Preconditions for Improved Energy Efficiency and Increased Use of Renewable Energy In the Barents Region

Final report

2010-09-14

Report prepared by CENTEK AB, Luleå Sweden
for
the Nordic Environment Finance Corporation (NEFCO)

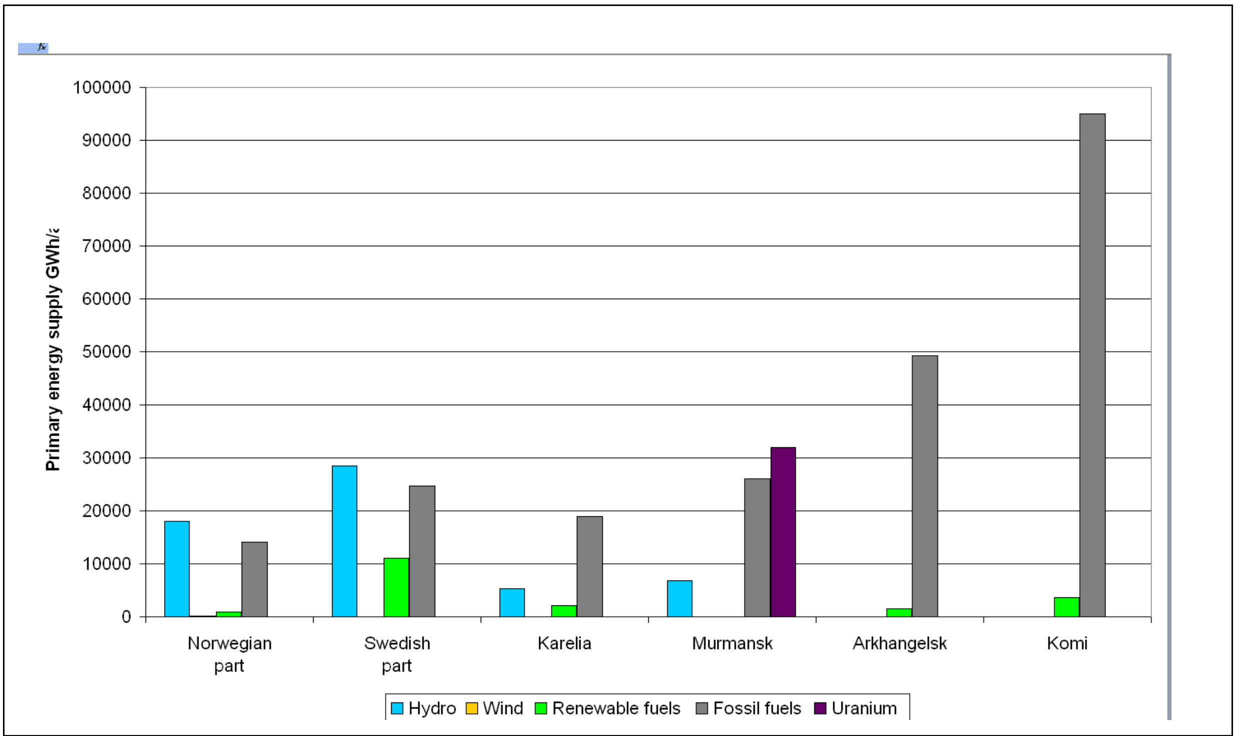
Executive summary

Background

This study was conducted primarily to serve as a basis for formulation of guidelines and recommendations for the further use of the funds provided by Sida in Sweden within the Barents Window. The study includes collection and analysis of relevant existing information about the conditions in the Barents region in general compared to those in the Russian parts of the Barents region. Due to limited time and resources, Finland and Norway have only to a very limited extent been included in the fact collection process. so far.

Inclusion of more data from Finland and Norway will give a better understanding of the status of energy efficiency and renewable energy in the western parts of the Barents region. It is nevertheless believed that the main conclusions will not change when such data are considered.

There are large differences between the energy supply structures of the different parts of the Barents region. This is illustrated by the figure below.



Primary energy supply to different parts of the Barents region

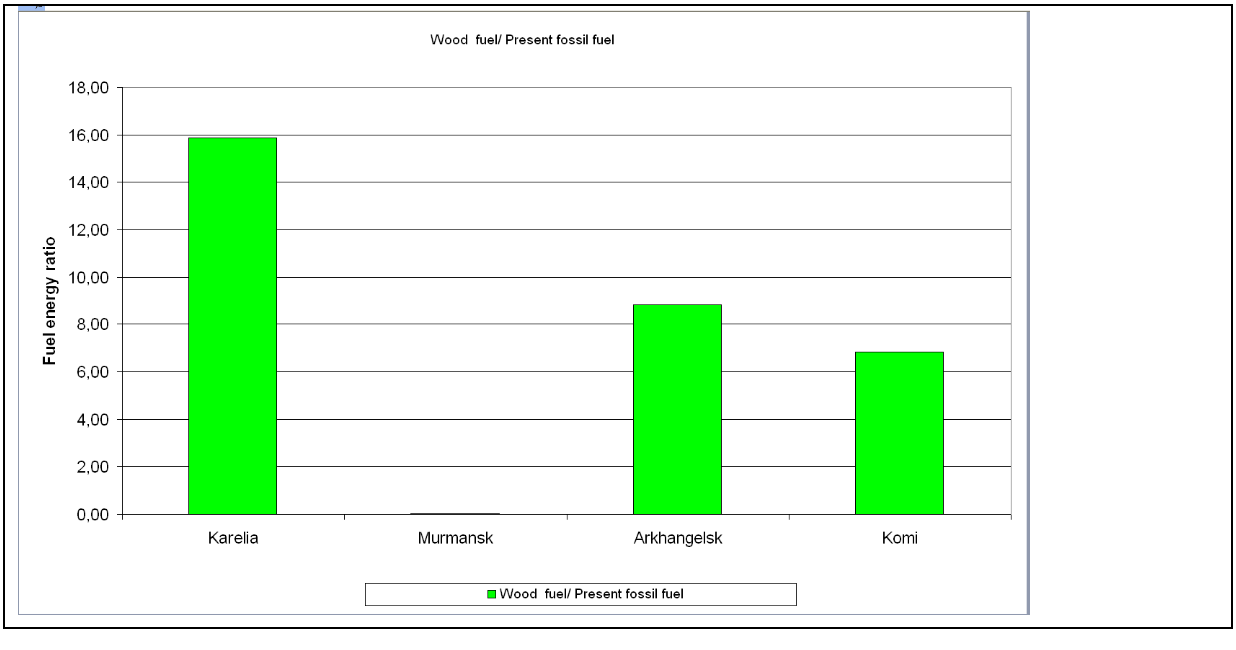
Fossil fuels are much more important in the energy balance of the Russian parts than in the Norwegian and Swedish parts. Renewable fuels (biomass and urban waste) are important in Sweden but not so much in the Norwegian and Russian parts. Murmansk Oblast alone relies on nuclear power.

Potential for improved energy efficiency and renewable energy in the Russian parts of the Barents region

The available information shows that there is a considerable technical potential for improved energy efficiency in heating of buildings and perhaps also in electricity generation by thermal power plants in the Russian parts of the Barents region. The comparatively high specific energy use for heating of buildings in Russia has mainly historical reasons, in particular relatively low prices of fuels. Also, standardisation of designs without consideration to climatic conditions is an important reason. As for electricity generation, the lower annual efficiency than in for instance Swedish thermal power plants may to a large extent be explained by the different structures of the electricity system and by the use of fuels with high sulphur content. Further studies will be necessary to clarify the technical potential for efficiency improvements in that sector.

The available averaged data for energy use in different industrial sectors in the Russian parts of the Barents region do not indicate that the energy efficiency is much different from that in comparable industries in the western parts of the region. This is in contrast with findings in a recent report prepared by the World Bank dealing with energy efficiency in the entire Russian Federation. According to this study, the Russian industry is less efficient. Averaged data are however not effective for identification of possible efficiency improvements. It will be necessary to conduct energy audits for each industrial enterprise for assessment if energy efficiency improvements are financially justified.

The necessary transition from fossil fuels to renewable energy has progressed much further in Finland and Sweden than in the Russian part of the Barents region. In Murmansk oblast the reason is mainly that the technical potential is quite limited. In the other parts of the Russian Barents region there appears to be a significant technical potential for increased use of forestry and forest industry residues, by far exceeding the present use of fossil fuel energy. This is illustrated in the figure below.



Unused technical potential for renewable fuels relative to present fossil fuel energy

Wind energy can also give important contributions from installations in certain coastal areas of the Russian Barents region.

A few pilot and demonstration projects using biomass energy, wind energy, small scale hydro power and tidal power have been implemented in the Russian parts of the Barents region. It appears as if low prices for fossil fuels are the most important reason for the slow development of renewable energy there. There is an apparent need in the Russian parts of the Barents region for an affordable, efficient and reliable technology for biomass fuelled co-generation plants that are suitable for heat demands below the MW-range, to be used for replacing diesel generators in isolated electric grids. Development of such a technology should be of common interest to at least Russia, Finland and Sweden.

Significant improvements of the energy efficiency and shift to renewable energy sources in the Russian part of the Barents Region will require substantial investments. Such investments will not be made unless energy prices have reached a level that gives a reasonable pay-back time for the investments. Needs for more information about the existence of suitable technologies and the experiences from using these might be an obstacle to implementation of such technologies. The major obstacles appear to be shortage of capital and lack of effective policy instruments, however.

The changes in the energy sector in the western parts of the Barents Region, leading to more efficient energy use and significant use of renewable fuels since the early 1980´s would not have happened without strong government intervention. Reducing the dependence of petroleum fuels but also, at least in Sweden, the net emissions of carbon dioxide were the main reason for government intervention. The reduced use of fossil fuels also brought other benefits. The emissions of sulphur oxides were reduced with positive effects for the environment. New employment opportunities in the energy sector and in industries making new products for the energy sector and energy users were created. Such effects can be important reasons for promoting energy efficiency and renewable energy.

Recommendations

CENTEK recommends that the four nations in the Euro-Arctic Barents Region agree on carrying out coordinated actions with the objective to improve the efficiency of energy use and increase the use of renewable energy in the region. These activities should include for instance exchange of statistical data, joint research and development projects and exchange of experiences between actors in the public sector. Possibilities for financial support should be provided to public institutions participating in the activities and also for pilot and demonstration projects based on technologies that are not yet commercially proven.

It is recommended that the BEAC Joint Working Group on Energy encourages the ministries responsible for implementation of the activities outlined in the Memorandums of Understanding between Russia and Finland, Norway and Sweden respectively to identify organisations that can act as focal points in the Finnish, Norwegian and Swedish parts of the Barents region and each of the administrative units in the Russian part of the Barents region: Karelia, Murmansk, Archangelsk, Komi and Nenets.

A series of focal points workshops should be organized with the objectives to:

- exchange information about the present state of technologies and the experiences from using the technologies of interest
- identify specific fields of cooperation
- outline plans for cooperative activities covering the next 3-year period.

It is recommended that these workshops focus on the energy efficiency of buildings, energy efficiency for generation of electricity and district heat and the potential and technologies for utilisation of biomass energy and wind energy.

Based on the findings from this study, useful topics for such workshops could be:

1. Cost effective energy efficiency improvements for apartment buildings
2. Cost effective energy efficiency improvements for hospitals
3. Cost effective energy efficiency improvements for schools
4. Minimising losses in district heat generation and distribution
5. Potential for introducing heat pumps in district heating networks in the Russian parts of the Barents region
6. Efficient use of electric energy for lighting
7. Efficient use of electric energy for driving electric motors
8. Assessment of the sustainable potential for biomass energy use in the Russian parts of the Barents region;
9. Assessment of markets for increased use of biomass energy in the Russian parts of the Barents region
10. Feasibility of internal combustion engines powered by wood gasifiers for power generation in isolated networks
11. Feasibility of wind-diesel hybrid power plants for power generation in isolated networks
12. Integration of wind power in the power systems of Northwest Russia
13. Potential for expansion of thermal power generation by co-generation of electricity and heat in the power systems of Northwest Russia
14. Potential for using solid and liquid urban waste as energy source in the Barents region parts of Russia
15. Potential for increased use of biomass residues and improved energy efficiency in the paper and pulp industries in the Barents region parts of Russia
16. Potential for increased use of biomass residues and improved energy efficiency in the sawmill industries in the Barents region parts of Russia

Improved energy efficiency in the industries engaged in mining, mineral processing and metallurgy is obviously also important but it is less obvious that the industries in the Russian parts of the Barents region will benefit from participation in technical workshops. The processes are very dependent on raw material properties and the type of products and these may differ considerably. A workshop on organisation of energy management in industry would however be beneficial and a possible spin-off from such a workshop could be concrete ideas for cooperation on special topics where two or more enterprises are prepared to cooperate for improvement of their energy efficiency.

When the JEWG discusses priorities for workshop topics it is recommended that the possibilities for funding of concrete projects are given large weight. Workshops leading to proposals that cannot be implemented are of little value. Coordination with the activities of the Working group on energy efficiency of the Commission on Modernization and Technological Development of the Russian Economy under the president of the Russian Federation, see [33] appears as reasonable.

It is finally recommended that the trust fund the "Barents Window" is used partly for financing of studies carried out in cooperation between Swedish consultants and the energy efficiency centers in the Russian part of the Barents region for preparation of background documents for at least five of the workshops to be organised by the BEAC Joint Working Group for Energy and that most of the funds is utilised for part financing of pilot projects or implementation projects that have been identified as result of these workshops.

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List of abbreviations

a	annum
BEAC	Barents Euro-Arctic Council
CO_2	Carbon dioxide
DNF	Data Not Found (data may be available but could not be sourced)
EUR	Euro
(e)	Electric energy
(f)	Fuel energy
FEDARENE	European Federation of Regional Energy and Environment Agencies
(fr)	Residual fuel energy
GDP	Gross domestic product
(h)	Heat energy
HC	Hydro carbons
(hr)	Residual heat energy
GWh	Giga watthour
JEWG	Joint working group on energy
i.a.	inter alia (amongst other things)
kW	kilo watt
kWh	kilo watthour electric energy
MEUR	Million Euro
MoU	Memorandum of understanding
MRUR	Million Russian rubels
MSEK	Million Swedish crowns
MW	Mega watt
MWh	Mega watthour
NEFCO	Nordic Environment Finance Corporation
NO	Norway
NOK	Norwegian crowns
NO_x	Nitrogen oxides
NSP	No such plants
(p)	Primary energy
(PPP)	Purchasing power parity
RHD	Relative heating demand (data in table 2)
RF	Russian Federation
RUR	Russian rubels
SE	Sweden
SEK	Swedish crowns
SO_2	Sulphur dioxide
SF	Finland
TWh	Tera watthour
VOC	Volatile organic compounds

Currency conversion rates

The following exchange rates, valid April 1, 2010 have been used for currency conversions in this document:

	Amount in:			
↓	EUR	NOK	RUR	SEK
1 EUR	1,00	8,13	40,9	9,80
1 NOK	0,123	1,00	5,04	1,21
1 RUR	0,0244	0,198	1,00	0,240
1 SEK	0,102	0,826	4,17	1,00

Note on statistical data

When available, statistical data for 2008 have been used in tables including energy statistics. In a few cases data for 2007 have been used. Elimination of this inconsistency is not believed to change the conclusions from the study.

Map of the Barents Region

Preface

This study of the preconditions for improved energy efficiency and increased use of renewable energy in the Barents region was initially discussed in early February 2010 and commissioned to CENTEK on 5 March, 2010.

The available time has been limited and one consequence of this is that the focus in the data collection has been on Russia and Sweden. It is believed that the conclusions drawn from the more limited comparisons that are possible would not be much different if also complete data for Finland and Norway had been included.

The collection of background information for the Russian parts of the Barents region has been assigned to the Energy Efficiency Centers in Kirovsk, Arkhangelsk, Petrozavodsk, Syktyvkar and Naryan-Mar. Valuable input has also been provided by the Northwest Federal District in Saint Petersburg.

The Norrbotten Energy Network has contributed with the limited fact collection for Norway and some of the fact collection for Sweden. Valuable input regarding the situation in Finland was provided by dr Arto Nuorkivi of Energy-AN Consulting in Helsinki. Additional data collection for Sweden, evaluation of the available data and preparation of this report has been made by professor em. Björn Kjellström, Luleå University of Technology, Sweden.

An early draft of the report was discussed in Luleå with Mr. Vadim Eremeev, Arkhangelsk Oblast Energy Efficiency Center, Mr Mr Anatoly Lukin, co-chairman of the Joint Working Group on Energy (JEWG) and Ms Elisabet Paulig-Tönnes, NEFCO, who gave valuable input for formulation of the conclusions. A draft version of this report has been reviewed by NEFCO and the comments offered by NEFCO have been taken into consideration. It should be understood that the final draft version of the report has not been reviewed by representatives of the Energy Efficiency Centers.

Luleå 14 September 2010

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CENTEK AB, Luleå, Sweden

1 Introduction

The intergovernmental cooperation in the Barents Region was established in 1993. It is an important forum for cooperation in the European High North. The general aim is to promote stability and sustainable development in the region. The cooperation takes place both at a national and regional level and covers a broad spectre of areas such as environmental protection, economy, science, technology, infrastructure, indigenous population, culture and tourism.

An important step towards co-operation between the Nordic countries and the northern parts of Russia that went beyond nice words to concrete projects was taken by Norway in 1996 with the bi-lateral Energy Efficiency Collaboration Arrangement. It included development of:

- demonstration zones in north-west Russia,
- information, training and education schemes
- demonstration projects (including renewable energy)
- cooperation between Russian and Norwegian companies and organisations

As a result of this program, Energy Efficiency Centers were established in Kirovsk (1996), Murmansk (1998), Arkhangelsk (1999), Petrozavodsk (1999), Syktyvkar (2003) and Naryan-Mar (2004), that has acted as focal points for the activities within the program. All these centers are still active.

An Action Plan for the Improvement of the Energy Situation in the Barents Euro-Arctic Region was adopted by the Barents Euro-Arctic Council in January 1998. The Council decided to establish an ad hoc Working Group on Energy, (EWG), with a three-year mandate to promote the attainment of the objectives addressed in the Action Plan. Enhancement of energy efficiency was agreed as primary priority for the work. Sweden chaired the group followed by Norway. In its work the EWG focused on five prioritised areas:

- Establishment of Barents Energy Focal Points in the Russian part of the Barents Region, for promotion of contacts and networks between establishments in the Russian regions and corresponding entities in the Nordic countries on energy saving and energy efficiency issues.
- Analysis of problems and proposals for activities and measures to support energy project financing in the Barents Region.
- Improvement of information exchange and communication between actors in the Barents energy network, including financiers.
- Capacity building in energy management and financial engineering.
- Coordination with other energy efficiency initiatives.

The Energy Efficiency Centers that had been established as part of the agreement between Norway and Russia were identified as the Energy Focal points.

Examples of Swedish contributions to fulfillment of the objectives are financial support from Sida for efficiency improvements in the district heating sector in Murmansk oblast as well as programs for informing decision makers in energy intensive industries about energy efficiency programs conducted in similar Swedish industries.

In September 2009, the JEWG organised the Workshop "Energy Efficiency and Renewables; Possibilities and Challenges for Russian Municipalities" in Arkhangelsk, financed by the

Nordic Council of Ministers. The Workshop, focusing on the practical possibilities and results already achieved in the region, was well received by the 70 participants. A similar Workshop will be organised in Murmansk during the autumn of 2010.

Sweden chairs the Barents Euro-Arctic Council (BEAC) in 2009–2011. In parallel, Sweden will also chair the BEAC Working Group on Environment. A key role for the stated Swedish focus will be to intensify efforts in the field of energy efficiency and build networks for and raise awareness of sustainable production and consumption in the Barents region. This will include strengthening of the work of the newly re-established Joint Working Group on Energy (JEWG) that is co-chaired by Norway and Arkhangelsk Oblast. Issues related to this were subjects for discussions during the meeting of the Ministers for Competitiveness in Umeå, Sweden May 18th and 19th 2010.

Norway, Finland and Sweden have all signed Memorandums of Understanding with Russia in 2010 regarding cooperation in the field of energy. Co-operation for improved energy efficiency and increased use of renewable energy is emphasised in these documents.

A recent report from the World Bank [5] concludes that the energy system in Russia is very inefficient by comparison to those of other industrialised countries and that considerable improvements of the energy efficiency would be possible with financially justified investments. The conclusion is based partly on comparisons of energy input per USD GDP (PPP). Such comparisons can be quite misleading and are definitely not helpful for identifying activities where improvements are most desirable. There are also comparisons of indicators for energy input per unit of produced commodity, like GJ/ton product, annual Gcal/heated m^2 floor area that indicate where there are differences from other countries, but these data are not necessarily valid for the Barents region. The general message is however that improvements of the energy efficiency by at least 20% is financially viable and that economically viable improvements are considerably larger[1].

In order to develop the energy cooperation within the Barents region for improvement of energy efficiency and increased use of renewable energy it will be necessary to examine the present status of energy supply and use as well as the potential for renewable energy in that region. For that reason, the Nordic Environment Finance Corporation (NEFCO) has engaged CENTEK in Luleå, Sweden, to carry out this study of the preconditions for improved energy efficiency and increased use of renewable energy in these parts of Finland, Norway, Russia and Sweden.

The **wider objective** of the study is to clarify the situation and circumstances in the Barents Region with general relation to the stated Focus Area of the Swedish BEAC Chairmanship with its particular focus on Russia and renewable energy and energy efficiency. The **specific objective** is to provide guidelines and recommendations for the further use of the Swedish trust fund "The Barents Window", to provide recommendations on priorities for the JEWG, and to provide appropriate input to the Ministers Meeting in Umeå. The study shall include collection and analysis of relevant existing information about the conditions in the Barents region in general compared to those in the Russian parts of the Barents region.

[1] The estimated potential improvements differ between the energy use sectors. For residential buildings the financially viable potential is estimated to 22% and the economically viable potential to 41%. In the public sector the estimated potentials are 24 and 38%, for industry the potentials are 30 and 37% and for electricity generation 4 and 28%, respectively

2 Present energy supply and use in the Barents region

2.1 Conditions that determine energy demand

2.1.1 Demography

The population of different parts of the Barents region is shown in Table 1. The Russian administrative units are generally much larger in size, both with respect to area and population than the administrative units in Finland, Norway and Sweden. The Russian parts of the Barents include almost 80% of the land area and 70% of the population.

Table 1. Basic demographic data for the Finnish, Norwegian, Russian and Swedish parts of the Barents Region

Administrative unit	Population [thousands]	Urban[2] fraction	Area [km²]	Population density [persons/km²]
Nordland	235	38%	38460	6.1
Troms	154,6	56%	25870	1.5
Finnmark	72,4	25%	48616	1.5
Norwegian part total	**462**	**42%**	**112946**	**4,1**
Västerbotten	257,8	42%	55432	4.7
Norrbotten	249,6	42%	98249	2.5
Swedish part total	**508,2**	**42%**	**153681**	**3,3**
Lapland	184,4	57%	98984	1.9
Oulu	383,4	46%	37149	10.3
Kainuu	84,4	45%	24452	3.4
Finnish part total	**652,2**	**49%**	**160585**	**4,1**
Karelia (2008)	688	58%	180500	3,8
Murmansk (2008)	842,5	80%	144900	5,8
Archangelsk (2008)	1262	62%	587400	2,2
Komi (2008)	959	60%	416800	2,3
Nenets (2009)	42	46%	176800	0,2
Russian part total	**3793,5**	**65%**	**1506400**	**2,5**

The structure of the human settlements differs between the Russian parts of the Barents region and the western parts. A larger fraction of the Russian population lives in comparatively large urban centers with more than 15 000 inhabitants. This, to a large extent, can be explained by the differences in the structure of the economic activities. All over the Barents region most of the land area is uninhabited wilderness. The population of the Russian parts of the Barents region is slowly declining. This is true for all administrative units except Nenets autonomus okrug. Since 2005, the average annual decline is less than 1%. The population in the administrative units in Finland, Norway and Sweden is roughly constant during the same period.

[2] Defined here as the part of the population that lives in municipalities with more than 15 000 inhabitants

2.1.2 Climate

There are large variations in the climatic conditions of different parts of the Barents region. The area of interest for this study extends between latitudes 60^{o}N in south part of Komi to about 71^{o}N in the north part of Finnmark. The Gulf Stream affects the temperature in the western part of the region. The latitude as such is important for the need for artificial lighting and the temperature is important in particular for the energy demand for heating of buildings. Comparisons of energy use in different parts of the Barents region will be misleading if these effects are not accounted for.

In Russia as well as in Sweden, "degreedays" is used as a measure for heating demands of buildings. It is defined as the sum of daily average temperatures (24 h average) below a given reference temperature. The meteorological data, see Table 2, show that almost all the large population centers in the region have a more favourable climate with respect to heating of buildings, than Kiruna in Sweden, where the average heating demand corresponds to 6473 degreedays[3]. Kiruna should therefore be a useful town for benchmarking since a specific energy use for heating that exceeds that in Kiruna will indicate a technical potential for improved energy efficiency.

Table 2. Relative annual heating demands in selected population centers. Kiruna in Sweden is used as reference. Estimates based on the Russian definition of degreedays

Administrative unit	Population Center	Population thousand	Relative heating demand RHD
Nordland	Mo i Rana	25	0,73
	Narvik	18	0,68
Troms	Tromsö	32	0,75
Finnmark	Kirkenes	3	0,94
Västerbotten	Umeå	76	0,75
Norrbotten	Luleå	45	0,82
	Kiruna	18	1,00
Lapland	Rovaniemi	58,5	0,93
Oulu	Oulu	129	0,80
Kainuu	Kajaani	38	0,88
Karelia	Petrozavodsk	271	0,78
	Sortavala	19	0,75
Murmansk	Murmansk	311	0,90
	Apatity	62	0,96
	Monchegorsk	48	0,95
	Kovdor	19	0,99
Arkhangelsk	Arkhangelsk	348	0,88
	Kotlas	59	0,85
Komi	Syktyvkar	233	0,90
	Ukhta	103	0,98
	Vorkuta	71	1,28
Nenets	Narjan Mar	20	1,13

[3] Calculated with the Russian definition for degreedays.

2.1.3 Industrial activities

The economy in the Barents region relies mainly on extraction and processing of raw materials. The structure of the industrial activities varies across the region depending on the availability of natural resources. In particular for Sweden, Finland and Russia, the parts within the Barents region dominate the production of minerals, mineral products and products from the forest industries. In several branches of energy intensive industries are there plants in at least three of the countries included in the Barents region that are active in the same branch. This, in principle, opens possibilities for comparisons of indicators for energy efficiency. A brief overview of the industrial activities in the energy intensive branches is given below. Energy efficiency indicators are discussed in section 2.3.3

Ferrous metallurgy and metal working

Figure 1 illustrates the structure of the industrial activities related to ferrous metallurgy and metal working in north-west Russia. Most of the large enterprises are located in the Barents region. The steel rolling mill Severstal is however located in Vologda oblast.

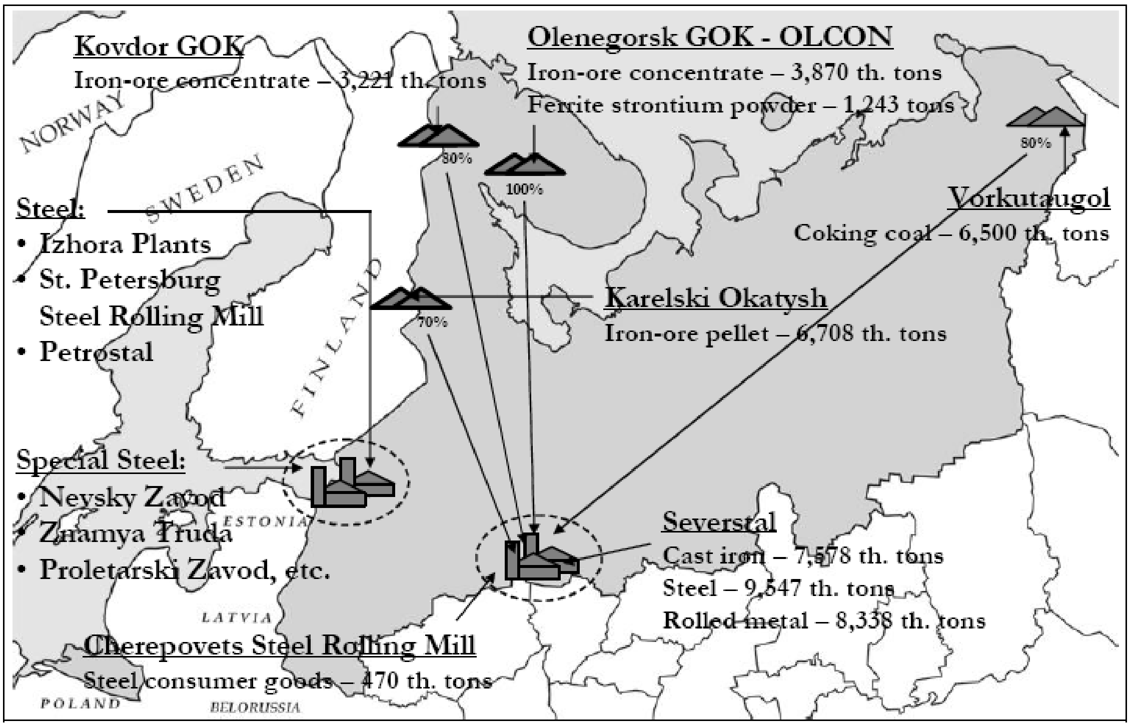

Figure 1. Ferrous metallurgy and metal working in north-west Russia [20]. Production data for 2004

In the western part of the Barents region, the company LKAB is mining iron ore in Kiruna and Malmberget, Sweden and producing iron ore concentrate. Steel production and steel rolling takes place in Luleå, Sweden at a plant operated by SSAB. In Finland, Outokumpu Oyj operates a ferrocrome smelting plant in Tornio and Rautaruukki Oyj a steel mill producing steel plates and strips in Raahe, Oulu region. In Norway, iron ore is mined at Mo i Rana, Nordland fylke and at Kirkenes, Finnmark fylke, by Rana Gruber A/S and Arctic Bulk Materials A/S respectively. There is a ferrosilica smelting plants at Mo i Rana and a smaller one at Finnsnes, Troms fylke operated by FESIL ASA.

Non-ferrous metallurgy

In Norway there is a large aluminium smelting plant Mosjoen, Nordland fylke, operated by Alcoa Inc.

In Sweden, Boliden AB operates mines at Aitik, Norrbotten and in the vicinity of Boliden, Västerbotten, a dressing plant in Boliden and a smelting plant, Rönnskärsverken, close to Skellefteå, Västerbotten.

Non-ferrous mining and metallurgy are important parts of the economy of north-west Russia. Figure 2 gives an overview of the industry in north-west Russia. Many of the large operations are located in the Barents region part.

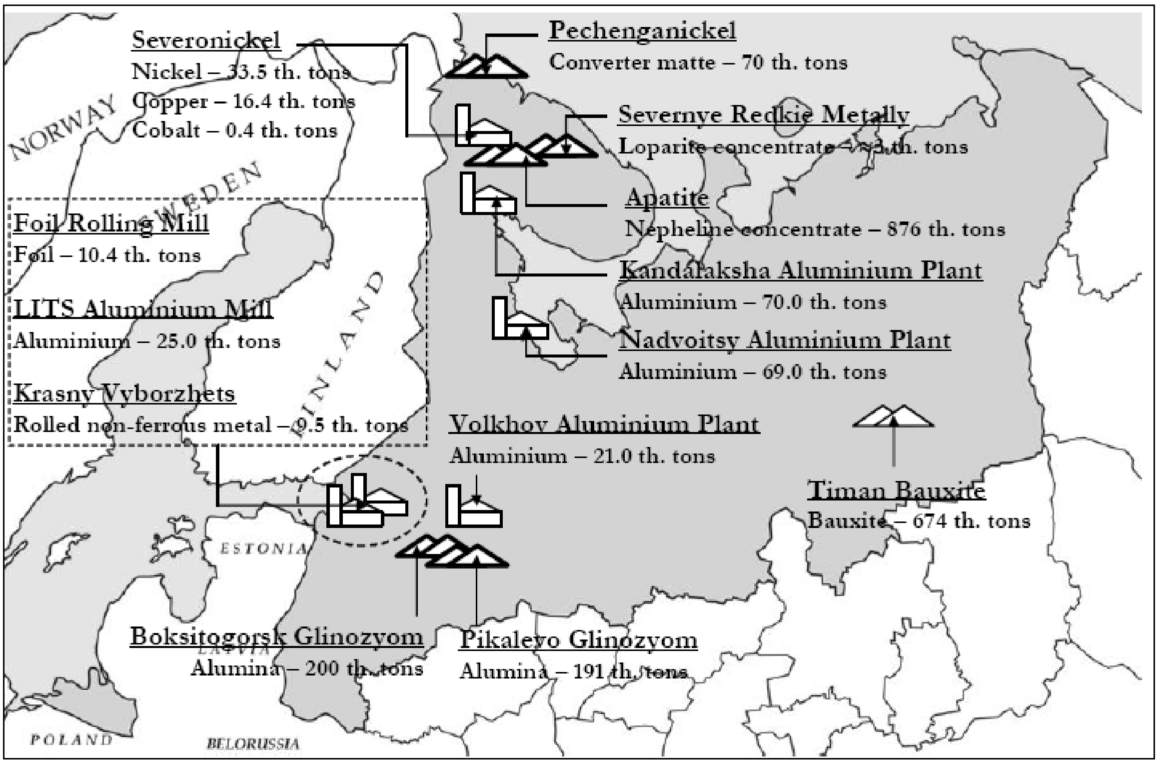

Figure 2.. Non-ferrous mining and metallurgy in north-west Russia [20]. Production data for 2004

Pulp and paper production

There are four large pulp and paper mills in the Swedish part of the Barents region. Billerud Karlsborg is producing mainly bleached pulp and bleached kraft paper. There are three kraftliner mills, Smurfit Kappa Kraftliner, SCA Munksund, both in Piteå and SCA Obbola, close to Umeå. The first three mills are located in Norrbotten and the SCA Obbola plant in Västerbotten.

Two large pulp and paper mills are located in the Finnish part, Veitsiluoto paper mill by Kemi, producing office papers and mechanical papers and Oulu paper mill, by Oulu, producing fine paper. Both are operated by Stora Enso Oyj.

Pulp and paper production in the Russian part of the Barents region is important in Karelia, Arkhangelsk oblast and Komi, which have large forest areas. Figure 3 shows the location of the largest mills in north-west Russia. Most of them are located in the Barents region.

The leading enterprises of pulp and paper industry in Karelia are JSC Kondopoga, producing newsprint paper, Segezha PPM producing bleached pulp and high quality sack paper, and JSC Pulp Mill Pitkyaranta (not shown on the map). In Arkhangelsk oblast, the Arkhangelsk Pulp and Paper Mill produces market pulp, paper, paperboard, fiberboard and sawn products, Kotlas Pulp and Paper Mill, market pulp, offset paper and paperboard and Solombala pulp and paper mill, market pulp.

In Komi, JSC Mondi Syktyvkar is one of the largest producers of offset paper in Eastern Europe.

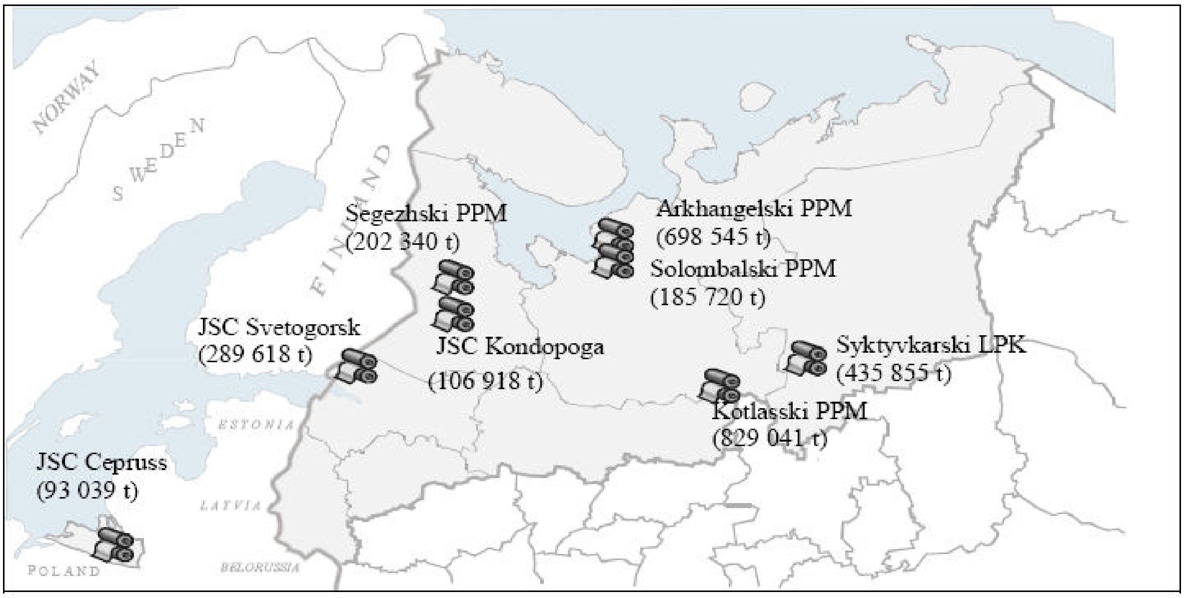

Figure 3. The major pulp and paper mills in north-west Russia [20]. Production data for 2004

Mechanical wood processing

The forest industry is important in Norrbotten and Västerbotten in Sweden. There are 15 sawmills with production exceeding 50 000 m^3/a. The largest are those in Munksund, Piteå, Norrbotten and in Rundvik, Västerbotten operated by SCA Timber AB and that operated by Martinsons Såg AB in Bygdsiljum, Västerbotten all with capacities over 250 000 m^3/a.

In the Finnish parts of the Barents region the largest sawmill is the Veistiluoto sawmill by Kemi in Lapland with a capacity of about 250 000 m^3/a. There are nine sawmills with capacities above 50 000 m^3/s.

In the Russian parts the mechanical wood processing includes sawmills as well as plywood and fibreboard plants. Figure 4 illustrates where the largest plants in north-west Russia are located.

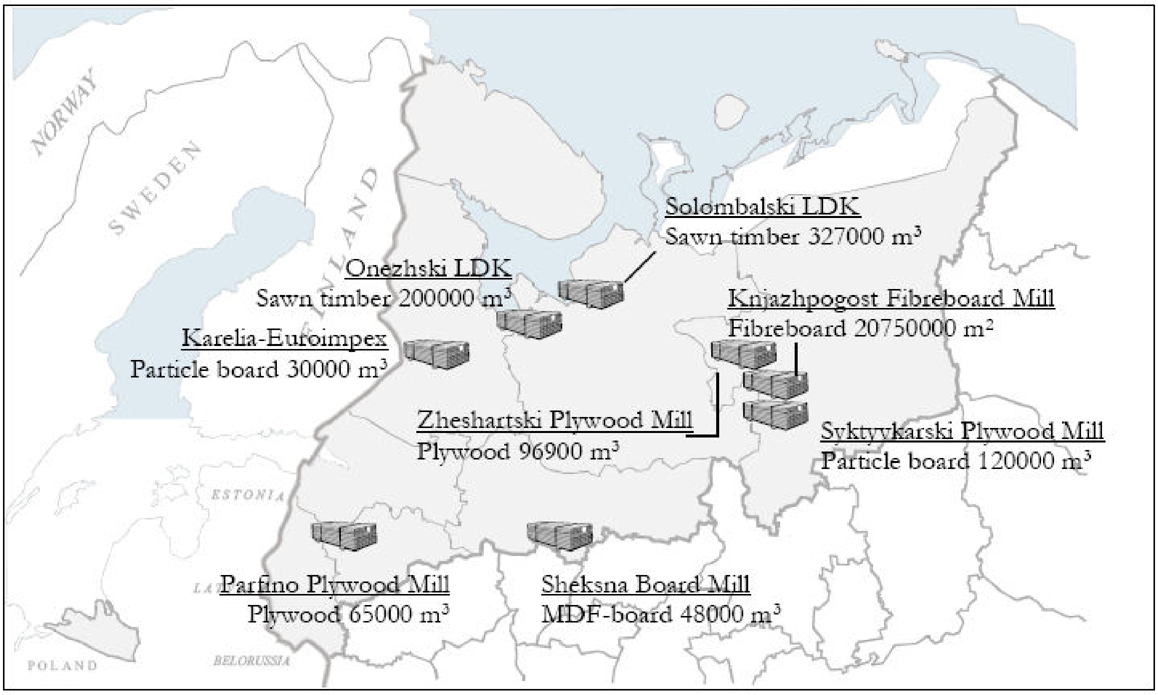

Figure 4. The largest mechanical wood processing industries in north-west Russia [20]. Production data for 2004

Oil and natural gas

In Finnmark, Norway, natural gas is extracted from the Snøhvit field and liquefied at the LNG plant on Melkøya. The production is operated by Statoil. Extraction and processing of the major natural gas reserves in Komi republic is carried out by a unit of OAO Gazprom in Sosnogorsk.

The bulk of oil production in the Komi republic comes from LUKOIL-Komi and RN - Northern Oil. A key element is the oil refinery LUKOIL-Ukhtaneftepererabotka, producing automotive gasoline, diesel fuel, aviation kerosene, fuel oil, bitumen, vacuum gas oil and other petroleum products.

2.1.4 Housing and building standards

The structure of the residential sector differs considerably between the western and Russian parts of the Barents region. In the western part, a majority of the population lives in single family houses. In Västerbotten and Norrbotten this fraction is roughly 60%. In the Russian parts most people live in relatively large towns, in apartment buildings. The Russian homes are also less spacious as shown by the data in table 3. An inhabitant in Västerbotten and Norrbotten enjoys, on the average, a floor area in the home of 45 m^2, whereas those living in the Russian parts of the Barents region, on the average, utilise about half of that. The homes in the Finnish parts of the Barents region are slightly less spacious than those in the Swedish parts but much roomier than those in the Russian parts.

Table 3. Floor area per capita in residential buildings in different parts of the Barents Region

Administrative unit	**Population [thousands]**	**Residential area m²**	
		Total m²	**m²/capita**
Lapland	180,6	7 187 880	40
Oulu	387,3	14 717 400	38
Kainuu	81,5	3 251 850	40
Finnish part total	**649,4**	25 261 660	39
Nordland	235	DNF	
Troms	154,6		
Finnmark	72,4		
Norwegian part total	**462**		
Västerbotten	257,8	11 618578	45
Norrbotten	249,6	11 434 066	46
Swedish part total	**508,2**	**23 052 644**	**45**
Karelia (2008)	688	DNF	
Murmansk (2008)	842,5	18 977 900	23
Archangelsk (2008)	1262	29 693 000	23
Komi (2008)	959	17 862 400	19
Russian part total	**3793,5**		**21**

There are also differences in the historical development of the requirements on energy efficiency stipulated in the building codes. In Sweden, the oil crisis in 1973 resulted in requirements for thermal resistance of different parts of the building and maximum air leakage that came into effect 1977[4]. The requirements have later been modified to allow more flexibility in the design but with gradually increasing demands for low energy intensity expressed in kWh/m^2. The most recent regulation [15] maximises the annual heating energy for new residential buildings in Västerbotten and Norrbotten to 95 kWh/m^2 when electric heating is used and to 150 kWh/m^2 for other heating methods. Almost all buildings built later than 1965 in Sweden have mechanical ventilation and after 1980 also systems for heat recovery. Heating systems with thermostatic valves for room temperature control are dominating. In Finland, the development of building codes for improved energy efficiency is similar to that in Sweden.

In Russia, most of the apartment buildings have been built during the Soviet era and can be classified by the periods when they were constructed, into “stalinsky”, “chrushchovsky” and “breznevsky”. Buildings constructed in the same period in the north and south parts of Russia are of the same standard in terms of climate shelter. The heating and ventilation standard is the same in almost all types of buildings. Natural ventilation is dominating. Almost no buildings have mechanical ventilation and heat recovery. The heating systems have almost no thermostatic valves for room temperature control. There are buildings with other standards such as hotels but they are very few. According to [14], the norm for heat consumption in residential buildings constructed after 1999 is 252 kWh/m^2. Most of the buildings were however built earlier.

[4] Supplement to SBN 75

2.1.5 Prices for energy carriers

Prices of energy carriers are important for the optimisation of equipment for energy conversion and energy use and also for the competitiveness of renewable energy sources that can replace fossil fuels. Table 4 shows current prices of the most important energy carriers in the different parts of the Barents region.

Table 4. Prices for energy carriers in different parts of the Barents region 2009, expressed in EUR/MWh. Includes taxes[5].

	Finland	Norway	Sweden		Russia	
			Industrial processes	Households and Heating	Industry	Households and Heating
Coal	14	DNF	14	47	7	11[6]
Fuel oil (mazut)	45	DNF	37	67	24	30[5]
Light fuel oil	63	88	77	107	35	DNF
Natural gas[7]	28	DNF	38-55	95-148	5	8[5]
Peat	10 – 13	DNF	15	15	5	7[5]
Raw wood chips	18	DNF	19	19	7	11[5]
Wood pellets	53	DNF	30	57	19	DNF
Electricity	100 - 150	98[8]	52-125	145	56-80[6]	34-50[9]
District heat	52	DNF		70		13

It must be understood that the prices may vary with location, depending for instance on transportation costs and that in particular prices of petroleum fuels in Finland, Norway in Sweden are affected by the international prices for crude oil which has varied betweeen 10 and 60 EUR/MWh(f) during the last decade and was about 30 EUR/MWh(f) in 2009. Also the prices for coal imported to Europe (Rotterdam) has been varying considerably with a peak at about 22 EUR/MWh(f) in 2008 down to about 7 EUR/MWh(f) in 2009. The Russian prices for fuel oil reported in table 4 are about the same as the international crude oil price during 2009. The coal prices in Russia shown in table 4 are about the same as the Rotterdam prices.

In Russia, energy prices have increased significantly in the recent years[10]. The price data in table 4 show that prices for fuels and other energy carriers are, despite this development, in general consistently lower in the Russian parts of the Barents region than in Finland and Sweden. For fossil fuels that are all imported to Finland and Sweden, the main reason for the differences are the taxes taken by the government for such fuels. Table 5 shows the currently valid energy taxes in Sweden for the most important energy carriers.

[5] Taxes that are deductible for industry, like VAT, are not included in the prices for industrial users. Distribution costs are included in the electricity price. Ranges are given only if the range exceeds ± 20%
[6] Applies 2008 for heat generation in Karelia [14]
[7] Natural gas is not available in the Barents region parts of Finland and Sweden
[8] Average for households. Significantly less for industry. The electricity prices have traditionally been low in Norway but internationalisation of the electricity market has resulted in increasing prices
[9] Applies in Arkhangelsk [3]. Tariffs will be 10 -50% higher in 2010, in the range 45-73 EUR/MWh(e) for households and 87-90 EUR/MWh(e) for industries
[10] In the Russian part of the Barents region electricity tariffs have almost doubled between 2008 and 2010.

Table 5. Energy taxes in Sweden 2010

Energy carrier	Total energy tax	
	Industrial processes	Heating of buildings
Coal	56 EUR/ton	302 EUR/ton
Fuel oils	65 EUR/m^3	388 EUR/m^3
Natural gas	48 EUR/th m^3	256 EUR/th m^3
Biomass fuels and peat	No taxes	
Electricity	0,5 EUR/MWh	18,5[11] or 28 EUR/MWh

2.2 Energy supply and use in the regions

2.2.1 Primary energy supply

Figure 5 illustrates the structure of the primary energy supply to the different parts of the Barents region in a summarised way[12].

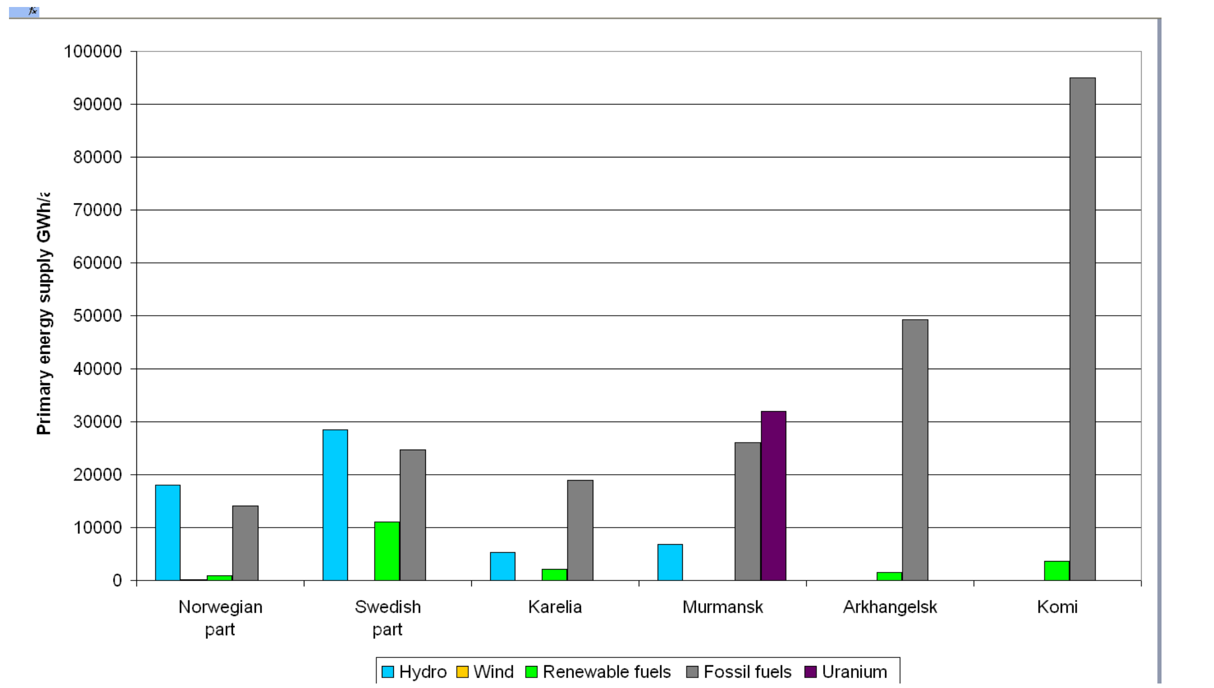

Figure 5. Primary energy supply to different parts of the Barents region

The contributions from hydro power and wind power are shown as the electric energy generated in the power plants. The contribution from nuclear energy is shown as the thermal energy released in fission of the uranium, estimated as three times the generated electric

[11] The lower tax is paid in northern Sweden and applies to Norrbotten and Västerbotten. VAT 25% is added on top of the taxed price
[12] Regional data for Finland seem not to be available. Comparisons including the Finnish parts of the Barents region have therefore not been possible.

energy. Fuels brought into a part of the region either for conversion to an energy carrier like electricity, district heat or refined fuel or for final conversion by the user have been considered as primary energy, even if the fuel has been refined before brought in.

It is apparent that the total use of fossil fuels in the Russian parts of the Barents region by far exceeds that in Norway and Sweden. It is also apparent that renewable energy, in this case hydro power, wind power, biomass fuels and urban waste, represent a larger fraction of the primary energy in Norway and Sweden than in Russia.

2.2.2 Generation and use of electric energy and district heat

In table 6 the supply/use balances for of electricity and district heating are shown[13]. Available data do not allow specification of the amounts of the fuels that are used for generation of these energy carriers in most of the Russian part of the Barents region. It is nevertheless obvious that electricity and heat generation are much more depending on fossil fuels in Russia than in Norway and Sweden. Almost the entire fossil fuel contribution in Sweden comes from one single plant, using combustible gases from the SSAB steel mill in Luleå. The alternative, to flare off the combustible gases would have given the same emissions of CO_2. Significant amounts of industrial waste heat is utilised for generation of district heat in three Swedish towns in the region, Kiruna, Skellefteå and Piteå.

Table 6 also shows how the electricity use is distributed between the main sectors. It is apparent that industry and transportation use a larger share of the electricity in Russia than in Norway and Sweden. It is also apparent that households in Russia use a much smaller fraction of the electricity and that the share for public and commercial services varies considerably between the different administrative units in Russia. This is further discussed in section 2.3.5.

2.2.3 Electricity supply systems

Regional statistics for the structure of electric power generation in the Finnish part of the Barents region have not been found. According to [21] summarising the situation in 2002, electric power generation in these parts of Finland was dominated by hydro power (1 680 MW). The capacity of thermal power, either combined with production of process heat or district heating was 935 MW(e). Most of this generation was based on fossil fuels, peat, coal or blast furnace gas. The installed capacity of wind power was then 13,5 MW.

As shown by table 6, the electric power generation in the Norwegian part of the Barents region is entirely based on hydro power, with a small contribution from wind.

[13] Regional data for Finland have not been found. Comparisons including the Finnish parts of the Barents region have therefore not been possible.

Table 6. Primary energy supply for generation of electricity and heat and supply/use balances for these energy carriers.

	Finnish part	**Norwegian part**	**Swedish part**	**Karelia**	**Murmansk**	**Arkhangelsk and Nenets**	**Komi**
Primary energy supply for electricity and district heat generation GWh(p)/a							
Hydro power	DNF	18 078	28 425	3 340	6 840	0	0
Wind	DNF	216	4	DNF	DNF	0	DNF
Fission of uranium	0	0	0	0	31 860	0	0
Fossil fuels	DNF	62	1 682	DNF	DNF	35 906	DNF
Renewable fuel	DNF	217	3 144	DNF	DNF	8 494	DNF
Industrial waste heat	DNF	DNF	291	DNF	DNF	DNF	DNF
District heat generation and use GWh(h)/a							
Generation	DNF	DNF	3738	6 621	15 365	20 390	9 680
Distribution losses	DNF	DNF	343	DNF	DNF	DNF	DNF
Delivered to users	DNF	135	3 104	DNF	DNF	DNF	DNF
Electricity supply by source GWh(e)/a							
Hydro power	DNF	18 078	28 425	3 340	6 840	0	0
Wind	DNF	216	4	0	0	0	0
Fission of uranium (Nuclear power)	0	0	0	0	10 620	0	0
Fuel based thermal power	DNF	0	1 667	935	540	7 101	9 287
From outside (or delivered to outside)	DNF	-3 367	-18 080	+5 555	- 4 914	+821	-458
Total	DNF	14 927	12 016	9 830	13 086	7 922	8 829
Final electric energy use %							
Agriculture, fishing etc	DNF	3,7	1,2	1,2	0,9	1,1	1,0
Industry and construction	DNF	50,7	43,8	65,3	54,6	50,2	53,2
Transport	DNF	0,0	2,0	12,1	4,4	7,5	7,0
Public and commercial service	DNF	18,6	20,2	3,9	20,9	17,2	13,5
Households	DNF	27,0	21,3	5,3	7,1	9,6	8,5
Internal use	DNF	DNF	4,4	1,6	6,7	6,9	6,1
Distribution losses	DNF	DNF	7,0	10,6	5,3	7,5	10,9

*) Large difference in reported data

In the Swedish parts, electricity generation is dominated by hydro power plants located in the large rivers flowing from the mountain areas in the west towards the coast. Co-generation of electricity and heat takes place in the pulp- and paper mills located along the coast of the Gulf of Bothnia and in the larger towns that all have district heating systems installed. The fuels used for the boilers are black liquor, bark and waste wood in the pulp- and paper mills. Urban waste and wood waste are used in most of the boilers supplying co-generation in district heating plants. One plant, in Luleå, uses combustible gases from the SSAB steel mill. There is a small contribution from wind power as well. The electricity distribution network covers the entire region and all places where people live permanently, even isolated farms, are reached by the national grid.

In Karelia, as shown in table 6, most of the electricity is supplied from outside and hydro power dominates the generation inside the republic. Steam power plants in the pulp and paper plants generate most of the thermal power and the rest is generated in the co-generation plant connected to the district heating network of Petrozavodsk. More than 50% of the fuel used for power generation is natural gas. Renewable fuels account for about 17%. The rest is heavy fuel oil and coal. 99% of the territory is reached by the national grid. About 4 000 people live in forest villages that are not connected. These villages are supplied by diesel generator sets.

Murmansk Oblast is served mainly by the Kola nuclear power plant Polyarnye Zori and by hydro power. A small fraction is supplied by two co-generation plants using heavy fuel oil or coal as fuel, one in Murmansk rated at 12 MW(e) and one in Apatity rated at 323 MW(e). Almost 30% of the electric power is supplied to other parts of the region or exported. There are remote villages and naval bases that are not connected to the national grid. These are supplied with diesel generator sets.

Electric power in the Arkhangelsk Oblast is produced entirely with thermal power plants, mainly designed for co-generation of electricity and heat using a fossil fuel. In Arkhangelsk Oblast the national grid serves about 70% of the territory, where about 95% of the population lives. In the remaining part, the population centres are supplied with diesel power stations. The utility ArkhOblEnergo operates 59 of these with a total rated power of 36 MW(e) and the local municipalities 84 with a total rated power of 14 MW(e), see [3]. Diesel power is relatively expensive. The generation cost is reported in [3] as between 560 – 880 EUR/MWh(e). The difference between this and the tariff of about 49 EUR/MWh(e) is covered as subsidy from the federal budget and achieves 4% of the regional budget. For these subsidies, 700 million RUR were allocated in the budget for 2009 [3].

Also Komi is depending on thermal power generation only. Natural gas dominates the fuel supply and accounts for about 70%. Renewable fuels contribute about 10%. The remaining fuel energy comes from heavy fuel oil and gas.

2.2.4 District heating systems

Regional statistics for district heating in Finland appears not to be available in open sources. It can however safely be assumed that most of the population centers in the Finnish part of the Barents region are heated with district heating.

In Norway, district heating is not commonly used. There are, however, a few networks in the Norwegian part of the Barents region. Data for 2004 [22] show five networks, the largest in Mo i Rana supplying 51 GWh(h) and that in Tromsø 43 GWh(h). The latter plant uses about 50% biomass fuel. In 2008 the amount of district heat delivered by the systems in the region is reported as 135 GWh(h). According to [22] several district heating projects are considered in the region. They will all be based on residual heat from industries, biofuels, or heat pumps.

In the Swedish parts of the Barents region there are 46 towns or population centers with district heating systems, supplying annually from about 750 GWh(h) in the largest towns to only some few GWh(h) in small population centers. Only small amounts of fossil fuels are used, mainly for peak production, with the exception of Luleå where residual gases from the steel mill is used as the main fuel. The small plants with capacities below 3 MW(h) all use wood chips or wood pellets as the main fuel. In the municipalities served by district heating, the distribution systems cover the central parts with commercial and official buildings, residential areas with apartment buildings and also often large residential areas with single family houses.

In Karelia, Petrozavodsk is supplied with district heat from a co-generation plant burning natural gas. There are ten larger systems served by boilers with capacities above 100 MW(h), 34 medium systems supplied with boilers with capacities above 10 MW(h) owned by municipal utilities and about 465 smaller ones. District heating is also common in the other parts of the Russian Barents region, in the larger networks supplied by plants co-generating electricity and heat. The fuel mix is similar to that for electricity generation, i.e. dominated by fossil fuels.

2.3 Energy efficiency indicators

2.3.1 Electricity generation, transmission and distribution

Table 7 shows a comparison of some energy efficiency indicators for electricity generation and distribution in Russia and Sweden. The indicators have been calculated from aggregated data in the energy statistics. There are certainly differences between the individual plants depending on size, fuel used, process conditions and operating schedule.

In general, small cogeneration plants with a back pressure steam process give less electric yield, expressed as MWh(e)/MWh(h), than larger plants where a more advanced steam process can be justified economically. The reason for the difference between the aggregated data for Västerbotten and Norrbotten in Sweden is that while all the cogeneration plants in Västerbotten are straight back-pressure steam plants, the largest co-generation plant in Norrbotten, in Luleå; is equipped with a cold condenser in order to allow electric power generation independently of the heat load.

Table 7. Indicators for electrical generation, transmission and distribution efficiency

Region	**All thermal plants MWh(f) per MWh(e)**	**Co-generation plants**		**Internal use %**	**Distribution losses %**
		MWh(f) per MWh(e+h)	**MWh(e) per MWh(h)**		
Finnish part	About 1,13	1,11 – 1,17	0,3 – 0,5	DNF	About 3
Norwegian part	NSP	NSP	NSP	DNF	DNF
Västerbotten	1,08	1,11	0,27	1,3	2,6
Norrbotten	1,26	1,12	0,54	1,3	3,0
Swedish part	**1,21**	**1,11**	**0,42**	**1,3**	**2,8**
Karelia	2,30	DNF		1,6	10,6
Murmansk	2,66	DNF		6,7	5,3
Arkhangelsk	2,65	DNF		6,9	7,5
Komi	2,66 - 3,33	DNF		6,1	10,9
Russian part		DNF			

The average specific fuel consumptions of the thermal plants in the Russian parts of the Barents region, reported in [9] are very high by comparison. The reasons deserve to be investigated. It must be understood however that the possibilities to operate a co-generation plant with high electric efficiency are much better in an electric grid served by mainly hydro power than in a grid served only by thermal power. In the latter it is not possible to let the heat demand determine the electric output. A larger fraction of the electricity generation must then be made with wasting of the condensation heat. Another reason for lower efficiency in the Russian thermal plants is the relatively high sulphur content of the fuels used. This makes it necessary to operate with higher exhaust temperatures to avoid corrosion of the low temperature parts of the boiler.

2.3.2 District heating

Indicators for the efficiency of district heat generation and distribution are MWh(f) used per MWh(h) produced, distribution losses and the MWh(h) delivered per MWh(h) produced. A comparison between these indicators is shown in Table 8.

The indicators have been calculated from aggregated data in the energy statistics. As for electric power generation, there are certainly differences between the individual plants depending on size, fuel used, process conditions and operating schedule. The distribution losses depend on the area covered by the distribution system relative to the capacity of the production plant and the demand density, which can be measured in MWh/a and km^2. A large portion of the load being single family houses generally leads to higher distribution losses. The statistical data from the Swedish District Heating Association for Västerbotten and Norrbotten show variations of the specific fuel use for generation in the range 0,9 -1,4

MWh(f)/MWh(h) for plants that do not use industrial waste heat as a heat source[14]. In the extreme case, Piteå, the fuel energy input is just above 5% of the heat supplied to the network. The distribution losses in the networks in Västerbotten and Norrbotten range from less than 1% to almost 50%.

Table 8. Indicators for average efficiency of district heat generation and distribution

Part of the region	MWh(f) per MWh(h) generated	Distribution losses %	MWh(f) per MWh(h) delivered
Finnish part	About 1,1	About 10	About 1,2
Norwegian part	DNF	DNF	1,45
Västerbotten	0,99	14,9	1,17
Norrbotten	1,03	3,6	1,07
Swedish part	1,01	9,2	1,12
Karelia	-[15]	DNF	
Murmansk	1,13	DNF	
Arkhangelsk	1,37	5,3	1,45
Komi	1,13 – 1,17	DNF	
Russian part		DNF	

Data for quantification of the average specific fuel energy required for heat generation in the Russian parts of the Barents region are given in [9] and [11]. It appears that empirical data for distribution losses are often not available since most of the buildings are not equipped with meters for the heat delivered. Average distribution losses are reported in [11] for Arkhangelsk oblast as shown in Table 8. Distribution losses are discussed in [12] for the systems of Kirovsk and Apatity in Murmansk oblast. Data collected in 2000 indicate distribution losses of about 40% but later data for Apatity show these losses to be 12%.

2.3.3 Energy use in industrial processes

Assessments of the potential for energy efficiency improvements for an industrial activity by "bench-marking", i.e. by comparisons with other industries producing the same type of products, must be used with great caution, since differences in raw material properties, product quality, climate and environmental regulations can have a major impact on the energy requirements of the processes under ideal conditions. Large differences in specific energy use do however justify deeper investigations of the reasons for the difference, and such studies may lead to identification of possible improvements of the energy efficiency.

Tables 9 and 10 show comparisons of simple energy efficiency indicators for some of the energy intensive industries in the Barents region. Some of the industries produce residual energy in form of fuel, electricity and heat. The specific fuel shown in the first column is the

[14] Several plants are equipped with heat recovery from condensation of exhaust gas moisture. This explains efficiencies above 100% if the lower heating value is used for calculation of the fuel energy.
[15] Reported specific fuel demand is questionable

net consumption, calculated by deduction of the residual fuel energy from the total input of fuel energy.

Data for Swedish industries are available on an annual basis in “Sustainability reports” that must be submitted to the Environmental Protection Agency.

It seems difficult to collect comparable data for the industries in the Russian part of the Barents region. According to [12], official statistical information on the energy use in industry has not been collected after 2005. It is therefore necessary to acquire the data by contacts directly with the company concerned, but this kind of information is often considered as confidential. Some aggregated data for industries in Arkhangelsk oblast are included in [11] and data for the mining and dressing operations in Kirovsk and Apatity valid for 2002 are reported in [12].

Table 9. Energy efficiency indicators for forest industries in the Barents region

Enterprise	**Main product**	**Energy use**		**Residual energy used by others**		**kg CO_2/ton From net fossil fuel use**
		Net fuels kWh(f)/ton	**Electricity kWh(e)/ton**	**Fuels kWh(fr)/ton**	**Heat kWh(hr)/ton**	
Paper and pulp						
Stora Enso, Oulu, (SF)	70/30% pulp/ paper	DNF	739			267
Stora Enso, Veitsiluoto, (SF)	20/80% pulp/paper	about 2000	812			225
Billerud, Karlsborg, (SE)	Bleached pulp	6 586	1 125	0	0	43
Smurfit Kappa, Piteå, (SE)	Kraftliner	3 776	902	0	310	36
SCA, Munksund, (SE)	Kraftliner	4 621	948	0	21	100
SCA, Obbola, (SE)	Kraftliner	4 054	802	0	145	109
Arkhangelsk, average	Not specified	about 3 500	931	DNF		909
Komi average	Not specified	9800	2300	DNF		1475
Sawmill[16]						
Stora Enso, Veitsiluoto (SF)	Not specified	279[12]	67[17]			DNF
Martinsons Såg, (SE)	Not specified	311	55	775	1,3	0
Arkhangelsk, average	Not specified	471	91	DNF		114
Komi average	Not specified	340	250	DNF		180

[16] Specific energy use and emissions based on produced solid m^3
[17] Adjusted number. Data in Sustainability report probably total consumption and not specific consumption.

Table 10. Energy efficiency indicators for mining and metallurgical industries in the Barents region

Enterprise	Main product	Energy use		Residual energy used by others		kg CO_2/ton From net fossil fuel use
		Net fuels kWh(f)/ton	Electricity kWh(e)/ton	Fuels kWh(fr)/ton	Heat kWh(hr)/ton	
Mining						
Boliden, Aitik, (SE)	Raw ore	10	23	0	0	5
LKAB, Kiruna, (SE)[18]	Raw ore	DNF	11	0	0	DNF
Kirovsk, (RF)[12]	Raw ore	20	19	0	0	9
Arkhangelsk, average	Not specified	about 6	37	DNF		9
Komi average	Not specified	170	120	DNF		90
Mining and iron pellets						
LKAB, Norrbotten, (SE)	Iron pellets	343	109	0	0,6	31
Steel mills						
Outokumpu, Tornio, (SF)	Stainless steel sheet	609	932	DNF		1
Rautaruukki, Rahe works (SF)	Steel plate and strips	5 259	403	0	56	1731
SSAB, Luleå, (SE)	Steel slabs	5 260	235	about 1 000	0	1 590
Mineral dressing						
ANOF 2 +3, Apatity, (RF)	Apatit concentrate	297	99	0	0	84
Metallurgy						
Boliden, Rönnskär, (SE)	Cu-cathodes	358	1 858	0	120	98
Arkhangelsk, average	Not specified	about 1 400	1 064	DNF		536

[18] Data from 2002 for underground mines [8]

2.3.4 Heating of buildings

A commonly used indicator for the efficiency of heating systems in buildings is the annual kWh(h)/m^2 heated building floor area. It appears that such data are not in general available for the Russian parts of the region. It is therefore necessary to base the comparison on the heat energy delivered into the district heating network. The comparison is made in Table 11. For Sweden, where data are available for heat delivered to the buildings, the average distribution system losses shown in table 8, have been used to calculate the specific heat demand data.

Table 11. Average specific annual heat generation demand kWh/m^2 for buildings supplied with district heating (includes heat used for heating of tap water)

Part of the region	Single family houses	Apartment buildings	Other buildings
Finnish part	About 140	About 140	About 140
Norwegian part	DNF		
Swedish part	163	176	142
Karelia	DNF		
Murmansk	587		DNF
Arkhangelsk	420		331
Komi	DNF		

The data in Table 11 indicate significantly higher specific heat energy demands for the buildings in the Russian parts of the Barents region than those in the Swedish and Finnish parts. Houses of the same size use more than twice as much heating energy in Russia as in Sweden. Part of the explanation can of course be higher distribution losses in the Russian networks. Data reported in [12] for the towns Murmansk, Apatity, Kirovsk, Kandalaksha and Olenogorsk in Murmansk oblast indicate a specific heat demand of 370 – 420 kWh(h)/m^2 for residential buildings and 275 – 330 kWh(h)/m^2 for public sector buildings.

Climatic differences can not explain the higher specific heating demand in Russia. According to [8] data for the town of Kiruna in Sweden that has a more severe climate than most of the towns in the Russian parts of the Barents region, show a specific annual demand for generated heat of 268 kWh/m^2, i.e. much less than the data reported for the Russian towns.

Other efficiency indicators that might be considered are the annual use of heating energy per capita and the annual use of fossil fuel energy per capita for heating of buildings. These indicators are compared in Table 12. As shown there, the difference between Murmansk and Arkhangelsk on the Russian side and Västerbotten and Norrbotten on the Swedish side is much less for the heating use per capita than the heat demand per area unit. The main explanation is of course that the Russian homes are generally smaller than the Swedish. The different structure of the energy supply for district heating, with much less fossil fuels being used in Sweden, results in a significantly higher per capita use of fossil fuels for heating of buildings in the Russian parts of the region.

Table 12. Per capita use of heating energy to buildings and fossil fuel energy for this heating

Part of the region	kWh/(h)/capita	Fossil fuel kWh(f)/capita
Finnish part	About 10 000	DNF
Norwegian part	DNF	
Västerbotten	10 529	1 216
Norrbotten	11 299	4 641
Swedish part	**10 891**	**2 669**
Karelia	DNF	
Murmansk	13 491	15 245
Arkhangelsk	8021	9119
Komi	DNF	
Russian part	DNF	

2.3.5 Electric energy in households

Figure 6 shows a comparison of the per capita use of electricity for households and service in the different parts of the region.

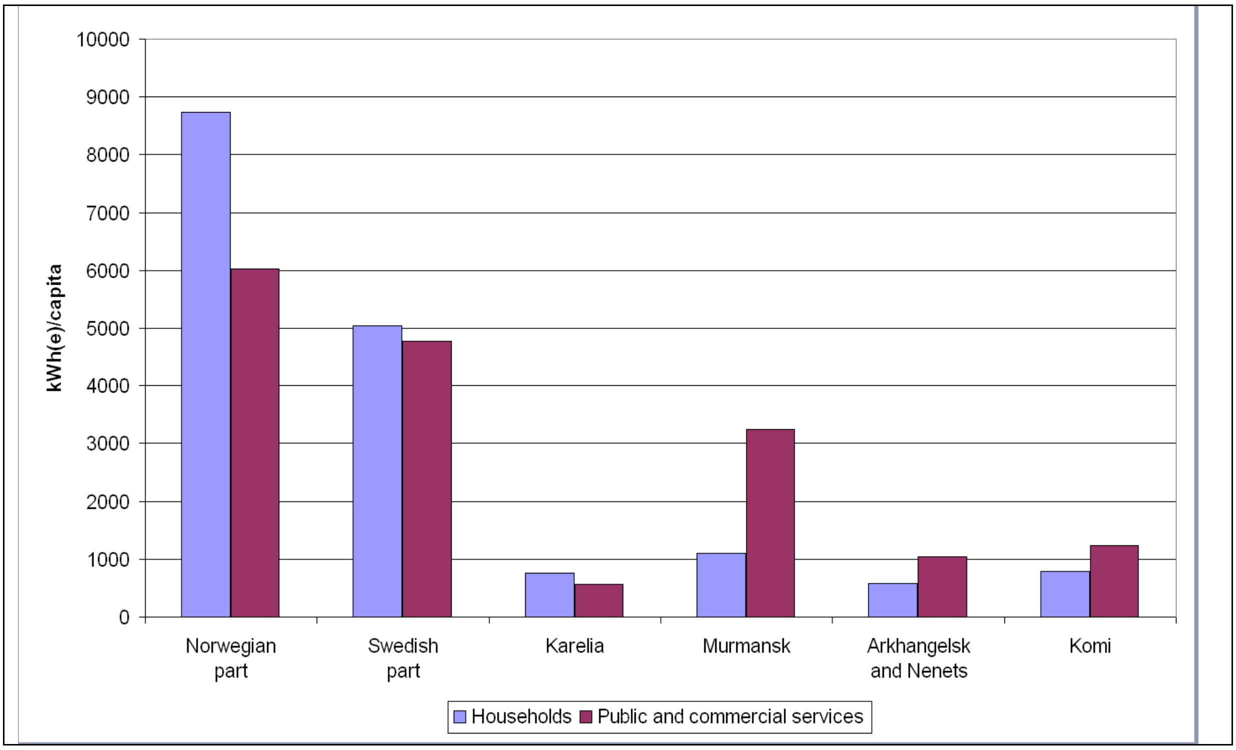

Figure 6. Electricity use in households and for services per capita

The differences in electricity use for these "soft" sectors are apparent. The population in the Norwegian and Swedish parts of the region uses significantly more electricity for these purposes than the population in the Russian parts. Part of the explanation for this is that electric heating (including heat pumps) is more common in the Norwegian and Swedish parts of the region than in the Russian parts. However, the annual per capita use of electricity in Swedish households in houses without electric heating is in the range of 2 000 -3 000 kWh, i.e. at least twice the average level in the Russian parts of the Barents region. This indicates differences in possession of electrical appliances, lighting standards or user patterns.

2.4 Experiences from use of renewable energy

2.4.1 Small hydro power plants

Hydro power plants with a rated capacity below 10 MW(e) are often categorized as “small hydro power plants”. As the costs of hydroelectric power technology are not proportional to plant size, electricity generated in small scale hydro power generation is often more expensive than electricity from larger plants. On the upside is increased supply security, lower capital costs for transmission lines and reduced transmission losses. Other benefits with small scale hydro are employment opportunities in rural areas and that existing dams, of which many have existed since ancient times, are often used and taken care of.

Data for small hydro power plants in the western parts of the Barents region have not been found. The total number of such plants in Sweden is 1 894 generating annually 4,3 TWh(e). The total annual generation in Norway is reported to 6 TWh(e). There should be no doubt that the technology is commercially available and that there are considerable accumulated operating experiences.

There are also experiences in the Russian parts of the Barents region, at least in Karelia where six small hydro power plants, with capacities 1,3 – 3 MW(e) are operated [14].

2.4.2 Wind

Electricity generation with wind power has grown considerably worldwide in the last decade and wind generators in a range of capacities up to MW-scale are commercially available from several suppliers. There were initial concerns about problems with icing for wind generators operated in cold climate but the experiences show that these problems can be managed [24]. Recommendations regarding wind power projects in cold climates have been put forward by IEA [25].

Wind power contributes to the electricity supply with a small fraction in the Barents region parts of Finland, Norway and Sweden. The most northerly located wind power plant in the World is located at Havøygavlen I Finnmark, which has a rated power of 40 MW and has been operating since 2003. There are also experiences from the Russian parts of the Barents region. A small wind generator with rated power 250 kW(e) is operated since several years close to the hotel Ogni Murmanska, near Murmansk. It used to supply the hotel with electric power but is now connected to the main network. The operational cost is reported as about 30 EUR/MWh(e) [12]. In Komi a wind power plant with rated power 2,5 MW(e)[19] is operating in Vorkuta region [13].

[19] Other sources report the capacity as 1,5 MW(e)

Until now, there seems to be limited experiences from wind-diesel hybrid plants supplying isolated grids in the Barents region. A Swedish company PitchWind has delivered three plants to isolated sites in Murmansk Oblast, Set-Navalok, Charlov and Kildin, each with two 30 kW windgenerators and two 64 kVA diesel generators. The first of these was delivered in 2007. Wind-diesel hybrid plants have also been successfully operated in Alaska and Antarctica, with wind energy contributing up to 55 % on an annual basis, see [26].

2.4.3 Biomass

Biomass fuels include i.a. forestry residues, sawmill residues, fuel wood (cut only for energy purposes), agricultural residues, wood or agricultural products grown to be used as fuel and the black liquor appearing as a residue in pulp production. The use of the latter in recovery boilers is standard procedure in modern pulp mills. Before the oil price increases in the 1970:s biomass fuels were used in Sweden and Finland only in industries that produced wood residue that had to be disposed of and by parts of the rural population who found it more attractive to spend time on cutting and preparing fuel wood than buying fuel oil.

In Norway, the use of biomass fuels is still not very important. The sustainable biomass fuel potential in the Norwegian parts of the Barents region is also relatively small [The total use is but in Sweden and Finland, there is an important biomass fuel industry mainly supplying different types of fuel for co-generation of electricity and heat and for district heating. There is also significant use of refined biomass fuels in the form of wood pellets for heating of single family homes. The methods for retrieving, preparation, distribution and combustion of biomass fuels for large and small scale use are well developed and the equipment required is commercially available. Even though the combustion technology has been dramatically improved, emissions of carcinogenic VOC:s from small boilers is still of some concern. Collection, preparation and up-grading of forestry residues and sawmill residues has created new employment opportunities in the forested areas. The experiences show that production of 1 000 GWh(f) biomass fuel energy involves 80 – 200 full time workers [23].

Wood fuels give a significant input to the fuel energy supply in Karelia. Out of 450 boiler houses supplying heating for households and social facilities in the republic, 125 use firewood and 15 wood chips [14]. Most of these boilers were designed for burning coal and have not been modified. They are not particularly efficient. There are 15 boilers optimised for wood burning, with capacities of 1,5 – 6 MW(h) in operation.

In Arkhangelsk oblast, 10 projects for utilisation of biomass energy in sawmills have been implemented since 2004. Four of these deal with wood pellet[20] or wood briquette production (up to 50 kton/a) from sawmill residue, the other with construction of wood fired boilers, in one case for co-generation of electricity and heat 2,2 MW(e)/15MW(h).

2.4.4 Urban waste

In the Swedish parts of the Barents region, urban waste is used as fuel for co-generation of electricity and heat in Umeå, Boden and Kiruna. In Boden with a population of about 27 000,

[20] One plant is not operating, the largest produces 50 kton/a and will double the production during 2010

3000 m^3 biogas is produced per day from sewage sludge and food waste. A part of the biogas is up-graded to motor fuel quality and is used primarily for local buses and vehicles used by the town. In Rovaniemi, Finland, 6,7 TJ of biogas is annually used to produce district heating.

Since 1986 a waste incinerating plant has been operating in Murmansk, providing 2,5 – 3% of the heat to the city, see [12]

2.4.5 Other sources

A small tidal power plant, with rated capacity 0,4 MW(e) is in operation in Murmansk Oblast [12]

3 Emissions to the atmosphere

3.1 Emission data

Table 13 shows emissions to the atmosphere in the different parts of the Barents region.

It appears that data on emissions of particulates are not available on a regional level in Sweden. The concentration of particles in the air is measured at selected locations but the emission data are not compiled.

Table 13. Atmospheric emissions from stationary sources in the Barents region

Part of the region	Solids kton	HC[21] kton	SO_2 kton	NO_x kton	CO kton	VOC kton	CO_2 Mton
Finnish part	DNF						
Norwegian part	DNF						3,3
Swedish part	DNF	DNF	8,2	7,6	DNF	3,0	4,9
Karelia (2007)	27	0,2	66	7,4	18	1,4	4,2
Murmansk (2008)	29	1	206	15	21	2,5	7,0
Arkhangelsk (2008)	54	33	133	33	136	6,8	10,6
Komi (2008)	66	279	53	179	30	10	20,0

It is apparent that sources in the Russian parts of the Barents region dominate the emissions of sulphur oxides, nitrogen oxides and carbon dioxide. This is because most of the fossil fuels are used in the Russian parts of the region. Another reason for the large emissions of sulphur oxides is the use of fuels with relatively high sulphur content.

[21] VOC not included

3.2 Environmental indicators

Table 14 shows emission indicators calculated from the data in Table 13 for emissions from stationary sources.

Table 14. Emission indicators for fuels used in stationary applications

Part of the region	kg SO_2 per MWh(f)	kg NO_x per MWh(f)	kg CO_2 per MWh(f)	Ton CO_2 per capita
Finnish part	DNF			
Norwegian part	DNF		235	7,1
Swedish part	0,3	0,3	161	9,6
Karelia (2007)	3,6	0,4	231	6,1
Murmansk (2008)	9,5	0,6	323	8,3
Arkhangelsk (2008)	2,9	0,6	232	8,4
Komi (2008)	0,6	1,8	219	20,0

The low sulphur content of the fuels used in the Swedish parts of the region and in Komi explains the lower specific emissions of sulphur oxide. The differences in specific emissions of nitrogen oxides can be explained by the use of different combustion technologies. In Sweden, those using large boilers pay a penalty on nitrogen oxide emissions and this has promoted modification of burners and other measures to reduce emissions of this pollutant. The lower specific emissions of carbon dioxide in Sweden is an effect of the larger fraction of renewable fuels used in the industry and for generation of electricity and district heat.

The CO_2-emissions per fuel energy unit is less in the Swedish parts of the Barents region than in the Russian parts. This is a consequence of the larger fraction of biofuels used in the Swedish parts. The emission of CO_2 per capita is nevertheless higher in the Swedish parts than in most of the Russian parts. The reason is the large coal and coke use in the large steel mill in Luleå in a region with a rather small population.

4 Administrative measures for promotion of energy efficiency and renewable energy

4.1 General remarks

It is important to distinguish between the technical potential for increased energy efficiency and increased use of renewable energy, the economic potential and the financial potential[22]. The technical potential for improved energy efficiency depends on thermodynamic conditions

[22] A brief discussion of the different potentials can be found in [5]. Often also ecological and social limitations must be considered. Ecological limitations are important for the exploitation of hydro power resources and the use of residues from forestry and agriculture. Social acceptance can be a problem for instance for installation of wind power plants.

and on availability of suitable technologies. The technical potential for use of renewable energy depends on natural conditions, such as meteorology and hydrology, the requirements of the energy user and on availability of a technology that makes use of renewable energy possible. The financial potential depends on the capital costs for the investment required and the possible saving in operating costs. The latter is to a large extent determined by energy prices including taxes and may be off-set by various types of subsidies that may also reduce the capital costs. The financial potential is always less than the technical. The economic potential is determined by the cost and benefits of the change for the society and includes consideration of the effects on the environment of alternative uses for the fuels used.

Governments can influence the technical potential by support to research and development and the financial potential by policy instruments of different types like subsidies, penalties and regulations. Ideally, the policy instruments shall be used to eliminate any difference between the financial and economic costs, but this is easier said than done. The main problem is quantification of the environmental impacts and putting appropriate price tags on these. The quantification of the environmental impacts is often associated with large uncertainties and the costing with ethical controversy.

4.2 Finland

The National Climate Policy adopted in year 2001 has set the objectives to energy policy until today. A few years ago, on November 6, 2008 the Government of Finland approved the Long-term Climate and Energy Strategy, according to which the building code will be tightened in order to improve energy efficiency. In the first phase, the allowed heat consumption levels will be tightened by 30% in the current year 2010, and in the second stage, the target is to change the energy saving objective to cover the entire primary energy consumption of the building, an approach that is not largely used elsewhere at the moment. At the same time, the general allowed energy level will be reduced by 20%. An action plan for energy efficiency has been published in 2007 [27]. Measures to stimulate energy efficiency includes energy labelling of appliances, tax deductions for households that up-grade their heating systems, subsidies to the public sector, the private service sector and the industry for energy audits and investments in energy saving.

Just recently, on July 1, 2010, The Finnish parliament approved a comprehensive energy package to address the climate change. In addition to allowing two nuclear power plants to be built, one of them to Barents region (Simo or Pyhäjoki commune), there will be a renewable energy package that will introduce the feed-in tariff in Finland to kick off construction wind power and biomass driven power and heat plants. The national target is to raise the share of renewable energy to 38% level by year 2020 with much of the effort to take place in the Barents region part of the country, where large resources for biomass and wind energy prevail.

Motiva Oy promotes energy efficiency in the Finnish society. The specific feature is the energy saving agreement system, in which several industries, municipalities and communities have voluntarily agreed to save energy. SITRA, the Finnish Innovation Fund, is running a 20 million EUR program to promote energy efficiency and renewable energy in Finland. The Program is for the years 2008-2013.

4.3 Norway

The transition of the Norwegian energy system to be more efficient and environmentally friendly is since 2002 managed by Enova SF, a public enterprise for promoting energy savings, renewable energy and environmentally friendly natural gas solutions. Enova SF is fully owned by the Government of Norway, represented by the Ministry of Petroleum and Energy.

Enova relies primarily on financial instruments and incentives to stimulate market actors and mechanisms to achieve the national energy policy goals. The activities are financed through the Energy Fund that in turn is financed through a surcharge on the grid tariff of about 1 EUR/MWh(e). Industry can receive grants up to 20% of the investment for improvement of energy efficiency, use of waste heat or use of renewable energy if the effect is that at least 500 MWh/a of conventional energy is saved. Private and public owners of buildings can receive grants to cover additional costs for planning, implementation and/or investments in energy efficient buildings. The grant level is normally 20 – 60 EUR/MWh saved or produced. In 2009 Enova introduced a special programme for improved energy efficiency in public buildings. Communities can receive up to 50% financing of costs for preparation of local energy- and climate plans.

In addition to this Enova collects energy consumption and production figures from the industry in a data base. This is used for calculation of specific energy consumption data for different industry sectors that can be used for benchmarking[23]. Enova also operates a helpline giving free advice and distributes information material. There is a special program for children age 6 to 15 years with books, website, networks, and competitions.

An important feature of Enova´s grant programme is that recipients of grants are contractually bound to achieve the anticipated energy saving or generation of renewable energy. Grants given in different activity sectors and the contracted effects are summarised in Table 15. The effects of the programme are monitored. The difference between anticipated effects and those actually achieved is less than 0,1% [29].

Table 15. Results of grants distributed by Enova during 2009 [29]

Sector	Projects approved	Grants approved MEUR	Contracted effect 2009 GWh	EUR/MWh saved or generated
Large demo projects for power generation	6	10,8	32	338
Energy efficient buildings	225	66,2	303	218
Improvements of industrial processes	43	71,3	1250	57
Renewable heating	337	96,2	993	97
Wind power plants	4	131,4	453	290

[23] See http://www.enova.no/industrinettverk/

4.4 Russia

A new federal law "On energy saving and energy efficiency increase" [16] applies since November 27, 2009. The law is focussed on promotion of reduced and more efficient energy use. It defines the powers of authorities on different levels with respect to this. In brief summary, the law outlines how state regulation in the field of energy saving and energy efficiency shall be performed and specifies requirements and activities to be carried out. Issues included in the law are:

- Energy efficiency of commodities. (Includes phase-out of incandescent lamps starting 2011)
- Energy supply to buildings, construction and facilities (Energy efficiency requirements will be defined)
- Metering of energy consumed (Meters installed in state and municipal buildings by January 1, 2001 and in all residential buildings by January 1, 2012)
- Development of regional and municipal energy savings programs
- Energy audits (Mandatory for i.a. public companies, utility companies generating electricity or heat, organisations with annual energy costs exceeding about 250 000 EUR)
- Collection and analysis of energy ID data developed on the basis of energy audit results
- Energy saving and energy efficiency in the public sector[24] (From January 1, 2010, annual use of energy resources shall be reduced from the 2009 level by 3% per year during a five year period)
- Regulation of tariffs. (Tariffs will be designed to stimulate energy efficiency and energy saving)
- State support for promotion of energy saving and energy efficiency (Support for i.a. investments[25], technical development, education and information activities)

Until August 1, 2010, all regions and municipalities are obliged to work out and adopt integrated energy efficiency programs.

Transition to renewable energy sources is not included in the law of November 23, 2009, but is emphasised in the energy strategy for Russia [17] as a measure in particular for reducing the costs for electricity and heat generation in remote municipalities. Targets for the entire Russian Federation concerning substitution of fossil fuels, reduction of greenhouse gas emissions and electricity generation from renewable energy sources to be reached by the year 2020 have been formulated [19]. New regulations guaranteeing the development of renewable energy in Russia are under preparation [12].

4.5 Sweden

In Sweden, promotion of energy efficiency and a transition from fuel oil to renewable energy in form of biomass in particular has been a part of the governments energy policy since the early 1980:s. The government has supported research and development and mainly used

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[24] The "budgetary organisations"
[25] Tax rebate can be obtained for investments exceeding 2,4 MEUR in Arkhangelsk oblast [18]

economic policy instruments for promotion of a shift from fuel oil to renewable fuels and for stimulation of installation of energy saving technologies. The latest energy bill see [6] includes quantitative targets for 2020 as follows:

- 50 % renewable energy (44 % in 2008)
- 10% renewable energy in the transport sector (3,4 % in 2008)
- 20% more efficient energy use (relative to 2008)[26]
- 40% reduction in greenhouse gas emissions[27]

The use of fossil fuels for heating will be phased out by 2020. By 2030 Sweden should have a vehicle stock that is independent of fossil fuels. The dependence on nuclear power and hydro power for electricity generation will be reduced by increased use of cogeneration based on renewable fuels and wind power.

In summary the policy instruments presently used for promotion of energy efficiency and renewable energy sources in Sweden are:

- Energy taxes (see table 5). The taxes include a CO_2-tax of 107 EUR/ton CO_2 for heating, 22 EUR/ton for industrial use[28].
- Subsidies for
  - Environmentally benign cars
  - Installation of photovoltaic systems
  - Replacement of direct electric heating systems for residential buildings by district heating, heat pumps or biofuel boilers
  - General improvements of residential buildings. Many such improvements are expected to reduce the specific energy consumption.
  - Energy efficiency advice and energy audits
- Exemption from energy tax on electric energy for energy intensive industries that make commitments to take measures for improvement of electric energy efficiency.
- Green certificates for new electricity generation with renewable energy sources. The target for 2020 is 25 TWh/a[29] (projected electricity demand is then 133 TWh/a)
- Building standards. In the Barents region parts of Sweden, the most recent standard [7] allows a maximum annual heat energy (including hot water) use of 95 kWh/m^2 for electric heating and 150 kWh/m^2 for other heat sources.
- Mandatory energy declarations for buildings.
- Financial support to communities that formulate a strategy for energy efficiency improvement and implement at least two of the measures listed below [30]:
  1. utilise financial instruments for improving energy efficiency, among these contracts on energy performance, where measurable and pre-determined reductions of energy use are a requirement;

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[26] "20% less energy supply per GDP-unit corrected for inflation
[27] Applies to the sector outside of the European Emissions Trading System and is equivalent to a reduction by 20 Mton/a . Two-thirds of the reduction shall be made in Sweden and the rest in the form of investments in other EU-countries or through the Clean Development Mechanism (CDM).
[28] Will gradually be increased to reach 60 EUR/ton 2015 [6]
[29] The projected demand is then 133 TWh/a. Existing hydropower and co-generation using biomass fuels contributes about 75 TWh.

2. purchase equipment on basis of lists provided by the Swedish Energy Administration that include energy efficiency data for different types of equipment;
3. purchase equipment with efficient energy use in all operating modes also at stand-by;
4. exchange or modify existing equipment with equipment mentioned under 2 or 3;
5. use energy audits and implement recommendations resulting from these provided the recommendations can be justified financially;
6. purchase or rent energy efficient buildings or parts of these, or take measures to improve the energy efficiency of buildings that the community already owns.

5 Potential for improved energy efficiency

5.1 General considerations

As emphasised in section 4.1, it is important to distinguish between the technical potential for increased energy efficiency, the economic potential and the financial potential.

5.2 Conversion to energy carriers

5.2.1 Electricity generation

The comparison of energy efficiency indicators presented in section 2.3.1 indicates that there might be a technical potential for improvement of the efficiency of the thermal power generation in the Russian parts of the Barents region. Quantification of this potential requires more detailed information about the structure of the thermal power generation and the performance of the individual power plants.

The technical potential is also depending on the structure of the entire electric power system and the load pattern. The potential for co-generation of electricity and heat in Murmansk may appear as underutilised. However, there might be no room for more thermal power generation in that part of the grid.

5.2.2 District heating systems

Improvements of the efficiency of district heating systems can be made either by utilising waste energy as energy source, reducing the losses from the boilers or reducing the heat losses from the distribution system.

Heat generation

The comparisons shown in Table 7 indicate that the fuel energy consumption for generation of district heat in the Russian parts of the Barents region can be reduced by 10 – 35% if the systems were designed and operated like those in the Swedish parts. The main reason for the low average specific fuel use for district heat generation in the Swedish part of the Barents region is however that some of the plants use industrial waste heat as energy input to the district heating system. If this is feasible in the Russian district heating systems needs to be investigated for each community.

The Swedish plants that rely entirely on combustion of fuels for district heat generation show efficiencies in the same range as the average for Russian plants. All the Swedish plants except the one in Luleå burn bio fuels. For those using raw wood waste, very high efficiencies, above 100%, are possible if part of the latent heat in the water vapour in the exhaust gas is recovered. This can not be utilised in the Russian plants burning coal or heavy fuel oil.

It is inferred in the recent World Bank report [5] that the boiler plants in Russia are less efficient than suggested by the official statistics. If this is true for the boilers serving district heating networks in the parts of Russia that are of interest for this study, can only be answered by energy audits for each plant. It must be understood however that the high sulphur content in some of the coals and fuel oils being used makes it necessary to operate with relatively high exhaust gas temperatures in order to avoid low temperature corrosion in the economisers.

As reported in [12] it has been suggested for Kirovsk, Apatity and Kandalaksha that heat pumps, with municipal sewage water or industrial waste water are introduced for pre-heating of the large amounts of make-up water used in open district heating systems. This will lead to a saving of fossil fuel energy if the additional electricity can be generated with a specific fossil fuel input less than the coefficient of performance for the heat pumps. The heat pump option is therefore more favourable in a system where a fuel is not needed for generation of the additional electricity required for running the heat pump. It is not necessarily energy efficient if the marginal electric energy is generated in steam power plants without recovery of the condensation heat.

Distribution systems

In the recent report from the World Bank [5] it is reported that about 60 out of 200 district heating systems in Russia that had been studied, show distribution losses above 10%, considered to be the maximum acceptable level. The information received from the Energy Efficiency Centres, summarised in section 2.3.2, is not sufficient for assessment if a similar situation applies in the Russian parts of the Barents region. The average losses reported for Arkhangelsk oblast are in fact almost a factor of two less than the average value reported for the Swedish parts of the Barents region and only about 30% of the average for Västerbotten.

It is important to realise that the losses also for well insulated and optimised distribution systems, will depend a lot on the structure of the district heat supply where a high fraction of disperse single family houses inevitably leads to high distribution losses, well above the 10% level. District heating may still be justified as an alternative to individual heating systems since district heating allows use of renewable fuels like raw wood chips or municipal waste instead of more expensive renewable fuels, like wood pellets or a fossil fuel like light fuel oil that would be used in distributed boilers.

When more reliable data for the amounts of heating energy actually delivered to the buildings connected to the Russian district heating systems are available, it will be possible to quantify the losses for each network. Evaluations on an individual basis will show if investments or modification of operating conditions are justified for reduction of the losses.

5.3 Energy use in industry

It is not possible to draw any conclusion about the efficiency of energy use in the industries in the Russian parts of the Barents region, in comparison to Swedish industry on basis of the comparisons of indicators shown in Tables 9 and 10. The reason is that the information about the energy use on the Russian side is either not up-to-date or too aggregated.

A recent study by the World Bank [5] reports a significant technical potential for improved energy efficiency in two of the industrial sectors included in Tables 9 and 10, namely production of ferrous metal and pulp and paper. The data for these industries in the Barents region indicate that the specific electricity and fuel energy use for pulp and paper production in the most effective plant in the northern part of Sweden and the average plant in Arkhangelsk oblast are not much different. Regarding iron pellet production, an average energy use of 355 kWh(f)/ton is reported for the Russian industry in [5]. This is very close to the LKAB-operation in Sweden as shown in Table 10. Assuming that the Swedish plants are well optimised, the financial potential for further improvements of the Russian plants will be small, since energy prices in Russia are generally lower than in Sweden, see Table 4.

Obviously, there may nevertheless be a financial potential for improved efficiency in particular industries that operate in the Russian parts of the Barents regions. Energy audits for each industry and feasibility studies where the financial implications of investments in new equipment and processes are evaluated, will be required for identification of the actual potential for improvement of the energy efficiency.

Regardless of this, Tables 9 and 10 clearly show that there is a significant technical potential for reduced CO_2-emissions from the pulp and paper industries in Arkhangelsk oblast. In the Swedish plants, fossil fuels contribute with between 2 and 12 % of the fuel energy used, whereas on the average 42 % is used in the plants in Arkhangelsk oblast. If a shift from fossil fuels to biomass fuels in the Russian plants can be financially justified depends on the relation between the fuel prices at each site.

5.4 Energy use for heating of buildings

As shown in Table 10 and discussed in more detail in section 2.3.4, the available information shows clearly that the specific heat demand of buildings in the Russian parts of the Barents region, on the average is considerably higher than in the Swedish parts. In comparison with Kiruna in Sweden, where the climate justifies more heating than in most of the large population centres in Russia, the average specific heating demand in the Russian buildings is at least 60% higher. It is not unlikely that the specific energy use would be less than half of the present, if the buildings had the same isolation standards as those in the northern parts of Sweden. A technical potential for reducing the energy use in buildings to 50% of the present is also estimated in [5]. Experiences reported in [12] demonstrate reduction of the specific heat demand for schools and kindergartens in Olenogorsk from 331 to 240 kWh(h)/m^2.

Introduction of improved thermal performance standards for new buildings will not have much effect in the next decade unless a drastic programme for replacement of old buildings is enforced. The present rate of new construction ranges between 0,5 and 1% for the parts of Russia considered here [9].

Rehabilitation of the existing buildings to reach specific heat demands at the Swedish level is a tremendous undertaking that will require substantial investments. However, according to the World Bank study [5], roughly 85% of the energy savings in buildings are economically justified and about 45% financially justified with the energy prices of 2007. The main barriers identified in that study are essentially lack of data and incentives, but shortage of capital for the necessary investments is also important. Some of the improvements, like improved systems for control of the indoor temperature and reduction leakages past windows and doors do not involve large investments and can be implemented fairly quickly. Complete add-on insulation of walls requires more capital, will take a long time to accomplish but will give larger savings. The few standard types of apartment buildings should facilitate the planning for a rehabilitation program, but buildings are to some extent individuals. When energy meters have been installed, it will be possible to identify the buildings where improvement of the energy efficiency is most urgent. It is possible however that focussing initially on buildings in the social sector, for which regional or municipal authorities can take the necessary decisions, will lead to more rapid effects on the total use of fuels.

A project conducted by a working group for energy efficiency of the Commission on Modernization and Technological Development of the Russian Economy under the president of the Russian Federation called “Energy Efficient Cities” is focussed on two major cities in the Barents region part of Russia, namely Apatity in Murmansk oblast and Vorkuta in the Republic of Komi. In Apatity a pilot district has been identified. Funding for a full energy survey is being sought. For Vorkuta, the project is reported to be city-wide. The objectives are to reduce the overall energy consumption by 25 – 30% and reduce harmful emissions by 10 – 15% [33].

6 Potential for increased use of renewable energy sources

6.1 General considerations

As explained in section 4.1, it is important to distinguish between the technical potential for use of each type of renewable energy source, the economic potential and the financial potential.

The reports [11 – 14] from the Energy Efficiency Centres in the Russian parts of the Barents region that have been used as an important part of the background material for this study, indicate that there are potentials for increased use of renewable energy. It appears however that quantification of total technical potentials and costs for exploitation will require further studies.

What appears to be an important source of information about the potential for renewable energy in Russia in general, is the recent report issued by Alternativnaja Energia [34] which can be purchased from this organisation. According to a press release about the study, the report provides complete information for decision making and contains a wide range of information including:

- A review of renewable energy market development in 2009 in Russia on each of the following segments: bio energy, solar energy, wind power, tidal power, geothermal power
- Resource potential of renewable energy in Russia
- Accepted and upcoming normative legal acts in the renewable energy sphere
- A detailed forecast of cause and consequences for gas and electricity supply crisis in the years 2010-2020
- An analysis of ready-made solutions on energy-savings and usage of renewable energy sources

6.2 Small hydro power

There is an increased interest in many countries for small scale hydropower schemes as a renewable energy source. Installations of run-of-river type can be designed to cause less environmental impact and smaller ecological foot-print than large hydropower schemes with dammed reservoirs. Development works on low-maintenance, completely submersible, oil-free power units with fish-friendly turbines are underway and pilot tests for low-head and low flow applications are planned in Norrbotten, Sweden with participation from power companies in Sweden, Norway and Finland.

The government of Karelia and the companies Nord-Hydro and CJSC New Energy have signed an agreement regarding construction and rehabilitation of small hydro power plants in Karelia. It includes plants with a total capacity of 100 MW.

In Murmansk oblast, there is a potential for generation of about 2,9 TWh(e) annually in small hydro power plants located in about 40 small and medium sized rivers [12]. Three projects with capacities 250, 500 and 6 000 kW(e) respectively are suggested as high priority in [12]. Five possible locations in Arkhangelsk oblast, with capacities 0,5 – 2 MW(e) are reported in [11].

It must be expected that on most sites, small hydro power plants will provide less power in winter time when the flow in rivers is low. A back-up system like diesel generators may be required for isolated grids.

6.3 Wind

In the western parts of the Barents region, wind power generation can be expected to increase at a rate determined by the market forces and the incentives provided by the national governments for promotion of electricity generation with renewable energy sources. Visual impact and negative effects on reindeer behavior are possible obstacles for a large expansion of wind power in the northern parts of Sweden. Construction of wind power parks along the coast and in the mountain areas, where the wind conditions are most favorable will therefore be controversial.

The Swedish government has recently approved construction of a large wind power park close to Piteå in Norrbotten in a sparsely populated area. When completed the annual generation is expected to be 12 TWh(e). Studies are being made for several sites in Västerbotten.

In Murmansk Oblast, there is a very large technical potential for wind power generation, in particular on the northern coast of the Kola Peninsula. According to [12], utilising only 1 – 2% of this potential in windmills with an installed capacity of 1 000 – 2 000 MW, would generate some 3 – 7 TWh(e)/a. This is far more than the present generation in thermal power plants using solid fuels. It remains to establish how much wind power, the electric power system that is supplied by mainly nuclear power, can handle. Rapid load following is not realistic for nuclear power plants and the possibilities to use the hydro power plants for the frequency control is limited. At present two wind park projects on the Kola Peninsula, with a total rated capacity of 300 MW(e) have been approved. There are also plans for two smaller wind parks with capacities 5 and 1,5 MW(e) respectively.

Seven wind-diesel combinations may be implemented in remote parts of Arkhangelsk Oblast [11]. Five of these are relatively small with capacities 5 – 15 kW(e), one will have a capacity of 90 kW(e) and another projected one on Solovetsky island a capacity of 2 MW(e). Even though there is a considerable technical potential for wind power in Arkhangelsk Oblast along the shores of the White Sea and Barents Sea, grid connected wind power is not considered cost effective in the near future mostly due to problems with the electricity grid infrastructure [11].

In Komi a wind park is planned in Vorkuta on a hydro power dam [13]. The objective is to boost electricity generation in winter time when the water flow is low. Information about the planned capacity is not provided in [13].

There appears to be no estimates of the financial potential for wind energy generation in the Russian parts of the Barents region. Use of wind power in combination with diesel generators, however, most likely offers possibilities for considerable savings in fuel costs for remote settlements with isolated electrical grids. Site specific feasibility studies will be needed for identification of the most promising projects.

6.4 Biomass

There remains some technical potential for increased exploitation of biomass fuels from the forests in the Swedish parts of the Barents region. Much focus is now however on utilisation of abandoned farm land and used peat bogs for cultivation of an annual energy crop, canary reed. If production and use of this energy source will be financially attractive remains to find out. With the limited time and resources available for this study, it has not been possible to evaluate the potential for increased use of biomass fuels in Finland and Norway.

It is apparent that there is a considerable sustainable technical potential for increased use of wood fuels in Karelia, but no estimates of the potential are presented in [14]. On basis of the forest area in Karelia relative to that in Arkhangelsk oblast and the estimate presented in [11] for Arkhangelsk, the potential in Karelia can be estimated to about 300 TWh(f)/a. This is almost 16 times the present use of fossil fuel energy in the republic.

The technical potential for utilisation of wood waste and organic waste from livestock and poultry farms is quite limited in Murmansk oblast, estimated to less than 1 TWh(f)/a in [12]. Data for the additional fuel energy potentially available in solid urban waste and sewage water do not seem to be available.

In Arkhangelsk oblast, the sustainable supply of wood residues has been estimated to about 430 TWh(f)/a [11], which is more than 8 times the present consumption of fossil fuels. In addition to this a technical potential for using biogas from four large animal farms estimated as 7 GWh(f)/a and a substantial but not yet quantified potential for using solid urban waste and and sewage water could be utilised.

There are currently 11 biomass energy projects in different stages of completion in Arkhangelsk oblast. One of these will achieve biogas production at a farm for combined heat and power production at the 200 kW(e) level. Five projects are focused on wood pellet or briquette production and the other six on construction of wood fired boilers in the capacity range 3 – 15 MW(h). Two will be used for co-generation of electricity and heat. These projects will after completion only use a very small fraction of the estimated sustainable supply of wood residues. Willow plantations are considered potentially interesting in Arkhangelsk oblast where large land areas close to populated areas are abandoned farm land, not currently used [11]. Research will be needed to generate more information for assessment of this option.

In Komi wood residues from the forest industry equivalent to some 2,3 TWh(f) is generated annually. Most of this is not used according to [13]. This is just a few % of the fossil fuel energy supply to the republic, but according to [13] about twice the fuel energy of coal and oil used in the districts where these industries are located. Data for the estimated total sustainable technical potential for biomass energy are not included in [13]. By using the estimate for Arkhangelsk oblast and assuming that the potential is roughly proportional to the forested area it is found that the technical potential would be around 650 TWh(f)/a, i.e. almost 7 times the present supply of fossil fuel energy. Recently, Rantasalmi Institute of Environmental Education and Envitecpolis Oy from Finland have carried out a pre-project study of wood pellet production at a scale of 75 000 ton/a from sawmill by-products in Komi [32].

Figure 7 illustrates the ratios between the presently not used technical potential for renewable fuels and the present use of fossil fuel energy in the different parts of the Barents region.

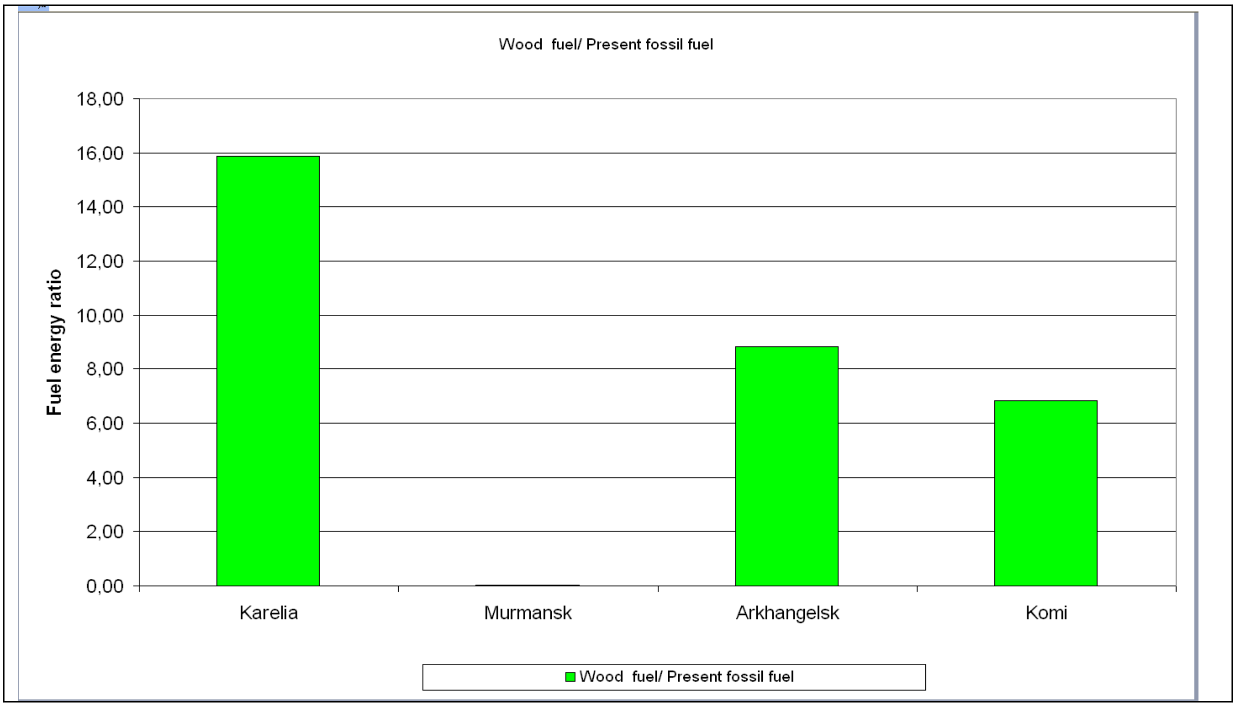

Figure 7. Unused technical potential for renewable fuels relative to present fossil fuel energy

It is obvious that a technical potential for replacement of all or most of the fossil fuels used in stationary applications exists in Karelia, Arkhangelsk oblast and Komi. With the fuel prices shown in table 4, the relative transport costs for wood residues vs those for the fossil fuels will determine if a shift from fossil fuels to wood residue can be financially justified.

6.5 Urban waste

Even though estimates for the fuel potential in solid urban waste have not been sourced, it is likely that urban waste could be used to reduce the use of fossil fuels in the Russian parts of the Barents region. Effective and environmentally friendly use of solid urban waste as an energy source requires fractionation of the waste into combustible and non-combustible fractions and combustion in relatively large boilers equipped with exhaust gas cleaning systems.

There are considerable experiences from use of solid urban waste for co-generation of electricity and heat in the Swedish towns of Umeå, Boden and Kiruna that might be valuable for towns in the Russian parts of the Barents region interested in using this renewable energy source.

6.6 Other sources

Expanding the use of tidal energy is possible on the Kola Peninsula according to [12]. It has been estimated that a future tidal power plant at Lumbovsky bay with a capacity of between 320 and 670 MW(e), could generate 2 TWh(e)/a. The remote location and the large investment required is expected to push this project into an uncertain future. A smaller project of 40 MW(e) in the Dolgaya Bay might have larger possibilities for realisation in the coming years.

As far as wave energy is concerned, the technical potential on the northern coast of the entire Barents region is apparently very large. The climatic conditions do not appear favourable however. It is concluded in [12] that at least for the Kola Peninsula, there are no obvious premises warranting the development of this energy source.

Also in Arkangelsk there is a potential for use of tidal energy with at least one location identified with a capacity of 12 MW [11].

7 Energy co-operation within the Euro-Arctic Barents region

7.1 Multilateral energy cooperation within the framework of BEAC

The international cooperation in the Barents Euro-Arctic Region is based on a series of bilateral initiatives, projects and programs as well as an overall multilateral umbrella monitoring and facilitating networking and concrete projects and programmes.

The major multilateral framework for cooperation in the region focusing on the energy sector and issues relating to energy efficiency is the Barents Euro-Arctic Council (BEAC). The work is organized through various working groups reporting to the Committee of Senior Officials within BEAC.

The BEAC Joint Working Group on Energy (JEWG)
In the energy field a BEAC Joint Working Group on Energy (JEWG) has been established. The group consists of representatives of the governments from the Nordic countries, the Russian Federation and the regions in all countries. The EU-Commission is an observer in the group.

The group is currently co-chaired by the Ministry of Petroleum and Energy in Norway and the Arkhangelsk region. The BEAC JEWG has operated since the mid 1990s and focused mainly on energy efficiency and renewable energy. The working group was active in facilitating the establishment of the various energy efficiency centers in North West Russia. The initial efforts and support to establish these centers were made by the Norwegian government in the 1990's. The objective was to make these as centers of competence which could provide services and information in the energy field.

The mandate of the BEAC JEWG has recently been modified and the terms of reference of the working group have been updated. In 2009 the BEAC JEWG re-convened and it was agreed that the main thrust of the work should focus on stimulating improved energy efficiency and stimulating the production of renewable energy in the region. A workshop on energy efficiency improvement in the public municipal buildings formed the kick-off for a renewed focus in September 2009, and was organized back to back with the BEAC JEWG formal meeting. The workshop was organized by the support of the Nordic Council of Ministers.

It was in the formal meeting tentatively agreed on the main themes for further cooperation and that the energy efficiency improvements were potentially immense in the NW Russia. In parallel one should continue to undertake work on renewable energy in the region.

The twin policies of energy efficiency and renewable energy is the core of the BEAC cooperation in the energy field and serves the overall policy objectives of mitigating climate change, improving security of supply and contributing to competitiveness and industrial and regional development. The BEAC JEWG will continue to look into how projects and programmes could serve these objectives.

The focus on energy efficiency and renewable energy within the BEAC JEWG agenda fits well into the wider international energy policy agenda. It is in line with the EU focus on Northern Dimension. It is line with the analysis of various international bodies like the International Energy Agency (IEA). It is line with the more global initiatives like International Partnership for Energy Efficiency (IPEEC) and IRENA (renewable energy). The bilateral dialogue between the Russian Federation and the EU has a thematic focus on energy efficiency which is in line with the BEAC JEWG priorities.

However, the main challenge for the BEAC JEWG would be to mobilize local forces and reap the benefits from better coordination of networking between the existing energy efficiency centers and to contribute to improved exchange of information between the Nordic countries and regions and NW Russia. New legislation on energy efficiency in the Russian Federation constitutes a very good opportunity for improved cooperation both bilaterally and multilaterally. The BEAC framework would constitute a platform for exchange of information on the series of bilateral MoUs and projects between Russia and individual Nordic countries.

The BEAC JEWG could according to the recent upgrading of terms of reference and mandate strengthen its focus on how Nordic models could be relevant for NW-Russia. This would need to involve how to mobilize investments from the market and from financing institutions. The twinning of various cities, communes and regions to strengthen cooperation on regional level could be considered by the BEAC JEWG. Promotion of cooperation between commercial actors is also a possibility but this involves complicated issues related to intellectual property rights and commercial competition.

The Working Group on Environment
The BEAC Working Group on Environment (BEAC WGE) promotes important co-operation to strengthen capacity to meet regional environmental challenges and facilitate environmental investments in cleaner technologies. The subgroup on Cleaner Production and Environmentally Sound Consumption (CPESC) has the mandate to work to promote best available techniques (BAT), implementation of production and environmentally sound consumption strategy, projects on reduction of anthropogenic greenhouse gases emissions, projects on cleaner production, energy efficiency and sustainable consumption, projects on prevention and reduction of the pollution of environment by dangerous and harmful

substances. Activities on Energy Efficiency have so far mainly been integrated in the projects run by the Centre on Cleaner Production in Moscow together with enterprises. In the Ministerial Declaration from the BEAC WGE meeting in Tromsø in February 2010, the Environment Ministers called for coordinated efforts between the Working Group on Environment and the Joint Working Group on Energy on developing projects on energy efficiency, renewable energy, and cleaner production and consumption (paragraph 19). The CPESC is now discussing how to develop the work on energy efficiency and cooperation with the BEAC JEWG. One issue of mutual interest could be housing and buildings and to cooperate with the Energy Efficiency Centers. The CPESC group, together with NEFCO, is currently exploring the possibilities of strengthening cleaner production measures to be able to speed up the exclusion of the environmental hot spots, the urgent areas of concern related to pollution in North West Russia. While the environmental “hot spots” target a broad range of environmental problems, energy related issues are concerned in many different aspects. The exclusion of environmental “hot spots” is a priority for the Swedish Chairmanship in BEAC. Several “hot spots” are directly or indirectly linked to energy issues.

Cooperation with other organisations
The BEAC cooperation could also call upon the Nordic Council of Ministers in order to coordinate efforts in training and capacity building across borders. The Nordic Council of Ministers has been quite active in organizing activities in the energy field in the geographical area of NW Russia as a priority. It has been noted by the BEAC JEWG that projects are complementary to BEAC activities in the energy field.

During the BEAC Competitiveness Council meeting in Umeå the Ministers agreed to[30]: *emphasise* the following identified working areas for an increased competitiveness; promote an expanded sustainable use of natural resources; promote access to the global markets for the region’s resources and thereby increase the region’s interconnectedness for transport, support the development of energy efficiency and the supply of renewable energy, promote entrepreneurship by increased cross-border co-operation; and expand sustainable tourism. The Ministers called upon the BEAC Joint Working Group on Energy and the BEAC Working Group on Economic Co-operation, to identify and implement actions in these areas, also in co-operation with other BEAC working groups.

7.2 Financing possibilities

In 1990 the five Nordic countries established the Nordic Environment Finance Corporation (NEFCO) that finances investments and projects primarily in Russia, Ukraine, Estonia, Latvia, Lithuania and Belarus, in order to generate positive environmental effects of interest to the Nordic region. NEFCO is engaged in a wide variety of project types including improved energy efficiency and use of renewable energy.

The Nordic Environmental Development Fund (NMF) at NEFCO was set up in1995 by the Nordic countries in partnership with the Nordic Council of Ministers to provide concessional financing for environmental projects. The Fund has been allocated approximately EUR 60

[30] Brief summary of the Declaration from the Barents Euro-Arctic Councils first meeting of the ministers for competitiveness, Umeå 18 – 19 May, 2010. For full text, see www.beac.st

million since its inception. Concessional financing initiatives include revolving credit programmes and other innovative forms of support. Finance is provided to projects that have been identified as having a high environmental priority. The Fund runs several programmes with distinctly different aims. The Revolving Facility for Cleaner Production investments provides loans directly to enterprises implementing cleaner production programmes, as well as to municipal utilities for the financing of eco-efficient measures mainly within the water, waste water or heating sector. The Energy Savings Credit Facility supports a range of small municipal energy-efficiency measures in the social sector. The Agri Environment Credit Facility provides financing for environmental investments on farms.

NEFCO's Energy Saving Credits Facility offers soft term loans for energy saving measures in social objects comprising schools, kindergartens, hospitals, sport facilities and street lighting in Russian and Ukrainian municipalities. The small scale projects are expected to result in significant environmental effects in the form of reduced emissions to air. An eligible investment should generate annual savings of at least 25 % of the investment as the repayment is tied directly to the savings of the investment.

7.3 Recent bi-lateral agreements

Development of closer co-operation across national borders in the Barents region is facilitated if there are formal bilateral co-operation agreements between the four nations. Each of Finland, Norway and Sweden has recently separately signed a Memorandum of Understanding (MoU) with Russia regarding energy co-operation. These MoUs give a framework for energy co-operation in general but obviously, as a part of this, for co-operation within the Barents region focussed on improved energy efficiency and increased use of renewable energy.

In Table 16, the focus areas highlighted in the MoUs and the agreed forms of cooperation can be compared. There are some differences in the texts of the MoUs but all include actions to improve energy efficiency and increased use of renewable energy. It is clear that the differences in the text and the slight differences in emphasis will not cause any difficulty in the context of regional cooperation in the Barents region.

The parties responsible for the implementation of the activities are:

- Ministry of Employment and Economic Development of Finland – Department of Energy
- Ministry of Petroleum and Energy of Norway
- Ministry of Enterprise, Energy and Communications of Sweden
- Ministry of Energy of the Russian Federation – Department of State Energy Policy and Energy Efficiency

Table 16. Focus areas and forms of co-operation highlighted in the MoU:s covering co-operation in the energy sector

	MoU between Finland and Russia	**MoU between Norway and Russia**	**MoU between Sweden and Russia**
Focus areas	• Efficient energy use including the industrial and residential sectors • Efficient generation of electricity and co-generation of electricity and heat • Increased use of renewable energy including peat as a renewable energy • Strengthening of the cooperation at institutional level in the sphere of state policy tools and energy efficiency on federal and regional level • Development of legislation for promotion of energy efficiency and renewable energy, financing of such projects and other administrative tools including measures on regional and municipal levels	• Cooperation on institutional level for promotion of energy efficient technologies and renewable energy • Development of cooperation and dialog between universities, technology centers and commercial actors, including exchange of information about projects in the field of energy efficiency and renewable energy	• Improved energy security • Improved energy efficiency • Development and increased use of renewable energy • Application of technologies for environmentally friendly waste management • Coordination of activities during implementation of multilateral projects in the energy field • Promotion of Swedish and Russian actors for implementation of projects in Sweden, Russian Federation or a third country • Promotion of development of legal and normative frameworks in the energy sector
Forms of cooperation	• Support to cooperation between companies and to pilot and investment projects in the spheres of energy efficiency and renewable energy • Development of partnership and initiation of joint projects between research institutes, technology centers and companies • Support to information and experience exchange between municipalities and regions in the spheres of cooperation • Joint analysis of barriers hampering implementation of energy efficiency and renewable energy projects and development of proposals for elimination of such barriers • Exchange of information on technical development, forecasts and strategies in workshops, conferences and training programmes	• Regular exchange of publicly available information and statistical data • Exchange of experiences about approaches used for promotion of energy conservation and development of renewable energy • Promote joint pilot projects in these fields • Development of cooperation and dialog between universities, technology centers and commercial actors • Conduction of joint seminars, conferences and training programmes • Promotion of creation and operation of a business forum for energy efficiency and sustainable development, open for representatives of private companies and government institutions that are active in these fields	• Regular exchange of open information and statistics • Development of partnerships and information exchange between universities, research organisations, industries and other organisations that disseminate new technologies • Promotion of efforts for improvement of energy efficiency as part of co-operation between municipalities or regions; • Joint seminars, conferences and educational programs • Promotion of creation and operation of a business forum for energy efficiency and sustainable development, open for representatives of private companies and government institutions that are active in these fields

7.4 Barents Energy Focal Points

7.4.1 Need for focal points

Realisation of the ambitions expressed in the Memorandums of Understanding between the Nordic Countries and Russia summarised under 7.3 and in the draft declaration from the ministers meeting in Umeå May, 18 – 19, 2010, summarised under 7.2 will require involvement of many types of organisations and experts from a wide range of specialities, including not only energy engineers and scientists, but also economists, social scientists, public administrators and lawyers.

It is clear from the MoUs that the ultimate responsibility for implementation of the activities that should include organisation of the cooperation rests with a central Government Ministry in each country.

It appears that the more limited co-operation within the Barents region could benefit from identification of an organisation in each administrative unit that acts as a coordinator of the activities within that sub-region and as a focal point for the regional energy co-operation. With such an arrangement the dissemination of information and exchange of experiences can be facilitated and the risk for double-work reduced. The limited time available for this study has not allowed a careful inventory and evaluation of possible candidates for this role. If such organisation of the Barents Energy Cooperation is considered as suitable, each central Government Ministry must make the selection of the organisation that best can serve the purpose as a focal point for the cooperation. The organisations mentioned in the following might be considered in this process.

7.4.2 Focal points for regional energy co-operation in Russia

The development of the six energy efficiency centers established as part of the bi-lateral agreement between Norway and Russia, and later identified as Barents Energy Focal Points by the JEWG, has been depending on the ability of the staff at each of the centers to attract financing for projects. The history of the Kirovsk center illustrates the difficulties involved in operating such organisations. The Kirovsk center expanded from one staff member in 1996 to a staff of ten in 2004 – 2005. The turnover then exceeded 200 000 EUR. The following years were less successful and the staff had to be reduced. During 2009 there was only one staff member employed. The center was then re-organised from a non-commercial partnership to a limited company and appears now to be expanding again. At present, the center in Arkhangelsk appears as being the most successful in attracting project financing. NEFCO is apparently an important partner. Out of 33 projects for which information about financing is available, NEFCO has contributed to 23.

The present status of the energy efficiency centers is summarised in Table 17[31].

[31] Information based on communication with the Energy Efficiency Centers

Table 17. Status of the energy efficiency centers in the Russian parts of the Barents region

Year	Kirovsk	Murmansk [32)]	Arkhangelsk	Petro-zavodsk	Syktyv-kar	Naryan-Mar
Established year	1996	1998	1999	1999	2003	2004
Staff employed 2010	3		10	3	3	1
Financial turnover EUR	4 600		180 085	106 951	12 082	27 000
Projects during last 5 years	14		42	32	7	5
Difficulties	Weak economy. Small staff.		Securing financing for projects.	Securing financing for projects.	Potential recipients of soft loans too passive.	Weak economy. Small staff.

The types of projects the centers can carry out according to their own assessments include:

- Collection, analysis and synthesis of data needed for project identification and project evaluation
- Identification of promising projects
- Preparation of project documents, including feasibility evaluations
- Attraction of external financing for realisation of projects
- Project implementation
- Dissemination of experiences from implemented projects
- Energy audits
- Organisation and conducting of training programs
- Organisation of seminars and conferences

7.4.3 Focal points for regional energy co-operation in Sweden

Norrbotten Energy Network (NENET) is one of 13 regional energy efficiency centers in Sweden that are partly supported financially by the Swedish Energy Administration. In Sweden it is responsible for activities in Norrbotten and Västerbotten. NENET is a member of FEDARENE, the European Federation of Regional Energy and Environment Agencies. NENET has its main office in Luleå and a staff of 12. NENET appears to have no experience from energy cooperation with Russian organisations but has established relationships with the actors in the energy field in Norrbotten and Västerbotten.

In Norrbotten and Västerbotten there are universities in Umeå and Luleå with strong energy departments, energy research centers, ETC in Piteå and BTC in Umeå that are specialised on bioenergy conversion and utilisation and a metallurgical research center MEFOS in Luleå that is engaged in energy research with applications in the metallurgical industry. The Department of Energy Engineering at Luleå University of Technology has been engaged in energy

[32] There has so far been no response on request for information

efficiency projects in Murmansk oblast in cooperation with Murmansk State Technical University and Kola Energy Efficiency Center.

7.4.4 Focal points for regional energy co-operation in Finland

It has not been possible within the limited time of this study to collect much information about organisations in the Finnish parts of the Barents region that might be considered as focal points for the regional energy cooperation. There is a regional energy agency in North Ostrobothnia located in Muhos, close to Oulu. It appears to be closely linked to the Finnish Forest Research Institute[33]. There is no information available on previous experiences from cooperation with organisations in the Russian parts of the Barents region.

The Regional Council of Central Finland located in Jyväskylä, that is a member of FEDARENE has made an agreement with the Republic of Karelia for developing especially renewable energy sources. The City of Oulu together with the consulting company Planora Oy has been active in organizing co-operation with the Republic of Karelia in energy efficiency and in use of renewable energy.

7.4.5 Focal points for regional energy co-operation in Norway

The Norwegian support to energy efficiency and renewable energy projects in Northwest Russia have been successfully managed by the consultant companies Rambøll Storvik AS (now Rambøll Barents AS), Norsk Energi and ENSI (Energy Saving International AS). A report documenting the activities up to 2007 is available [31].

There appears to be no regional energy agency in Norway focussing in particular on the Norwegian parts of the Barents region.

8 Conclusions

This study has relied entirely on existing documentation, which to some extent might not give a fair picture of the actual situation, in particular as regards the situation in the Russian part of the Barents region. It is nevertheless believed that the following conclusions are justified:

1. In general, the lack of statistical data and differences in the aggregation of data make comparisons of energy efficiencies between the different parts of the Barents region quite difficult. A particular problem is that it has been almost impossible to access recent data for energy use and production in the energy intensive industries in the Russian part on a company level.
2. According to a recent report from the World Bank, the level of energy efficiency in all sectors is less in Russia than in other industrialised countries. The comparisons that have been made here for indicators based on available data from the Russian and Swedish parts of the Barents region confirm that the specific energy use in Russia for heating of

[33] The home page is only in Finnish and does not seem to include much information that is not directly related to forest research.

buildings, expressed in kWh/m^2, and the specific fuel use for electricity generation in thermal power plants, expressed in MWh(f)/MWh(e) is much higher in those applications. The available data for industrial use of energy as well as generation and distribution of district heat in the Russian parts of the Barents region do not however confirm the findings in the World Bank study.

3. The available data for the energy use in Russia are incomplete and the aggregation of data to the regional level may hide more wasteful use of energy in some enterprises or utilities. Energy audits are necessary if a better basis for assessment of the technical potential for improved energy efficiency in all sectors of energy conversion and use in the Russian part of the Barents region.
4. Comparisons of prices for fuels and electricity expressed in EUR per energy unit show that in general, the energy prices in Russia are lower than those in the Nordic parts of the Barents region, with a possible exception for electricity used in the large industries. This indicates that financial optimisation of energy systems in Russia should in general lead to less emphasis on energy conservation. The World Bank study [5] nevertheless concludes that there is a considerable potential for financially justified investments in improved energy efficiency in Russia. That study is based on energy prices for 2007. Prices have increased since then and the financial potential should therefore now be larger.
5. The use of electricity per capita for households and services is significantly higher in the Norwegian and Swedish parts of the Barents region than in the Russian parts. This can only partly be explained by electric heating being more common in Norway and Sweden. Despite the fact that the heat use per m^2 of the buildings in the Russian parts of the Barents region is more than twice that in the Swedish parts, the energy used for heating per capita appears to be about the same. It is evident that by comparison, the Swedish lifestyle is more energy intensive than that of the average Russian living in the Barents region.
6. Significant improvements of the energy efficiency and shift to renewable energy sources in the Russian part of the Barents region will require substantial investments. Such investments will not be made unless energy prices have reached a level that gives a reasonable pay-back time for the investments. Needs for more information about the existence of suitable technologies and the experiences from using these might be an obstacle to implementation of such technologies. The major obstacles appear to be lack of effective policy instruments and that investors on the Russian side have difficulties to contribute their share of the investment required by international financing institutes.
7. The necessary transition from fossil fuels to renewable energy has progressed much further in Finland and Sweden than in the Russian part of the Barents region. In Murmansk oblast the reason is partly that the technical potential is quite limited. In the other parts of the Russian Barents region there appears to be a significant technical potential for increased use of forestry and forest industry residues. The estimated technical potential exceeds by far the present use of fossil fuel energy in Karelia, Arkhangelsk oblast and Komi. Wind energy can also give important contributions from installations in the coastal areas. The resource is there but the technical potential is probably quite limited by the possibilities to balance fluctuations in wind energy supply by other power plants. A few pilot and demonstration projects related to renewable

energy have been implemented. Effective policy measures are probably required if a major transition to renewable energy shall take place in the coming decade.

8. There are parts of the Russian Barents region where the conditions for substitution of expensive diesel power plants by power plants using renewable energy appear as promising. For power demands of 1-2 MW(e) and above, a steam power plant with co-generation of district heat, fuelled by wood waste, such as sawmill residue or forestry residue is the preferred solution. The technology is commercially available from Swedish and Finnish suppliers, but can most probably also be supplied by Russian companies. Most of the present diesel plants appear to serve communities with much lower power demands. For these either wind-diesel combinations or power plants using a wood gasifier and an internal combustion engine can be considered. These are technologies that are not used in the western part of the Barents region, but there might be a common interest in development of them. This needs to be further explored.
9. The new law on energy saving and energy efficiency that came into effect in November 2009 in Russia and the targets formulated for transition from fossil fuels to renewable energy show that the Russian Federal Government is aware that the large dependance on fossil fuels is not sustainable. It is too early to judge if the administrative measures introduced are sufficient for reaching the targets set. It is obvious however that the market forces will not lead to much shift from fossil fuels to renewable energy if the present fuel prices prevail.
10. The projects leading to improved energy efficiency and increased use of renewable energy that have been implemented with financial or technical support from Finland, Norway and Sweden have to a large extent been limited to projects requiring small or moderate investments in the range up to about 250 000 EUR. The direct effects on local economy and local environment have certainly justified these projects but the effects on the global environment will be insignificant unless the positive effects of these projects stimulate others to make similar investments and if financing for repetition of the projects is available.
11. In order to reduce greenhouse gas emissions and emissions of air pollutants that certainly contribute to significant reductions of the average life of the inhabitants of the most heavily polluted areas in the Russian part of the Barents region within the next few years, it will be necessary to focus on improvement of the processes and equipment used in large scale conversion of fuels to electricity and heat. This means that utility companies and industrial companies engaged in mining, mineral processing, metallurgy and pulp and paper production must be part of the process of modernising the energy system of the Russian part of the Barents region. This will require implementation of effective policy instruments. The recently introduced law on Energy Saving and Energy Efficiency will contribute to reduced emissions from electricity and district heat generation as the demand for these energy carriers will be reduced. Introduction of more efficient combustion and energy conversion technologies in utilities and energy intensive industry and improved stack gas cleaning processes is not directly promoted by this law.
12. The inevitable modernization of the energy systems in the Russian parts of the Barents region will not only reduce the negative effects on the local and global environment. Other important benefits for Russia are conservation of valuable fossil fuel resources for the use of coming generations, improved international competitiveness of the Russian

industries, increased economic activities during the transition period, leading to more employment opportunities and creation of new employment opportunities in the renewable energy sector.

13. Increased cooperation within the Barents Euro-Arctic region for improving energy efficiency and increasing the use of renewable energy will not develop without public funding. Implementation of concrete projects will certainly be made on commercial terms but identification of possibilities for such projects, pre-feasibility studies, common research and development projects, exchange of experiences regarding energy efficiency improvements and use of renewable energy between actors in the public sector will require that special funds are allocated to such activities.
14. The six Energy Efficiency Centers, located in Apatity/Kirovsk, Murmansk, Arkhangelsk, Petrozavodsk, Syktyvkar and Naryan-Mar that were established in the period 1996 to 2004 with technical and financial support mainly from Norway can play an important role for identification and implementation of projects resulting from activities within the energy co-operation between Russia and the Nordic countries in the Barents region. Some of the centers appear to need strengthening of their staff however.
15. In Norway the consulting companies that have hitherto managed the Norwegian support for energy efficiency improvement and development of renewable energy in Nortwest Russia are obviously well qualified to continue in this capacity. If focal points for the Barents energy cooperation would also be appointed in Finland and Sweden, which appears as a good idea, additional work is needed for identification of the most suitable organisations that can take this role.

9 Recommendations

9.1 General recommendations

Based on the findings summarised in the preceeding section, it is recommended that the four nations in the Euro-Arctic Barents Region agree on carrying out coordinated actions with the objective to improve the efficiency of energy use and increase the use of renewable energy in the region. These activities should include the following elements:

1. Further studies in order to better clarify the actual status of energy use in different sectors, the technical potential for increased use of renewable energy and the financial and economical potentials for improved energy efficiency and increased use of renewable energy for all the parts of the Euro-Arctic Barents region.
2. Regular exchange of official statistical data and if possible harmonisation of definitions used in collection and presentation of statistical data.
3. Research and development projects of common interest to at least two of the countries in the Euro-Arctic Barents Region to be identified and proposals developed for joint completion of the work required, with the objective to ultimately carry out joint demonstration projects.
4. Facilitation of information exchange between actors in the public sector regarding experiences from application of energy efficient technologies or procedures and also regarding use of renewable energy sources.

Possibilities for financial support should be provided to public institutions participating in the activities and also for pilot and demonstration projects based on technologies that are not yet commercially proven.

9.2 Recommendations regarding priorities for the JEWG

As a first step the JEWG should contact the ministries that are responsible for coordination of the activities identified in the Memorandums of Understanding between Russia, Finland, Norway and Sweden for identification of organisations that can act as focal points in Finland, Norway, Sweden and each of the administrative units in the Russian part of the Barents region, Karelia, Murmansk, Archangelsk and Komi.
After that a series of workshops should be organized by the JEWG and if possible in cooperation with other working groups and/or international organisations to

- exchange information about the present state of technologies and the experiences from using the technologies of interest
- identify specific fields of cooperation
- outline plans for cooperative activities covering the next 3-year period.

It is recommended that these workshops focus on the energy efficiency of buildings, energy efficiency for generation of electricity and district heat and the potential and technologies for utilisation of biomass energy and wind energy.

Based on the findings from this study, useful topics for such workshops could be:

1. Cost effective energy efficiency improvements for apartment buildings
2. Cost effective energy efficiency improvements for hospitals
3. Cost effective energy efficiency improvements for schools
4. Minimising losses in district heat generation and distribution
5. Potential for introducing heat pumps in district heating networks in the Russian parts of the Barents region Efficient use of electric energy for lighting
6. Efficient use of electric energy for driving electric motors
7. Assessment of the sustainable potential for biomass energy use in the Russian parts of the Barents region;
8. Assessment of markets for increased use of biomass energy in the Russian parts of the Barents region
9. Feasibility of internal combustion engines powered by wood gasifiers for power generation in isolated networks
10. Feasibility of wind-diesel hybrid power plants for power generation in isolated networks
11. Integration of wind power in the power systems of Northwest Russia
12. Potential for expansion of thermal power generation by co-generation of electricity and heat in the power systems of Northwest Russia
13. Potential for using solid and liquid urban waste as energy source in the Barents region parts of Russia
14. Potential for increased use of biomass residues and improved energy efficiency in the paper and pulp industries in the Barents region parts of Russia
15. Potential for increased use of biomass residues and improved energy efficiency in the sawmill industries in the Barents region parts of Russia

Improved energy efficiency in the industries engaged in mining, mineral processing and metallurgy is obviously also important but it is less obvious that the industries in the Russian parts of the Barents region will benefit from participation in technical workshops. The processes are very dependent on raw material properties and the type of products and these may differ considerably. A workshop on organisation of energy management in industry would however be beneficial and a possible spin-off from such a workshop could be concrete ideas for cooperation on special topics where two or more enterprises are prepared to cooperate for improvement of their energy efficiency.

When the JEWG discusses priorities for workshop topics it is recommended the possibilities for funding of concrete projects is given large weight. Workshops leading to proposals that cannot be implemented are of little value. Coordination with the activities of the Working group on energy efficiency of the Commission on Modernization and Technological Development of the Russian Economy under the president of the Russian Federation, see [33] appears as reasonable. Close cooperation should also be sought for other BEAC working groups such as the Working Group on Environment, to coorganise activities and find synergies in activities.

9.3 Recommendations regarding the Barents Window trust fund

In December 2009, NEFCO was entrusted by Sida with 12 MSEK (about 1,2 MEUR or 50 MRUR) in a Swedish trust fund named the "Barents Window" (BW). The purpose of the fund is *"to support identification, preparation, implementation and supervision of projects and programmes in Northwest Russia that relate to the Barents environment and energy action program, the priorities of the Swedish Chairmanship in the Barents Euro-Arctic Council in 2009-2011 and the principle of an "eco-efficient economy". ... Priority shall be given to the energy efficiency, energy saving and renewable energy sectors, projects that address emission reductions of greenhouse gases and ozone depleting substances, and such projects and programmes that promote the regional co-operation in the Barents region."*

The limited size of the fund excludes financing for implementation of large schemes. It is recommended that less than 50% of the fund is used "to support identification and preparation of projects" by financing of studies carried out in cooperation between Swedish consultants and the energy efficiency centers in the Russian part of the Barents region for preparation of background documents for at least five of the workshops proposed in section 9.2. Important synergies could be established in including other BEAC working groups, such as the Working Group on Environment, and international organisations, such as the Nordic Council of Ministers, in the holding of workshops.

The remaining funds should be utilised for part financing of pilot projects or implementation projects that have been identified as result of these workshops. This work could preferably be closely co-ordinated with other related activities within the Barents Euro-Arctic Council, such as the promotion of cleaner production for the exclusion of environmental "hot spots".

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