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TOP-DOWN CO_2 EMISSION BASELINES FOR THE ESTONIAN DISTRICT HEATING SECTOR

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Report commissioned by the Swedish National Energy Administration

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Foreword

Since 1998 the Swedish National Energy Administration (STEM) has been responsible for the Swedish Government Programme for Activities Implemented Jointly in the Baltic Sea Region and Eastern Europe. This programme is Sweden's contribution to the pilot phase of Activities Implemented Jointly (AIJ) within the UN Framework Convention on Climate Change (UNFCCC). Within the Swedish Programme more than 50 AIJ projects have been implemented and reported to the UNFCCC Secretariat. About half of these projects are boiler conversion projects in the district heating sector in Estonia, Latvia and Lithuania, where heat boilers have been converted from heavy fuel oil or coal to biomass fuels such as wood chips.

In order to reduce reporting and transaction costs STEM is conducting work on how to simplify the preparation and monitoring of AIJ projects. An important part of this methodological work is to examine possible ways to construct standardised CO_2 emission baselines for various project types. This report, *Top-down CO_2 Emission Baselines for the Estonian District Heating Sector*, was commissioned by STEM and written by two Estonian experts, Tiit Kallaste and Inge Roos. The objective of the report is to examine different ways of standardising baselines for AIJ or JI projects in the district heating sector in Estonia. The report is based on Estonian energy statistics and energy development programs and thus provides valuable information on energy use and CO_2 emissions in Estonia. It is hoped that the report by Kallaste and Roos will contribute to the current discussion on baseline methods within the framework of the UNFCCC and the Kyoto Protocol.

The report was edited by Jürgen Salay. The views expressed in this report are those of the authors and are not intended to reflect or imply priorities of the Swedish National Energy Administration or the Swedish Government.

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ABSTRACT

In this report an attempt is made to construct top-down CO_2 emission baselines for the district heating sector in Estonia for the period 1993-2005. Its principal objective is to give a methodological basis for CO_2 emission baseline construction in the Estonian district heating sector. The more far-reaching aim is to suggest possible ways to construct standardised baselines for AIJ and the two project-based flexible mechanisms: the Clean Development Mechanism (CDM) and Joint Implementation (JI) which were established by the Kyoto Protocol. The report presents Estonia's climate policy as well as data on its energy use and CO_2 emission. The report also includes an overview of different baseline methods.

The baseline construction is based on the analysis of fuel consumption by different types of fuel for the period 1990-1998 and on a fuel consumption forecast to the year 2015. The forecast is based on macro-economic analysis of Estonian development trends, relevant government policy such as targets for increased renewable energy supply and CO_2 taxation, and the emission reduction commitments agreed at Kyoto. The CO_2 emission baseline is made in two ways: the first includes the effects of AIJ projects in the DH sector, the second excludes them. It is discussed how these baselines may be used for the DH sector and applied for the assessment of individual AIJ and JI projects.

1. INTRODUCTION

Emissions of greenhouse gases (GHG) are assumed to be a major cause of global warming. The energy sector is responsible for 80% of CO_2 emissions and over two thirds of all emissions of GHG. If current trends continue, it is very probable that they will lead to higher average global temperatures. This may cause serious damage; changed patterns of vegetation and production, rise in sea level, drought and less predictable climate conditions. In contrast to other environmental problems, the potential damage caused by the greenhouse effect is independent of where the emissions take place. Besides, with current technologies it is very expensive to clean emissions of most GHG. Emission reductions are therefore greatly dependent on decreased use of fossil fuels, such as coal, oil shale, petroleum and natural gas. Mitigation of GHG emissions will thus have to be focused on changing the consumption patterns for carbon-intensive energy sources. Enterprises must change their production processes to reduce GHG emissions, and consumers are may face higher prices when CO_2 emissions are taxed and industry and other sectors change to less fossil-intensive fuels.

Because of the associated costs of stabilising GHG emissions, the climate change issue became a major challenge for international co-operation. The cost of reducing GHG emissions varies between regions and countries, and also within regions. GHG emission reduction brings global benefits regardless of in which country the most measures are taken. It therefore makes sense to implement abatement measures in the countries, where the costs are the lowest. This is the reason why international cost effectiveness is a basic principle of the Climate Convention in the process of negotiations and in implementation. Analysis in many OECD countries of implementing sufficient measures on national basis has shown that greater effects may be achieved if resources were invested in GHG reductions in countries where the marginal costs of such measures are lower. This particularly applies to countries that have a high share of non-fossil fuels in their energy balance and therefore have limited possibilities for fuel substitution, e.g. Norway and Sweden (Joint Implementation, 1995).

Estonia, as a party to the United Nations Framework Convention on Climate Change (UNFCCC), has taken early steps to mitigate GHG emissions. Thanks to its geopolitical location Estonia has historically close relations to Denmark, Finland and Sweden. Many cultural, business and scientific contacts were established in the beginning of 1990s shortly after Estonia's political independence in 1991. For Estonia the environmental help from neighbouring countries has been significant. Several assistance projects have been realised in the energy sector. Sweden and Denmark have been financed projects to improve energy efficiency, replace outdated combustion technologies in the district heating sector, and improve energy conservation in buildings. These projects also resulted in reduced GHG emissions, although many of them were not initiated because of climate policy reasons.

Sweden has been a pioneer among the parties to the UNFCCC in implementing AIJ projects in the Baltic States, Poland and Russia. In the present study the effects of projects within the Swedish AIJ Programme in Estonia are analysed. Its principal objective is to give a methodological basis for CO_2 emission baseline construction in the Estonian district heating sector. The more far-reaching aim is to suggest possible ways to construct standardised baselines for AIJ and the two project-based flexible mechanisms: the Clean Development Mechanism (CDM) and Joint Implementation (JI) which were established by the Kyoto Protocol.

Emission baselines are a tool to quantify *"what would have happened"* in terms of greenhouse gas emissions in the absence of AIJ-, JI- or CDM-projects in the case of normal economic development in the host country, i.e., *business as usual*. Actual emissions from the project are measured against the baseline emissions, and if the project's emissions are lower, it can generate so called *emission credits*. Baselines are thus hypothetical reference cases and are subject to a number of uncertainties (Ellis and Bosi, 1999).

The authors of this report have analysed statistical data on the Estonian energy sector in order to be able to construct a top-down CO_2 emission baseline for the district heating sector in period 1990-2005. The baseline construction is based on the analysis of fuel consumption by different types of fuel for the period 1990-1998 and on a fuel consumption forecast to the year 2015. The forecast is based on macro-economic analysis of Estonian development trends, relevant government policy such as targets for increased renewable energy supply and CO_2 taxation, and the emission reduction commitments agreed at Kyoto.

The authors acknowledge the support of the Secretariat for Climate Policy and International Co-operation of Swedish National Energy Administration.. The authors hope that the approach and results presented here will contribute to the ongoing discussions on rules and guidelines for baseline methods and baseline construction.

2. ESTONIA AND THE UN FRAMEWORK CONVENTION ON CLIMATE CHANGE

2.1 *Fulfilment of the obligations according to UNFCCC and Kyoto Protocol*

Estonia signed the Framework Convention on Climate Change (UNFCCC) during the UN Conference on Environment and Development in Rio de Janeiro in 1992. In May of 1994, the Estonian Parliament approved the ratification of the Convention and the President promulgated the Act on Ratification. In July 1994 Estonia deposited its instrument of ratification and the Convention entered into force for Estonia in October 1994.

Estonia has also signed the Kyoto Protocol. Estonia's platform to the UNFCCC Conference of the Parties in Kyoto was in conformity with the European Union's one. Estonia was prepared to significantly reduce its CO_2 emissions by 2005 and 2010. The actually agreed reduction commitments in the Protocol were somewhat smaller than expected. As for the European Union and the Associated Countries the Kyoto Protocol stipulates that GHG emissions should be decreased to 8% compared with 1990 by 2008-2012. Estonia is in the process of ratifying the Kyoto Protocol.

A Government Committee on the Implementation of Climate Convention was established in January 1995. The Committee's task is to consider greenhouse gas emission reduction strategies such as Joint Implementation and preparation and launching of its pilot phase activities – Activities Implemented Jointly. The Committee has to develop alternative policies and strategies to be targeted in further work on climate issues and to create a country specific implementation mechanism acceptable to potential donors amongst the Annex I countries. The Committee's obligations were fixed and the responsibilities shared between several institutions, amongst which the Ministry of Environment has the leading role. The Committee's important responsibility is to select the most suitable from the country prospective projects to be launched with the help of donor countries. The Committee should find a well-defined basis and determine the main goals in the international negotiating process for reduction of GHG emissions. The Committee nevertheless lacks an efficient working institution such as a Secretariat on JI implementation or a JI Project Preparation Facility, or any kind of a Steering Committee. Consequently, up to present time the Government is lacking the appropriate system of identification and verification of future Joint Implementation activities.

Other institutions have actually taken its place in developing relevant activities and programmes. Recently this type of Inter-ministerial Joint Implementation Steering Group was created on the initiative of the Stockholm Environment Institute Tallinn Centre. The main aim of the JI Steering Group is to bring together decision-makers from the Ministry of Environment and the Ministry of Economic Affairs, who are the main players in implementation of Climate Convention in country. The Steering Group's main objectives are to build institutional capacity for JI and international emission trading in Estonia, work out the principles and regulations in the form of appropriate documentation for the guidance to potential donor countries, and prepare the procedures for identification and verification of Joint Implementation projects. An important task is to set up a list of JI projects and activities according to national priorities fixed in The National Environmental Action Plan (NEAP, 1998). It should be carefully compiled by the representatives of several governmental institutions and climate experts in coherence with the NEAP, which in its turn evaluates all activities in the field of environmental protection.

As for the obligations and commitments of Estonia under the Convention, there exists great variety of activities, which could be applied to perform the abatement of GHG emissions. These include commonly accepted rules, abatement measures and activities. Also, the participation in various United Nations programmes devoted to climate change issues has a significant role to play for Estonia. (Kallaste, 1999). Also important are the international climate co-operation, networking, and regular inventories on GHG emissions. The inventories are included in the National Communications to the Secretariat of the Convention. The National Communication represents the latest information on climate activities and policies in the country. Information dissemination internationally and domestically is a priority for Estonia. The first GHG inventory was made for energy, industry, transport, agriculture, forestry and land-use sectors. Several ministries and institutions contributed to this report. Estonia was assisted in the preparation of its communication by the United States in the framework programme "US Support for Country Studies to Address Climate Change". Estonia was involved to Climate Change Country Studies Programme in 1994. For the estimation of GHG emissions the IPCC methodological guidelines were used. According to it 1990 was chosen as the base year. For oil shale – an important domestic fuel in Estonia -- a country-specific carbon emission factor was used. Estonia's first national communication under Articles 4 and 12 of the Convention was presented to the UNFCCC secretariat in March 1995 (see Table 3.2).

The second national communication under the UNFCCC was presented to the Secretariat in autumn 1998. According to it the total emission of GHG decreased significantly between 1996 and 1990. (see Table 3.3). For CO_2 the decrease has been almost 50%.

To reach its emission reduction commitment according to the Kyoto Protocol Estonia must change its economic structure, but particularly in the energy sector as energy is the biggest contributor to GHG emissions. Transfer to new, low-carbon technologies of burning oil shale in power plants, developed in Estonia, gives a possibility to cut to minimum the emissions of CO_2 and SO_2 at the same time.

2.2 *Implications of CO_2 taxes*

The newly established CO_2 tax, which entered into force in January 2000, creates a new fiscal burden for energy producing enterprises and taxpayers which may require compensatory measures by politicians and decision makers. The big oil shale based power plants will have serious problems in coping with the new tax. According to preliminary calculations, their total environmental charges will grow from 14.8 million EEK in 1998 to 52.5 million in 2000 and to 76.7 million in 2001. The bulk of this increase is due to the CO_2

tax. (The calculations have been done considering the annual output of electricity of 5460 GWh.)

The increasing environmental tax burden in connection with the EU approximation process and the obligations according to the Kyoto Protocol are causing a lively discussion in the Estonian media and among energy policy experts as well as in governmental institutions. In a recent methodological study on GHG Mitigation Options in the frame of UNEP/GEF global case studies programme (Economics of GHG…, 1998), a variety of options regarding fuel use in Estonia during next thirty-five year period were modelled. In case of high GDP growth rate together with a high CO_2 tax rate (about 40 USD per ton of CO_2) highly polluting technologies, such as oil shale combustion would be phased out. The alternatives to be considered include natural gas and new oil shale burning technologies like the pressurised fluidised bed combustion (PFBC) technique. The application of the PFBC technology would reduce the power plants' CO_2 emissions from the present level of 12.5 Mt/yr. to 7.0-7.5 Mt/yr (given the same output of electricity). The emissions of nitrogen oxides will also decrease. The use of the PFBC technology for oil shale does not mean only a rise in the efficiency of energy conversion process and reduced CO_2 emission but also a slower depletion of the reserves of oil shale as a domestic fuel (Mitigation…, 1999).

The Estonian oil shale fired power plants are old, very inefficient and have high concentrations of CO_2 and sulphur dioxide in the flue gas. The power plants fired with oil shale need to be reconstructed or technologically upgraded. If the currently applied pulverised combustion technology remains in use, it will not be possible to reduce the concentration of CO_2 in the flue gas. The emission of CO_2 may be reduced marginally if the efficiency of the power plants is improved.

In the case of heat production and heat and power co-generation, there is scope for increased use of biofuels. Biofuels have several advantages. The most significant of them are the following:

?? a transfer from fossil fuels like heavy oil, coal and natural gas to wood chips and other local biofuels reduce CO_2 emissions and thus taxes paid by heat plants;
?? significant decrease of political dependence on Russia and other countries because of reduced fuel imports;
?? big economic savings as the share of imported fuels will decrease significantly;
?? positive environmental results thanks to reduced air pollution;
?? rise of employment in rural areas, it is estimated that every MW of installed biomass capacity creates three new jobs;
?? creation of favourable conditions for project-based activities such as AIJ and JI on the basis of technology transfer; and
?? creation of joint ventures to implement biofuels use in heat and power co-generation.

The legislation in Estonia is likely to be revised to stimulate the wider use of biofuels in municipal heat production. This topic has been under the discussion in the governmental commission on renewable energy in the Ministry of Economic Affairs, however, no practical steps have yet been taken.

3. ESTONIA'S CO_2 EMISSIONS IN 1990 - 1998

In June 1994 the first internationally co-ordinated climate project (*Estonian Country Study on Climate Change GHG Emissions Inventory, Impacts and Adaptations Assessment in the Republic of Estonia*) was initiated within the U.S. Climate Change Country Study Programme. The project was aimed at raising Estonia's capacity to meet the requirements of the UNFCCC in the sphere of climate studies, particularly through the inventory of GHG emissions, identifying contemporary trends to investigate the impact of climate change on the Estonian ecosystems and economy and to formulate national strategies for Estonia addressing global climate change .

In 1994-1996 a GHG inventory was compiled for the year of 1990 using IPCC Guidelines for National GHG Inventories (IPCC, 1994). Later the same methodology was applied in the compilation of GHG Inventories for 1991-1996.

The IPCC Guidelines for 1994 and 1995 do not contain information about the Estonian oil shale and its carbon emission factor. As oil shale is Estonia's main indigenous fuel, a short description of it is given below.

Estonian oil shale as fuel is characterized by high ash content (45-50%), a moderate content of moisture (11-13%) and of sulphur (1.4-1.8%), a low net caloric value (8.5-9 MJ/kg), a high content of volatile matter in the combustible part (up to 90%). The dry matter in Estonian oil shale is considered to consist of three main parts: organic, sandy-clay and carbonate.

In 1996 oil shale reserves in the Estonian field amounted to 4,400 million tonnes, while commercial supplies are estimated at 1,200 million tonnes. Oil shale is produced in three open pits and six underground mines and oil shale is mined in two qualities: coarse (grain size 25-250 mm) or crushed (grain size 0-25 mm). Coarse oil shale is processed into oil shale oil. Crushed oil shale (approximately 80%) with a caloric value of 8.5-9 MJ/kg is suitable to be used as boiler fuel in big power plants.

From the point of view of greenhouse gas emissions, it is important to note that during combustion of powdered oil shale, CO_2 has been formed not only as a burning product of organic carbon, but also as a decomposition product of ash carbonate part. Therefore the total quantity of carbon dioxide increases up to 25% in flue gases of oil shale.

A specific for Estonia factor derived on the basis of formula introduced by Estonian scientist, Dr. A. Martins (Estonian Energy Research Institute), for calculation of Estonian oil shale carbon emission factor, taking in consideration the decomposition of its ash carbonate part, is as follows:

$$\mathbf{CEF_{oil\ shale} = 10 \frac{C^r_t + k(CO_2)^r_M\ 12/44}{Q^r_l}} \qquad \mathbf{(tC/TJ)}$$

where Q^r_l - net caloric value oil shale as it burned, MJ/kg;

C^r_t - carbon content of oil shale as it burned, %

$(CO_2)^r_M$ - mineral carbon dioxide content of oil shale as it burned, %;

k -decomposition rate of ash carbon part (k = 0.95-1.0) for pulverised combustion of oil shale).

The net calorific value of oil shale is changeable, showing decrease tendency, because the oil shale layers with best quality are almost exhausted. In 1990, the medium net caloric value of oil shale, burned in power plants, was 8.6 MJ/kg (data from Estonian Energy).

Calculation of oil shale carbon emission factor:

$$\mathbf{CEF_{oil\ shale} = 10\ (20.6 + 0.95 \times 17.0 \times 12/44)/\ 8.6 = 29.1,\ (tC/TJ)}$$

To compile the GHG Inventory for 1997 the new 1996 IPCC Guidelines was used (IPCC, 1996). In the new Guidelines, CEF for oil shale, calculated by A. Martins, was included.

Carbon Emission Factors (CEF) of fuels are given in Table 3.1

Table 3.1 Carbon Emission Factors (CEF)

Fuel	CEF (tC/TJ)	Fuel	CEF (tC/TJ)
Primary Fuels		**Primary Fuels**	
LIQUID FOSSIL		**SOLID FOSSIL**	
Crude Oil	20.0	Anthracite	26.8
Natural Gas Liquids	17.2	Cooking Coal	25.8
Secondary Fuels		Sub-Bituminous Coal	26.2
Gasoline	18.9	Lignite	27.6
Jet Kerosene	19.5	Peat	28.9
Other Kerosene	19.6	Oil Shale	29.1
Gas/Diesel Oil	20.2	**Secondary Fuels/Products**	
Residual Fuel Oil	21.1	BKB & Patent Fuel	25.8
LPG	17.2	Coke	29.5
Ethane	16.8	**BIOMASS**	
Bitumen	22.0	Solid Biomass	29.9
Lubricants	20.0		
Petroleum Coke	27.5		
Refinery Feedstocks	20.0		
Other Oil	20.0		
GASEOUS FOSSIL			
Natural Gas (Dry)	15.3		

As for solid biomass, IPCC Guidelines states that net CO_2 emissions equal zero during combustion. In Estonia wood, including wood, wood-waste, saw mill dust, bark and wood chips are used as biomass fuels. All calculations of emissions from these fuels are carried out using CEF from the IPCC Guidelines, but are not taken into account in the calculation of total CO_2 emissions.

The latest GHG Inventory, with the respective emission data for 1998 was performed by the Estonian Institute of Energy Research in the spring of 1999 for the energy, industry, transport, agriculture, forestry and land-use sectors; in other words, for all activities related to emissions of greenhouse gases in Estonia. An overview is given in Table 3.2.

At present energy-related activities are the most significant contributors to Estonian greenhouse gas emissions. The production, transmission, storage and distribution of fossil fuels also serve as sources for greenhouse gases, as do primary fugitive emissions from natural gas systems, oil shale mining and shale oil production. The of GHG emissions in 1990 are given in Table 3.3.

Table 3.2 CO_2 and non-CO_2 emissions by Sector in 1990, thousand tonnes

Sector	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
Total (Fuel Combustion)	**37184**	**2.61**	**1.417**	**79.41**	**183.54**	**22.92**	**232**
Energy Industry	28461	0.05	0.002	35.78	7.33	NA	239
Industrial	2897	0.05	NA	4.85	1.67	NA	
Transport	2656	1.93	0.036	32.64	171.95	22.92	
Household*	1588	0.46	0.425	3.04	0.95	NA	
Other Sectors	1581	0.12	0.954	3.13	1.62	NA	

Note: The totals provided here do not reflect emissions from fugitive emissions[1].

Table 3.3 CO_2 and non-CO_2 emissions by sectors in 1998, thousand tonnes

Sector	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
Total Energy (1+2)	**18890**	**34.75**	**0.14**	**40.72**	**158.57**	**24.34**	**139.8**
1. Fuel Combustion	**18890**	5.49	0.14	40.72	158.57	24.34	139.8
Energy Industry	15731	0.39	0.06	23.47	14.06	2.45	
Industrial	666	0.02	0	1.16	0.92	0.03	
Transport	1236	0.18	0.01	12.97	66.58	12.61	
Households	1079	4.08	0.07	2.87	75.74	9.09	
Other Sectors	177	0.1	0.1	0.25	1.27	0.16	
2. Fugitive emissions		29.26					

In 1990 the total CO_2 emissions from the consumption of fossil fuels was 37,184 thousand tonnes, in 1998 they had decreased to 18,890 thousand tonnes. This means that during

[1] Fugitive emissions are the leakages of methane from, e.g., natural gas pipelines or oil shale mining.

these years the total emission of CO_2 from energy production and use decreased by 49% (see Table 3.4). The reduction of fossil fuel consumption, especially that of imported fuels, was a major reason for this decrease. The CO_2 emissions, according to fuel types, decreased as follows: natural gas by 50%, coal by 80%, gasoline by 38%, kerosene by 38%, heavy fuel oil by 81% and diesel oil by 35%.

Table 3.4 CO_2 from energy sources, thousand tonnes

Fuel Types	1990	1991	1992	1993	1994	1995	1996	1997	1998
Fossil fuels total*	**37183.8**	**36342.2**	**27453.3**	**21786.0**	**22667.5**	**20637.6**	**21216.2**	**21362.3**	**18889.6**
Liquid fossil fuels	**9734.4**	**8566.6**	**5023.4**	**5191.4**	**4782.3**	**3721.6**	**3647.2**	**3933.1**	**3851.2**
Natural gas liquids	95.6	91.9	40.4	21.6	30.3	21.2	14.2	24.5	24.9
Gasoline	1688.4	1417.3	681.4	694.6	858.1	649.6	740.8	1099.75	1043.7
Kerosene	335.7	262.7	68.8	157.6	147.2	70.4	139.3	140.7	208.5
Jet Kerosene	112.1	109.9	37.3	57.4	47.4	52.5	49.0	67.6	0.1
Diesel oil	1887.0	1826.2	1198.9	1280.1	1174.7	1100.0	1043.4	1137.8	1218.3
Heavy fuel oil	5500.2	4700.0	2921.2	3229.2	1975.0	1247.5	1194.4	990.1	1025.5
Other oils	115.4	158.6	75.4	525.3	549.6	580.5	466.1	472.7	330.2
Solid fossil fuels	**24595.4**	**24908.6**	**20753.5**	**15761.6**	**16690.2**	**15549.9**	**16064.7**	**16097.6**	**13625.1**
Oil shale	23051.4	23011.7	19347.8	14854.9	15867.1	14727.1	15196.7	15029.3	13040.8
Coal	880.1	863.4	536.3	282.4	211.6	201.1	229.2	231.8	176.3
Peat / peat briquette	653.7	1024.1	861.3	615.9	605.3	615.6	635.6	834.8	404.7
Coke	10.2	9.4	8.1	8.4	6.3	6.2	3.1	1.68	3.3
Gaseous fossil	**2854.0**	**2867.0**	**1676.4**	**833.1**	**1193.9**	**1366.1**	**1504.4**	**1276.7**	**1413.3**
Natural gas	2854.0	2867.0	1676.4	833.1	1194.9	1366.1	1504.4	1276.7	1413.3
Biomass total*	**1074.0**	**797.5**	**843.7**	**793.4**	**1289.3**	**1445.9**	**1613.5**	**2633.6**	**2303.4**
Solid biomass	1074.0	796.5	843.7	793.4	1289.3	1445.9	1613.5	2633.6	2303.5

*biomass is not included into fossil fuels total

Concerning the statistical data on biofuels it should be noted that the increases in 1993-1994 and 1995-1996 partly are explained by improved collection of data. In the 1980s and in the beginning of the 1990s the fuel-wood used in small households was only partially accounted for in energy statistics. It is therefore difficult to compare the data on solid biofuels after 1993 with those of earlier periods.

In 1998, 136 PJ of primary energy was produced in Estonia of which oil shale accounted for 83% (Energy Balance, 1999). The remaining 17% came from natural gas, heavy fuel oil, or other energy sources. Oil shale accounted for 69% of Estonia's total energy-related CO_2 emissions. (Table 3.4).

4. ENERGY USE

4.1 Characterisation of the energy sector

The Estonian economy and the energy sector experienced significant changes in the 1990s. Primary energy use and energy consumption by end users have decreased almost halved compared to 1990. The biggest decline in energy consumption occurred in industry and agriculture. However, actual changes and decisions will be affected by forthcoming privatisation of the power sector. Since 1993, energy consumption has started to stabilise gradually. In 1998 the share of domestic energy resources in the primary energy balance accounted for 58% (see Figure 4.1).

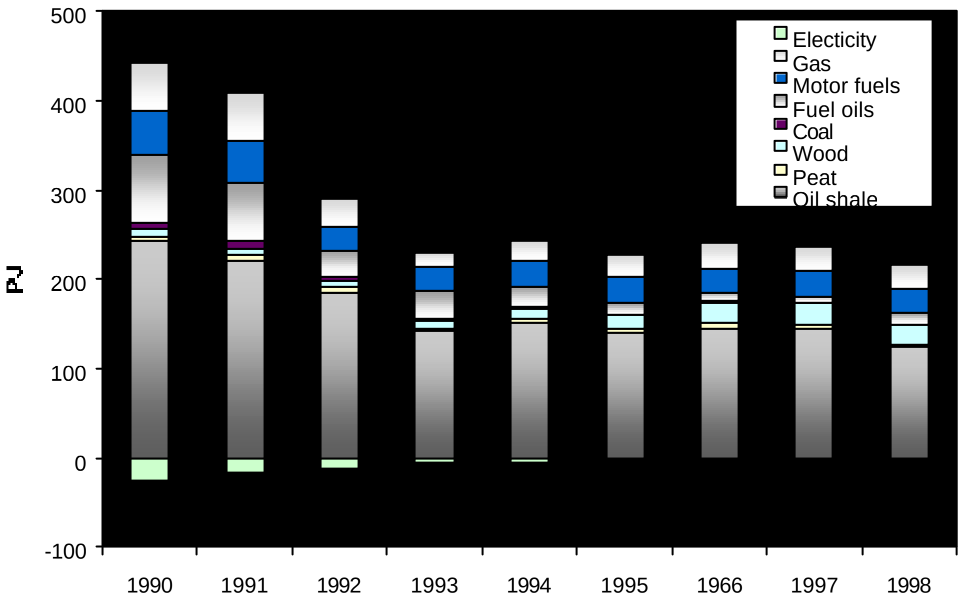

Figure 4.1 Primary energy resources, 1990 - 1998

A specific feature in the Estonian energy sector is the mining and use of oil shale. Oil shale accounted for 58% of the primary energy balance in 1998. Oil shale is mined in underground mines and surface mines whose the production capacity has depended on the demand of power plants and the oil shale processing industry. While in 1980 31.3 megatonnes (Mt) of oil shale were mined, in 1990 the production was 22.5 Mt and in 1998 only 12.5 Mt. Oil shale is mainly used for electricity generation, but also as a raw material for the chemical industry. The share of natural gas in the primary energy supply has been 11-12% in the last years. Renewables include wood and small-scale hydropower. Fuel peat and fuel wood accounted for 12% from the primary energy resources in 1998. Approximately 4 GWh of electricity was produced by hydro, which makes about 0.05% of the total electricity production. Wind and solar energy are also being implemented, but still at the pilot equipment level (Energy Balance, 1999).

Energy efficiency is improving -- primary energy use per GDP was about 30% lower in 1998 (4.39 MJ/EEK in 1995 prices) compared to 1990. Between 1990 and 1998 the consumption of primary energy per capita dropped by 44% to 148 GJ/capita. In 1998, 43% of primary energy was used for electricity generation and 25% was used for heat production. Oil shale accounted for 93% of electricity production. Both electricity production and consumption levels have recovered to some extent after the sharp fall during the transition period. Since 1996 they have been more or less stable. For heat generation mainly fuel oils, natural gas and oil shale were used. The heat production has dropped from 79 PJ in 1990 to 41-45 PJ. Since 1993, the share of natural gas in heat production has increased continuously while that of fuel oils has decreased.

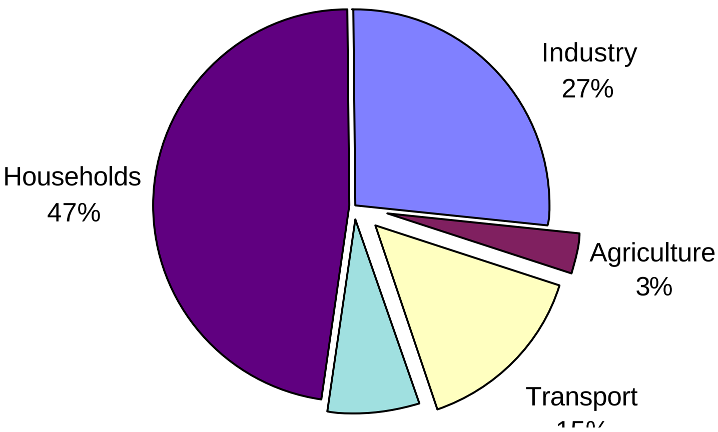

Figure 4.2 Final energy consumption by economic sectors in 1998.

Households accounted for 47 percent of final energy consumption in 1998 (see Figure 4.2), while industry accounted for 27 percent. The share of industry increased slightly in 1998 compared to 1997.

4.2 Economic development scenarios for Estonia

Estonia is a typical example of an economy in transition. However, at the same time Estonia's economic development and growth indicators differ significantly from those of other neighbouring countries, especially Latvia and Lithuania. During the first half of the 1990s, there was a 35% decline in the whole economy due to the transition from a centrally planned to a market economy and the shock caused by drastic changes in foreign economic relations and prices.

After the initial decline and structural change of the economy, it started to grow again in 1995. Estonia's relatively successful integration to EU, significant foreign investments and a growing transit trade have been the major driving forces behind this development. The GDP growth was 4.3 % in 1995, 4.0 % in 1996, 10.6 % in 1997 and 4% in 1998. (Table 4.1)

Table 4.1 GDP growth rate compared to the previous year (Statistical Yearbook of Estonia, 1996, 1999)

Years	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
GDP Growth %	–14	–15	–6.7	–1.8	+4.3	+4	+10.6	+4

The further economic development of Estonia will depend on the integration process of Estonia with other groups of countries such as the EU, the Baltic states, Russia and the Commonwealth of Independent States (CIS). To cope with these uncertain developments, two scenarios have been developed by Estonian economists (Purju, 1996): the base or moderate-growth scenario and the high-growth scenario. Both scenarios assume that global political and economic development has a strong influence on the economic development in Estonia on the macro and sectoral levels. For the purposes of this study the moderate-growth scenario is considered the most appropriate.

The moderate-growth scenario assumes Estonia's close political and economic integration with the West, especially with the EU, while relations with Russia and other CIS countries will be relatively underdeveloped. In this scenario, the GDP is expected to grow by an average of 2.5% annually. The relatively modest growth assumed in this scenario is based on the small size of the Estonian economy. The service sector will be of great importance and the share of manufacturing in the economy will further decrease.

In the context of this scenario, Estonia will not have wider access to the Russian market under the conditions and this will diminish incentives of large international companies to invest into Estonia. Scandinavian foreign investments will continue to dominate and will influence the structure of the Estonian economy.

The high-growth scenario assumes that Estonia's economy will be oriented towards both the West and the East. The flows of transit goods and related services will have a greater role in the economy. Under this scenario, the average annual GDP growth is expected to be 5.3%. Closer relationships with the CIS markets will attract more large international corporations and foreign investments from those companies, will have an increasing role in the Estonian economy. Integration with the EU and the transfer of business culture, know-how and technology through foreign investments will provide the Estonian economy with a good basis for international trade.

4.3 Future energy development

According to the Estonian energy sector long-term development plan (Long-term …, 1998), oil shale will remain as Estonia's largest source of energy in the foreseeable future.

As mentioned earlier modern oil shale combustion technologies will have a key role to play in GHG mitigation.

The share of natural gas will be increased significantly, mostly due to the low environmental impact of this fuel. Its share in the primary energy balance is expected to increase twofold in the next 10-15 years. The use of natural gas will increase mainly in the regions where no other economically feasible resource (like biofuels) is available. With respect to the security of fuel supply, a high dependence on natural gas in the power and heating sectors is problematic as Estonia has only one gas supplier – Russia. An increase in the share of imported fuels in the energy balance would have a negative influence on the balance of payments and would further increase the already high foreign trade and current account deficit.

So far only a small share of available renewable energy sources are in use in Estonia. In the longer-term perspective, the Government envisages an increase in the share of peat, wood and wind energy from the present 8% to 13% in 2010. The substitution of some part of primary energy produced from oil shale with energy from renewable resources will be one way of GHG mitigation.

Possibilities to save energy in production, distribution and consumption are also of increasing importance in the Estonian economy. There is a significant scope for improving energy efficiency in buildings. Examples of such measures are the addition of a third glass to the existing double glazed windows or the replacement with new three-glass panes, improvement of thermal insulation of external walls, installation of new insulated sloped roofs or insulation of flat roofs, replacement of old inefficient heat boilers with new and efficient ones, and installation of new thermal substations in buildings.

When considering the costs of such energy saving methods one should also consider possible indirect benefits related to GHG mitigation and additional potential costs that will occur in the economy if those energy saving methods are not applied (Possible Energy Sector Trend in Estonia, 1999).

The introduction of additional supportive financial schemes for increasing the amount and share of renewable energy sources in energy production could be one important tool for GHG mitigation. Such financial schemes could cover tax exemptions for renewable energy and energy efficiency projects and subsidies for developing and introducing new technologies. These issues are currently discussed at expert level in many Estonian institutions such as the Commission on Renewable Energy in The Ministry of Economic Affairs, the Research Council on the Energy Sector in the Academy of Sciences, and some research institutes and NGOs.

The restructuring of the Estonian energy system and the increased use of renewable energy sources could also be discussed in the framework of regional development. The distribution of economic activities more uniformly between the regions could be supported by the development of local energy production based on renewable energy sources. Regional development is one of the priorities of the future economic policy in Estonia. Regional development policy targets and wider use of renewable energy sources could be integrated.

5. THE CONCEPT OF BASELINE

5.1 Project based mechanisms

In recent years the OECD, the International Energy Agency, JIN (Joint Implementation Netherlands) and Climate Convention Secretariat, plus a great number of other climate experts and researchers have paid considerable attention to the work on baseline construction for project-based mechanisms. There are at least three project-based co-operative mechanisms for climate change mitigation which have been established under the United Nations Framework Convention on Climate Change and the Kyoto Protocol (Puhl, 1999):

?? - Activities Implemented Jointly (AIJ): The first conference of the Parties (COP1) in 1995 decided to establish a pilot phase for Activities Implemented Jointly. This decision establishes that Parties can jointly implement climate mitigation activities. The decision stipulates that credits for sequestered or reduced GHG emissions shall not accrue to any Party during the pilot phase.

?? - Joint Implementation (JI): Article 6 of the Kyoto Protocol enables Annex I Parties and authorised legal entities in Annex I Parties to reduce emissions from specific projects and to transfer the “emission reduction units” thus generated to another Annex I Party.

?? - Clean Development Mechanism (CDM): Article 12 of the Kyoto Protocol enables developing (i.e. non-Annex I) countries to transfer certified emission reduction units from projects to Annex I Parties. The Article 12 allows Annex I Parties to account for such project-level emission reductions achieved from the year 2000 towards their compliance in the first commitment period, 2008 to 2012.

The final rules and guidelines for JI and CDM have yet to be decided by the Conference of the Parties.

To determine the environmental additionality of AIJ-, JI- and CDM-projects, one must establish baselines against which project emissions can be compared. There are more than 133 AIJ pilot projects launched till present time (Planned and ongoing…, 1999) and they may give useful lessons for the other project-based flexible mechanisms. The construction of project baselines is a critical issue in the implementation of these mechanisms.

Baseline construction approaches should take into account the regulatory capacity, national strategies for participation in the project based trading mechanisms, and the suitability of methods for different project types. Conclusions can be drawn from the application of the different baseline construction approaches to “real-world projects” that have already been implemented. Most of the practical experiences with baseline construction has been made in the AIJ pilot phase.

It is somewhat surprising, that until now considerable difficulties still remain in determining project baselines that are environmentally sound, have minimal transaction cost implications and at the same time are also politically feasible, i.e., that projects meet the policy objectives of the participating parties, such as the integration of national development objectives etc.

Assessment of additionality has been yet one of the most crucial and challenging issues in the implementation of the AIJ pilot phase. The additionality criterion is very important for the evaluation of environmental effectiveness of project baselines, but it is rather difficult to determine. It should be pointed out that the parties to the Climate Convention have not yet agreed on how to determine the additional emission reduction and carbon sequestration compared to that which would have occurred in the absence of the AIJ-, JI- or CDM project

Approaches used to calculate emission baselines in AIJ projects are rather diverse. In fact there are many feasible options from which to choose when determining an emissions baseline. This is particularly valid in case of new projects, so-called “greenfield projects”, where no direct comparison for fuel or technology is available for a situation in which an AIJ project was not implemented. It should be pointed out that also emission baselines for replacement or technology transfer projects are subject to significant uncertainties.

The OECD Information Paper “Experience with emission baselines under the AIJ pilot phase” (Ellis, 1999) summarises the reporting experiences to Climate Secretariat and states that: “…the variation in emission baselines between different AIJ projects could hardly be wider: some go up, others go down, many stay constant, and a few are a combination of all three. While some diversity in emission baselines is to be expected due to a wide variation in different AIJ project types, there is also significant variation even within similar projects. This is due to the importance of site-specific variations and to differences in key assumptions such as the time over which the project would generate emissions benefits. These variations mean that the anticipated environmental benefits from comparable projects sometimes vary considerably. It also means that many potential baseline shapes are valid for a given project type. This does not facilitate inter-project comparison, but is unavoidable in a system where project-based emission baselines are used exclusively.”

The OECD paper also gives recommendations for further guidance on evaluating project-specific baselines, which should be critically assessed by the reporting parties’ responsible institutions and adopted respectively. Site-specific information that influences the assumptions underlying the emission baseline estimation methodology should be included in reporting, such as vegetation types for biotic projects, and distance of the project site from alternative fuel sources (e.g. electricity/gas grids) for renewable energy projects. In addition, reports should distinguish between projects actually operating from those at the planning stage.

A general decision framework for common understanding on how a baseline should be developed is urgently needed. The criteria and guidelines should ensure that the baselines developed are objective and verifiable by a third party, which is of the utmost importance in the process of reporting to Climate Convention Secretariat.

It should be recognised that the development and agreement upon common framework on baseline rules is very important for the process of implementing JI and CDM. Standardised and easily applicable methods for baseline construction should also be considered. Such approaches may have both advantages or disadvantages when compared to the aggregated or project-specific approaches. Commonly agreed rules will, in turn, influence the cost and complexity of setting up project based mechanisms and therefore the number of JI and CDM projects in operation. The rules will determine the incentives for project based activities and their environmental integrity.

5.2 Strategic and operational criteria for baseline

This section gives an overview of relevant strategic and operational criteria for baseline construction. It is based on recent studies and papers on this subject ([2]). references rules and guidelines for flexible mechanisms criteria the literature, The following strategic criteria for baselines are proposed in the literature:

?? credibility;
?? environmental integrity;
?? environmental additionality;
?? verifiability;
?? consistency;
?? eligibility;
?? acceptability;
?? transparency.

Credibility of a baseline is enhanced by the quality of the baseline, defined in broad terms. Using the best data available and making clear and well-founded assumptions, leads to a better understanding of and confidence in the baseline. High quality requirement applies to data, to monitoring and reporting, also to the time horizon of the baseline. **Environmental integrity** reflects the environmental importance of the GHG mitigation project and define the emission reductions as tradable credits and is proved by additionality. It could be classified also as a project eligibility question. **Environmental additionality** refers to the additionality of the baseline. This means that a project must clearly demonstrate greenhouse gas emission reduction that are additional to the reference case (baseline). In case a rather old technology is replaced by a new technology, the baseline may not necessarily be based on the old technology; it is recommended that the baseline is based on the typical of technology in similar circumstances, thus leading to smaller emission reductions. However, the additionality is also determined by the time horizon of the baseline: the longer this period extends, the higher the chance that at some point the new technology is not additional anymore. In other words, it is recommended to establish baselines for a maximum period of time to see, if it can still be considered as additional.

[2] For references, please see the list at the end of the report

Verifiability means that the baseline construction must be performed in such a way that it, once completed, can be verified without any problem by independent entities.
Consistency applies to different levels; on an aggregate level it is important that identical data are used for establishment of baselines for similar projects. On project level consistency is important regarding the use of indicators such as growth rates for industry, emission factors etc. **Acceptability** means the baseline for project should be in line with common understanding of a baseline in that particular case. **Transparency** regarding the information used and assumptions made increases the chance of acceptance of a baseline by the host and donor countries, as well as by others.

The following operational criteria are emphasised in a number of studies:
?? data quality;
?? monitoring quality;
?? reporting quality;
?? predictability;
?? responsibility;
?? reliability.

Data quality means that the data which are used for construction of baseline are either registered by own monitoring or from sources that are verifiable. Uncertainty will always remain in collecting data, it is suggested that certain low (margin of 5%) is allowed, like in national inventory calculations. As for data quality, two additional criteria – comparability and reproducibility must be emphasised here. Good data is a fair basis for making a framework for baseline establishment, without actually defining the exact calculation of the baselines but rather guaranteeing its appropriateness. The baseline construction framework must ensure that the results of the different baseline calculations are comparable and reproducible. **Monitoring quality** is related to describe in a representative way the current situation and phase out the seasonal implications. Another way is to make use of reference groups, that actually avoids monitoring costs.

Reporting quality presents the minimum requirements to the project owner for the reporting of necessary data. **Predictability** refers to the need that the proposed baseline should forecast the future emissions, taking into account various expectations about relevant sectors' growth, improving energy efficiency, growth rate of national economy, estimated technological development, etc. The predictability decreases when the time horizon of the baseline extends. **Responsibility** means the project owner must take responsibility for the baseline and should be aware of this responsibility. **Reliability** applies to the emission credits resulting from a project and is important for two reasons: for the project investor, who might use the emission credits, but also for emission credit buyers on the secondary market.

5.3 Defining baselines

Historically the baseline issue was initiated when the AIJ pilot phase was decided at COP1 in 1995; it was stated that a baseline is equivalent to the level of emissions that would have prevailed in the absence of such AIJ activities.

Based on the language of Kyoto Protocol, a baseline is equivalent to the level of emissions that:
?? is additional to any that would otherwise occur (JI);
?? is additional to any that would occur in the absence of the certified project activity (CDM).

There have been several studies devoted to baseline construction for different types of projects, different donor and host country financial arrangements, and for varying time horizons as well as monitoring and verification procedures. OECD Environmental Directorate and IEA have been active in gathering experience from member states and generalise the results. Many overviews and articles have also been published by others in the past few years.[3]

From the OECD overview papers it is clear that there is no internationally agreed methodology on how to define and construct CO_2 emission baselines for AIJ or JI and CDM projects. However, in practice there exists already general guidance used by several investor countries for practical purposes. In the last years baseline and reporting practices have varied greatly. Some of them include quantified emission baselines, some reports presented more than one possible baseline for the same project, while other reports did not present any or only outlined the total projected emission benefits over the project lifetime.

There have been several other attempts to define baselines, such as a project baseline used as a benchmark to assess mitigation performance by comparison with actual emissions. Puhl (1998) defines it in the following way, baseline is a certain type of standard from which a measure of valid emission reductions or sink enhancement is derived and used for various reporting procedures.

Gustavsson (Gustavsson et al, 2000) gives a generalised definition of a baseline as a path through time that an accounting variable would have followed in the absence of a specific greenhouse gas mitigation activity. It is, of course, impossible to know the exact route of the path not followed, so the challenge is, for each project, to provide a credible description of its most probable path.

In the following an overview of different methods for baseline construction is given. It is based on Puhl and Ellis (1999).

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[3] See. for example, *Status of Research on Project Baselines under the UNFCCC and the Kyoto Protocol* (Puhl and Ellis, 1999), *Options for project emission baselines* (Ellis and Bosi, 1999), *Draft framework for baselines guideline* (Ellis and Bosi, 2000), *Review of reports on Activities Implemented Jointly under the pilot phase with a specific focus on baseline and additionality issues: lessons learned and recommendations regarding practical options* (Michaelowa, 1999), *Project-based greenhouse gas accounting. Guiding principles with a focus on baselines and additionality* (Gustavsson et.al., 2000).

The approaches for defining project baselines can in general be classified into three categories:

1) method-based approaches;
2) comparison-based approaches;
3) simulation based approaches.

Method-based approaches, such as a) benchmarking, b) top-down (e.g. sectoral) baselines, c) technology matrix, and d) default baselines, establish a standard baseline that can be applied to a number of projects once it has been agreed and the projects have been found eligible. Method-based approaches are based on the aggregation and seek to reduce transaction costs and improve consistency between projects by elaborating generally applicable guidelines that are independent from the specific conditions of some particular project. Such approaches would generalise the baseline setting process and move away from subjective case-by-case decisions.

Benchmarking is a standard which a project must meet in order to generate valid emission reductions. Baselines would be derived from those criteria. The benchmark could be based on objectively verifiable information such as the historic or current emission intensity of a sector (current practice in the host country or international best practice) or on projected emission intensities. Historic approaches are generally easier because information is more readily available, projected data could be more difficult to obtain and justify. In principle, the benchmarks could be static, fixed over the project life time, or dynamic, adjusted periodically.

Under a *top-down* approach, a baseline would be fixed at an aggregate level that would cover a number of possible activities. A baseline could be set for a sector, a type of technology, or a system. The level of aggregation should suit the respective circumstances. Once the aggregate baseline has been set, a national climate change authority can allocate baselines for project activities without project-by project assessment. Additionality of emission reductions from any projects that fall within the aggregate level is determined as any reduction from the project baseline that has been allocated, rather than individually assessed. All sources and sinks of GHG emissions included in the aggregate baseline would be monitored. The big advantage of top-down baselines includes that, once such baselines are constructed, their practical application to individual projects is significantly simpler and faster. Also, the project manager would be able to use the relatively simple baseline approach, which creates realistic incentives for him. There are significant time and cost saving implications in developing top-down baselines. For example, they may have high up-front development costs, but the approval costs of individual projects are minimised and the leakage possibilities are reduced.

Under a *technology matrix* approach, an inventory of existing technologies might be made for a country or region. Some or all of those technologies could be defined as baseline technologies. The technology selection could be limited to the average technology and the technologies used in the projects would be compared to the baseline technology or mix of technologies that best fits the profile of the proposed investment in terms of size and operation characteristics. The list of baseline technologies would be regularly updated and only those technologies are included which reach certain share in terms of production. Once they are included, they would no longer qualify as technologies that generate additional emission reductions. A drawback with this approach is that a too narrow range of technological options could be established as baseline technologies. This could inhibit innovation of non-recognised technologies if there were no suitable baseline technologies against which to compare emission reductions from the new technology.

Under the *default baseline* approach, a standard baseline would be defined for a narrow category of projects. Once fixed, further baseline additionality testing for each project in that category would not be required. It might be difficult to obtain the initial agreement on a list of projects that could generate emission reductions from the standard default baseline. Still, once such an agreement is made, unlimited numbers of projects of that category could be implemented, until the list of projects is reviewed.

Comparison based approaches do not seek to construct an artificial or "without-project" case but identify a "real-word" reference project (or so called control project) against which project emissions are measured. The approach entails finding a valid reference project and monitoring the GHG emissions in that particular project. This approach is suitable for so called replacement projects as there is a real baseline plant and the performance of two real facilities can be compared, Still, this approach raises questions about the validity of the baseline period. This approach is considered to be very costly and therefore of limited use.

Simulation based approaches include a) barrier removal, b) commercial tests and c) multiple baselines. They investigate which project would have been implemented in the absence of the proposed activity. The relevant assessment is carried out in the context of proposed activity. The approaches are used mostly with the help of economic models to predict whether the proposed project would have been undertaken anyway in preference to a baseline project or whether climate change mitigation provided an incentive to switch technologies. The *barrier removal* method entails identification of barriers what are specific to implementation of a project compared to a baseline project. If implementation of a project becomes feasible because the added benefits form climate change mitigation overcome such barriers, part of the GHG emission reduction from the project can be considered additional. List of relevant barriers for a number of project types already exists and can be regularly updated. The *commercial tests* method entails a shadow price calculation of the greenhouse gas benefits of a project by comparing the cost of the mitigation project against that of baseline project. If the cost of the mitigation project is higher than the baseline project, it might be argued that the additional cost reflects the value of climate change mitigation and therefore the project was undertaken at least partly for climate change mitigation purposes. This approach requires a significant amount of financial and environmental information that might be available to the project sponsors but is not likely to be available third party reviewers, because of commercial confidentiality and several other concerns. *Multiple baselines* methods elaborate a number of different baseline scenarios and on that bases the construction of a weighted baseline, taking into consideration the estimated probabilities for the different scenarios.

To compare all three characterised above approaches for baseline construction one can notice that some baseline construction methods use project-by-project methods, while others establish a standardised, aggregate baseline that can be applied to a number of projects once it has been agreed and projects have been found eligible. Aggregate baselines have three main advantages compared to project by project baselines; their transaction costs associated with the baseline construction are significantly lower. Secondly, the leakage possibilities, which are inherent in project by project baseline setting, could be reduced to a minimum. Thirdly, there is also improved consistency between the projects. All method-based approaches like benchmarking, top-down, technology matrix and default baseline are within the category of aggregate baselines, whereas simulation and comparison based approaches are project-specific approaches.

Some of the approaches like top-down baselines, have high up-front development costs, but minimise the approval costs of individual projects and reduce leakage possibilities. Other approaches require little up-front development, but place a high cost on the individual project developer. In addition, some approaches are suitable for single, "one-off projects" while others are more suitable for large number of projects within the context of a national programme.

5.4 Motivations for choosing the top-down method for this study

About half of the projects in the of Swedish AIJ Programme are boiler conversions from fossil fuels to biomass, i.e. renewable energy projects. Nine such projects have been implemented in the district heating sector in Estonia. It therefore was natural to chose this sector for constructing a sectoral baseline.

In this study the top-down approach was chosen to construct a sectoral CO_2 emission baseline for the district heating sector. One reason for choosing this method is that Estonia has relatively good statistics by sectors, but not by single heat plants and boilers. The availability of sectoral statistics is partly a result of the emission inventories carried out since 1994. The relatively high number of AIJ projects makes it reasonable to use a top-down approach for the construction of the baseline. When sectoral average values are used, the transaction costs of the projects can be reduced. This method also simplifies the reporting of the AIJ projects.

The benchmarking approach would have been more complicated in this case as the needed information for deriving the historic data on all heat boiler plants using fossil fuels, would have been too time-consuming. Moreover, the information on all boilers would be difficult to attain.

6. CO_2 EMISSION BASELINE CONSTRUCTION FOR THE DISTRICT HEATING SECTOR

This chapter describes how CO_2 emissions baselines were constructed for the district heating (DH) sector in Estonia according to the top-down method. First the main development trends of the district heating (DH) sector are analysed, including changes in heat production and fuel consumption. Based on these trends the CO_2 emissions from the DH sector for the period 1993-2005 are then calculated. The CO_2 emission projection for this period can be used as a baseline for the DH sector. The emission projections are made in two ways: the first includes the effects of AIJ projects in the DH sector, the second excludes them. In the final section of the chapter, it is discussed how these two projections may be used as baselines for the DH sector and applied for the assessment of individual AIJ and JI projects.

6.1 Development of the Estonian district heating sector

This section gives an overview of heat production and fuel use in the Estonian district heating sector since 1990. It is based on national statistics (Energy Balances, 1993-1999).

The Estonian Energy Act (1998) and the National Long Term Fuel and Energy Sector Development Plan (Long-term…, 1998), establish the main development plans of the energy sector. The development plan includes an energy conservation plan and is periodically revised and updated. The Second Energy Conservation Plan was adopted by Government in January 2000 (Energy…, 2000). The government is responsible for the control and development of the energy sector. The Planning and Construction Act (Planeerimis…, 1995) regulates the role of municipalities in controlling regional development, including the development of energy supply and rational consumption. Energy sector development plans for more than 40 municipalities have been elaborated with the assistance of the PHARE Programme Project Implementation Unit in Estonia in the past two years. They include the analysis of local energy demand and supply perspectives and proposals for energy-efficient development of local heating systems.

Estonia has a well developed district heating (DH) system. DH is considered to have good perspectives for further development. However, it is presently in urgent need of technical upgrading. The existing DH system was designed and built in the period of centrally planned economy before 1990s. The planners neglected the actual structure, supply and cost of fuels. The energy prices in use did not reflect the real costs, they were heavily subsidised. During the centrally planned economic system the operation of the energy systems deteriorated for many decades. Presently there is a great need for renovation of boilers and distribution networks in the Estonian DH system. The losses in the heat distribution networks are very high. Replacement of old pipes with pre-insulated pipes started in the mid-1990s.

Since 1991, when the deregulation of the energy market started, the DH companies had to adapt to the changing market conditions, including disruptions in fuel supply due to political pressure from the east in the early 1990s. Large investments are required to overcome the deficiencies in heat supply, particularly in the public sector and housing. In the expenditures of an average Estonian family, heating bills account for a significant share and the steady growth of heat prices continues to burden Estonian households. Thus, alternative solutions must be found. Between 1991 and 1993, prices on fuels and energy grew rapidly, energy demand decreased and consumers had difficulties in paying their energy bills while energy companies could not procure fuels. The Estonian DH companies survived the first years after regaining independence mainly with the support of loans for fuel. However, the loans repayment of these loans has prevented the companies from lowering the heat prices. Since the mid-1990s when the prices on fuels and heat increased rapidly many households have transferred from DH to private local natural gas fuelled small boilers.

Because the DH sector is capital-intensive and has a long investment payback period, investments can only be made if there is a reliable demand for the service in the long run. Therefore, the Estonian government will have to make further efforts to integrate environmental policy with macro-economic policies in order to improve consumers' confidence in district heating. This is particularly important when implementing local development plans.

6.2 Heat production and fuel use

Between 1985 and 1990, the production of heat increased continuously and peaked in 1990-1991. (Figure 6.1) In 1991-1993 there was a sharp drop in heat production due to the economic recession after the collapse of the centrally planned economy. The biggest drop of heat and power occurred in industry and agriculture due to the restructuring of those sectors. In 1998, 36% of heat was generated in power plants and 64% in boiler houses. In the DH sector a total of 7.3 TWh of heat was produced from 33228 TJ of fuels. (Table 6.1) In 1998, about 27% of heat was generated in boilers with a capacity above 20 MW and 73% in boilers with a capacity less than 20 MW. In 1998, the total number of boilers in Estonia was 4481 (including 742 boilers using biomass fuel) with a total capacity of 7934 MW.

The share of domestic fuels in boiler plants has continuously increased since the beginning of 1990s. In 1998 about 34% of heat produced in boiler houses was generated based on local fuels (oil shale, shale oil, peat, firewood and wood waste), the rest was based on imported liquid fuels from the east. In Sweden, for example, about 50% (26 TWh) of the heat produced in DH in 1998 was based on local wood fuels, peat, refuse, etc. accounting for 25.5 TWh (Energy in Sweden, 1999). Estonia also favourable conditions for local biomass use in the heating sector and it should therefore be possible to increase the share of biomass in heat production.

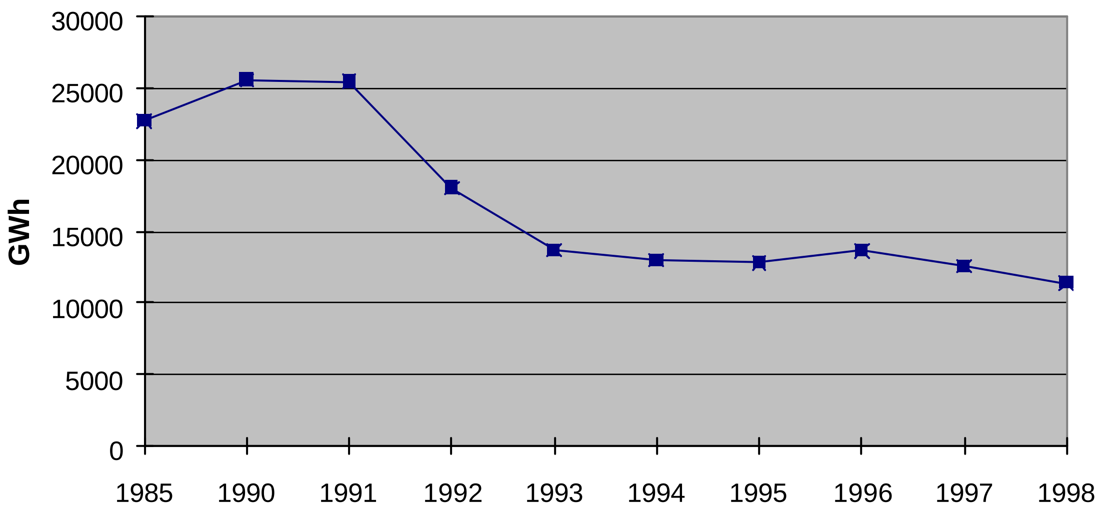


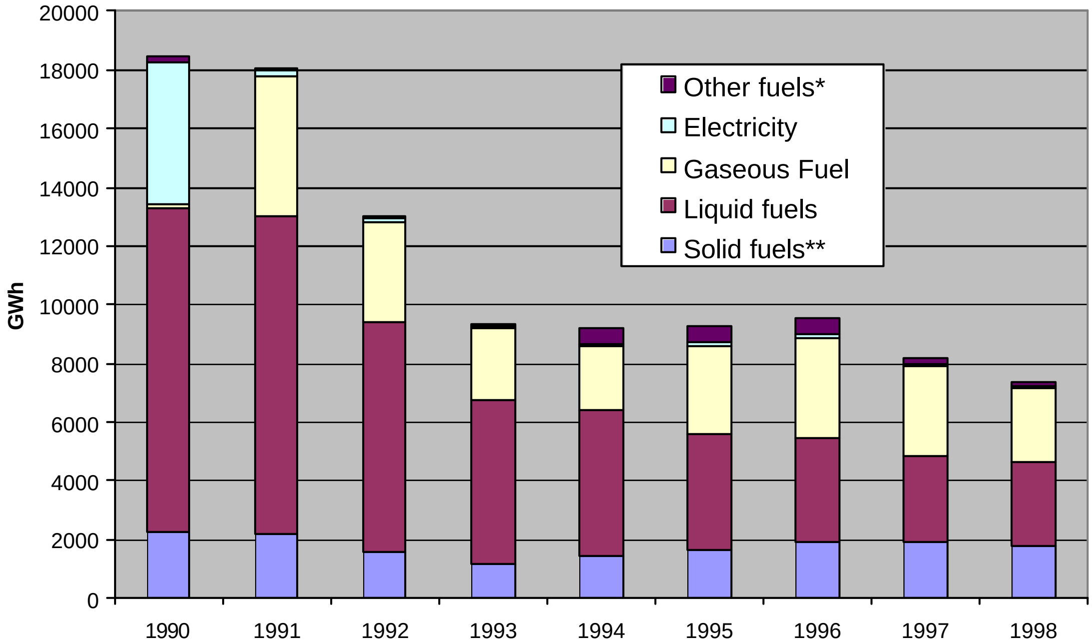
Figure 6.1 Total heat production in Estonia 1985 - 1998 (incl. heat from power plants)

Table 6.1 Fuel consumption and generated heat in boiler plants, TJ

Fuel	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Coal	4731	4639	3343	2396	2030	1723	1567	1077	800
Oil shale	992	973	701	502	432	483	873	531	764
Peat	1271	1246	898	644	1004	1436	1853	1637	1002
Wood	3792	3718	2679	1920	3565	4360	5207	5636	6097
HFO	41761	40951	29507	21146	16652	11431	11682	8994	8468
Shale Oil	8419	8255	5948	4263	5800	5899	3674	3646	3565
LFO	720	706	509	365	461	778	1114	1337	1288
Gaseous Fuel	19943	19556	14091	10098	8803	12239	13799	12585	10625
Electricity	694	681	490	352	455	485	481	379	258
Other fuels	340	333	240	172	2234	2365	2477	953	361
Total fuel consumption (TJ)	**82663**	**81058**	**58406**	**41858**	**41436**	**41199**	**42727**	**36775**	**33228**
Total heat generated (GWh)*	**16759**	**14580**	**12998**	**9313**	**9206**	**9248**	**9561**	**8212**	**7321**

* total heat generated in boiler houses

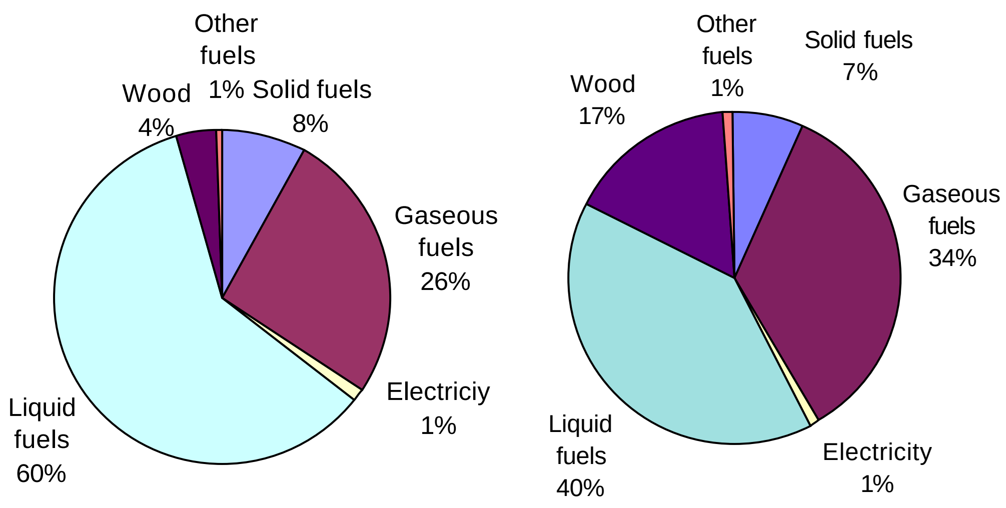
Among imported fuels, the share of heavy fuel oil is continuously decreasing. It is being replaced with natural gas, which has a lower carbon content than oil shale or coal and low emissions of sulphur and particulates. While 50% of heat was produced from heavy fuel oil in 1990, it was only 26% in 1998 This trend is in line with Estonia's development plan, which foresees a rapid increase in the share of domestic fuels for heat production. Some 34% of the heat produced in boiler plants in 1998 was produced from natural gas, the share of natural gas is foreseen to increase further. (Figure 6.2)



* including generator gas and methane gas
** including peat, wood, oil shale and coal.

Figure 6.2 Heat production in boiler houses by types of fuels, 1990-1998

The structural change in fuel consumption for heat production is clearly demonstrated in Figure 6.2. The share of liquid fuels dropped from 60% in 1993 to 40% in 1998. The share of solid fuels (coal, oil shale and peat) has been relatively stable, while the use of biomass increased significantly.



1993 1998

Figure 6.3 Changes in the fuel structure of heat production in the DH sector

The regaining of political and economic independence in 1991 led to drastic changes in the level and structure of fuel consumption. The transition from a centrally planned economy to a market economy resulted in a sharp increase in fuel prices and raw materials, especially for imported fuels. For example, the price of natural gas rose more than 700 times, that of heavy fuel oil about 450 times while the price of gasoline and diesel oil increased 150 times within one and half years.

There was a sharp decline in the use of coal from 4731 TJ in 1990 to 800 TJ in 1998, and also in the use of heavy-fuel oils (HFO) from 41761 TJ to 8468 TJ and shale oil from 8419 TJ to 3565 TJ in years 1990 and 1998 respectively. The use of wood increased from 1920 TJ in 1993 to 6097 TJ in 1998. This indicates that Estonia has switched from polluting fossil fuels to significantly less polluting renewable fuels and become less dependent on energy imports from Russia. This has rather important aspect of safety of supply, as the Estonian DH sector has become less vulnerable to the unreliable supply of fuel oils from Russia.

6.3 The future trends of heat production until 2015

In Table 6.2 the structure of different fuels for heat production in boiler houses in the Estonian DH sector is given for 1998 together with projections for the structure of fuel consumption until 2015. The principal development priority of the Estonian energy sector is the development of a well-functioning electricity and gas supply system. According to the Estonian Long Term Plan of Energy Sector Development (Long-term…, 1998), the share of natural gas will increase significantly, because of the low environmental impact of this type of fuel.

Heavy fuel oil and shale oil, used for heat generation in boiler houses accounted for about 36% of the fuel balance in 1998. Until 2015, their share will gradually decrease to about 18%. The share of LFO will remain constant. The share of biofuels (wood waste, fire wood, wood chips, etc.) is expected to increase and replace heavy fuel oil. According to the development plan (Long-term…, 1998), the share of wood is foreseen to grow from 20% in 2000 to 30% in 2015. A further increase in wood fuelled boilers is foreseen as well as an increase in co-generation of heat and power. The share of hard coal and oil shale is planned to decrease from 4% in 2000 to 2% in the next 15 years period. This will further reduce the level of pollution regarding all major air pollutants. The share of natural gas use is expected to increase. (Figure 6.4)

Table 6.2 The expected change in the fuel structure of heat production in boiler houses, in percent

Fuel	**1998**	**2000**	**2005**	**2010**	**2015**
Wood	18	20	25	28	30
Peat	3	4	3	3	3
HFO (incl. shale oil)	36	32	26	22	18
LFO	4	5	5	5	5
Natural gas	33	35	38	40	42
Other fuels (oil shale, coal, etc)	5	4	3	2	2

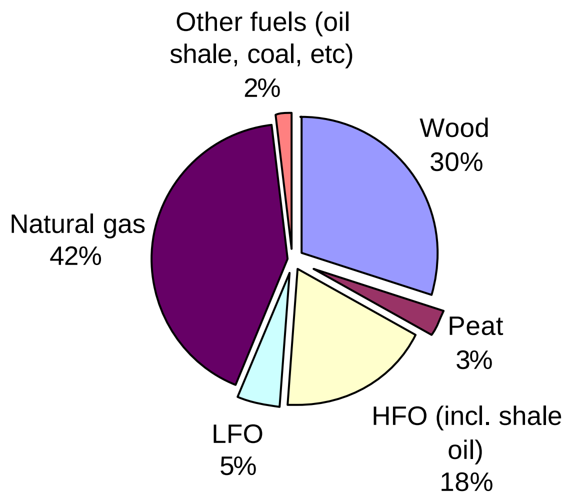


Figure 6.4 Expected fuel structure in the Estonian DH sector in 2015

Peat is an important local fuel in Estonia. The use of peat is planned to increase in the Long term development plan of energy sector (Long-term…, 1998). About 22% of Estonia's land area are covered with wetlands. According to some Estonian experts peat could be considered a renewable energy source, with some reservations, in the context of climate related issues. According to IPCC Guidelines, peat is considered as fossil fuel, Estonia has followed these guidelines in its National Communications under the UNFCCC. (Estonia's National Communications are presented in Chapter 3.) The exploitation of peat is controlled and performed at a sustainable rate in Estonia.

6.4 Calculation of CO_2 emissions for the district heating sector

In order to calculate the CO_2 emissions in the DH sector for the period 1993-2005 the IPCC Revised Guidelines for calculations of emissions from various fuels (IPCC Revised…, 1996) were followed. The CO_2 emissions were estimated based on the amount of fuels used and their carbon content. Data on fuels were taken from national energy statistics (Energy Balance, 1990-1998), where the data for heat generated (in GWh) in boiler houses and amounts of fuels (in TJ) used for heat production are given. Thus, the total consumption of each fuel was converted into CO_2 emissions using the appropriate carbon emission factor as follows:

Fuel consumption * Carbon Emission Factor

To transfer the carbon tonnes to CO_2 tonnes a straight transformation based on appropriate atom weights is applied. The atomic weight of carbon is 12 and the molecular weight of

CO_2 is 44, thus the coefficient value of 3.67 must be applied to convert 1 tonne of carbon into 1 tonne of CO_2. The carbon emission factors used for the fuels in the heating sector are given in Table 3.1.

In 1990 the total amount of CO_2 emissions from heat generation in the DH sector was 5717 thousand tons. In 1998 it had dropped to 1886 thousand tons (Table 6.3 and Figure 6.5). This represents a decrease in emission of CO_2 from heat generation in boiler houses by 67%. The sharpest drop was between 1991 and 1993 mostly due to a steep decline in the consumption of imported fossil fuel. As shown earlier there were also significant changes in the structure of fuel consumption between 1993 and 1998.

Table 6.3 CO_2 emissions from heat generation in the district heating sector, thousand tonnes

1990	1991	1992	1993	1994	1995	1996	1997	1998
5716.8	5605.8	4039.3	2914.5	2737.8	2589.0	2624.4	2168.4	1886.1

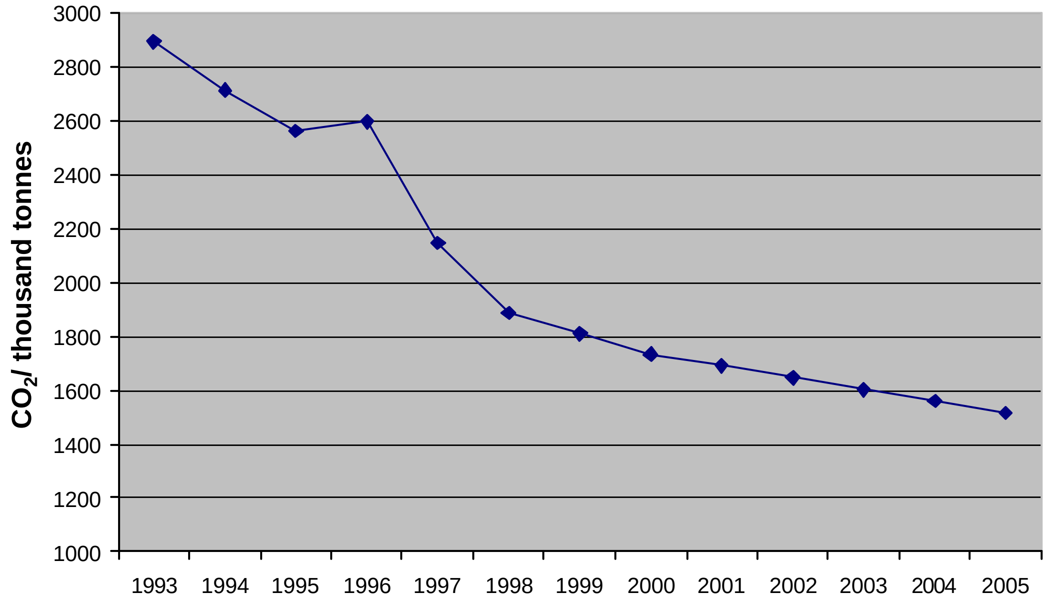


Figure 6.5 CO_2 emissions from heat generation in Estonia's DH sector 1993-2005

Figure 6.5 shows the CO_2 emissions of the Estonian district heating sector. The values for the period 1993-1998 were calculated based on reported fuel consumption data, as explained earlier. The values for the period 1999-2005 are projected data based on the information presented in section 6.3. Since the values before 1999 are actual, reported emissions, they include the effects of avoided emissions from AIJ projects in the district heating sector. The values for the period 1999-2005 were estimated on the basis of projections of present fuel consumption and were then adjusted for avoided emissions from AIJ projects. The value of the avoided CO_2 emissions for 1999 – 91.3 thousand tons — was used for each year in the period 1999-2005.

The CO_2 emission values for the period 1990-2005 were converted into emission intensity values of produced heat for the same period by dividing the CO_2 emissions for each year by the annual heat production. The result is depicted in Figure 6.6. It shows the average CO_2 emission per unit of heat production (CO_2 per MWh) for the district heating sector. It is a measure of how the CO_2 intensity of heat production in the DH sector changes from 1993 to 2005.

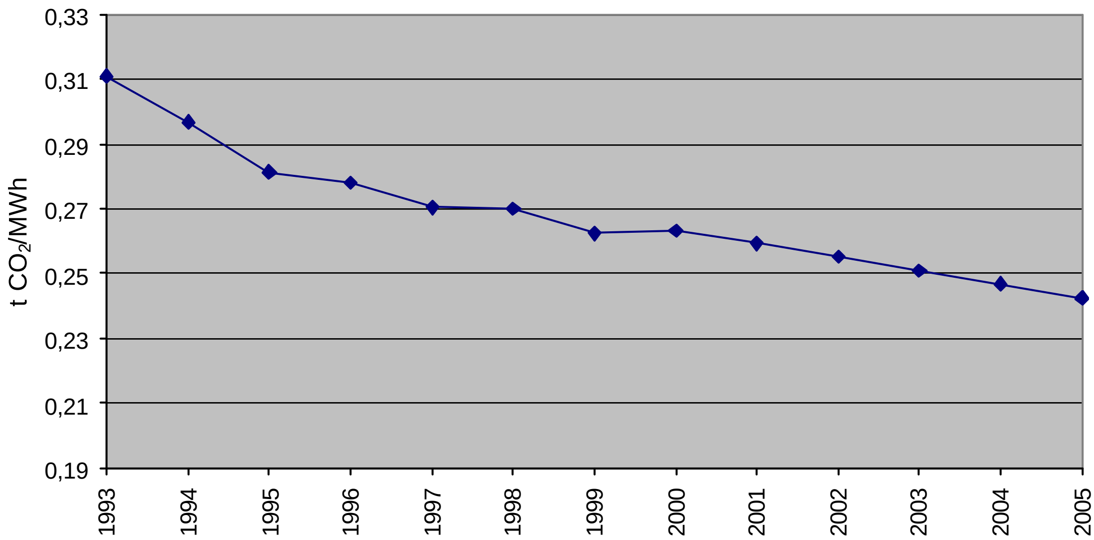


Figure 6.6 CO_2 emission intensity of heat production in the Estonian DH sector 1993-2005

6.5 *Effect of AIJ projects on the district heating baseline*

One of the objectives of this study was to examine the effects of AIJ projects in the district heating sector in Estonia. Because Estonia is a small country and there is a relatively high number of active AIJ projects in the same sector, the aggregated effect of their emission reductions may have a significant influence on the whole sector. In order to examine this effect in the DH sector the avoided CO_2 emissions from the AIJ projects were calculated and compared to the total CO_2 emission in the district heating sector. (Table 6.4)

Table 6.4 Reduction of CO_2 emissions by Swedish AIJ projects, tonnes

AIJ project category	1993	1994	1995	1996	1997	1998	1999
1. Boiler conversion to local fuel wood	879	18482	38771	56798	65109	75685	80000
2. DH networks renovation projects	0	0	468	2648	8890	11335	11335
Total	879	18482	39239	59446	73999	87020	91335

As shown in Table 6.4 the CO_2 emission reductions resulting from the Swedish AIJ projects in the DH sector amounts to 4-5 percent of the DH sector's total CO_2 emissions in 1998.

An adjusted CO_2 emission projection was then constructed and compared to the projection presented in section 6.4 which includes the effect of AIJ projects. The result of this comparison is shown in Figure 6.7. In the figure the upper curve shows the emissions without the effect of AIJ projects. The lower curve shows the emissions when the effect of AIJ projects is included. The difference between the upper and lower is the avoided CO_2 emissions which occur as a result of the AIJ projects, i.e., the reductions in Table 6.4. In Figure 6.8 the CO_2 emission intensity of the DH sector with and without the effect of AIJ projects is shown.

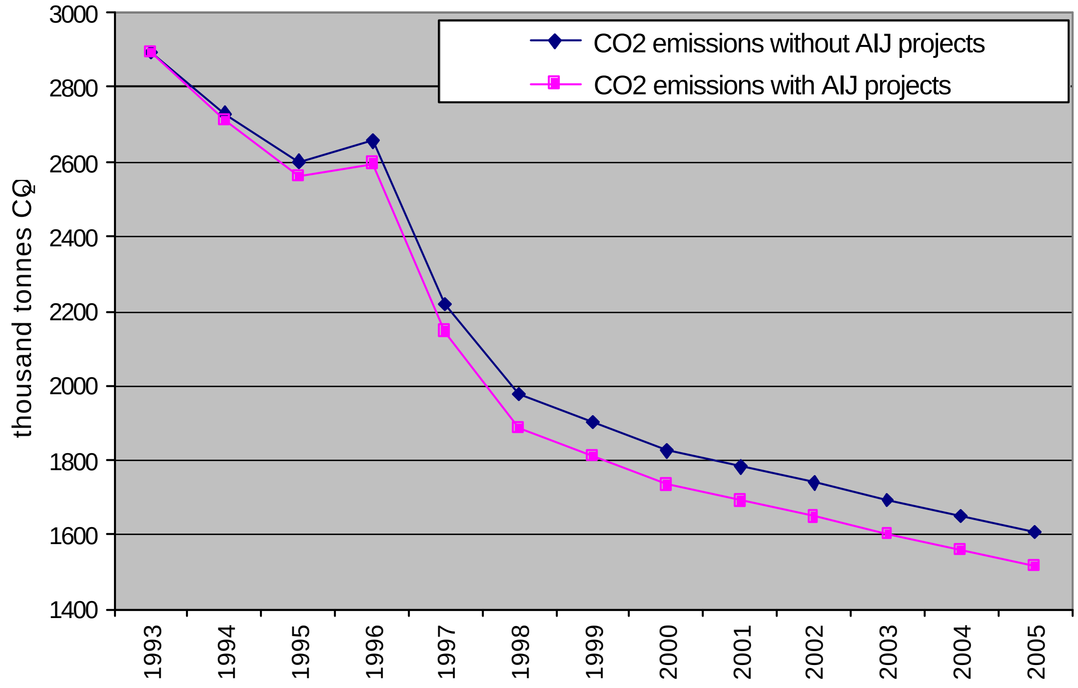


Figure 6.7 CO_2 emissions in Estonia's DH sector with and without the effect of AIJ projects

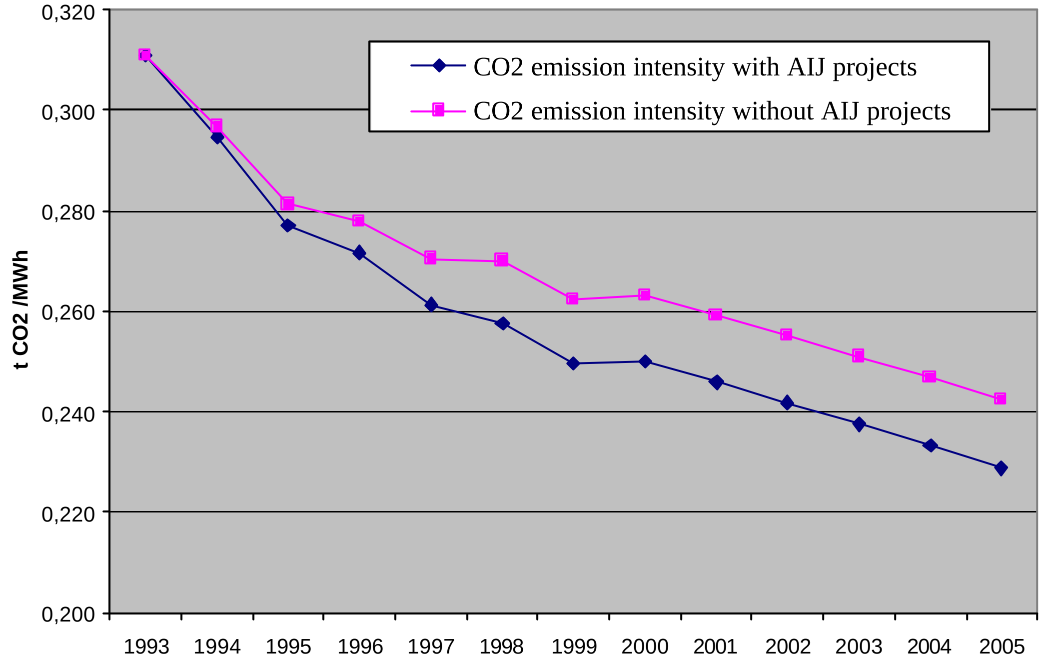


Figure 6.8 CO_2 emission intensity in Estonia's DH sector with and without the effect of AIJ projects

6.6 Application of baselines

There are two cases for which the CO_2 emission projections presented in the previous sections may be used as baselines in the district heating sector in Estonia. The first case is when the baseline is needed to test the environmental additionality of new AIJ or JI projects and to calculate their avoided CO_2 emissions. The second application is when the baseline is used for the reporting of already implemented AIJ projects in order to calculate their CO_2 emission reductions.

For the reporting of AIJ projects that were started before 2000 it is suggested that the CO_2 emission projection without the effect of AIJ projects is used as baseline, i.e. the upper curve in Figure 6.7. It seems reasonable that the effects of early AIJ projects should not affect the baseline and the emission reduction calculations for these projects.

In the case of new AIJ or JI projects in the DH sector in Estonia, i.e., projects starting in 2000 or later, the lower CO_2 emission projection in Figure 6.7 may be applied as baseline. This baseline accounts for the effects of AIJ projects started before 2000.
This means that projects, which starts in the year 2000 or later will have to use a revised baseline for the period 2000-2005. (It is, of course, also possible to extend this period beyond 2005.) Because of the dynamic economic development in Estonia and other economies in transition baselines for different sectors need to be revised at regular periods to meet the requirements of environmental additionality. This approach is a way to do such a revision and to account for the effects of already realised AIJ projects in the DH sector.

A practical way to apply the CO_2 emission baselines for the assessment of individual AIJ or JI projects in the DH sector, is to use the emission intensity curves in Figure 6.8. For new projects, i.e., for the period 2000-2005, the lower curve can be used as an additionality test; all projects with a lower emission intensity than the baseline will be additional. Moreover, it can be used to calculate avoided emissions when comparing the CO_2 emissions of the AIJ/JI project to those of the baseline case. The baseline emissions for the individual project can be calculated by multiplying the emission intensity curve (the baseline) with the project's heat production.

Similarly, CO_2 emission reductions of existing AIJ projects for reporting purposes can be calculated by applying the upper curve in Figure 6.8 as a baseline (i.e., the emission intensity of the DH sector without AIJ projects).

The approach discussed here is similar to that of benchmarks. A benchmark is defined as a constant emission intensity value characteristic to a particular technology or a whole sector over a certain period of time. In contrast to a benchmark, however, the approach suggested here does not use a fixed intensity value for a whole period but an intensity value that changes over time.

7. CONCLUSIONS

In this report a top-down CO_2 emission baseline was developed for the district heating sector in Estonia. When there is a high number of the same type of AIJ projects in one country the top-down approach can help to reduce transaction costs. It also reduces the reporting time and costs of the projects compared to many other baseline approaches presented in chapter 5. Another benefit of standardised methods is that they will make it easier to compare the results of AIJ and other climate projects in different countries.

Since the Estonian energy sector operates under dynamic market conditions, long-term forecasts for the fuel use and fuel structure in the district heating sector are difficult to make. The economic development and the development of the heating sector in Estonia should be carefully studied as changes may occur which will increase the share of renewable energy sources.

Significant changes in a country's economic development should be considered when constructing emission baselines. The CO_2 emission baseline presented in this study will therefore have to be revised in the future. However, it is important to reach an international consensus on the rules and guidelines for how such revisions should be made. The revision of baselines should be regulated according to certain criteria, such as the category of the project, the lifetime of the project and other specific factors, which may influence the level of CO_2 emissions. In conditions of relatively fast economic development and technical change, a lifetime period for baselines of 5-10 years may be practical to use for this type of projects.

The method presented in this report could also be applied to other sectors and countries. It is important that more analyses of this kind are made so different methods for baseline construction can be tested and discussed.

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