit, dairy and meat on its own. This means, on average, an eco-citizen purchases only 448 kg food per year from external sources.
However, there is no reliable data about the average energy consumption and CO_2 emissions related to the eco-society's agricultural activities. In our questionnaire, we assume that all energy consumption related to the production of food is included in the overall indicated consumption of the eco-society. Therefore, we can use the reduced consumption figure of 448 kg food products per year as a basis for our CO_2 emission calculation.

Moreover, an eco-citizen buys 65% of his products organic. In comparison "the 1 ton mindre" calculator assumes that an average Dane only buys 8.45% of its products organic.

In the following calculation, if nothing else is given as a source, all emission factors for food products derive from German databases called PROBAS and GEMIS, which are internationally recommended databases for embodied GHG emission related to products and

[8] Source: Danmarks Statistik, www.statistikbanken.dk, MREG6: Emissioner til luft forårsaget af endelige anvendelser efter forbrugsgruppe, emissionstype og enhed og NAT05, 07.07.09

[9] Source: Danmarks Statistik

processes. Data given from these databases refer to Germany. However, it is assumed that this data can be applied for Denmark as well, since no better Danish sources are available.[10]

Table 3: CO2 factors for different consumption goods as input data for calculations

in kg CO_2 per kg product		Beer	Bread	Butter	Cheese	Pastries	Meat mix	*Average*
Direct and indirect emissions in production	Conventional	0.26	0.42	4.28	1.65	0.49	2.27	
	Organic	0.25	0.40	2.07	1.01	0.47	1.56	
	Percentage of organic compared to conventional	0.97	0.94	0.48	0.61	0.97	0.69	***0.78***

Source: GEMIS and PROBAS, 2009

The difference in CO_2 emissions related to the production of organic goods compared to usual goods is on average 22%. See Table 3 above.
An average Dane emits 0.6368 kg CO_2 per kilogram food under the assumption that he/she already buys on average 8.45% organic products. An eco-citizen buys 65% organic products and therefore shows a lower CO_2 emission level of 249.8 kg CO_2.

[448 kg * (65%-8.45%) * (0.6368 kg CO_2/kg * 0.78%)] + [448 kg * (100%-65%+8.45%) * (0.6368 kg CO_2/kg] = **249.8 kg CO_2 per year**[11]

However, in the above calculations, emission savings due transportation and packaging of products, which will most likely not apply in the eco-society, are not reflected.

Eco-labels

All data used for calculation of CO_2 reductions through the use of eco labelled products is based on the "1 ton mindre" calculator.

The following assumptions are taken:

- Annual consumption: 33.5 kg paper[12] per year and 28.14 kg CO_2 per year[13]

Table 4: Average consumption of paper in Denmark and carbon factor of eco-labelled paper

	Annual consumption	**CO_2-savings in production of eco-labelled tissue paper** (compared to average tissue paper)
Eco-labelled paper (toilet and kitchen paper)	Kg/person 9,125	Kg CO_2 /kg 0,379

Sources: Annual consumption: own assumption that a person on average uses 175 g/week; CO_2-savings: AEA Technology, report produced for the EU Commission "Direct and indirect Benefits of the European Eco-label", 2004.

[10] Source: German Umweltbundesamt, ProBas database og Global Emission Model for Integrated Systems (GEMIS) Version 4.5; http://www.probas.umweltbundesamt.de/php/index.php
[11] Svanholm: 124.3 kg CO_2 per year; Hjortshøj: 260.3 kg CO_2 per year and Munksoegaard: 476.8 kg per year
[12] 1 ton mindre calculator,
[13] Danmarks Statistik, www,statistikbanken,dk, Emissions to air caused by final demand by unit, type of emission

For an average Dane, 22 pct. of its paper consumption is eco-labelled products.[14] For an eco-citizen, the questionnaire results in the assumption that the share of eco-labelled products is about 100%.

The CO_2 factor according to the above mentioned figures is: 0.923 kg CO_2 per kg paper produced.
Assuming a rate of 100% eco-labelled paper, would the emission factor be reduced by 0.379 kg CO_2 per kg paper which results in a new factor of 0.544 kg CO_2/kg paper.
Annually an eco-citizen would emit 18 kg CO_2 due to its paper consumption.[15] Compared to an average Dane an eco-citizen would save 10 kg CO_2 per year by consuming more eco-labelled paper.
We assume that an eco-citizen buys 100% eco-labelled goods in the product group of detergents, cleaning and caring products. Moreover, it is assumed that the consumption of these product groups is reduced by 35% accordingly.

Recycling

In the Energy Ministry's CO_2 calculator, the section "consumption of goods" (vareforbrug) includes the calculation for recycling of certain consumption goods. Because emission data is not available on the recycling of all products, the calculator focuses on paper, glass and plastic bottles as well as on beverage cans. In the questionnaire, the eco-citizens were asked about their recycling habits in regard to these product groups and more than 80% of the answers were indicating that the people recycle "most of the consumed goods".

On average in Denmark, 12% of the consumed glass bottles, 17% of the plastic bottles, 27% of the aluminium cans, 47% of the steal cans and 57% of the consumed paper is recycled.
In the calculation on how much an eco-citizen can save by recycling more than the above Danish average shares we assume that an average eco-citizen recycles about 80% of its consumed goods.

Recycling, compared to new production, results in an CO_2 emissions saving of 0.37 kg for a kilogram of glass bottles, 2.8 kg/kg for plastic bottles, 2.6 kg/kg for aluminium cans, 0.4 kg/kg for steal cans and 4.1 kg/kg for paper.[16]

The below table indicates average consumption volumes, recycling rates and emission volumes for bottles, cans and paper. Based on this data, we have been calculating the average emission volume saved by an eco-citizen due to higher recycling rates.

[14] Source: AEA Technology rapport produceret til EU Kommissionen "Direct and indirect Benefits of the European Ecolabel", 2004.
[15] Svanholm: 85% eco-labelled products = 20 kg CO_2 per year; Hjortshøj: 63% eco-labelled products = 23 kg CO_2 per year; Munksoegaard: 100% eco-labelled products = 18 kg CO_2 per year
[16] Source: Miljøstyrelsen, "Statistik for metal emballage -2002", "Statistik for returpapir og pap -2002"; "Statistik for plastik emballage -2002"; published in 2003

Table 5: Consumption data and recycling rates for bottles, cans and paper in Denmark

		Consumption		CO_2 emissions		
	Recycling rate	Consumption	Consumption per person	Incineration	Recycling	Difference
	%	*tons per year*	*kg per year*	*kg/1000kg*	*kg/1000kg*	*kg/1000kg*
Glas bottles	0.12	202143	37.66	52	-318	-370
Plastic bottles	0.17	7664	1.43	617	-2180	-2797
Aluminium cans	0.27	2266	0.42	-1800	-4420	-2620
Steal cans	0.47	5995	1.12	-1250	-1650	-400
						tons/ton
Paper	0.57	1345000	250.56			-4.1

Source: Miljøstyrelsen, Statistik for metal-, glas- og plastikemballage og retur papir og pap, 2003

In total an eco-citizen can save about 253 kilogram of CO_2 per year due to a higher recycling rate (80% of the consumed volume for paper, cans and bottles). The calculation assumes, that an eco-citizen consumes the same volume of paper, bottles and cans as the Danish average since the answered questionnaires do not indicate any consumption volumes more specifically.

Table 6: Assumptions on consumption volumes and recycling rates for bottles, cans and paper

	Glas bottles			Plastic bottles			Paper		
	Consumption	Recycling	Emission savings	Consumption	Recycling	Emission savings	Consumption	Recycling	Emission savings
	kg/a	*%*	*kg/a*	*kg/a*	*%*	*kg/a*	*kg/a*	*%*	*kg/a*
Average Denmark	37.66	0.12		1.43	0.17		250.56	0.57	
Average Eco-citizen	37.66	0.8	-9.47	1.43	0.8	-2.5	250.56	0.8	-240.39

	Aluminium cans			Steal cans		
	Consumption	Recycling	Emission savings	Consumption	Recycling	Emission savings
	kg/a	*%*	*kg/a*	*kg/a*	*%*	*kg/a*
Average Denmark	0.42	0.27		1.12	0.47	
Average Eco-citizen	0.42	0.8	-0.59	1.12	0.8	-0.15

Source: Miljøstyrelsen, "Indsamling af papir til genanvendelse fra husholdninger"; Institut for miljøvurdering "Pant på engangs-emballage, 2002"

The overall CO_2 emissions for non-food products for an eco-citizen results in 0.77 tons per year.

Table 7: Results of emission calculations for good consumption

tons per year	food	Non-food	Total
Danish average	0.45	1.04	1.49
Eco-society weighted average	0.3	0.76	1.05
Munksoegaard	*0.4*	*0.76*	*1.16*
Hjortshøj	*0.3*	*0.77*	*1.07*
Svanholm	*0.1*	*0.76*	*0.86*

WASTE AND WASTEWATER

Greenhouse gas (GHG) emissions from the waste and wastewater sector are a small contributor (about 2%) to Denmark's total anthropogenic GHG emissions. Emissions from the waste sector derive from three main sources: methane (18%) and nitrous oxide (4%) emissions from wastewater-treatment as well as methane emissions from solid waste disposal (landfill) (78%).[17]

Hence, the CH_4 from landfills and wastewater collectively accounts for about 96% of waste sector emissions. Wastewater N_2O and CO_2 from the incineration of waste containing fossil carbon (plastics; synthetic textiles) are minor sources.
But since this project only refers to the CO_2 emissions and does not consider other GHGs, in the following we are only concentrating on the related CO_2 emissions to waste collection and incineration.

Waste

Municipal waste collection involves transportation and the use of fuel. However, these emissions are very marginal and the main CO_2 emission source from waste is the incineration process itself which is determined by the proportion of waste whose carbon compounds are assumed to be of fossil origin. The allocation to fossil or biogenic carbon has a crucial influence on the calculated amounts of relevant CO_2 emissions.[18]

However, waste incineration is usually connected to an energy credit for the use of waste as a substitute for fossil fuel in energy production (waste incineration plants with energy recovery). The substitution of fossil fuel sources by waste in electricity and heat generation involves a lower CO_2 factor for each kWh produced in the overall system. In general, it can be assumed, that the CO_2 emissions related to collection and transportation of waste are offset/compensated by the energy credit related to substituting fossil fuels for energy production. This results in the conclusion, that the net CO_2 emission volume of the municipal waste collection, transportation and incineration can be considered as zero.
Furthermore, a change in the average Danish CO_2 factor for the heat or electricity grid due to a change in the waste volume would be reflected in the calculations within the heat and electricity section.

The eco-society's data indicates some lower waste volumes than Danish average, due to a higher share of organic waste composted and higher share of recycling. Composting may involve additional CH4 emissions once not captured. But they are not considered in this project. A higher degree of recycling will mean a certain CO_2 emission reduction. We have added these savings in the section "consumption of goods" since in our opinion the saving applies to the production of new goods rather than to the actual waste treatment.
So, that means an average eco-citizen has a lower volume of waste to landfill and usage in energy production. However, the effect on CO_2 emissions due to these lower waste volumes might be irrelevant or could actually be an increase in CO_2 emissions, due to the reduction of co-fired waste in energy production.

[17] http://www2.dmu.dk/Pub/FR611.pdf
[18] http://www.ipcc-nggip.iges.or.jp/public/gp/bgp/5_3_Waste_Incineration.pdf

Waste water treatment

Greenhouse gas emissions related to waste water treatment are methane from an-ærobic treatment of the waste water, direct nitrous oxide from the wastewater treatment processes at the sewage plants and indirect N_2O emission from the discharge from the treatment plants. Sewage sludge may also be incinerated, so that an energy credit might be applied. However, depending on the treatment methodology and the capturing of the methane emissions, GHGs emissions due to wastewater treatment only represent a very small share of 0.6% of Denmark's total GHG emissions.[19]
Furthermore, only considering CO_2 emissions, which represents a very marginal share of the waste water treatment sector's total GHG emissions, leads to the conclusion, that there is only minor differences in CO_2 emissions between the municipal waste water treatment and the eco-society's own waste water treatment.
Furthermore, the same arguments which are mentioned under the chapter "waste" do apply.

Any savings in energy consumption due to more efficient or renewable pumping of the waste water are reflected in the energy consumption figures.

[19] Data for the year 2005, http://www2.dmu.dk/Pub/FR611.pdf

FRESH WATER CONSUMPTION

The Environmental Agency of Germany (Bundesumweltamt) has estimated the cost of a litre of water supply 0,000359 kg CO_2.[20] Statistics Denmark has determined the average consumption of water to 47921 litres per capita per year in Denmark which results in ca. 17.2 kg of CO_2 emissions due to water consumption for an average Dane. (Under the assumption that 1 kg of water is the same as 1 litre of water)

Data from the Eco-society shows that the consumption of water for an Eco-citizen is below 47921 litres of water. Therefore the CO_2 emissions due to water consumption in the Eco-societies amounts to 15,43 kg CO_2 per year.[21] The consumption of water contains the consumption from agriculture. Some people in the Eco-societies use rainwater in their toilets and washing machine. In the calculations this are assumed to create zero CO_2 emissions.

Table 8: Calculated fresh water consumption and related CO_2 emissions

	Fresh water consumption in litre per year	**CO_2 emissions in kg CO_2 per year**
Danish average	47920.90	17.20
Eco-society	42972.00	15.43

[20] http://www.probas.umweltbundesamt.de/php/index.php

[21] Svanholm: 73333 litre per year and 26.3 kg CO_2 per year; Hjortshøj: 30200 litre per year and 10.84 kg CO_2 per year and Munksoegaard: 25383 litre per year and 9.11 kg CO_2 per year.

ANNEX 1

Questionnaire to eco-citizen

Hvilken type bolig bor du i?

a. Parcelhus inkl. villa og bungalow b. Rækkehus c. Stuehus d. Etagebolig/lejlighed
e. Lavenergihus f. andet

Hvad er størrelsen af din bolig?

a. < 40 m2 b. 40-59 m2 c. 60-79 m2 d.80-99 m2 e. 100-119 f. 120-159m2
g. 160-199 h. > 200 m2

Hvor mange personer er der i husstanden?

Hvornår er din bolig bygget?

a. Før 1930 b. 1930-1960 c. 1960-1990 d. Efter 1990

Hvad er det primære opvarmningssystem?

a. Centralvarme/naturgas b. Centralvarme/olie c. Centralvarme, træ/halm/masseovn
d. Fjernvarme e. Jordvarmepumpe f. Elektricitet g. Andet

Hvor mange biler har I i husstanden?

Varme

Kender du husstandens varme- eller brændselsforbrug?

Har du en sekundær varmekilde? (f.eks. brændeovn, solvarme, elektricitet)
Hvis ja: hvilken type?

a. solvarme b. Brændeovn c. Varmepumpe d. Elektricitet e. Andet

Hvad er din primære varmekilde til brugsvand?

a. Solvarme b. El c. ukendt d. Andet

Har I elektrisk gulvvarme i husstanden?

El

Kender du husstandens årlige el forbrug i kWh/år?

Har I et solcelleanlæg?

Madlavning

Laver I primært mad på el eller gas eller en kombination heraf?

Hvis I bruger gas, hvor meget gas bruger I om året?

Transport

Hvordan transporterer du dig rundt til daglig (f.eks. til skole, på arbejde etc.)?

a. prival bil, alene b. samkørsel med andre i bil c. tog d. Cykel e. Til fods f. Bus

g. Metro eller s-tog h. Motorcykel i. Knallert

Hvor langt har du hver vej (km)?

Hvor mange kilometer kører jeres køretøjer?

Privat bil	**Biltype** Firhjulstrækker, personbil eller varevogn	**Årlige kilometer**	**Brændselsforbrug (km/L)**	**Type brændstof** Benzin, biodiesel, biobenzin, diesel
Bil 1				
Bil 2				
Motorcykel				
Scooter/knallert				

Hvor mange km kører du om året i andre biler end egen bil? (Fx taxa, lejet bil, delebil eller lånt bil)

Hvor mange kilometer kører du med kollektiv transport om året?

a. < 100 km b. 101-500 km c. 501-1000 km d. 1001-3000 km
e. 3001-5000 km f. 5001-7000 km g. 7001-10.000 km h. > 10.000 km

Hvor mange fritids- og ferierejser *med fly* foretager du om året?

Antal indenrigsrejser om året?

Antal rejser indenfor Europa om året?

Antal oversøiske rejser om året?

Forbrug

Hvor meget kød/fjerkræ spiser du?

a. Hver dag b. 3-4 gange/ugen c. jeg er vegetar

Når du køber frugt og grønt, prøver du så at købe lokalt producerede sæsonvarer?

a. Ja, de fleste gange b. Ja, nogle gange c. nej

Afleverer du glasflasker, plastflasker, aluminiumsdåser og papir til genbrug?

a. Ja, de fleste gange b. Ja, nogle gange c. nej

Køber du miljømærket, f.eks. svane- eller blomst-mærket køkkenrulle og toiletpapir?

a. ja, altid b. Ja, nogle gange c. nej

Prøver du at reducere dit forbrug eller købe genbrugsvarer?

a. Ja jeg køber genbrug når det er muligt, og begrænser mit forbrug til det mest nødvendige
b. Ja jeg køber genbrug engang imellem og prøver at begrænse mit forbrug
c. nej

Questionnaire to eco-society

Affald

- Hvor mange kilo affald har I om året?
- Hvor meget er andelen af grønaffald som bliver komposteret?
- Hvor meget affald giver I til genbrug? (eks. papir, glas, dåser…)

Vandforbrug

- Hvad er årets vandforbrug i literen?
- Hvor stor af andelen af frisk vand og hvor stor er andelen af regnvand?
- Hvor meget spildevand producerer I om året?
- Behandler I jeres spildevand selv? Hvor stor er andelen af årets spildevand I selv behandler?
- Hvordan behandler/renser I jeres spildevand? Hvor meget energi bruger det (i kWh/a) og hvilken energikilde stemmer det fra?

Vareforbrug

- Hvor meget i procent af jeres fødevarer indkøb er økologiske varer?
- Hvor meget i procent af jeres fødevareforbrug producerer I selv?
- Hvilke produkter omfatter det primært?
- Hvad koster det i energiforbrug?

- Hvor langt er der til nærmeste indkøbsmulighed (fødevarer)?
- Hvad er jeres primære transportmiddel til indkøb?
- Hvor meget af jeres indkøb (i procent) inkluderer miljømærker?

ANNEX 2

Interpreted Answers from questionnaires

			Heat		Electricity		Transport					
		Citizens	Heat consumption, per person	Fresh water consumption	El-consumption, per person	El-consumption, per household	Car kilometer	Fuel use km per liter	Car sharing kilometer	Flight domestic	Flight european	Flight international
			kWh om året	*liter om året*	*kWh om året*	*kWh om året*	*km om året*		*km om året*	*number*	*number*	*number*
Munksoegaard	hjemmene		2,641	23,293	837							
	Fælleshus		870	2,091	405							
	Totalt	***250***	***3,511***	***25,383***	***1,243***	***3,034***	***981***	***15***	***3,949***	***0.0137***	***0.0044***	***0.0008***
Hjortshøj	hjemmene		2,647	30,200								
	Fælleshus											
	Totalt	**191**	***2,647***	***30,200***	***1,116***	***2,725***	***16***	***24***	***4,037***	***0.34***	***0.72***	***0.10***
Svanholm	hjemmene											
	Fælleshus											
	Totalt	***150***	***8,333***	***73,333***	***1,667***	***4,069***						
Vægtet gennemsnit			*4,455*		*1,309*	*3,197*			*3,987*			

		Waste water		Good consumption		
		Waste water	Waste	Share organic food products	Own food production	Share eco-labelled products
		liter om året	*liter om året*	%	%	%
Munksoegaard	hjemmene			50	7.5	100
	Fælleshus			100	0	100
	Totalt	***17,605***	***1,331***	***60***	***0***	***100***
Hjortshøj	hjemmene			0	0	0
	Fælleshus			0	0	0
	Totalt			***76.38***	***24.575***	***62.7***
Svanholm	hjemmene			0	0	0
	Fælleshus			0	0	0
	Totalt			***98***	***62***	***85***
Vægtet gennemsnit				*78.13*	*31.36*	*82.57*

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