Energy efficient and ecological housing in Finland, Estonia and Latvia:

current experiences and future perspectives

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Content

Foreword

Increasing energy efficiency, reducing energy consumption and considering the use of energy sources other than fossil fuels have become issues for discourse at high political level, in the daily life of municipalities as well as in households. The EU policy development trends indicate the targets of reaching high energy performance standards, known as "20-20-20" prescribing by 2020 achieving a 20% improvement in the EU's energy efficiency, raising the share of EU energy consumption produced from renewable energy sources to 20% and a 20% reduction in EU greenhouse gas emissions from 1990 levels. These targets represent an integrated approach to climate and energy policy aiming to diminish climate change, increase the EU's energy security and strengthen its competitiveness in the global market.

In order to reach these targets much attention has to be paid towards significant improvement of energy performance of buildings both in the public and private sectors. By the end of 2020 all new buildings and, after 31 December 2018, new buildings occupied and owned by public authorities shall be nearly zero-energy buildings. Although the exact energy consumption level is for each Member State to define, it clearly means that buildings shall have very high energy performance and those needing nearly zero or very low amount of energy should be covered to a great extent by energy from renewable sources. Energy production from renewable sources produced on-site or nearby shall be considered. While targets are set on a political level, practical implementation is taking place at local level and furthermore concerns every household having a need to reduce energy consumption in general but still satisfy the energy needs for room heating or electricity.

Preparation of reliable and easily accessible energy guidance for the public has been among the priority aims of the international project "Energy efficient and ecological housing" – EcoHousing (more information at www.ecohousing-project.eu). The project was supported by "Central Baltic INTERREG IVA Programme 2007-2013". The project was implemented in Finland, Estonia and Latvia in cooperation with higher educational institutions and non-governmental organisations. The publication "Energy efficient and ecological housing in Finland, Estonia and Latvia: current experiences and future perspectives" was developed within the frame of the project. It presents edited material from publicly available information sources on energy efficiency and renewable energy. Links to information sources can guide the reader to obtain more detailed knowledge.

This publication aims at emphasising complex solutions for sustainable consumption of energy resources at small scale applications starting from single family buildings up to the level of multi apartment and public buildings. It focuses on the issues related to energy performance of buildings; however the main part is devoted to various possibilities for the application of renewable energy sources topping up energy efficiency measures in buildings. It can help the reader to discover the most suitable solutions, taking into account individual circumstances as well as indicating the aspects to be considered when choosing and installing technologies for use of renewable energy sources.

The publication highlights the similarities and differences of Finland, Estonia and Latvia with regard to increasing energy performance of buildings and use of renewable energy sources. Here the reader will find practical examples from Finland, Estonia and Latvia of energy efficient buildings proving the application of complex approaches in practice. The publication provides insights into national legislation requirements, the roles and responsibilities of various stakeholders, as well as the economic incentives used in the three countries to promote increasing energy performance of buildings and use of renewable energy sources. In addition, the publication gives guidance for the appropriate use of electric appliances in an energy efficient manner.

Acknowledgement. The editorial team would like to express its thanks to all those who contributed to the preparation of this publication, providing data and valuable suggestions and comments.

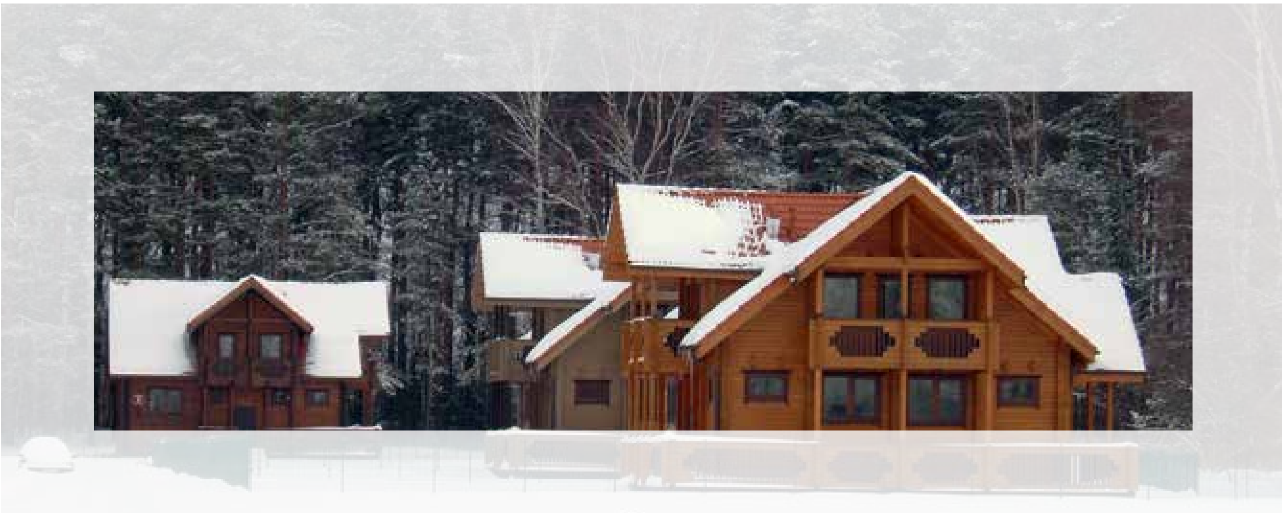
Introduction

The issue of the energy efficiency of buildings has received increasing attention since the beginning of the 21st century. In addition, it is envisaged that in perspective, the market will move away from fossil fuels and inefficient technological systems. Homeowners are increasingly interested in becoming independent in terms of fuel and operating flexible systems enabling them to switch from one fuel to another easily and economically. Also, municipalities are looking for solutions to use alternative, local energy sources in order to reduce fuel costs and satisfy the room heating and hot water needs of the public buildings e.g., kindergartens, schools. In this situation, renewable energy systems will undoubtedly occupy a notable market share.

The EU energy and climate policy supports increasing energy efficiency in the building sector, the use of sources other than fossil fuels as well as market penetration of energy efficient electric appliances. This publication refers to several EU Directives setting the direction for increasing energy performance of buildings, promoting broader use of renewable energy sources (RES), and requiring information for end-users on the energy consumption of household electric appliances:

- Directive on the energy performance of buildings 2010/31/EU (recast);
- Directive on energy end-use efficiency and energy services 2006/32/EC;
- Directive on the promotion of the use of energy from renewable sources 2009/28/EC;
- Directive on the promotion of cogeneration based on a useful heat demand in the internal energy market 2004/8/EC;
- Directive establishing a framework for the setting of ecodesign requirements for energy-related products 2009/125/EC (recast);
- Directive on the indication by labelling and standard product information of the consumption of energy and other resources by energy-related products 2010/30/EU.

The publication consists of 7 chapters highlighting different aspects of energy efficient and ecological housing in Finland, Estonia and Latvia. At the beginning it gives an overview of energy efficiency aspects related to building, providing insights of the housing sector in these three countries (chapter 1). Further, several options for the use of renewable energy at small scale applications topping up energy efficient buildings are presented. Particular attention is paid to the complex use of two or more types of RES in the so called "combi-systems" for heating, hot water and electricity production. Several practical examples of energy efficient buildings using RES are described (chapter 2). Significant energy savings can be achieved if applying energy efficient electric appliances, and even more if this is done appropriately. Chapter 3 gives guidance for the appropriate installation, use and maintenance of the most popular household electric appliances. The results of a small survey summarised in chapter 4 presents people´s eagerness to save energy and reduce energy consumption at home as well as indicating the need to raise awareness of consumers in order to improve energy efficiency at home. The last three chapters (chapters 5-7) provide an insight into the respective national policies, legislation, roles and responsibilities as well as economic incentives in Finland, Estonia and Latvia to increase energy efficiency of buildings and to promote the use of renewable energy sources. The annexes contain statistical overview on renewable energy sources, introduce devices for measuring and saving energy in households, present methods for measuring temperatures of the operation of ovens and boilers.



1. Energy efficiency in buildings

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1.1. Energy efficient environmentally friendly houses

Nowadays, there is a common understanding that buildings should be energy efficient, operate with low emissions and use environmentally friendly building materials. However, there is a large variety of definitions and classification of high performance buildings in the countries in terms of quality requirements and regarding the calculation methods used. The terms relate mostly to one of the three following options[1]:

- low energy consumption (low energy house, energy saving house, ultra low energy house, 3-litre-house, zero-heating energy house, zero-energy house, plus-energy house, very low energy house, energy self-sufficient house, energy autarkic house);
- low emissions (zero-emission house, zero-carbon house, emission-free house, carbon-free house);
- sustainable or green aspects (eco-buildings, green buildings, bioclimatic house, climate: active house).

Among the most commonly used terms in Finland, Estonia, Latvia are low energy house, passive house, (net) nearly zero-energy building, plus energy building.

Low energy house is understood in most countries as a building with a calculated energy consumption that is significantly lower than buildings just meeting the mandatory building regulations. However, the absolute energy performance of a low energy building differs in countries because of different national boundary conditions e.g., climate, calculation method, default values and also because the required ratio (if defined) will probably differ[2]. In North European countries the typical criteria are 25 – 50% better than minimum requirements[3].

Passive house. Generally, for "passive house standard" one criterion is heating energy demand per square metre of a house and primary energy demand. Furthermore, we can consider a passive house as a standard of a building in which a comfortable interior climate can be maintained without an active heating system. The house heats and cools itself, hence is "passive". The annual heating demand for passive houses is very low - in mid-Europe about 15 kWh/m^2 annually. The need for total primary energy use should not exceed 120 kWh/m^2/year, including heating and cooling, domestic hot water, and household electricity and air tightness given by n50 better than 0.6 1/h[4]. For comparison, common apartment blocks built in the 1980s, found throughout Central and Eastern Europe, on average consumes 12 times more heating energy than a passive house[5].

In Estonia and Latvia there is no official classification of passive house buildings, voluntary designers and builders aim to achieve the passive house standard described by the Passive House Institute in Germany[6]. In Finland, there is also no official definition for the passive house[7], several projects propose a slightly higher energy consumption standard for passive houses in Finland[8] compared to the standard by the Passive House Institute in Germany[9].

[1] Erhorn H., Erhorn-Kluttig H. (2011). Terms and definitions for high performance buildings, www.epbd-ca.eu

[2] Erhorn H., Erhorn-Kluttig H. (2011). Terms and definitions for high performance buildings, www.epbd-ca.eu

[3] NorthPass - Promotion of the Very Low-Energy House Concept to the North European Building Market. Very Low-Energy House Concepts in North European Countries, www.northpass.eu

[4] These are international values defined by Passivhaus Institute in Germany, http://passiv.de/en

[5] Faltin J., Tvrdoň M. (2011). Passive housing for active communities, www.rea.riga.lv/files/Passive_Housing_For_Active_Communities_INTENSE.pdf

[6] Buvik K. (2012). National Roadmaps for promotion of very low-energy house concepts, Sintef

[7] Buvik K. (2012). National Roadmaps for promotion of very low-energy house concepts, Sintef

[8] Erhorn H., Erhorn-Kluttig H. (2011). Terms and definitions for high performance buildings, www.epbd-ca.eu

[9] According to VTT's definition a passive building in Southern Finland requires approximately 20 kWh/m^2 heating energy per year and in Northern Finland approximately 30 kWh/m^2 per year, www.passiivi.info.

According to EU legislation a **nearly zero-energy building** means a building that has a very high energy performance. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby[10]. It is a requirement for all Member States to calculate the cost optimal levels of the minimum energy performance requirements.

Requirements for nearly zero-energy buildings

In **Latvia,** nearly zero-energy buildings shall not exceed 30 kWh/m^2/y for heating and 95 kWh/m^2/y primary energy consumption for heating, hot water preparation, mechanical ventilation, cooling and lighting[11]. In **Estonia,** the legislation that came into force on 9 January 2013[12] includes the definition of nearly zero-energy. The energy consumption for nearly zero-energy buildings is 50 kWh/m^2/y (small residential buildings), 100 kWh/m^2/y (apartment buildings) up to 270 kWh/m^2/y for healthcare centres and clinics. In **Finland,** the recent legislation from 2013 reflects the EU requirements on nearly zero-energy buildings.

Net-zero-energy building is the focus of modern energy efficient buildings. The wording "net" underlines the fact that there is a balance between energy taken and supplied back to the grids over a period of time (nominally a year)[13]. Such buildings have already been constructed e.g. in Finland[14].

A **plus energy building** produces energy in amounts exceeding its own consumption. In the case of electricity excess, it can be fed in the power grid and then the electricity bill is calculated by the difference in the outflow and inflow of energy[15].

The concept of energy efficient and environmentally friendly houses is gaining recognition and being implemented increasingly widely in countries. Further acceleration of the erection of such buildings is expected due to the discourse of recent EU policies setting a target that starting from 31 December 2018, all new buildings occupied and owned by public authorities shall be nearly zero-energy buildings. But this will not only concern public buildings because by 31 December 2020 every new building shall be a nearly zero-energy building.

In order to reach such high level standards, aspects that matter are:

- integrated design of a building - energy optimisation of the framework, joints and supply system, for minimum heating and cooling;
- very well insulated and air-tight building envelope, avoiding thermal bridges;
- ventilation, preferably with high efficiency heat recovery;
- very energy efficient devices for heating, hot water preparation, cooling, electricity generation, preferably using renewable energy sources;
- rational use of building e.g., upper class energy efficient electrical auxiliary and household applications, lighting, etc.

1.2. Overview on housing sector in Finland, Estonia, and Latvia

Activity in the construction sector is a reflection of the country's economy. It responds to developments in other sectors as well as to the desire of citizens for improving their living conditions. Being an

[10] Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (recast), Official Journal of the European Union, L 153/13, 18.6.2010

[11] Cabinet of Ministers Regulations No. 383 on energy certification of buildings // Ministru kabineta noteikumi Nr.383, Rīgā 2013.gada 9.jūlijā, Noteikumi par ēku energosertifikāciju, Publicēts: "Latvijas Vēstnesis", 138 (4944), 18.07.2013., http://likumi.lv/doc.php?id=258322

[12] Regulations on minimum efficiency requirements //Energiatõhususe miinimumnõuded (2012), www.riigiteataja.ee/akt/105092012004

[13] Sartori I., et al., Net zero energy buildings: A consistent definition framework. Energy buildings (2012), doi:10.1016/j.enbuild.2012.01.032

[14] Isover Saint-Gobain. Villa ISOVERin esittely, www.isover.fi/passiivitalo/seurantakohteet/villa-isover-asuntomessut-2013-hyvinkaa/villa-isoverin-esittely

[15] Motiva 2011, Hänninen & Association of Finnish Building Inspectors 2012

important contributor to the state gross domestic product, the construction sector is also a very good indicator of the development of the national economy as being closely linked with the activity of all market players (public and private) in the building sector, their evaluation of future perspectives and investments in the economy. Despite the recent economic crises the number of dwellings in Finland, Estonia and Latvia is increasing slightly (Table 1.1).

Table 1.1. The number of dwellings in Finland, Estonia and Latvia (2010-2012)*

Year	The number of dwellings (thousand)		
	Finland	Estonia	Latvia
2010	2 537	654	1 037
2011	2 556	656	1 040
2012	2 580	658	1 042

* Sources[16], own compilation

Figure 1.1. Examples of houses under construction or recently built in Southern Finland (Photos: Minna Kuusela)

A newly developed trend is clearly towards larger properties, detached houses and smaller apartment blocks. The construction of multi-apartment residential houses, but even more construction of single family and row houses is increasing, thus raising the number of small settlements around larger towns. In Finland the most common type of buildings are detached houses (approximately 3/4 of the building stock) while apartment buildings and terraced houses are less common (1/10 of the building stock)[17]. On the topic of construction trends, it is worth distinguishing the two separate directions – the construction of new buildings and the repair and renovation of existing buildings reaching high energy performance standards (see Figure 1.1 – 1.3).

Regarding demand for new houses, according to expert opinion, the construction of separate family homes will maintain a high interest by consumers despite the availability of flats in multi-storey buildings. However, future developers of separate family houses will most probably pay more attention to the quality and energy performance of buildings, the total volume of the floor areas and construction materials – potentially, prefabricated (wooden-frame buildings) could attract more attention in future. In line with EU requirements, Finland, Estonia, Latvia

[16] Central Statistical Bureau of Latvia, www.csb.gov.lv/en; Statistics Estonia, www.stat.ee/en; Statistics Finland, www.stat.fi/index_en.html

[17] Tilastokeskus. 2012a. Rakennukset ja kesämökit. Tilastotietokanta, http://pxweb2.stat.fi/database/StatFin/asu/rakke/rakke_fi.asp), http://pxweb2.stat.fi/database/StatFin/asu/rakke/rakke_sv.asp

Figure 1.2. Examples of houses recently built in Estonia (Photos: Ants Soon, Irina Aleksejeva)

Figure 1.3. Examples of recently renovated / built houses in Riga and its vicinity, Latvia (Photos: Daina Indriksone)

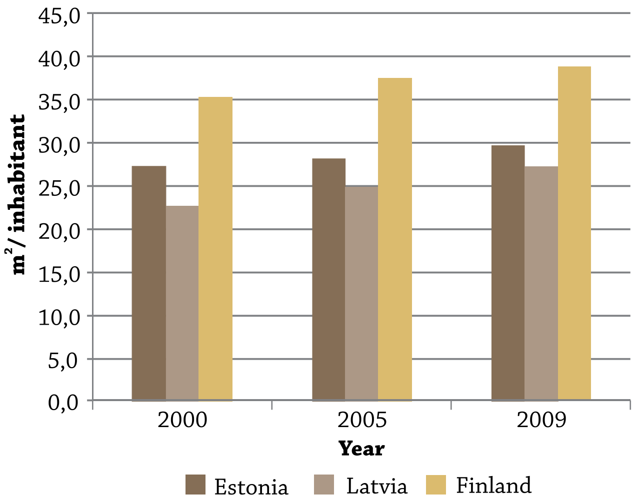
are preparing national action plans for progression to nearly zero-energy buildings and encouraging the construction and refurbishment of such.

There is an increasing trend of people occupying larger dwellings. For example, in Latvia in 2011, in comparison with the results of the previous Population and Housing Census in 2000, an increase can be observed in the number of persons occupying comparatively larger useful floor space[18].

[18] Central Statistical Bureau of Latvia: Latvia population opt for larger dwellings (27.06.2013)

The average floor space per inhabitant in Finland, Estonia and Latvia is shown in Figure 1.4. During the last decade the average floor space per person has increased by 0.2 - 0.3 m^2/y in all three countries. A higher number is found in Finland when compared to Estonia and Latvia. However, it is worth mentioning that historic data for Finland show a gradual increase in the average floor space per person: from only 14.3 m^2/person in 1960 to 18.9 m^2/person in 1970 and to 26.3 m^2/person in 1980 while reaching 35.3 m^2/person in 2000.

Figure 1.4. Average floor space (m^2) per inhabitant in Finland, Estonia and Latvia (Source[19], own compilation)



Climate conditions in Finland, Estonia and Latvia require the heating of dwellings during the cold season to ensure a comfortable indoor temperature. Currently, the central heating of dwellings plays a significant role. In Finland 50%[20], in Estonia 53%[21] and in Latvia 64%[22] of households (mainly in high-rise multi apartment buildings) are connected to central heating systems. For example, in Latvia the principal fuel for centralised heating systems is natural gas (70%); the second substantial source is wood fuel (24%)[23].

Historically, fossil fuels and biomass have been the main source for heat energy production, both in central and individual heating systems. Recent trends indicate that utilisation of technologies using renewable energy sources e.g., heat pumps, solar thermal collectors, solar panels are being favoured, particularly in individual applications.

19 Central Statistical Bureau of Latvia, www.csb.gov.lv/en; Statistics Estonia, www.stat.ee/en; Statistics Finland, www.stat.fi/index_en.html

20 Energy Statistics Yearbook 2011. Official Statistics of Finland, page 73, www.stat.fi/tup/julkaisut/tiedostot/julkaisuluettelo/yene_enev_201100_2012_6164_net.pdf

21 Statistics Estonia, www.stat.ee/en

22 Central Statistical Bureau of Latvia, www.csb.gov.lv/en

23 Sedlinieks A. (2010). Biomass activities the Latvian State Forest Sector. In EUSTAFOR. Biomass and Bioenergy report, www.eustafor.eu/failid/File/Publications/Biomass_Booklet.pdf

2. Use of renewable energy sources to top up energy efficient buildings

2. Use of renewable energy sources to top up energy efficient buildings

Renewable energy sources (RES) are in use at a small scale application by households and the commercial and public sectors in Latvia, Estonia and Finland. However, the main share is allocated to biomass combustion (more information in Annex 1). Alternatives, using inexhaustible sources, like solar energy, are used less. Ambient energy sources are well developed in Finland, while Estonia and Latvia are lagging behind in this regard.

The eco-village of Kempele close to Oulu, Finland

The eco-village consisting of 10 detached houses produces its own energy from RES and thus is not connected to the Finnish power-distribution network. The electricity and heating energy is fully produced in a local combined heat and power (CHP) station using wood chips and wind power. Low energy houses are built. Water circulatory floor heating is suitable for the low temperature heating network in the village. Every house is equipped with a 700 litre boiler. Cooling with electricity is prohibited in the area. In November 2010 the village received a prestigious award from the Finnish Association of Civil Engineers for its innovative development work[24].

In line with the recent focus on energy efficient buildings in the EU, it can be envisaged that the share of RES will increase and the diversification of their application will take place. Energy consumption for the heating of energy efficient buildings is low, therefore it can be satisfied by renewable energy sources currently applied at a comparatively smaller extent. Current technologies can efficiently be used to ensure room heating and hot water needs in majority of new and refurbished building with good insulation and high energy efficiency[25]. Taking into consideration the recent trends in housing sector development, it can be predicted that renewable heating and cooling market will develop quickly[26].

2.1. Solar energy – for heating and electricity

Solar energy can be used in different forms, be it to produce electricity or to produce heating (water heating, room heating) and cooling.

Solar for electricity. Systems, also known as solar photovoltaics (PV), capture the sun's energy using a number of photovoltaic cells. PV cells are made from layers of semi-conducting material, usually silicon (Si) and gallium arsenide (GaAs)[27] and assembled in solar panels or modules. The working life of a solar panel is about 25-30 years[28]. The cells convert the sunlight into electricity, which can be used to run household appliances and lighting. When light shines on the cell it creates an electric field across the layers. The stronger the sunshine, the more electricity is produced. Even if there is no direct sunlight they can still generate some electricity. Solar panels can be mounted on a roof or

[24] The eco-village of Kempele // Kempeleen ekokylä näyttää tietä, www.goodnewsfinland.fi/arkisto/teemat/uusiutuvat-energiamuodot/kempeleen-ekokyla-nayttaa-tieta/

[25] Strategic Energy Technologies Information System. Solar heating and cooling, http://setis.ec.europa.eu/technologies/Solar-heating-and-cooling/info

[26] European Renewable Energy Council. (2010). Re-thinking 2050. A 100% Renewable Energy Vision for the European Union (executive summary), www.rethinking2050.eu/fileadmin/documents/Rethinking2050ExecutiveSummary_final.pdf

[27] The manufacturing process of PV systems is complicated. While Silicon is not toxic, Gallium arsenide is carcinogenic material which is a serious problem in manufacturing and recycling operations.

[28] Latvian Renewable Energy Association, www.aea.lv/lv/saules-energija

placed free-standing in open fields[29]. These systems can be installed in residential and office buildings in which they generate some of the energy needed in the building. The electricity produced by a solar panel can be stored in one or several batteries, which are used during the night and on cloudy days. The capacity of the batteries should cover normal consumption for a few days without charging[30]. As most electricity from solar energy can be produced during the summer time, PV can be effectively used e.g., for the operation of air-conditioning.

Solar for heating. Solar thermal collectors collect heat from the sun and use it to heat up water to provide domestic hot water or room heating. There are two types of solar heating panels: flat plate collectors and evacuated tubes. Evacuated tube collectors are more efficient than flat panels, since they can collect scattered radiation more effectively. Both types of collectors can be fixed on the roof, mounted on the wall, integrated into the roof or mounted free-standing facing the sun. When the sun shines, cold water is heated in the collectors and the heat is transferred to the storage tank. Room heating by solar heat is limited.

There is a wide range in application of solar thermal collectors. Increasingly, collective solar domestic hot water systems are being installed into single family houses, multi-apartment buildings, hotels, office buildings etc. The collector surfaces range from ten to several hundred square metres. A solar heating system can be combined to all main heating forms. It is a particularly good option when connected to a heating system with an existing boiler. Homes with under-floor heating systems can gain more energy from solar heating systems, because the temperature of the circulating water is lower than in central heating systems using radiators[31].

Solar for cooling. The technical development of solar thermal cooling systems has progressed in recent years[32] and performed in numerous pilot projects.

Resource availability

The sun provides us with an unlimited resource of energy that is easily accessible. In fact, solar energy reaches us and we utilise it in a passive way on a daily basis. The amount of solar irradiation in Finland, Estonia and Latvia is sufficient for the application of technologies in economically viable way. The length and intensity of solar radiation varies depending on the season, climatic conditions and the geographical situation. The potential for "capturing" solar energy will also depend on the positioning of solar technologies - compass direction, angle (Table 2.1). For example, Finland is very extended (from North to South) with a natural tendency to have an important range in variation of solar irradiation. Thus, the potential for energy production using these systems is higher in the southern part of the country compared to that in northern areas. In Estonia and Latvia solar irradiation varies to a lesser extent depending on geographical location.

[29] Energy saving trust. Solar panels (PV), www.energysavingtrust.org.uk/Generating-energy/Choosing-a-renewable-technology/Solar-panels-PV

[30] Climateguide.fi. Wind and Solar Energy, https://ilmasto-opas.fi/en/ilmastonmuutos/hillinta/-/artikkeli/83fa215b-3f3d-4b48-9456-ce3a5940e830/tuuli-ja-aurinkoenergia.html

[31] Motiva group. Solar heating, www.motiva.fi/en/areas_of_operation/renewable_energy/solar_energy/solar_heating

[32] European Solar Thermal Industry Federation. Cooling with solar thermal, www.estif.org/st_energy/technology/solar_thermal_cooling_and_air_conditioning/

Table 2.1. Annual amount of global irradiation (kWh/m^2) in Finland, Estonia and Latvia*

Position of systems	Annual amount of global irradiation (kWh/m^2)		
	Finland	**Estonia**	**Latvia**
Horizontal surface	<700-1000	<950-1000	950-1050
Optimally-inclined surface (country range)	850-1200	1100-1200	1100-1200
Optimally-inclined surface (selected cities)	Helsinki ~1150 Lahti ~1100 Kuopio ~1050 Rovaniemi ~1000	Tallinn ~1150 Parnu ~1170 Tartu ~1150 Narva ~1150	Riga ~1170 Daugavpils ~1200 Liepaja ~1200 Valmiera ~1150

* Source[33], own compilation

In order to promote the utilisation of solar energy in countries, there are easily applicable tools available for users that help to calculate the average daily power generation by a photovoltaic system in different countries, regions and placement of panels[34]. In Finland, the Sun's radiation energy is ca. 1000 W/m^2 at noon, meaning that every square metre absorbs about 1 kWh of energy in an hour. Having sunshine about 1000 hours a year, every square metre absorbs about 1000 kWh of solar energy per year. As the efficiency rate of a solar panel is about 17%, a square metre of solar photovoltaics will produce, at its best, about 170 kWh of energy[35].

Historical overview

Utilisation of solar energy for heat and electricity production has been known since long ago. The first solar thermal collectors[36] and solar photovoltaic systems[37] for commercial use were developed in the 1950s. The market of these systems in Europe has sped up during the last few decades.

Projects in Finland

Eko-Viikki PV Building project presents the largest photovoltaic application in a residential building in Finland. It comprises innovative PV balcony concepts. The project consists of about 240 m^2 of photovoltaic modules forming part of the balcony glazing on the southern and western sides of the house. The PV technology and distributed energy system control has been developed partly with funding from the National Technology Agency (Tekes). The demonstration system was installed in late 2002 and was fully operational in February 2003.

The possibilities of utilising solar energy have also been looked into in some recent municipal development projects[38] e.g., in the city of Tampere[39]; in the city of Porvoo[40] and in Helsinki in the area called Eko-Viikki, where the first Finnish apartment buildings using solar energy (thermal and photovoltaic) are located[41].

Projects in Estonia

The first steps in solar energy use were taken in 1995, when a solar panel for central heating systems with a surface area of 40 m^2 was installed for the Vändra Hospital as humanitarian aid from the Swedish Nynäshammi Commune.

33 PVGIS, Solar radiation maps and photovoltaics electricity potential for European countries, www.renewable-energy-sources.com/2009/10/30/solar-radiation-maps-and-photovoltaic-electricity-potential-for-european-countries/

34 Solar Electricity Handbook 2013 Edition, http://solarelectricityhandbook.com/solar-irradiance.html presents solar irradiance calculator that takes data collated over a 22 year period

35 Solar Radiation Energy in Finland, www.groundenergy.fi/en2/solar-radiation-energy-in-finland/

36 ICAX Ltd. Solar Thermal Collectors, http://www.icax.co.uk/Solar_Thermal_Collectors.html

37 Sunlight Electric, Photovoltaic history, www.sunlightelectric.com/pvhistory.php

38 The Finnish Solar Cluster, 2012, www.tekes.fi

39 The City of Tampere, www.tampere.fi

40 Skaftkärr – development of an energy efficient residential area in Porvoo, Finland, www.skaftkarr.fi

41 SOLPROS Enhancing Sustainability Effectively, Ekoviikki Sustainable City Projects, www.solpros.org/ekoviikki.htm

The largest solar heating system so far was commissioned in 2009, in Tallinn. 64 solar panels with 1920 vacuum tubes were placed on the roof of a residential building. The total surface area of the system is 255 m^2. The peak energy output intensity is up to 1 MW. The planned annual energy delivery of the system is about 250 MWh, resulting in a fossil energy saving in fiscal units up to 15 000 EUR. The cost of the project was 100 000 EUR, covered by a bank loan. The calculated pay-back period of the project is below 10 years[42].

A new 100 kW power generation plant was erected in 2012 in Võru, Southern Estonia. Two more photovoltaic projects are planned for 50 kW in the town of Pukka; and 1 MW in Viljandi[43].

Projects in Latvia

One of the first sets of solar thermal collectors was installed in 2003, in Aizkraukle municipality on the roof of public buildings – a school and a boiler house. The system consisted of flat plate collectors with an area of 153m^2 (efficiency 75%)[44]. Acceleration of the development in use of solar energy has been promoted since 2009 by the Climate Change Financial Instrument, supporting complex solutions for the use of RES and increasing energy efficiency in Latvia. For example, the installation of solar thermal collectors in the area of 250m^2 (total capacity 150 kW) at a Sports Agency building was implemented in Ķekava municipality. Solar thermal collectors on public buildings (e.g., schools, kindergartens) have been installed in other municipalities, too e.g., in Rīga, Jelgava, Stopiņi, Rūjiena, Tērvete, Salacgrīva, Madona.

Present situation

Application of solar technologies in Europe is developing in 2 main directions – solar thermal collectors for heating and hot water preparation and solar photovoltaics for electricity production. The leading countries are Germany, Italy, Spain. Solar energy utilisation in Finland, Estonia and Latvia is on a rather small scale (Table 2.2).

Table 2.2. Cumulated solar thermal and photovoltaic capacities in 2012*

Installed capacities	Finland	Estonia	Latvia
Capacity of solar thermal collectors (MW_{th})	31.3	4.3	9.4
Solar thermal capacities per capita (kW_{th}/inhabitant)	0.006	0.003	0.005
Capacity of PV (MW_p)	11.2	0.2	1.5
PV capacities per capita (kW_p/ inhabitant)	0.0021	0.0001	0.0007

* Source[45], own compilation

Solar thermal collectors. In Europe, the most common application of solar thermal collectors are in single family houses for hot water supply (90% of capacity). Other types of application: hot water supply in multi-apartment buildings and combined hot water and room heating in single family houses are used in lesser extent[46]. Taking into consideration the amount of solar irradiation in Finland, Estonia and Latvia, the use of solar energy for hot water preparation is beneficial both for households as well as for public buildings e.g., swimming pools. It has been estimated that for a family of 3-4 persons, it is sufficient to install solar collectors with an area of 5-6m^2 to satisfy the hot water demand up to 70%[47]. Solar energy application for room heating has to

[42] INFORSE-Europe (2011), Sustainable Energy Vision for Estonia. A path to make Estonian energy independent and sustainable by 2050, www.inforse.org/europe/pdfs/Estonia-note.pdf

[43] Beetz B. (2012), Energy Smart plans PV projects for Estonia, www.pv-magazine.com/news/details/beitrag/energy-smart-plans-pv-projects-for-estonia_100008381/#ixzz2dAhfR0Jc

[44] Increase of energy efficiency and use of renewable energy sources in municipalities (in Latvian) // Energoefektivitātes paaugstināšana un atjaunojamo energoresursu izmantošana pašvaldībās (2006), Baltijas Vides Forums, ISBN: 9984-9898-0-1

[45] Eurobserv'er. Solar thermal and concentrated solar power barometer (2013), Photovoltaic barometer (2013), www.eurobserv-er.org/downloads.asp

[46] Strategic Energy Technologies Information System. Solar heating and cooling, http://setis.ec.europa.eu/technologies/solar-heating-and-cooling

[47] Šipkovs P. Saules enerģijas izmantošanas iespējas Latvijā, Prezentācija seminārā „Atjaunojamie energoresursi un to izmantošana siltumnīcefektu izraisošo gāzu emisiju samazināšanā", www.lasa.lv/KPFI/Semin/2_Sipkovs.pdf

be seen as auxiliary support because during the autumn and winter seasons the productivity of solar collectors decreases drastically. If the solar collector is applied only to produce domestic hot water, the savings in total heat demand are in the range of 5 – 15 %, but if it can also supply heating, the total saving is estimated to be in the range of 20 – 60 % of household heat consumption[48].

Currently in application, flat plate collectors prevail over vacuum tube collectors at solar thermal systems in Europe. Although vacuum tube collectors have a higher efficiency, they are 2-2.5 times more expensive compared to flat plate collectors[49]. Vacuum tube collectors can utilise the diffuse solar radiation more efficiently and produce approximately 30% more energy per square metre. In Southern Finland, the vacuum tube collectors already begin to produce heat in February and continue to provide heat through November[50].

Photovoltaics. Solar energy for electricity production in Finland, Estonia and Latvia is used about 10 times less compared to solar thermal applications. However, in Finland, solar energy systems connected to the grid are becoming more common, as more people are realising that solar energy can also be exploited to provide a considerable proportion of the electricity used in e.g., a typical home. Solar electricity systems can be easily integrated into the electrical system of a normal home connected to the local grid[51]. In Latvia, the interest of individual households to transmit the produced energy to the common electricity network will be promoted from 2014.

[48] INFORSE-Europe (2011), Sustainable Energy Vision for Estonia. A path to make Estonian energy independent and sustainable by 2050, www.inforse.org/europe/pdfs/Estonia-note.pdf

[49] Šipkovs P. (2008). Saules enerģija nav jāceļ uz pjedestālā vai jānopeļ – tā ir jāsaprot un racionāli jāizmanto, http://building.lv/news/250-menesa-cilveks/98632-peteris-sipkovs-saules-energija-nav-jacel-uz-pjedestala-vai-janopel

[50] Climateguide.fi. Wind and Solar Energy, https://ilmasto-opas.fi/en/ilmastonmuutos/hillinta/-/artikkeli/83fa215b-3f3d-4b48-9456-ce3a5940e830/tuuli-ja-aurinkoenergia.html

[51] Motiva group. Solar heating, www.motiva.fi/en/areas_of_operation/renewable_energy/solar_energy/solar_heating

Market overview

Solar thermal systems. The market offers solar thermal systems for use in households, for preparation of warm water and room heating. Essential components of such systems include one or more solar collector arrays and a hot water accumulation tank (the volume depends on the water demand of the number of persons-users), pumps for circulating the heat transfer medium and hot water circulation and the solar controller (ensures the safe operation and high yield of the system). Along with well known producers of solar thermal systems in Europe, these systems are also produced in Finland and Latvia. Solar thermal systems are able to cover 60-70% of the annual hot water needs and up to 30% of the heating needs. The life-time of these systems accounted for 25-30 years (guarantee for 5 years). The range of investment costs for different solar thermal systems are shown in Table 2.3. Amortisation (pay-back) of the solar thermal systems by various suppliers is usually calculated as 6-8 years (costs are usually compared to the fossil fuel sources).

Table 2.3. Investment costs for solar thermal systems (EUR)*

	Investment costs (EUR, including VAT)		
	Hot water, (accumulation tank 140-200 litres)	Hot water, (accumulation tank 250-400 litres)	Hot water + heating system support (combi-reservoir)
Solar thermal systems	1400 – 1800	2000 – 8000	3600 – 11000

* Data compiled from various home pages of producers and retailers in Europe

For solar thermal, the enablers for market growth can be found in the decreasing production costs, especially for the mass-produced vacuum-tube collectors, incentive systems and favourable government policies. Furthermore, improving energy self-sufficiency and environmental considerations at least partly contribute towards driving solar thermal expansion. In the future, with ever more energy efficient buildings, solar thermal could become an increasingly viable and cost efficient solution for producing heat and cooling. However, the substantial driving force for penetration of solar thermal technologies in small scale applications will be associated with the support programs and schemes for investments in these technologies.

Solar photovoltaic systems. The essential components of solar photovoltaic systems are the PV panels, grid inverter and the process monitoring and visualisation device(s). When investing in these systems it should be noted that PV panels usually have a guarantee of 10-12 years (>90% output) and up to 25 years (with 80% output), while the grid inverter, the process monitoring and visualisation devices may need to be changed more frequently as their guarantee period is shorter[52]. Currently, a substantial part of the investment costs is taken up by the solar PV panels, although the cost reduction may be expected for systems in future due to the fact that manufacturing technologies and operating efficiency are developing at a high rate. Technological advances should make solar energy systems cheaper for user[53].

The range of investment costs for solar photovoltaic systems are shown in Table 2.4. Solar photovoltaic systems can be characterised by good options of modification and adjustment – photovoltaic panels can be easily added; one system monitoring device can be allocated to a number of grid inverters and thus take advantage of multiple use of systems; there are several options for visualisation, e.g., PC, smartphone, special display service.

Along with well known producers of solar PV systems in Europe, there are companies in Finland, and Latvia that develop and produce solar PV technologies. Scientific research is also ongoing. For example, in Estonia scientific research on solar PV systems is conducted at the Semiconductor Faculty of Tallinn Technical University on the rise in the efficiency of thin film photovoltaic elements viable today. In Latvia, solar technologies are investigated at the Institute of Physical Energetics[54].

Table 2.4. Investment costs for solar photovoltaic system (EUR, including VAT)*

	Investment costs (EUR, including VAT)		
	PV panels	Inverter	Monitoring and visualisation
Solar photovoltaic system: installed capacity 5-5.5 kW system (production: 5000-5500 kWh/year)	6400 - 8600	1800 - 2700	800 - 3000

* Data compiled from various home pages of producers and retailers in Europe

Advantages and limitations, future perspectives

The potential for the penetration of solar heating and cooling technology in Europe, especially in the building sector, is large. Although currently solar energy has a relatively small market in Finland, Estonia and Latvia there are many visible signs of increasing interest towards solar technologies and solar energy. Solar energy systems are suitable for a wide range of application from small scale (single family households, apartment buildings, public buildings) to large scale applications (e.g., large energy production plants). Solar energy systems are suitable in locations not connected to conventional power grids e.g., holiday homes, and buildings on islands or in remote areas. The market of solar thermal technologies strongly depends on construction intensity in the country. Increasing energy efficiency of housing will foster the application of solar energy systems as lower demand for heating will be possible to cover

52 SINERGO OÜ, http://sinergo.lv/produkti/saules-paneli

53 Technology Roadmaps (2010), Solar photovoltaic energy, OECD/IEA, www.iea.org

54 Institute of Physical Energetics, www.innovation.lv/fei

by sources alternative to conventional heating systems. Application of solar PV can be beneficial in combination with installation of heat pumps to reach the nearly zero-energy or net zero building level. Advantages and limitations for use of solar energy in small scale applications are presented in Table 2.5.

The single most important factor affecting solar utilisation is the development of energy prices. The higher the cost of heating energy or retail price of electricity compared to solar energy, the more attractive solar energy becomes. Nevertheless, along with economic considerations there are other aspects to be taken into account (see the checklist below).

Table 2.5. Advantages and limitations for use of solar energy in small scale applications

Advantages	Limitations
Inexhaustible, abundant, free of charge energy source.	Availability is not permanent e.g., during the night time. Also on cloudy days the received amount of energy is smaller compared to clear days.
Use of solar energy decreases the consumption of fossil or other fuels.	An auxiliary source in most applications.
Production of energy does not create emissions and waste in comparison to combustion processes.	High initial investment costs at the installation phase. Payback period of installation of photovoltaic technologies could be reduced only by applying high efficiency technologies.
Application of solar thermal collectors reduces hot water and heating bills.	
Solar thermal systems can successfully complement other technologies e.g., with solid biomass (pellets, chips, briquettes) boiler or with a boiler fuelled by natural gas or oil. PV can be combined with e.g., heat pump for electricity production to operate the heat pump.	
Almost any rooftop and/or wall can be used for mounting solar systems so it is not necessary to reserve land for small-scale installations. Thus, solar power is also applicable in urban areas.	
PV technologies can be applied to produce electricity in locations not connected to conventional power grids e.g., in sparsely populated areas.	

Checklist for aspects to consider when choosing solar systems.

1. Are you ready to make an investment into solar technologies for your home? ☐

In most cases solar energy is an auxiliary energy source. Thus, it is recommended firstly to clearly determine the need and application purpose of solar systems in order to estimate the necessary investment costs and the potential pay-back period. It is advisable to check if any financial support schemes for installing solar technologies are available in the country.

2. Do you have a sunny place suitable to put solar collectors or PV? ☐

This space (e.g., roof, wall, open area) should receive direct sunlight for the main part of the day. When integrating the system in a building its load bearing capacity should be taken into account. The space needed for a thermal collector depends on hot water demand (for example, for a family building consisting of 3-4 persons, around 5m^2 of space is needed).

3. Have you decided to rearrange your house? ☐

In most cases, rearrangements in the house will be needed for installing the solar systems. In application of solar thermal systems, you will most probably need a technical room for the hot water storage tank. For PV systems, space for an inverter is required. In addition, an accumulator for electricity storage or installations for connection to the grid are necessary.

4. Have you consulted the professional system experts for selection of equipment? ☐

There is a high variety of commercial equipment types on the market. It is advisable to consult with professionals for selection of equipment according to the specific situation.

5. Have you contracted the professional system installers at your house? ☐

It is highly recommended to consult and contract the professionals who have appropriate technical knowledge and training, and thus can ensure the quality of installation of the system.

2.2. Heat pumps

Heat pumps transfer heat energy originating from the sun that has been stored in the ground, air or water into buildings to heat the indoor space or for the hot water supply. A coefficient of performance (COP) illustrates the efficiency of the device: a higher number shows better efficiency. There are four main types of heat pumps: air-to-air heat pumps, ground source heat pump, water-to water heat pump, and air-to-water heat pump. A brief description of the principles of each system is provided[55].

Air-to-air heat pump is a device which can heat or cool indoor air. The indoor temperature can be raised through moving outdoor air heat to indoor air. The indoor air cooling is a reverse operation. Air source heat pumps are very popular and cheap to use. However, the efficiency is dependent on the outdoor temperature - COP diminishes when the outdoor temperature gets colder. For example, when the outdoor temperature is about +7°C the COP is 5 and in -20°C the COP is only 2 even for the most efficient devices.

Ground source heat pump extracts heat from the ground – whose temperature will be warmer than the air in winter (and cooler than the air in summer). For this reason they are more efficient than air source heat pumps, especially in the coldest weather when they are most needed. Typical COP is between 2 and 4. It means that one power unit used produces 2-4 units of heat energy. These heat pumps are used mainly to warm up water in the boiler where heat is stored.

Water-to-water heat pump can provide a more constant input temperature than an air source heat pump. However, this system may fail to operate in the middle of winter during lower temperatures when heating is most needed, so a back-up heat source is needed.

Air-to-water heat pump is a device which transfers heat energy from air to water. The water can be used for the water supply or as central heating water. Typically a reserve heating system is also needed. Air-to-water heat pump can save 40 – 65 % of the electricity consumption. Air-to-water heat pump is analogous with the air source heat pump except that the heat is transferred to water (not to air). The supply water is also heated. The device is not suitable for cooling.

In addition for controlled domestic ventilation with heat recovery an **exhaust air heat pump** is applied. This is a device which takes heating energy from exhaust air to warm up the supply air. It can also be used for cooling. This device produces heat with constant power throughout the whole year.

Heat pump technology is developed for a wide range of applications: air conditioning and heating, refrigerating and cooling. Technical solutions range from small systems serving single needs to complex integrated heat pump systems to serve multiple needs, e.g., heating and hot water production and cooling. Hybrid heat pump systems are paired with other energy technologies, e.g., for energy storage, solar thermal or PV, in order to achieve very high levels of performance.

Operational functions of heat pumps

Application of heat pumps in (residential) buildings can be divided to 3 main categories depending on the operational functions:

- Heating-only heat pumps are used to provide room heating with or without water heating at households. By the method of operation, the annual heating demand can be met by a heat pump system alone (monovalent) or by a heat pump supplemented by an auxiliary heating system (bivalent) in order to assist the plant on unusually cold days, or when the heat pump is out of operation. Ground source heat pump systems can offer stable operating conditions with the constant temperature of the heat sources during the heating season.

[55] More information about heat pumps is available e.g., at: www.heatpumpcentre.org/en/aboutheatpumps/Sidor/default.aspx; www.heatpump-reviews.com, www.icax.co.uk/Heat_Pumps.html

- Heat pump for water heating only.
- Heating and cooling heat pumps can operate in reversible – heating or cooling mode and provide both room heating and cooling. Here the most common type in residential applications is reversible air-to-air heat pump. Heating and cooling air-to-air heat pumps are of increasing interest for the retrofit market in Europe.

Historical overview

Heat pumps are an old technology – the basic principle behind how a heat pump works was developed in the middle of the 19th century. Heat pump technology has not been extensively used as long as energy prices were kept low. Penetration of heat pumps had to be supported by meeting high requirements in terms of efficiency and decreasing of total costs for energy supply at households.

Flash back of penetration of heat pumps in European market.
The oil crisis (in 1978) has changed the situation in many countries in Europe and a rapid take on of the heat pump application started after the oil price shock. However, the promising market start-up was interrupted by a breakdown due to many mistakes allowed and faulty systems employed that destroyed the reputation of the heat pump. The rapid drop of oil prices (in 1986) led to significantly reduced sales figures and shrinking markets. Since the mid-1990s, an interest in heat pumps has returned along with the EU environmental policy (e.g., CO_2 reduction) and energy targets in countries, and technological advances for application of heat pump systems. A steadily growing interest for the utilising of heat pumps in Europe has led to increasing sales for residential applications in new buildings and the discovery of the potential market for heat pumps in the retrofitting of houses. During 2009-2011, a notable decline in heat pump sales was attributed to the economic recession in European countries and a sharp drop of activity in the construction sector. From 2012 onwards, the outlook for the heat pump market is more encouraging as the recovery of economic activity becomes visible in many national markets[56].

Finland, Estonia and Latvia each have their particular way in developing the market segment for application of heat pumps in buildings.

In **Finland,** most of the houses built between the 1970s and 1990s have electric radiators or electric floor heating, owing to cheap electricity and the aggressive marketing policy of an electricity supply company. Air-to-air heat pumps were found as an attractive and cost efficient complementary system for saving energy in these houses: by utilising free energy from the outside air (up to -15°C) for heating, or in air conditioning mode for cooling on hot summer days[57]. Air-to-air heat pumps have taken up the market rapidly and still provide by far the largest share in annual sales figures. The interest towards ground source heat energy in Finland grew rapidly in the late 1970s after the increase in oil prices. The heat pump market took off as a result of the oil crisis, and during the 1980s, several thousand heat pumps were installed as horizontal ground coupled systems, typically in farms of eastern Finland[58]. However, the period of relatively low prices of oil and electricity has reduced the competitiveness of heat pumps and thus the numbers of delivered ground-heat systems decreased dramatically. From 1985 to the mid-1990s, heat pumps almost vanished from the heating business. The major factor delaying the use of ground-heat systems in Finland has been the price: in a typical family house the costs for installing a heat pump using ground heat was about twice the price for installing oil or electricity based systems, although the running costs for ground-heat systems were much lower. In addition, the dispersed

[56] European Heat Pump Association, www.ehpa.org/market-data/2012
[57] Hirvonen J. (2002), Finland, a rapidly growing heat pump market. Presentation in the 7th International Heat Pump Conference in China, May 2002
[58] Kukkonen I. (2000). Geothermal energy in Finland. Proceedings World Geothermal Congress, Kyushu - Tohoku, Japan, May 28 - June 10, 2000

heat pump business was not very strong against major oil and electricity selling companies in the country, as well as the lack of knowledge on heat pumps among the general population. The public interest in heat pump systems was regained with the increasing demand for environmentally acceptable and sustainable technologies[59]. Since 1995, an increasing interest in heat pumps has returned and sales have streamed upwards steadily. During the last decade, except between 2009 - 2010, the market for heat pumps in residential applications in Finland has grown rapidly gradually achieving market acceptance amongst the public.

In **Estonia** and **Latvia**, the development of heat pump applications is closely linked to the situation in the construction sector. For decades between 1950 - 1990, construction was dominated by multi apartment buildings called "block houses". In the 1990s, investments in the construction of dwellings almost stopped. Between 1995 - 2001, mainly detached and terraced houses were built while the construction of multi-apartment buildings was very low in these years. Since the early 1990s, ground source heat pump systems are being installed. The years between 2002 - 2007, known as a "building boom" , were very favourable in the construction sector of individual and dwelling houses. This was supported by favourable loan conditions for developers. An increasing number of heat pump systems were sold for room heating purposes each year; the ground source heat pump market was mostly dominated by horizontally installed systems[60]. The recession in 2008 hit the construction sector strongly with significant reduction in activity; the purchasing power of the population became the key issue as well as the construction market where the developers could not complete projects from earlier years due to the rise in construction prices. However, in spite of the economic recession and low activity in the construction sector, the heat pump market continues to grow indicating that customers acknowledge the advantages of heat pumps. This may be caused by new perspectives opened for heat pumps incorporating ground source heat pumps of bigger power output into infrastructure projects, e.g., schools, kindergartens, industrial installations.

Supporting the heat pump application in countries.

In **Finland**, penetration of heat pumps has been supported by incentive schemes. Since 2001, heat pump installations qualify for the tax reduction scheme that applies to renovation and extension works in private households. In 2012, this tax reduction was 2000 EUR per person and up to 45% of the labour costs[61].

In **Estonia**, distribution of heat pumps was supported by lower electricity prices compared to the price of other fuels and price sensitivity has driven a change in consumer preferences for heat pump systems. The main activity and growth for the heat pump market has been shifted to the renovation sector driving a rapid increase in the share of air-to-air heat pumps while the share of ground source heat pumps has declined due to the halt in construction of new houses. In 2010/2011, the market for ground source heat pumps stabilised and increased numbers of these systems were sold compared to previous (recession) levels[62].

In **Latvia**, installation of heat pumps in small scale applications has been supported by the Climate Change Financial Instrument. Moreover, due to a widening of the retrofit building market, quite often these projects encompass application of heat pumps substituting conventional heat production systems. Such infrastructure projects may sometimes be supported by local governments, international or national subsidy funds.

[59] Kukkonen I. (2000). Geothermal energy in Finland. Proceedings World Geothermal Congress, Kyushu - Tohoku, Japan, May 28 - June 10, 2000

[60] European Heat Pump Statistics Outlook 2010, www.ehpa.org

[61] European Heat Pump Market and Statistics REPORT 2013, Focus reports on selected European markets (Finland), www.sulpu.fi

[62] European Heat Pump Association, www.ehpa.org

Present situation

In general the application of heat pumps in Europe is well developed; traditionally the highest sales of heat pump installations are in Italy, France and Sweden. From different types of heat pumps available, the air-to-air systems are predominant in small scale applications; they are predominantly installed in existing houses as a complementary solution for direct electricity heating or other heating systems. Air-to-water heat pumps are mainly used where there is not enough land for ground source heat pump solutions.

Comparing Finland, Estonia and Latvia, the higher installed capacity of ground source heat pumps is in Finland, while in Estonia the capacity is roughly ten times lower. In Latvia, the installed capacity is quite low (Table 2.6).

Table 2.6. Energy for heating by ground source heat pumps (2010)*

	Finland	Estonia	Latvia
Installed capacity of ground source heat pumps (MW_{th})	1113	92	0.3
Renewable energy captured by ground source heat pumps (GWh/year)	2597	214	1.2
Renewable energy captured by ground source heat pumps per capita (kWh_{th}/ inhabitant/year)	483	160	0.6

* Source[63], own compilation

Ground source heat pumps that are installed in Estonia and Latvia are mainly dominated by horizontal systems, while vertical indirect systems clearly prevail in Finland. There are several reasons for such preferences. Horizontal systems require large areas of land suitable for installation: this is available in Estonia and Latvia while quite limited in Finland. On the other hand, the main reasons for successful penetration of vertical systems in Finland include favourable structure of the earth's crust - crystalline bedrock of high thermal conductivity, liberal administrative requirements - regulations regarding drilling and reasonable costs for drilling.

Heat pumps in Finland.

There are now almost 500 000 heat pumps in Finland (2012). These pumps already produce 3 - 4 TWh energy/year. Air-to-air heat pumps are most commonly used in houses. The number of installed heat pumps in 2011 was more than 70 000 pieces. More than 55 000 air-to-air heat pumps and 14 000 ground source heat pumps were sold in 2011. The outlook for the heat-pump industry is promising. More than half of all new single-family house builders end up choosing a heat pump in one form or another[64].

Market overview

The heat pump market is well developed, offering various solutions for different customer needs. The investment costs depend on the complexity of the heat pump systems. Air-to-air heat pump systems are simpler and less expensive while high investment costs are necessary for ground source heat pump systems being able to secure both heating and domestic hot water needs (Table 2.7).

Table 2.7. Investment costs for heat pump units*

	Investment costs (EUR, including VAT)		
	Air-to-air	Air-to-water	Ground source
Heat pump system	1000 - 3500	3000 - 12000	5500 - 20000

* Data compiled from various home pages of producers and retailers in Europe

63 Heat pumps barometer - Eurobserv'er - 2011, data on population from Central Statistical Bureau of Latvia, www.csb.gov.lv/en; Statistics Estonia, www.stat.ee/en; Statistics Finland, www.stat.fi/index_en.html

64 The Finnish Heat Pump Association, www.sulpu.fi

Heat pumps are a possible replacement for standard fossil-fuel based burners. However, any major shift in heating systems in favour of heat pumps will only take place if the change makes economic sense as lower investment costs are of higher importance today. Although ground and water source heat pumps are characterised by higher investment costs in comparison to conventional combustion systems. However, heat pumps will have much lower operating costs compared to these systems. Comparative ratio of investment and operation costs may become important in future for selection of systems particularly if prices of fossil fuel rise substantially.

Advantages and limitations, future perspectives

Heat pump systems are increasingly penetrating the housing sector. Future perspectives will depend on successful use of advantages and efficient solutions to overcome the limitations of these technologies (Table 2.8).

Heat pumps can be integrated into most existing heating/cooling systems but will be more cost effective in some buildings or sites than others. The savings obtainable by using such systems vary according to the heating needs of a building and its characteristics, including the size of the area to be heated, and how well the building is insulated. New growth opportunities for heat pumps exist in the renovation sector particularly in refurbishment projects reaching high energy performance e.g. nearly zero-energy building standards.

Table 2.8. Advantages and limitations for use of heat pumps in small scale application

Advantages	**Limitations**
Inexhaustible, abundant, free of charge energy source.	Electricity is needed to ensure operation of heat pumps. The required electricity can be produced from other technologies using RES.
Use of heat pumps can substitute conventional fossil fuel systems.	Except for air-to-air heat pumps, other heat pump systems require sufficient volume of environment for operation (i.e. transfer of heat).
Production of energy does not create emissions and waste in comparison to combustion processes.	Rather high initial investment costs especially for integrated systems.

Checklist on aspects to consider before choosing to install a heat pump in an existing building

1. **Is your building energy efficient?** ☐

   Before installation of a heat pump, the energy performance of a building has to be evaluated. The building should be well insulated and airtight. Heat pumps are most efficient when used in highly insulated buildings.

2. **Is the heat pump technology cost beneficial for your house?** ☐

   Usually house owners can consider several alternatives for heat supply, including different heat pump systems. Comparing the installation, operational, maintenance costs, current and possible future price for electricity or different types of fuel help to make a decision.

3. **Have you considered the most suitable energy source for the heat pump?** ☐

   For every heat pump technology there are several aspects to take into consideration:
   - Water-to-water heat pump is suitable if there is a water body in the nearby vicinity that can be used for placing of the collector e.g., proper depth and size, small water flow velocity;
   - Horizontal ground source heat pump is suitable if there is a sufficient area of land available for placement of collector to avoid the potential side-effect of a decrease in the ground temperature at the locality of ground source collector;
   - Vertical ground source heat pump is suitable if the space available is limited and if the making of boreholes is technically feasible;
   - Air-to-air heat pump is suitable as a supplementary heating source. They can produce as much as 40-66% of the heat energy used by a typical household[65].

4. **Is your current heating system appropriate for combining it with a heat pump?** ☐

   From the energy efficiency point of view it is recommended to have low temperature heating systems e.g. under floor heating rather than conventional radiators. Combining heat pumps with radiators would mean increasing the size or number of radiators or reducing the operating efficiency of the heat pump.

5. **Do you have an appropriate sized space for installing a heat pump?** ☐

   Except for air-to-air source heat pumps, systems using ground base heating systems require land either for borehole(s) or horizontal underground pipe systems for heat collection. In order to produce a kilowatt of heat energy a loop buried in a trench can need around 35-50 metres or a borehole for a depth of around 20 metres[66].

6. **Have you checked what kind of permits are needed?** ☐

   When installation of a heat pump requires interference into land or water bodies, be aware to check what kind of permits need to be obtained.

7. **Are you ready to cope with disruption of a landscape?** ☐

   Installation of ground source heat pump requires excavation of the surrounding area, which after installation of heat pump will need some time to recover.

8. **Have you consulted the professional system experts for selection of equipment?** ☐

   There is a high variety of commercial equipment types on the market. It is advisable to consult with the professionals for selection of equipment according to the specific situation. Use of equipment that has not been designed for our climate zone may result in a significant efficiency drop and cause dissatisfaction thereof.

9. **Have you contracted the professional system installers at your house?** ☐

   It is highly recommended to consult and contract the professionals who have appropriate technical knowledge and training, and thus can ensure the quality of installation of the system.

[65] Motiva group, www.motiva.fi

[66] Department of Energy and Climate Change. Low Carbon Buildings Programme. Stream 2A Project Case Study: Solar Thermal Hot Water, Wind Turbine & Ground Source Heat Pump, www.oakleyelectricalservices.co.uk/LiteratureRetrieve.aspx?ID=43265

2.3. Biogas

Biogas is a renewable energy source that can be considered as an alternative to provide energy, particularly in rural areas close to its production site. It is a mixture of various types of gas, for the most part with a methane content of 50% - 80% in volume, thus being similar to natural gas having >70% methane. Industrial production requires erection of particular reactors (anaerobic digestion plants), which include digesters on farms that generally convert e.g., slurry, crop residues, and energy crops. In addition, a biodegradable fraction of food-processing, household and green waste can be used for production of biogas. Economically viable production of biogas is possible in areas where these materials are available at sufficient quantities and for low costs. Having suitable technology is a crucial step for collection of biogas for further energy production. The collected biogas can be used for electricity and heat production, through cogeneration or otherwise, for production of hydrogen, or as a transport fuel.

Historical overview

From the three countries, **Finland** started demonstrations of biogas production in 1902. Thirty years later, the first commercial use of biogas as town gas (lighting, heating, cooking etc.) was seen, and soon afterwards, around the 1930s, biogas was produced in municipal sewage treatment plants (Rajasaari/Helsinki city), in industrial plants (Rajamäki yeast and ethanol factory) and used in combined heat and electricity production. The use of biogas in transport in Finland dates back to 1941. Later, in the 1980s-1990s, biogas production was also started in agricultural plants (Lauttakylä), municipal solid waste plants (Stormossen/Vaasa area regional company) and in landfill gas plants (Vuosaari landfill/Helsinki city)[67].

In the Baltic States, investigation into the possibilities of biogas production was started in later decades. For example, in **Latvia** investigations were carried out around the 1980s, but construction of biogas production plants started several years later. By 2008, three biogas production plants affiliated with cogeneration facilities were put in operation. Two of them were located in municipal landfills ("Getliņi", "Ķīvītes"), one in sewage treatment plant ("Daugavgrīva"). Their total installed capacity of electricity production was 7.8 MW_e[68]. After introduction of the feed-in tariff system in 2009, a rapid development was observed in the biogas market until 2011 when the feed-in tariff system for new operators was cancelled. According to expert judgement from EULS, the biogas sector in **Estonia** is in an early stage of development, both in the sense of acquiring know-how and implementing practical solutions. In this development stage there is an acute need for know-how worldwide. When asking owners of biomass resources, the most mentioned need is finances – the issue of (un)profitability.

Present situation

The leading countries in the EU producing energy from biogas are Germany, the United Kingdom and Italy. The primary energy production of biogas (landfill gas, sewage sludge gas and other biogas in total) in Finland, Estonia and Latvia is presented in Table 2.9. The main utilisation of primary energy produced from biogas is in the transformation sector (for further production of energy).

[67] Lampinen A., Finnish Biogas Association, Biogas in Finland – Present situation, experiences, future – potentials to increase the biogas production and consumption, Biogassys workshop, Helsinki, 9.10.2012, www.wspgroup.com/upload/documents/Finland/2012/Biogassys/04_Lampinen_Biogassys_Helsinki091012.pdf

[68] Dzene I. (2009), Biogāzes potenciāls Latvijā. Kopsavilkuma atskaite, Projekts BIG>East, www.big-east.eu/downloads/IR-reports/ANNEX%202-12_WP2_D2.2_Summary-Latvia_LV.pdf // Dzene I. (2009), Biogas Potential in Latvia. Summary Report, Project: BiG>East, www.big-east.eu/downloads/IR-reports/ANNEX%202-13_WP2_D2.2_Summary-Latvia_EN.pdf

Table 2.9. Primary energy production from biogas in 2011*

	Finland	Estonia	Latvia
Primary energy production from biogas (GWh)	489	38	256
Primary energy production from biogas per capita (kWh_{th}/inhabitant/year)	90	29	123

* Source[69], own compilation

Biogas production in Finland, Estonia and Latvia.

In 2012, in **Finland**, there were 89 plants producing biogas – most of them (41) are plants producing landfill gas, others are municipal solid waste and co-digestion facilities, incl. agricultural and industrial waste; sewage facilities, agricultural and industrial plants[70]. Since 2013, Finland hosts the largest biogas plant in the world, operated by Vaskiluodon Voima Oy. This 140 MW biomass gasifier is located in the city of Vaasa and is fuelled primarily with the help of wood residue from the large forestry sector of the country. It is estimated that this factory could help the country cut the use of coal by up to 40% and will also help in reducing the emission of carbon dioxide by 230 000 tonnes per year[71]. Other biogas power plants e.g., 1.8 MW biogas plant in Jeppo[72], are under construction.

In **Estonia,** 6 biogas plants are currently in operation (2 in landfill, 2 on sludge, 1 on industrial, 1 on agricultural substrate), with a total annual production of 11 million Nm^3/y[73]. The low economic feasibility of biogas production is the main reason for not exploiting the Estonian biogas potential.

Utilisation of biogas in **Latvia** during the last decades can be regarded as being at its initial stage of development, aimed towards finding economically and environmentally sound solutions[74]. By 2012 there were 34 biogas production facilities of a total installed capacity ~39 MW – 3 facilities in municipal landfills (Ltd. “ZAAO”, Ltd. “Liepājas RAS” and Ltd. “Getliņi-Eko”), 1 in municipal wastewater treatment plant (WWTP of “Daugavgrīva” of Ltd. “Rīgas ūdens”), 2 in food production enterprises (Kalsnava ethanol production factory “Biodegviela” and JSC “Cēsu alus”), 1 facility of wood biomass gasification (Ltd. “Kņavas granulas”) and 27 biogas production stations related to agricultural companies[75].

A number of administrative, technical, financial and economic obstacles can inhibit developments in the biogas sector. For example, in Estonia the current economic and market situation is not profitable for the production of biogas. The production of biogas largely depends on subsidies. Small towns and regions face difficulties to secure investments required to transfer to biogas production. Financial incentives to encourage smaller boiler houses to change to using biogas are needed.

Advantages and limitations, future perspectives

Production of biogas is an environmentally friendly way of waste processing as it helps to reduce the amount of organic waste to be placed in landfills, penetration of methane (greenhouse gas) into the atmosphere, as well as reducing the related odours. Use of biogas promotes development of agriculture, rural areas, creates new jobs and contributes towards to energy subsistence. Key advantages and limitations are presented in Table 2.10.

69 Biogas barometer. Eurobserv’er - December 2012, data on population from Central Statistical Bureau of Latvia, www.csb.gov.lv/en; Statistics Estonia, www.stat.ee/en; Statistics Finland, www.stat.fi/index_en.html

70 Lampinen A., Finnish Biogas Association, Biogas in Finland – Present situation, experiences, future – potentials to increase the biogas production and consumption, Biogassys workshop, Helsinki, 9.10.2012, www.wspgroup.com/upload/documents/Finland/2012/Biogassys/04_Lampinen_Biogassys_Helsinki091012.pdf

71 World’s Largest Biogas Plant Inaugurated in Finland (Agence France-Presse, 2013), www.industryweek.com/energy/worlds-largest-biogas-plant-inaugurated-finland

72 Weltec Biopower constructs 1.8MW biogas plant in Finland (ed. by Josie Le Blond, 14 May 2013), www.renewableenergyfocus.com/view/32392/weltec-biopower-constructs-1-8mw-biogas-plant-in-finland/

73 Oja A., Trink T. (2011). The Estonian theoretical and practical biogas production potential and economically feasible feed-in-tariff for renewable electricity for micro CHP using biogas, http://monusminek.ee/documents/oja_trink_Estonian_biogas_hohenheim_110211_6_pages.pdf

74 Blumberga D., et al. Biogāze. Rokasgrāmata., www.big-east.eu/downloads/IR-reports/ANNEX%202-42_WP4_D4.2_Handbook-Latvia.pdf

75 Dubrovskis V., Niklass M., Emsis I., Kārkliņš A., Biogāzes ražošana un efektīva izmantošana, http://latvijasbiogaze.lv/files/Buklet_LQ.pdf

Table 2.10. Advantages and limitations for use of biogas.

Advantages	Limitations
Sustainable use of waste for production of energy particularly in rural areas.	High initial investment costs.
Use of biogas decreases the consumption of fossil fuels.	Potential conflicts related to competition on land used for agriculture.
Suitable for electricity and heat production, through cogeneration or otherwise, for production of hydrogen, or as a transport fuel.	Requires permanent supply of raw material in sufficient quantities for biogas production.
	Collection of biogas in economically viable amounts requires large volumes of biodegradable raw material and sufficient space for reactor.

Experts judge that in **Finland** the current level of biogas technology diffusion is very low and there is a large potential for increase. The technically feasible potential of 6.7-17.6 TWh (by 2015) for production of energy from biogas has been estimated in the country[76]. In **Estonia**, the resources for biogas production are barely used. It has been assessed that the economically usable amount of biogas is 286 million Nm^3. This amount of biogas could be used to produce electricity 688 GWh/y[77]. In **Latvia**, there is a good potential for biogas production due to the availability of resources suitable for production of biogas[78]. It has been estimated that energy crops growing on unused agricultural areas are the most important biomass feedstock, and its share is around 88% of the whole biogas potential in Latvia[79]. It can be envisaged that in Latvia, in parallel to improvements in logistics of waste collection and separation, the volume of biogas production will increase[80]. It is envisaged that by the year 2020, the biogas production will be about 300 million m^3 biogas. This amount of biogas could yield 640 GWh/y of electricity and at least 320 GWh/y of heat[81].

2.4. Biomass

Biomass is the most commonly used source for production of energy in small scale applications in Finland, Estonia, Latvia. There are various types of biomass suitable for energy production purposes - wood based fuels, but also peat, straw, charcoal and various agricultural residues.

Within the current classification system solid biofuels[82] are divided into four groups: woody biomass, herbaceous biomass (i.e., biomass from plants that have a non-woody stem), fruit biomass (i.e., biomass from parts of plant which are from or hold seeds), and blends and mixtures (i.e., biomass of various origin). Woody biomass is the most commonly applied and there are different types of wood based biomass produced for small scale applications e.g., in households.

76 Rintala J., Pakarinen O., Biogas in Finland – Country Report, IEA Bioenergy Task 37 Energy from Biogas and Landfill Gas (15-16 November, 2012, Wien), www.iea-biogas.net/country-reports.html

77 Oja A., Trink T. (2011). The Estonian theoretical and practical biogas production potential and economically feasible feed-in-tariff for renewable electricity for micro CHP using biogas, http://monusminek.ee/documents/oja_trink_Estonian_biogas_hohenheim_110211_6_pages.pdf

78 Dzene I. (2009), Biogāzes potenciāls Latvijā. Kopsavilkuma atskaite, Projekts BIG>East, www.big-east.eu/downloads/IR-reports/ANNEX%202-12_WP2_D2.2_Summary-Latvia_LV.pdf // Dzene I. (2009), Biogas Potential in Latvia. Summary Report, Project: BiG>East, www.big-east.eu/downloads/IR-reports/ANNEX%202-13_WP2_D2.2_Summary-Latvia_EN.pdf

79 Dubrovskis V. et al. (2012), Biogas production potential from agricultural biomass and organic residues in Latvia. http://llufb.llu.lv/conference/Renewable_energy_energy_efficiency/Latvia_Univ_Agriculture_REEE_conference_2012-115-120.pdf

80 Dzene I. (2009), Biogāzes potenciāls Latvijā. Kopsavilkuma atskaite, Projekts BIG>East, www.big-east.eu/downloads/IR-reports/ANNEX%202-12_WP2_D2.2_Summary-Latvia_LV.pdf // Dzene I. (2009), Biogas Potential in Latvia. Summary Report, Project: BiG>East, www.big-east.eu/downloads/IR-reports/ANNEX%202-13_WP2_D2.2_Summary-Latvia_EN.pdf

81 Dubrovskis V., Niklass M., Emsis I., Kārkliņš A., Biogāzes ražošana un efektīva izmantošana, http://latvijasbiogaze.lv/files/Buklet_LQ.pdf

82 EN14961-1:2010. Solid biofuels. Fuel specifications and classes – Part 1: General requirements

Commonly used wood based fuels

Photo: Anna Beloborodko

Pellets are a solid fuel produced from biomass in a process of milling, drying and compacting[83]. Production of pellets is efficient use of wood residue material, e.g., cutter filing, sawdust, and abrasion dust. The key advantages of pellets compared to unprocessed biomass are high density and high energy content, standardised properties and consequently reduced costs for transport storage and handling. Pellets are pressed into small cylinders, usually 6-10 mm in diameter and 10-30 mm in length. Moisture content of 6-12% is typical for pellets.

Photo: Daina Indriksone

Wood chips are cut from wood usually to a size of 5-100 mm. Heating with wood chips works like pellet heating, but the devices are slightly different. The moisture content of wood chips is usually higher compared to pellets. Thus, a larger amount of the fuel is needed to produce heat and a bigger ash content is generated. The fuel logistics are also different because of the bigger space requirement. The boiler must be larger because moist wood chips demand typically more room for burning.

[83] European Biomass Association. (2008). A pellet road map for Europe (2008), www.aebiom.org/IMG/pdf/Pellet_Roadmap_final.pdf

Photo: Anna Beloborodko

Briquettes are pressed from dry wood sawdust into its shape (usually in the form of a cylinder or brick for small scale applications). It has many advantages - big energy content, low exhaust emissions, and a small stockpile. Briquettes are used in boilers, fireplaces, baking ovens, sauna stoves, campfires, and in grills. A moisture content of 4-8% is common for briquettes.

Photo: Daina Indriksone

Wood logs are firewood made from spruce, pine, aspen or birch. Birch logs are most usually used in baking ovens, in fireplaces, and in sauna stoves. They are the best heat generator so it is also most typically used as firewood. Wood logs can be cut in different ways, so the technology is complicated. Conventionally firewood is felled in the winter with a moisture content of around 50% and must be seasoned down to between 20-30% to make it suitable for use in smaller combustion systems e.g. wood burning stoves. Larger combustion systems can burn wetter wood but they sacrifice considerable amounts of energy for the convenience of using such fuel[84].

[84] Potter P., Seasoning wood for fuel, Woodfuel East, www.forestry.gov.uk/pdf/eng-yh-seasoningwoodforfuel.pdf/$FILE/eng-yh-seasoningwoodforfuel.pdf

Photo: Daina Indriksone

Forest residues consist of tops, branches, crowns, foliage, stumps and roots remaining from harvesting. They are typically burned in boilers after crushing, very similar to wood chips. Forest residues can provide a sustainable source of wood fuel provided that adequate quantities are left behind in the forest for ecological purposes[85].

Photo: Daina Indriksone

Waste wood (including sawdust, edgings, etc.) originates from construction and demolition, wood processing industry, wood packaging etc. Waste wood generally has a low moisture content. Processed wood may contain various contaminants that result in harmful emissions (e.g., volatile organic compounds) and thus cleaning of flue gases is required.

Other biomass fuels

Other types of biomass used for energy production comprise peat[86], straw, common reed, crops, rape seed, buckwheat, spent grain, potato pulp, hogweed, etc. While peat and straw have been more commonly used, application of other types of biomass have to be carefully studied, including technical feasibility and combustion properties, to avoid health or environmental risks[87].

Energy production from biomass

Energy production from biomass involves a combustion process. This chapter will cover biomass as a fuel source and combustion devices for application at small scale. The main types of biomass fuelled installations include boiler and furnace:

- **BOILER** — the term “boiler” typically refers to a device that converts water to steam for the purpose of heating or power generation. It is an enclosed vessel in which water is heated and circulated under pressure, either as hot water or as steam;
- **FURNACE** — an enclosed space for the burning of fuel. Most common use of furnaces is for room heating of buildings[88].

Resource availability

Being rich in forests (Table 2.11) Finland, Estonia and Latvia have a high potential for energy production from wood-based fuels. In countries throughout Europe, forest resources have been increasing during the last 50 years; an increasing amount of wood has accumulated in the forests[89].

Estimations indicate that the use of forest biomass for energy production in the European Union could increase in future[90]. In **Finland**, the potential for a noticeable increase in the use of wood is associated with the bio-energy sector. However, due to a rapid increase in export of wood based fuels, no drastic increase in the use of wood fuel for domestic energy

[85] Food and Agriculture organization of the United Nations (2010), Criteria and indicators for sustainable woodfuels, www.fao.org/docrep/012/i1673e/i1673e00.pdf

[86] Debate on classification of peat as renewable energy source is still ongoing. For example, in Finland peat is classified as a slowly renewable biomass fuel (Ministry of Employment and the Economy, Finland, www.tem.fi/en/energy/renewable_energy_sources)

[87] Beloborodko A., et al. (2013), Study on availability of herbaceous resources for production of solid biomass fuels in Latvia. Agronomy Research 11 (2), 283-294

[88] Greenwood clean energy, Inc., Glossary of Wood Heating Terms, www.greenwoodusa.com/glossary-wood-terms.php

[89] Asikainen A., et al. (2008), Forest energy potential in Europe (EU27). Working papers of the Finnish Forest Research Institute, www.metla.fi/julkaisut/workingpapers/2008/mwp069.htm

[90] EUSTAFOR. (2010), Biomass and Bioenergy report, www.eustafor.eu/failid/File/Publications/Biomass_Booklet.pdf

production is expected up to 2030. In **Estonia**, annual felling is well below the annual increment and therefore it is most likely that the increased supply of wood biomass will be associated with present forest management practices. In **Latvia**, wood based energy production is playing an increasing role in the forestry sector. However, currently the major production of wood pellets and briquettes are for export needs. In the near and medium term it is expected that utilisation of wood biomass will increase, although this increase will be due to exports of wood based fuel to other EU countries[91].

Table 2.11. Forest resources and utilisation in Estonia, Finland and Latvia in 2010*.

	Finland	Estonia	Latvia
Area covered by forests (million ha)	26.1 (86% of territory)	2.2 (49% of territory)	3.4 (52% of territory)
Total stock of wood (million m^3)	2284	458	633
Felling volume of wood (million m^3)	71.5	10.5	13

* Sources[92], own compilation

Historical overview

The use of biomass, particularly wood fuels, for heat production in small scale application has a long tradition as an easily accessible local energy source in Finland, Estonia and Latvia.

In **Finland**, more than half of single-family houses use wood as a major or supplementary heat source. The wood used in fireplaces, boilers and saunas originates from the dwellers' own forests or wood being purchased economically. By 2010, single-family houses (detached houses, farms and summer cottages) used 6.7 million m^3 of wood for heating purposes. Birch was the most commonly burned type of wood. During the last twenty years, combustion installations have developed remarkably. This can be seen especially in the reduction of the combustion gas emissions. More recently, different heat pumps (ground source heat pumps, air-to-air heat pumps or exhaust air heat pumps) are being installed in addition to wood heating[93].

In **Latvia**, historically two main sources of biomass – wood and peat were used. Peat as a local fuel was intensively exploited in the 1970s. Over the recent decades, fuel peat extraction and usage in Latvia has substantially decreased giving way to other biomass sources. Consumption of wood fuel is maintaining quite a stable position for energy production in small scale applications.

In **Estonia**, a substantial amount of wood is being used as a major or supplementary heat source in small scale applications, especially in households. Up to the 1990s peat briquettes were an important fuel for households, too. In the nineties, many households stopped using peat briquettes due to a rapid price increase, while wood fuel has been kept as an important source for energy production. There are examples of the use of other types of biomass in addition.

Use of herbaceous biomass for heating in Lihula municipality, Estonia.

In 2006, Lihula town was facing rapidly growing fossil fuel prices. Oil shale oil has been used for providing heating to buildings connected to the central district heating network. At the same time, a considerable amount of available biomass sources remained unused. In 2008, by implementing a project supported by EEA Grants a new multi fuel boiler for combustion of either herbaceous biomass (humidity <18%) or wood chips (humidity <45%) 1.8 MW was installed. Oil shale oil is only used as reserve fuel. The project

[91] Jonsson R., et al. (2013), Conditions and prospects for increasing forest yield in Northern Europe. Working papers of the Finnish Forest Research Institute, www.metla.fi/julkaisut/workingpapers/2013/mwp271.htm

[92] Finnish Statistical Yearbook of Forestry 2011 and Finnish Statistical Yearbook of Forestry 2012; Yearbook Forest, (2012) www.keskkonnainfo.ee/failid/aastaraamat_2010a_parandatud.pdf; http://geoportaal.maaamet.ee/docs/geoloogia/maavaravarude_koondbilanss_2010_seletuskiri.pdf?t=20110620085440; Central Statistical Bureau of Latvia, www.csb.gov.lv/en; Statistics Estonia, www.stat.ee/en

[93] TTS publication No. 312, 1990; Build Up Skills Finland, National Roadmap ensuring energy efficiency competence in construction (2013), www.motiva.fi/files/7224/BUILD_UP_Skills_Finland_Roadmap_in_English_.pdf

has resulted in significant reduction of CO_2 emissions. In addition, the municipality can use local biomass fuel. The installed technology allows using grass e.g., from the alluvial meadows of the Matsalu Nature Park. In order to preserve the natural diversity in the area, the grass here has to be mowed annually. In addition, since 2009, the leftover straw is utilised in the boiler house[94].

Present situation

Consumption of biomass fuels in small scale applications (households, commercial and public sector) provides a significant contribution to heat energy supply in Finland, Latvia and Estonia (Table 2.12).

Table 2.12. Energy consumption for heating in small scale applications (average 2008-2011)*.

	Finland**	Estonia	Latvia
Total heat energy consumption in households, commercial and public sector (GWh/year)	54640	18910	23850
Consumption of biomass in household and commercial and public sector (GWh/year)	15020	4690	9240
Consumption of biomass per capita (kWh_{th}/inhabitant/year)	2800	3500	4320

* Sources[95], own compilation
** Consumption in residential sector

In Finland, 27% of energy consumption in residential buildings was covered by biomass (wood, peat) in 2011[96]. Biomass is widely used for heating in detached houses and in recreational residential buildings. Use of other fuel types for heating prevail in multi-apartment buildings (blocks of flats) and terraced houses. The share of biomass[97] for heating in different types of houses is presented in Figure 2.3.

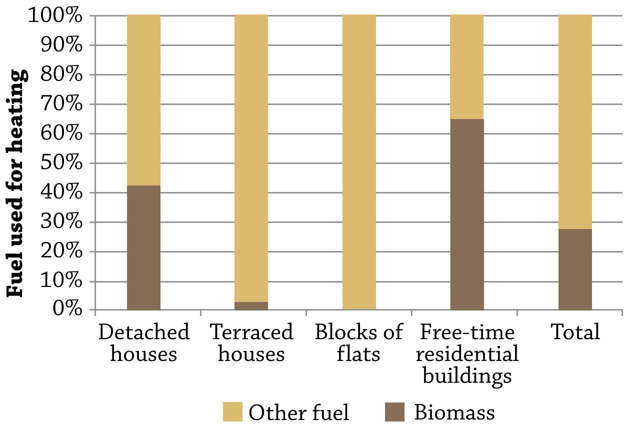


Figure 2.3. Share of biomass and other fuels used for heating in different types of residential buildings in Finland in 2011 (Source[98], own compilation).

While wood based fuels in small scale applications are the main source, peat and other biomass (straw, charcoal, agricultural waste) play a minor role. Energy produced from various types of biomass is presented in Figure 2.4. for Estonia, and in Figure 2.5. for Latvia.

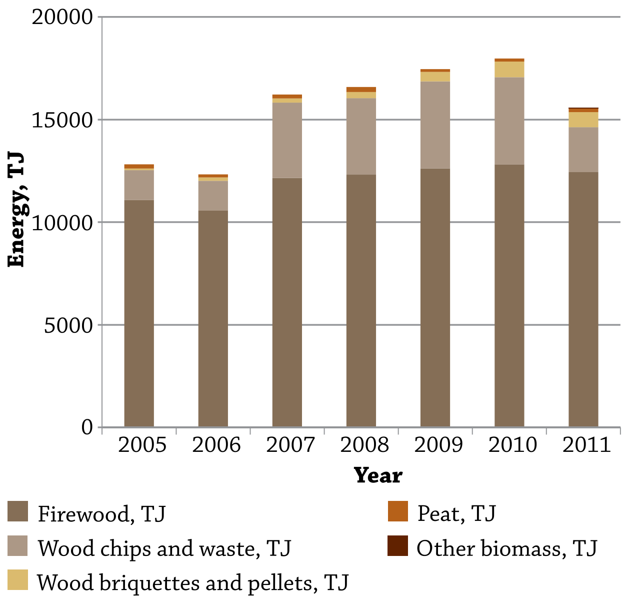


Figure 2.4. Production of energy from biomass in small scale applications in Estonia (Source[99], own compilation).

[94] Reduction of Greenhouse Gas Emissions through the Adoption of Renewable Biofuels in the Boiler House of OÜ Lihula Soojus, http://eeagrants.org/Results/Project-stories/98-reduction-in-CO2-emissions; Källe M. (2010), Kohalikud biokütused ja Lihula katlamaja, www.polvamaa.ee/energeetika/esitlused/Margus_Kalle/margus_kalle_esitlus_101021_lihula_soojus.pdf;

[95] Central Statistical Bureau of Latvia, www.csb.gov.lv/en; Statistics Estonia, www.stat.ee/en; Statistics Finland, www.stat.fi/index_en.html

[96] Statistics Finland, www.stat.fi/index_en.html

[97] Share of biomass used in district heating plants is not accounted here.

[98] Statistics Finland, www.stat.fi/index_en.html

[99] Statistics Estonia, www.stat.ee/en

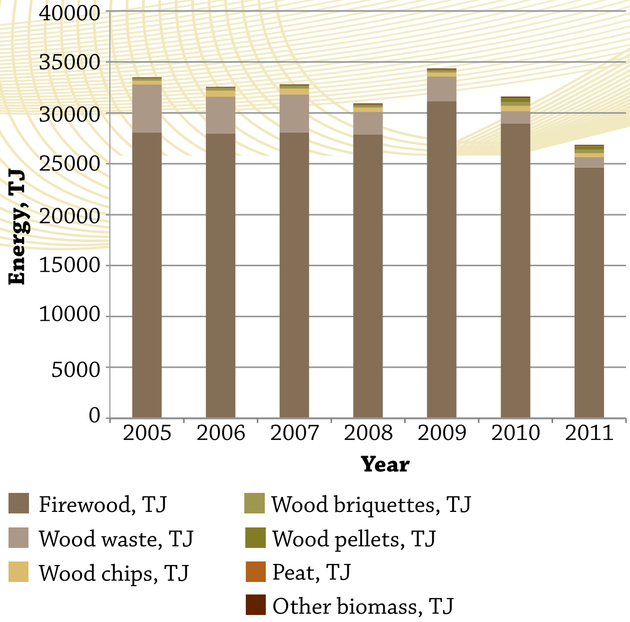


Figure 2.5. Production of energy from biomass in small scale applications in Latvia (Source[100], own compilation).

It is evident that firewood (wood logs) is the most popular type of wood fuel in Latvia and Estonia, followed by wood waste (forest residues, waste wood), briquettes, wood chips and pellets. In Finland, the most popular type of wood fuel is firewood. Next are wood chips being very popular in farms. Wood pellet users are rare and the use of briquettes in small scale applications is very limited[101].

As shown in Figure 2.4. and 2.5., the trend in production of energy from biomass in Latvia and Estonia is quite stable, showing a slight decline in 2011. Due to the exceptionally mild winter of 2011, a lower demand in firewood was observed in the whole of Northern Europe[102]. Fluctuation in energy production from biomass in small scale applications depends on various factors e.g., weather conditions, fuel prices.

In order to satisfy the needs for room heating and/or hot water in households, commercial and public buildings, the most appropriate installations can be selected (Table 2.13).

Although various fuels from biomass are available, households prefer firewood in their combustion facilities. For example, nearly 19% of households using biomass in Latvia utilise firewood in boilers, about 40% in furnaces and 30% in stoves. Use of pellets and briquettes is on a smaller scale with around 2% in boilers and furnaces (each) and only 0.6% in stoves[103].

One of the aspects influencing the efficiency of the use of biomass is the age of the combustion facility. In Latvia, in this respect, the average age of boilers fuelled by wood pellets in households is about 5-6 years old while boilers fuelled by firewood are considerably older - 11-16 years (data of 2010).

Table 2.13. Types of biomass fuelled installation used for room heating and hot water supply in small scale applications.

Typical capacity of installation	**< 50 kW_{th}**	**50 - 100 kW_{th}**
Application	**Households**	**Commercial and public buildings**
Type of installation	• Boilers - advanced technology, high conversion efficiency, use of pellets or firewood, low environmental impact;	• Individual boilers - typically automated (or semi-automated), fuelled with wood pellets or chips;
	• Furnaces (including stoves, fireplaces) - conventional technology, mainly use firewood, relatively low technical efficiency, low environmental performance.	• Energy centre (plant) with boilers fuelled with pellets, chips or, less commonly, chopped straw; distribution of heat and hot water to individual households.

[100] Central Statistical Bureau of Latvia, www.csb.gov.lv/en
[101] Statistics Finland, www.stat.fi/index_en.html
[102] Solid Biomass barometer, Eurobserv'er, December 2012
[103] Central Statistical Bureau of Latvia, www.csb.gov.lv/en

Households use 30-40 year old room furnaces and 25-30 year old kitchen stoves. The operation of economic furnaces started relatively recently, and thus the age of installations are 5-8 years[104].

Market overview

Manufacturers of combustion installations offer a very wide range of capacities, from a few kilowatts to larger capacities to satisfy the needs of detached houses, up to multi-apartment building blocks, larger public and commercial buildings. The market is fairly mature and well structured. Manufacturers offer various installations e.g., stoves, furnaces, boilers either for single or multi-purpose applications. Sauna stoves are quite simple and less expensive while higher investments are needed for more advanced boilers of larger capacity with multi-purpose applications (Table 2.14).

Table 2.14. Average investment costs for wood fuelled combustion installations at households (< 50 kW_{th})*.

	Investment costs (EUR, including VAT)			
	Sauna stoves	Kitchen stoves	Furnaces (room heaters, fireplaces)	Boilers
Biomass combustion installation	250 - 1 800	470 - 3 500	700 - 4 000	700 - 9 000

** Data compiled from various home pages of producers and retailers in Europe*

Advantages and limitations, future perspectives

One of the main advantages of biomass is its occurrence as a domestic fuel source. In addition, there is a large possibility of alternatives for application of fuel types (wood logs, pellets, wood chips, briquettes, forest residues, waste wood, peat and various types of herbaceous fuels). An overview on the main advantages and limitations for the use of biomass in small scale applications is presented in Table 2.15.

In order to maximise the gains from biomass combustion, modern and efficient technologies should be complemented with a high quality biomass fuel. Various types of biomass fuel have a certain range of application. It can be envisaged that fuels having a high combustion heat will prevail over those with moderate or low heating (calorific) value.

Potential range of application of different types of biomass fuel in small scale applications in Finland, Estonia and Latvia.

Wood logs are the most widely used type of wood fuels and it is envisaged that this type of wood fuel will keep its position, especially because of its suitability for almost all small-scale applications. Both wood pellets and wood

Table 2.15. Advantages and limitations for the use of biomass in small scale applications.

Advantages	Limitations
Local renewable energy source.	Potential for non sustainable use of forests e.g., over exploitation.
Use of biomass decreases the consumption of fossil fuels.	Possible shortage of good quality biomass fuel due to competition between domestic use and export.
Creation of job opportunities for local inhabitants.	Requires permanent supply of biomass fuel in sufficient quantities for energy production.
Mature technology - modern biomass boilers can operate with about 90% efficiency.	Efficiency of energy production from biomass fuels strongly depends on the quality of biomass.

[104] Central Statistical Bureau of Latvia, www.csb.gov.lv/en

briquettes have good potential for all small scale applications. They are convenient for advanced boilers and furnaces. However the share of application can be influenced by the competition between export and local use. Wood chips (including chopped forest residues) are more convenient for commercial and public buildings. The application of waste wood will probably continue to diminish in households. It can be envisaged that utilisation of peat as a fuel source will remain marginal due to the availability of better alternatives of biomass fuel for energy production.

Along with the application of wood-based biomass, increased attention has recently been paid to the use of herbaceous sources (e.g., straw, common reed, crops, rapeseed, buckwheat, spent grains). Although herbaceous biomass has a lower energy content per mass unit than wood-based biomass, this source (in the form of briquettes, pellets) could have some potential for energy production[105].

The combination of woody biomass with other types of biomass gives several opportunities. Due to the diverse properties of herbaceous biomass, it can be effectively used in mixtures to improve specific parameters of the biomass fuel. Results of the combustion tests prove that several types of herbaceous biomass can stabilise the combustion process by reducing combustion intensity[106].

It is important to ensure a convenient, sufficient and regular supply of biomass to satisfy the heating demand throughout the year. There is a large variety of biomass fuels available on the market and often the customer has to weigh the price against the quality of the biomass. Investment in higher quality biomass may easily pay off by higher calorific value and better operational conditions at the same time being environmentally friendly. Key aspects to consider when assessing the quality of fuel include calorific value, size of particles, moisture content, ash content, and mechanical properties[107]. The biomass heating can be the main or supplementary source of energy. To satisfy the main heating demand of the dwelling, there are different types of boilers available, while stoves, furnaces and fireplaces are suitable as a supplementary heating source.

[105] Beloborodko A., et al. (2013), Study on availability of herbaceous resources for production of solid biomass fuels in Latvia. Agronomy Research 11 (2), 283-294

[106] Riga Technical University, Faculty of Power and Electrical Engineering, Institute of Energy Systems and Environment, Environmental Monitoring Laboratory (2013) „Non-woody biomass briquettes. Fuel analysis and combustion tests”, Energy Efficient and Ecological Housing “ECOHOUSING”, Project Report, www.ecohousing-project.eu/wp-content/uploads/2013/06/Ecohousing_report_2nd-FR.pdf

[107] Biomass Energy Centre. Summary of wood fuel standards, www.biomassenergycentre.org.uk

Checklist on aspects to consider when selecting a biomass combustion installation in small scale applications

1. Have you selected the most suitable type of biomass fuel? ☐

Different combustion installations have their advantages and disadvantages.

- Wood log and briquette stoves:

Advantages: simple and cheap technology; cheap fuel, possible integration of water boiler. Disadvantages: low comfort; short working time; low efficiency, high emissions.

- Wood log and briquette boilers:

Advantages: simple and cheap technology; relatively cheap fuel, multiple choice of fuel. Disadvantages: relatively short working time with one fuel load; no automatic operation; low efficiency in real life conditions.

- Pellet stoves:

Advantages: designed for installation in living area; fully automatic operation. Disadvantages: more expensive than traditional wood stoves; many of them are noisy, inconvenience due to dust from pellets.

- Pellet boilers:

Advantages: high efficiency, low emissions; automatic/semi-automatic operation; variable load; fuel storage for long period; wide choice of technologies. Disadvantages: relatively expensive technology.

2. Do you have information about the calorific value of the fuel? ☐

Calorific value is important for characterising fuels. For comparison, the net calorific value of 1 tonne of wood fuels is 2.36 MWh for freshly cut wood (50% moisture content), 5.3-5.7 MWh for dry wood, 4.5-5.0 MWh for wood pellets, briquettes[108].

3. Have you designated a place for storage of biomass fuel? ☐

Depending on the installed capacity and intended application of combustion installation, an appropriate storage place has to be allocated.

4. Have you consulted the professional system experts for selection of equipment? ☐

There is a high variety of commercial equipment types on the market. It is advisable to consult with the professionals on the selection of equipment (installed capacity, purpose of use, etc.).

5. Have you contracted the professional system installers at your house? ☐

It is highly recommended to consult and contract the professionals who have appropriate technical knowledge and training, and thus can ensure the quality of installation of the system.

[108] SIA Meža un koksnes produktu pētniecības un attīstības institūts (2011), Koksnes biomasas izmantošana enerģijas ieguvē. Attīstības tendenču un iespēju novērtējums (Gala ziņojums), www.zm.gov.lv/public/files/CMS_Static_Page_Doc/00/00/00/15/87/MN_pet_gala_atskaite_20032012.pdf

2.5. Combined systems

In combined systems two or more energy sources are applied to provide energy needs. The great advantage of these systems lies with the possibility to optimise the application of individual systems (Table 2.16.) and to guarantee that e.g., the heating is continuous despite the weather conditions.

Most typically a combined system is an integrated unit where solar or wind energy is combined with a biomass based solution or heat pumps.

Combined solar and biomass systems

Solar thermal

Biomass

Solar energy combined systems that provide both room heating and hot water, and have a great system automation and efficiency have high potential. Using of solar energy require a combination with other (renewable) energy source to compensate insufficient solar irradiation during the cold and dark season of the year. Technological solutions have been developed of compact solar and wood pellet heating systems providing hot water and room heating for a building.

Combined system for multi-apartment building in Sigulda, Latvia

Based on this approach a pilot combined system has been installed for a multi-apartment building in Sigulda, Latvia. Before installation of the system, an energy audit of the building was performed. The most suitable energy efficiency improvement measures were determined and implemented. The previous autonomous heating system was replaced by solar thermal collectors mounted on the roof top of the building and by a pellet boiler placed in a container type installation outside the building[109].

Photo: Daina Bojāre

Table. 2.16. Application of individual systems for energy supply in small scale applications

	Solar thermal collectors	Photovoltaics	Wind	Heat pumps	Biogas	Biomass
Application	Hot water/ room heating	Electricity generation	Electricity generation	Room heating/ cooling/ hot water	Electricity generation/ room heating	Room heating/ hot water
Principle	Collection of solar radiation	Collection of solar radiation	Utilisation of wind energy	Collection of ambient energy	Combustion	Combustion
Investments	Moderate	High	Moderate to high	Moderate to high	High	Moderate
Fuel supply	Ambient	Ambient	Ambient	Ambient	Continuous production of biogas	Continuous purchase/supply of biomass
Limitation of application	Sufficient area	Sufficient area	Wind speed	Sufficient area	Distance to production site	Quality of fuel

[109] More information (in Latvian) is available at: www.inovacijas.rtu.lv/node/89, http://esfinanses.lv/esbuklets/projekti/74888_dzivojamas-majas-krisjana-barona-iela-2-sigulda-siltinasana

Aspects to consider for application

The energy source of future projects of apartment buildings and the effective use of renewable energy is certainly related to the widespread use of solar combined systems. Adjusting the system parameters, it can be applied to apartment buildings, single-family, commercial and public buildings. System parameters will mainly depend on the buildings heated area, specific heat consumption and number of residents.

A compact solar and pellet module will be more efficient in application when:

- orientation of roof is towards the south and area of the roof is sufficient to place solar collectors,
- measures for increasing energy performance of a building are implemented.

Complex application of photovoltaic, solar thermal, heat pump and biomass systems

Photovoltaic

Solar thermal

Heat pump

Biomass

Modern technologies and architecture offer more and more solutions for designing and constructing energy efficient buildings where renewable energy sources can sufficiently be used to produce energy as much as the house consumes itself or even more. The hybrid system consisting of photovoltaic, solar thermal, geothermal heat pump and biomass combustion has the advantage that the energy can be produced in the most economical manner all year around. In winter, geothermal energy is used as the main heat energy source complemented by a fireplace, while in summer, when the building does not need to be heated, solar collectors are used for production of hot water. Combination with photovoltaic allows production of electricity that can be utilised for the internal needs or delivered to the common grid.

Application of combined systems in a single family house in Hyvinkää, Finland

Villa Isover in Hyvinkää, Finland is an example of achieving net zero energy by combining different renewable energy technologies. This project proves that implementation of a net zero energy house is possible by applying existing construction practices, available construction materials and building technology solutions, and that it also makes economic sense. The heating system for this newly constructed single family house is a ground source heat pump with water circulation floor heating, fireplace, solar thermal collectors and photovoltaic. The ventilation utilises an underground piping system, which heats the air in the winter and cools it in the summer (more information in Chapter 2.6).

Aspects to consider for application:

- Combining different renewable energy technologies will bring more benefits if the building itself complies with high energy efficiency parameters (e.g., well insulated, airtight construction).
- Designing of the heating, cooling and ventilation system applying a combination of various energy sources is a challenging task that requires involvement of highly qualified experts.

Complex application of solar thermal, heat pump and wind energy systems

Solar thermal

Heat pump

Wind

Combining different renewable energy sources gives better possibilities to satisfy the energy demand of the buildings and avoiding the use of fossil fuels. There are examples in Europe of using solar thermal panels, heat pump technologies for room heating and providing hot water while the electricity produced from the wind turbine is used to run the heat pump[110], used for other purposes or fed into the common electricity grid.

Application of combined systems in a kindergarten in Tartu, Estonia

A combined heating system (solar, wind, geothermal) has been installed in a kindergarten in Tartu, Estonia. There are solar thermal collectors, a wind turbine and ground source heat pump. The combined system allows 100% coverage of the kindergarten's room heating and domestic hot water needs, including heating of a swimming pool. Redundant energy produced in spring, summer and autumn is used for room heating and hot water preparation for the school building located nearby (more information in Chapter 2.6).

[110] Department of Energy and Climate Change. Low Carbon Buildings Programme. Stream 2A Project Case Study: Solar Thermal Hot Water, Wind Turbine & Ground Source Heat Pump, www.oakleyelectricalservices.co.uk/LiteratureRetrieve.aspx?ID=43265

Aspects to consider for application

- In public buildings (e.g., schools, kindergartens) where the room heating and hot water need is in seasonal demand, it is advisable to find a solution for additional utilisation of produced energy (e.g., heating of a swimming pool, another user).

2.6. Practical examples - public buildings in Finland, Estonia, and Latvia

The following examples present a combination of energy efficiency measures and application of renewable energy sources in public buildings.

Use of geothermal and solar energy in Mårtensbro school and daycare, Espoo, Finland



Photos: Erkki Pesonen

Location of the building	Rehtorinkuja 4, 02360 Espoo, Finland
Description of the building	Construction of this municipal school and daycare building in Espoo was completed in 2012. The architecture company is Playa Arkkitehdit Oy.
Building parameters	This building provides day-care, pre-school and school facilities for 550 students and 70 members of staff. In order to adapt to the site topography the building varies in height from a single storey day-care wing to three storeys on the northern side. The size of the building is 7116 m^2. The facades are mostly of hand-made white brick and of large timber columns on the courtyard facade. The main lobby is located centrally between the wings and connects all the different levels and offers long views to the surroundings. Inside, the materials and colours are neutral (hand-made brick, concrete and birch) to provide a long-lasting backdrop for the hustle and bustle of children.
Energy consumption	100 kWh/br m^2
Engineering systems	The building utilises district heating, geothermal and solar energy both passively and actively. Geothermal energy is used for heating and cooling. Solar energy is collected by solar panels and solar thermal collectors (12m^2, capacity 5kW). Electricity by solar panels is utilised through electricity distribution network of the house. Solar thermal collectors are used for heating the water used in the school building.
Project financing	The construction of the building was financed by the municipality.
Key aspects making this building a good practice example	The school building is a pilot project for energy efficient education buildings for the City of Espoo. Particular attention was paid to estimate the building's energy consumption during the initial design stage.
Information source	www.playa.fi/MAR/MAR.html

Modern technologies using RES in Viikki Environmental House, Helsinki, Finland

Photos: Minna Kuusela

Location of the building	Viikinkaari 2, 00790 Helsinki, Finland
Description of the building	Viikki Environment house was completed in September 2011. This energy-efficient office building is used by the City of Helsinki Environment Centre and the University of Helsinki. The design and construction was managed by the City of Helsinki's HKR-Rakennuttaja.
Building parameters	The heated net floor area of this building is 6390 m^2. Various technical solutions are used to achieve low energy consumption e.g., energy efficient windows (U-value is 0.8 W/m^2K). The thermal insulation capacity of walls is better than average. The south facade (double facade) has been designed for efficient utilisation of solar panels, which also shade the facade to prevent an excessive heat load in the summer. Natural daylight is utilised by means of, e.g., light shafts. Average U-value of building envelope is 0.259 W/m^2K. Particular attention is paid to air tightness of building.
Energy consumption	Total energy consumption of the building is 85 $kWh/m^2/y$ (the standard for such type of building is double this amount).
Engineering systems	The building utilises district heating, which is based on the energy-efficient cogeneration (about 90% efficiency). District heating is used for hot water preparation and for room heating through central air handling units and hot water radiators. All cooling needs are covered by free cooling from borehole water. The borehole system consists of 25 boreholes, each 250 m deep. The building has an air-conditioning system with mechanical supply, and exhaust ventilation and chilled beams. The ventilation system is equipped with heat recovery.
Project financing	Construction costs were 16.4 million EUR (2430 EUR/m^2).
Key aspects making this building a good practice example	• Bedrock-based cooling is used to cool the premises: cool water for cooling the building is obtained from wells drilled in the bedrock. • Solar and wind power are utilised for electricity production: the roof features solar panels and four city wind turbines. • Solar panels are mounted in a way to shade the southern facade in order to prevent excessive heat load in the summer. • Renewable energy production systems satisfy ca. 20% of the building's energy needs.
Information source	www.hel.fi/hki/Ymk/en/About+the+Centre/Viikki+Environment+House www.hel.fi/hki/hkr/fi/hkr-rakennuttaja/kohteemme/viikin+ymparistotalo/ymparistotalo

Increasing energy efficiency and using RES in the kindergarten in Tartu, Estonia




Photos: Ants Soon, Irina Aleksejeva

Location of the building	Lasteaia 4, Kõrveküla borough, Tartu parish, Tartu county, Estonia
Description of the building	The building of the municipality owned kindergarten was refurbished in 2009. The implemented works included refurbishment of 692 m^2 and construction of an annex of 1844 m^2.
Building parameters	The building comprises stone and small block walls with concrete floors. During the refurbishment works, the walls and roof were insulated. The heated area of the building is 2448 m^2. Solar, geothermal and wind energy is used for room heating and hot water preparation. Gas heating is in reserve.
Energy consumption	Specific energy consumption for heating and hot water: - before refurbishment 558 MWh/y; - refurbishment and installation of local energy production systems allows to cover energy demand for heating and hot water needs.
Engineering systems	The heating system consists of a heat pipe vacuum tube solar heating system (40 collectors, area 160 m^2, annual rate of return up to 212 MWh heat energy) used for preparation of warm water in the swimming pool and the room heating of the kindergarten. Wind turbine with vertical axis (capacity up to 6kW, annual rate of return 7 000 – 1 0000 kWh) is installed. The geothermal heating capacity is 120 kW, annual estimated yield 395.74 MWh. The equipment operates automatically. Parameters are digitally controlled and processed online by using an Internet based environment. In addition, a ventilation system with heat recovery (6 ventilation aggregates) has been installed.
Finances	The total cost of the project is 370 285 EUR.
Key aspects making this building a good practice example	• Combined heating system (solar, wind, geothermal) allows to cover 100% of the kindergarten's room heating and hot water needs. • Redundant power from the periods of spring, summer and autumn is used for heating and hot water of the Kõrveküla school that is located near the kindergarten.
Information source	Leidi Consult OÜ (builder and the designer of the heating system) www.leidi.ee

Increasing energy performance and use of solar thermal collectors in the kindergarten “Kaseke”, in Valga, Estonia



Photos: Maila Rajamets

Location of the building	Kase 6, Valga, Estonia
Description of the building	The building was built in 1966. In 2008-2009 it was reconstructed from a Soviet-time energy-wasting panel house into a modern energy-efficient construction. It is the very first refurbishment with passive house components in Estonia and as a pilot project it has become good learning material for innovative architects. The building has solar collectors on the roof which provide energy for the hot water system and room heating. For internal decoration natural materials were used.
Building parameters	The heated area of this silicate brick construction building is 1156.5m^2. After refurbishment, heat transmission coefficient (U-value) for exterior wall is 0.10 W/m^{2}K; exterior wall (below ground): 0.21 W/m^{2}K; roof: 0.07 W/m^{2}K; floor slab: 0.12 W/m^{2}K; hatch to the attic: 1.00 W/m^{2}K; windows: glazing: 0.51 W/m^{2}K and frame 0.73-0.74 W/m^{2}K.
Energy consumption	Specific energy consumption for heating and hot water: - before refurbishment 250 MWh/y; - after refurbishment 20 MWh/y.
Engineering systems	For providing the room heating, solar thermal collectors are combined with the district heating system. A ventilation system with heat recovery has been installed (declared heat recovery efficiency 92%).
Finances	Construction costs: 1269 EUR/m^2; the total project costs 1.5 million EUR.
Key aspects making this building a good practice example	The building has been planned and designed according to passive house criteria. The implemented measures allowed a decrease in energy consumption of about 12 times.
Information source	http://tuitftp.ut.ee/kindergarten_valga/Kindergarten_valga.pdf http://activethroughpassive.eu/en/passive-house-project-in-ee/example-house

Increasing energy performance and installing a ground source heat pump in kindergarten "Kastanītis", Riga, Latvia

Photos: Daina Indriksone, Irina Aleksejeva

Location of the building	Stērstu 19, Riga, Latvia
Description of the building	This 2-storey public building was built in 1963. It is located far from the district central heating system and therefore a local heat supply system is used. In 2010, refurbishment was performed: the external walls, aisles of windows, basement, and roof were insulated. In addition, the coal fuelled heating system was substituted by a ground source heat pump.
Building parameters	The building comprises classrooms and recreation rooms for 110 children. It is constructed from silica bricks (51 cm) with calcium mortar finishing inside. Before refurbishment, windows and doors were replaced with double glazing panes (U=1.8-2.0 W/m^2K). Insulation of external walls: rock wool (10 cm), window aisles: rock wool (2 cm), basement: EPS (5 cm), roof: rock wool (18 cm) with hydro-isolation (bitumen). The heated area is 1172m^2.
Energy consumption	Specific energy consumption for heating and hot water: • before refurbishment 250-270 kWh/m^2/y; • after refurbishment 99 kWh/m^2/y.
Engineering systems	In the past, the building was heated using coal (105-140 tons per year). For the heat pump system, the ground loop was installed vertically in 10 boreholes, each 120 m deep with a total length of 2900 m of pipes within an area of 300m^2. A 2-stage heat pump (thermal capacity 57.5 kW) was erected. For balancing of heat supply and consumption, an accumulation tank (1000 l, throughput 20 l/min) was added. An electric boiler (150 l) for hot water preparation complements the system. An electric heater (24 kW) has been placed as a reserve. The heating system is optimised by automatic regulation of the room temperature: a reduction in temperature of 2-3°C during nights and on weekends. Heat elements - steel radiators and convectors are supplied with thermostatic regulation valves. Ventilation of rooms is performed by opening the windows.
Finances	Total costs for refurbishment and heat pump - 237 324 EUR. The project was financed by Norway Grants (77.9%) and Riga City Council.
Key aspects making this building a good practice example	• Energy consumption has decreased 10 times, thus halving costs for heat and hot water supply at the same time increasing indoor comfort. • Instead of coal, renewable energy is used, thus reducing environmental impacts e.g., on air quality. • The building received the 1st place award in the category "The most energy efficient refurbished public building in Latvia 2010" in the competition "The most energy efficient building in Latvia 2010" organised by the Ministry of Economics, Ministry of Environmental Protection and Regional Development and the magazine „Latvijas Būvniecība".
Information source	www.rea.riga.lv/rea-projekti/projektu-arhivs?id=35

Increasing energy performance of a municipal police office building and installing solar thermal collectors, Liepāja, Latvia

Photos: Kaspars Vārpiņš

Location of the building	Jelgavas 48, Liepāja, Latvia
Description of the building	The Liepāja municipal police office building was constructed in 1974. The building is used 24 hours per day. Reconstruction works were finished in spring 2011. In order to increase energy performance, the building envelope has been insulated (rock wool 15 cm). In addition, solar thermal collectors have been installed on the roof of the building. The author of the project is „A Projekts" Ltd. and construction company „Kurzemes krāsas" Ltd. The house management is carried out by Liepaja municipal police.
Building parameters	The load bearing walls of this 2-storey high building are made of silicate bricks. The total floor space of the building is 991.9 m^2.
Energy consumption	Specific energy consumption for heating and hot water: • before refurbishment 105.1 $kWh/m^2/y$ in 2010; • after refurbishment 39.8 $kWh/m^2/y$ in 2012.
Engineering systems	Six solar thermal collectors (12 kW total capacity) are installed on the roof of the building providing hot water. Collectors are also connected to the heat supply system complementing the heating received from the central district heating. In addition, a controlled ventilation system with heat recovery has been installed in the basement of the building. Implementation of works was done under the supervision of an energy auditor. Data loggers for recording temperature, humidity and CO_2 in the building have been installed. Personnel are trained on how to use and analyse the recorded data in order to ensure indoor comfort.
Finances	The total costs of the projects comprise 71 967 EUR. The project was financed by the Climate change financial instrument (79%) and Liepaja municipality (21%). The estimated pay-back period for the total investment is 3.5 years.
Key aspects making this building a good practice example	• Considerable reduction of energy consumption for room heating. • Utilising renewable energy source for heating and hot water supply. • The building received the award (second place) in the category "The most energy efficient public building in Latvia 2011" in the competition "The most energy efficient building in Latvia 2011" organised by the Ministry of Economics, Ministry of Environmental Protection and Regional Development and the magazine „Latvijas Būvniecība".
Information source	www.pp.liepaja.lv/?page_id=17

2.7. Practical examples – multi-apartment buildings in Finland, Estonia, and Latvia

Low energy apartment building in Heinola, Finland



Photos: RKL Reponen Oy

Location of the building	Telakkatie 1, 18100 Heinola, Finland
Description of the building	Construction of this building was realised in 2008 – 2009. It is the first low-energy apartment house in Finland.
Building parameters	The building comprises 31 apartments with a total area of 1100 m^2. The concept includes application of energy efficient construction materials and windows. Heat transmission coefficient (U-value) for windows: 0.59 - 0.72 W/m^2K; for exterior walls: 0.10 – 0.14 W/m^2K; and for the roof: 0.08 W/m^2K. The concept of this low energy house also includes modern energy efficient ventilation and heating - the ventilation system collects the heat from all equipment and appliances that produce heat in the apartments.
Energy consumption	20 – 30 kWh/krs-m^2
Engineering systems	The building design sets the target that up to 80% of the room heating can be derived from the heat produced by electrical appliances and the occupants. Some extra heating is needed during the coldest period of the year. The ventilation/heating unit provides both heating and ventilation for apartments.
Finances	The construction of the building was financed from private funding sources.
Key aspects making this building a good practice example	The concept of the building was developed in co-operation between the developer and the Technical Research Centre of Finland (VTT). Practical development of the building was carried out in co-operation with suppliers of innovative building materials. The low energy construction and energy efficient engineering solutions are demonstrated.
Information source	www.rklreponen.com www.merainfo.fi www.kakko.fi

Five-storey wooden-built apartment building in Heinola (Vierumäki), Finland

Photos: RKL Reponen Oy

Location of the building	Jauhokalliontie 2, 19110 Vierumäki, Finland
Description of the building	This five-storey wooden-built apartment building was constructed in 2012. The building is owned by Heinola town.
Building parameters	The building has 27 apartments. The total area of the house is 2123 m^2 (heated floor area 1915 m^2). It is a hybrid construction, in which large wooden elements are joined to the laminated timber structure of the staircase. The frame is reinforced with panel components. The lift shaft is of concrete. The balconies are supported on 215 x 215 mm laminated timber columns. The end-walls and cross-walls are faced with plywood. The dimensioning of the boarding, the constructional details and the industrial manufacture of the components were optimised to provide a standard construction system. Load-bearing external and cross-walls, roof slab and intermediate floor slabs were delivered to the site as ready-to-fix components. The building was designed to be a low-energy house. The staircase and plant-rooms are on the north side of the building, while the apartments, especially the balconies, face the south. The building has very well insulated windows (U-value: 0.59 – 0.72 W/m^2K), exterior walls (U-value: 0.10 – 0.14 W/m^2K), and roof (U-value: 0.08 W/m^2K).
Energy consumption	20-30 kWh/krs-m^2
Engineering systems	Up to 80% of the heating is derived from the heat produced by electrical appliances and the occupants. The ventilation/heating unit provides both heating and ventilation for apartments. Some extra heating is needed during the coldest period of year. Heat energy for this building is supplied by district heating powered by wood chips.
Finances	Private and municipal funding was used for implementation of this project.
Key aspects making this building a good practice example	• The use of construction elements on site allowed to minimise the number of construction stages. The whole building was constructed under a cover inside a tent. Working in dry conditions speeded up installation of the elements. • Fresh air is introduced directly through the external walls and exhaust air is also expelled through the walls. The ducts leading to the flats are fire-proofed. • This wooden construction building received a Finnish Wood Award 2012.
Information source	www.puuera.fi/ www.puuinfo.fi/ajankohtaista/vuoden-2012-puupalkinto-vierumaen-puukerrostalo-asunto-osakeyhtio-puuera www.puuwoodholzbois.com/projects/housing-development-puuera

The largest multi-apartment building fully refurbished increasing its energy performance in Tallinn, Estonia



Photos: Aivar Paabo

Location of the building	Sõpruse pst. 202, Tallinn, Estonia
Description of the building	This apartment building was built in 1970. It is owned by an apartment association. Complete refurbishment increasing the energy performance of the building was performed in 2012-2013.
Building parameters	The total floor area of the building is 9630 m^2. The building has 162 flats. During the refurbishment the entire facade and the roof were insulated; all old windows were replaced with triple glazed new windows. Heat transmission coefficient (U-value) for walls is < 0.17-0.19 W/m^2K; for roof < 0.14 W/m^2K and for all windows < 1.1 W/m^2K. In addition, the heating and ventilation system was also renovated. Hoonele on paigaldatud sundväljatõmbe- ja soojustagastusega ventilatsiooonisüsteem.
Energy consumption	The energy consumption: • before refurbishment 221 $kWh/m^2/y$; • after refurbishment 82 $kWh/m^2/y$.
Engineering systems	The renovated heating system in the building is equipped with individual heat cost allocators. Room heating and hot water supply is ensured by a central heating system and heat pumps (capacity 120 kW). The entire heating and ventilation performance is monitored in real time over the Internet, and thus operatively managed.
Finances	Total investment costs were about 2 062 000 EUR. For implementation a bank loan was used (65%) to complement the grant given by KredEx (35%).
Key aspects making this building a good practice example	This is the largest fully refurbished apartment house in Estonia where energy performance of the building has been significantly increased.
Information source	www.kredex.ee

Heat recovery from the exhaust air in a multi-apartment building in Tallinn, Estonia




Photos: Aivar Paabo

Location of the building	Järveotsa 17, Tallinn, Estonia
Description of the building	This 9-storey multi-apartment building was constructed in 1978. Refurbishment works increasing the energy performance of the building and modernisation of the heating system were performed during 2012-2013.
Building parameters	The building has 72 apartments. Its heated area is 4360 m^2. The house is made of concrete blocks, with a U-value 0.95 W/m^2K before refurbishment and 0.28 W/m^2K after the refurbishment.
Energy consumption	Energy consumption: • before refurbishment 167 $kWh/m^2/y$; • after refurbishment 88 $kWh/m^2/y$.
Engineering systems	The building is connected to the district heating unit with a plate heat exchanger for heating and hot water supply. Exhaust air heat recovery is ensured by the help of two heat pumps (30 kW total capacity). District heating unit and heat pumps are followed and managed automatically via Internet.
Finances	The total project costs were 420 000 EUR, including 74 000 EUR for the heat pump system.
Key aspects making this building a good practice example	Such multi-apartment buildings are very common in Eastern Europe and are very energy-inefficient. The experience of this refurbishment project leading to significant reduction of energy consumption could easily be multiplied in other countries.
Information source	www.profener.ee/referentsid-jarveotsa.html

Increasing energy performance of a multi-apartment building, installing solar thermal collectors and a heat pump, Rēzekne, Latvia



Photos: Juris Romaņenko

Location of the building	Atbrīvošanas aleja 52, Rēzekne, Latvia
Description of the building	This multi-apartment building was built in 1949. Refurbishment works were implemented in 2010; technologies for using RES were installed in 2012.
Building parameters	The 3-storey building is made of silicate bricks. The building has 11 flats. The total living space is 705 m^2. Refurbishment works comprised insulation of external walls (rock wool 100 mm) and the roof (rock wool 150 mm) as well as insulation of the plinth (polystyrene foam 50 mm), basement (extruded polystyrene foam 30 mm) and basement slab (rock wool 90 mm), replacement of old windows and doors, reconstruction of a heating unit, installation of double-pipes heating system and heat consumption meters in every flat.
Energy consumption	Energy consumption for room heating: • before insulation works – 136 kWh/m^2/y; • after refurbishment – 66 kWh/m^2/y. Electricity for hot water preparation for all apartments: • before RES installation – 1000 - 1700 kWh/month; • after RES installation – 130 - 490 kWh/month.
Engineering systems	Ten solar thermal collectors (total capacity 16 kW) and a ground source heat pump (30 kW) have been assembled. For the heat pump system, the ground loop was installed vertically in 10 boreholes (each 60 m deep). The set up technologies ensure the hot water supply all year round and the room heating demand during the heating season. Thus, there is no need for connection to the central district heating system.
Finances	The total costs for refurbishment and installation of technologies for use of RES comprised 205 000 EUR. Implementation was financed by the European Regional Development Fund, State budget, NGO "Green buildings". It is estimated that the payback period of all investments is 15 years.
Key aspects making this building a good practice example	• Significant (51%) reduction of energy consumption for room heating after refurbishment. • Combination of technologies (solar thermal collectors and heat pump) using RES ensures the supply of hot water and room heating. • Heat rate in Rēzekne central heating system in 2012/2013 heating season was 89.1 EUR/MWh but heat rate in the multi-apartment building using local renewable energy resources system was 41.3-46.1 EUR/MWh. Thus, the total heat rate was reduced by 53%.
Information source	www.greenbuildings.lv

2.8. Practical examples - single family houses in Finland, Estonia, and Latvia

Passive house LUPAUS in Valkeakoski, Finland

Photos: Jari Kiuru

Location of the building	Kuikankaari 15, 37630 Valkeakoski, Finland
Description of the building	This very energy efficient single-family house "House Lupaus" was constructed in 2009. The house was presented to professionals and the general public at a housing fair in Valkeakoski 2009 and was chosen as the second best house at the fair.
Building parameters	The total area of the house is 320 brm^2, heated volume: 782 m^3. The house has distinctive arched walls and roof. The walls consist of wooden elements. Stone wool is used for insulation (on the outer walls 480 mm, in the roof 600 mm). Inner walls are made mostly of Finnish wood products. Heat transmission coefficient (U-values) for windows is 0.78 - 0.84 Wm^2/K; walls 0.09 W/m^{2}K; roof 0.06 - 0.08 W/m^{2}K; base floor 0.07 - 0.08 W/m^{2}K; doors 0.60 - 0.72 W/m^{2}K. Air tightness of the building is 0.28 l/h (much better than the target level of passive houses in Finland).
Energy consumption	According to the definition of the VTT Technical Research Centre of Finland, a passive building in Southern Finland requires approximately 20 kWh/m^2 heating energy per year and in Northern Finland approximately 30 kWh/m^2 per year. The calculated energy consumption for house Lupaus is 23.8 kWh/m^2/year.
Engineering systems	Ventilation with heat recovery (80 % efficiency) is installed. The heating system for the ground floor is hydronic under floor heating while for the upper floor, heat from the exhaust ventilation air is used. Energy for heating and warm water is produced mainly with air-to-water heat pump.
Finances	The construction was privately funded.
Key aspects making this building a good practice example	• House Lupaus is a pilot house of VTT´s and Paroc´s passive house research project. • Experiences from the Lupaus project has been utilised when creating a guide of passive house planning for architects (www.passiivi.info).
Information source	www.paroc.fi/~/media/Files/Brochures/Finland/Passive-house-Paroc-Lupaus-FI.ashx www.tts.fi/index.php/galleria/hyvaet-kodit/ekotoimiviaesimerkkeja/lupaus

Low-carbon passive-energy house Tervakukka in Tampere, Finland

Photos: Jussi Koivunen, Ari Ijäs

Location of the building	Kiplinginkuja 1, Tampere, Finland
Description of the building	House Tervakukka is a single-family house constructed in the area built for Finnish Housing Fair 2012.
Building parameters	The gross floor area of this 2-storey building is 258 m^2 (living area 198 m^2). A separate garage is attached to the main building by a bridge-like balcony. Construction materials were chosen so that their carbon footprint would be minimal. The frame of the building is made from engineering wood product I-joists and glued laminated timber (glulam). Insulation material is recycled cellulose fibre. The majority of the internal and external claddings are made from wood panels. The measured air-tightness of the house is 0.6 1/h. The heat transmission coefficient (U-value) for walls is 0.11 W/m^2K, for roof and base floor 0.07 W/m^2K and for windows and doors 0.76 W/m^2K.
Energy consumption	The total primary energy consumption is 128 kWh/m^2/year.
Engineering systems	The building has a hybrid heating/cooling system, which consists of electric floor heating, electric air heating and ventilation with integrated heat pump and heat recovery. In addition, a wood stove and solar thermal collectors heat the household water. The ventilation air temperature is pre-adjusted with underground intake pipes. All electricity is “EKOenergy” (www.ekoenergy.org) labelled green electricity that has zero greenhouse gas emissions.
Finances	House Tervakukka is privately funded. Its construction budget was 434 800 EUR.
Key aspects making this building a good practice example	Much attention has been paid to reduce emissions. Different scenarios of design and use of construction materials were compared. Manufacturing of the wooden version required 30% less energy and caused 38% smaller greenhouse gas emissions than the alternative design. In addition, house Tervakukka proved to have significant carbon storage: over 51 000 kg of CO_2e are stored in the structures. It has been used for a case study in a European research project “€CO_2”.
Information source	http://webon.nss.ee/GB/Tervakukka_nettiversio.pdf www.eco2wood.com

Energy efficient and ecological solutions in Villa ISOVER, Hyvinkää, Finland



Photos: Minna Kuusela, Irina Aleksejeva

Location of the building	Lounatuulentie 11, Hyvinkää, Finland
Description of the building	Villa Isover is a private single-family house constructed in the area built for Finnish Housing Fair 2013.
Building parameters	Villa Isover has two floors. The total area of building is 203 m^2; the heated volume is 507 m^3. The building has very good thermal insulation - heat transmission coefficient (U-value) for the roof is 0.06 W/m^2K and for the base floor 0.09 W/m^2K. The walls of the building are made of prefabricated wood elements with ISOVER mineral wool insulation system and Weber plastering (U-value 0.08 W/m^2K).
Energy consumption	Calculated energy consumption is 43 kWh/m^2/year (the whole house 8 200 kWh).
Engineering systems	The building has hybrid solutions for energy generation. Heat energy is produced by ground source heat pump with water circulation floor heating. The house also has a fire place and a wood heated sauna. Solar collectors (area 6m^2) are used for preparation of hot water. The ventilation utilises an underground piping system, which heats the air in winter and cools it in summer. A ventilation system with heat recovery was installed (>80% efficiency). For electricity production, solar panels (area 60 m^2) were erected. The estimated electricity production is about 8.6 MWh per year. During sunny summer days, electricity generated significantly exceeds the needs of house. Then the surplus is sold to the national grid (the house has two-way metering).
Finances	Privately funded
Key aspects making this building a good practice example	• The house has been constructed with net zero-energy principle combining different renewable energy technologies. • This project proves in practice that implementation of net zero energy house by applying existing construction practices, available construction materials and building technology solutions is possible and also makes economic sense. • The measurement of energy consumption continues after the Housing Fair with several indicators and will be followed up by Motiva.
Information source	www.isover.fi/passiivitalo/seurantakohteet/villa-isover-asuntomessut-2013-hyvinkaa/villa-isoverin-esittely www.asuntomessut.fi/hyvinkaa-2013/17-villa-isover www.energiatehokaskoti.fi/kohteet/seurantakohteet/villa_isover

Use of solar collectors and ground source heat pump in a passive hose in Põlva, Estonia




Photos: Ants Soon

Location of the building	Metsa 5a, Põlva, Estonia
Description of the building	This 3-storey detached single family house was constructed in 2013.
Building parameters	The total floor area of the building is 285 m². The house has a rectangular ground-plan and cubic like shape. Part of the first floor is under ground. The main facade with its large windows is oriented towards the south. The building is designed to be a passive house and therefore incorporates many of the most high-end products available. To increase indoor comfort massive constructions (cross laminated timber), clay indoor walls and clay plaster were used. On the southern walls and roof, solar thermal collectors and photovoltaic panels have been installed. The average heat transmission coefficient (U-value) of the exterior walls is 0.1 W/m²K, basement floor/floor slab 0.09 W/m²K, roof 0.07 W/m²K.
Energy consumption	By using the Passive House Planning Package (PHPP), it is calculated that the annual heating demand of the building will be 15 kWh/m²/y. The total demand on heating, domestic hot water, household electricity and auxiliary electricity will be 101 kWh/m²/y.
Engineering systems	Needs for heating and warm water is ensured by Viessmann Vitocal 300-G BWC heat pump and Sonnenkraft solar thermal panel (30.5 m²) connected to a 2000l reservoir. The heat is distributed via floor and wall heating systems. Heat recovery ventilation with ground heat exchanger preheating is used.
Finances	Private funding
Key aspects making this building a good practice example	• This house is the first passive house in Estonia certified by Passive House Institute, Germany. • High energy performance concept is complemented with solar hot water generation and a photovoltaic system to ensure sustainable energy supply with renewable energy sources.
Information source	www.passiivmajaliit.ee http://sense.ee/#/metsa-5a-polva http://archive.is/GpBHV

Solar energy and natural gas combined for heating of a passive house in Tartu county, Estonia



Photos: Toivo Kabanen, Ants Soon

Location of the building	Pihla 2, Õssu village, Ülenurme parish, Tartu county, Estonia
Description of the building	This single-family house is planned to be finished in 2014.
Building parameters	The total useable area of the house is ca. 152 m^2. The building has a 20 m^2 storage room attached. It is made of pre-fabricated wooden construction elements and concrete floor slabs. The construction elements are well insulated: heat transmission coefficient (U-value) for walls is 0.081 W/m^2K, for roof 0.070 W/m^2K, for floor slabs 0.067 W/m^2K. The building design is created to utilise maximum solar gains during the winter time. The estimated air tightness of the building is 0.4 1/h.
Energy consumption	Estimated heating demand is ca. 14.9 $kWh/m^2/y$.
Engineering systems	Gas, radiators. Gas plus Sonnenkraft Compact E solar system (DHW plus heating) Fresh air supply is controlled through a heat recovery ventilation system.
Finances	Private funding
Key aspects making this building a good practice example	It is envisaged that this house will be the second passive house in Estonia certified by Passive House Institute, Germany.
Information source	www.passiivmajaliit.ee

3. Energy efficient electric appliances to top up energy efficient buildings

3. Energy efficient electric appliances to top up energy efficient buildings

No household can be imagined free of domestic electrical devices. These goods and appliances present a wide variety of devices from large refrigerators to small kettles. For the purpose of financial and market sector analyses, domestic electrical goods can be divided into the following categories: "white goods", "brown goods", "grey goods" and small domestic appliances.

Groups of domestic electrical goods

White goods are e.g., home laundry appliances, refrigeration equipment, cooking appliances, microwave ovens and dishwashers. These are goods formerly finished with white enamel, but now often coloured. **Brown goods** comprise televisions, CD and DVD players, video cassette recorders, camcorders, all audio products and home entertainment systems. 'Brown goods' is a reference to early TVs and radios that came packaged in wooden, wood-coloured plastic or Bakelite cases. Brown goods are all essentially entertainment products. **Grey goods** include computers and mobile telephones. **Small domestic appliances** are e.g., kettles, toasters, coffee and tea makers[111].

A truly energy efficient building is a building where tenants care about energy consumption of their household electric appliances and choose only the most efficient ones. Energy efficiency of an appliance is indicated by the energy label. Products that are labelled with the "old" label (labels that have been put into action through national legislation) are electric ovens, washing machines with drying capability, light sources, air-conditioners and tumble driers. Air-conditioners, tumble driers and light sources and luminaries are now under the new EU energy label. Products already labelled with the EU energy label are refrigerating appliances, (including wine storage appliances), washing machines, dishwashers and televisions.

EU energy efficiency classes of electric appliances

The energy efficiency of electric appliances is divided into classes: from "A" (most efficient) to "G" (least efficient). The energy label is attached to the appliance in the shop. The closer to "A" the device is rated, the more energy-efficient it is. As domestic appliances develop, energy consumption has decreased, so the criteria for energy labelling have also been renewed. The new energy labelling is language neutral, which means that the information content is delivered using symbols, also classes "A+", "A++" and "A+++" have been introduced to the rating. The meaning of the "+" signs varies from one product to the other. For example, in refrigerating appliances a product labelled "A+++" is 60% more efficient than an "A" class product. In washing machines "A+++" is 32% more efficient than "A", and in dishwashers "A+++" is 30% more efficient than "A". "A" is the market minimum in many cases, in refrigerating appliances it is "A+"[112].

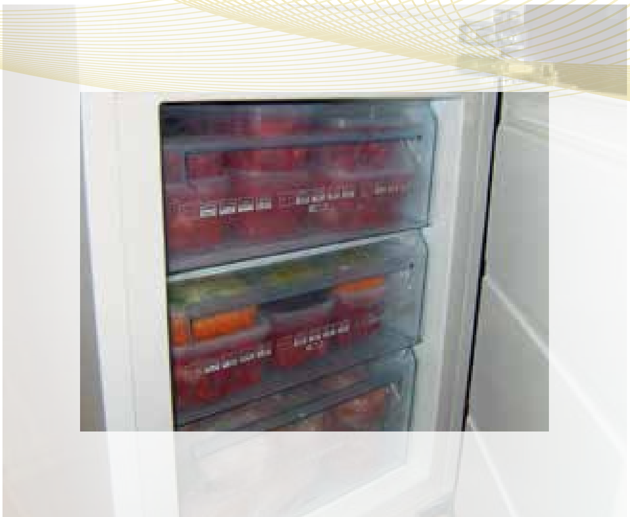
Studies performed in Europe as well as in Finland, show that energy labelling has had a clear effect on the market of "white goods".

[111] Office for fair trading (2010), Domestic electrical goods. Market review of white and brown domestic electrical goods, www.oft.gov.uk/shared_oft/markets-work/oft1287.pdf

[112] Marjomaa T., Reisbacka A., TTS (2013), Conserving energy when choosing and using domestic appliances. TTS's bulletin, Housing, technology and service, 2013 (663B), www.ecohousing-project.eu/wp-content/uploads/2011/08/koti663_UK-a.pdf

Market of energy efficient electric goods

In a study[113] carried out in 10 EU countries the market share of energy efficient refrigerating ("A" class or better) is nearly 90%. An annual survey carried out by Motiva Oy shows that the market of e.g., fridges and freezers has changed in a few years - the share of "A+" and better appliances has increased significantly. In 2012, the share of "A+" and better fridge freezers was 90%, with 20% of the appliances in "A++" class. It is envisaged that the change in market shares will be even more visible in the coming years.



Compulsory energy labelling is a starting point for comparing the energy efficiency of appliances. The energy labelling on domestic appliances aims to help the consumer choose an energy-efficient alternative by giving comparative information on the appliances energy consumption in comparison to other devices of the same size and type. When choosing appliances, the salesperson has an important role in helping the customer to find an energy-efficient device that matches the customer's needs. Furthermore, a device's energy consumption is affected by many additional factors e.g., by the placement of the device, adjustment of the temperature regime, the temperature of the surrounding environment, frequency of use, method of use and maintenance. Well prepared user manuals support the energy-efficient use of the appliance. Experts at Work Efficiency Institute (TTS) are proving consumer guidance in Finland (their advises are summarised in the bulletins of TTS[114]). This chapter highlights information to consumers prepared by TTS experts.

3.1. Freezing appliances (fridges, freezers, and others)

Refrigeration appliances consume a lot of electricity, as they are on at all times. How much and what kind of refrigerated space is required depends on the particular needs. There are many refrigerators, freezers and their combinations on the market.

Aspects to consider when choosing freezing appliances

It is sensible to think about the interior (volume) of the appliance and what size of device is needed, because cooling an empty space is a waste of electricity. The freezing capacity (kg/d) shows how much the freezer can freeze at one time. It is recommended to choose an appliance that has low energy consumption – attention should be paid to the energy efficiency label. Thick insulation decreases the device's energy consumption and lengthens the period of time that it takes for the products to thaw in case of disturbances.

Electronic temperature adjustment technology and clear temperature displays on the outside of the appliance help when choosing and monitoring an energy-efficient storage temperature:

- A "good" temperature for a refrigerator is +5 °C. The storage temperature for a freezer is -18 °C. Every degree below this increases energy consumption by 5%.
- Refrigerators and freezers should have their own temperature adjusters, so the temperatures of the different compartments are not dependent on each other, but can be adjusted independently and correctly.
- Warning lights and alarms increase the safe use and ease of monitoring the temperature.

[113] ComeOn Labels project, www.come-on-labels.eu/about-the-project/welcome-eu

[114] Marjomaa T., Reisbacka A., TTS (2013), Conserving energy when choosing and using domestic appliances. TTS's bulletin, Housing, technology and service, 2013 (663B), www.ecohousing-project.eu/wp-content/uploads/2011/08/koti663_UK-a.pdf

Checklist for energy efficient use of freezing appliances:

1. Does your freezing appliance have enough space? ☐

Refrigeration appliances require space for air circulation. Therefore it is necessary to measure the space available at home, check the external measurements of the device and the need for free air circulation space from the installation manual. Insufficient air circulation may triple the energy consumption of a refrigeration appliance. In addition, placing the device next to a radiator, stove or dish washer increases the energy consumption of refrigeration appliances by 10 -20%.

2. Have you considered the impact of placement of your freezing appliance on energy consumption? ☐

Freezing appliances can stand alone or be integrated into the kitchen units. Appliances mounted into kitchen units consume more energy than devices placed on their own. Integrated refrigeration appliances require special cupboards that take the need for air circulation into consideration.

3. Is the surrounding environment favourable for the freezing appliance? ☐

When the environment's temperature rises from, e.g. +25 °C to +32 °C, energy consumption increases by 25–40%. The refrigeration appliance consumes less energy in a cool, dry and well ventilated space. On the other hand, for operational purposes, devices may not be used at temperatures below +16, +10 or +5°C, depending on the manufacturer.

4. Do you pay attention to sorting of products? ☐

Filling the refrigerator completely full and opening the door often increase the consumption by 15–12%. Keep products in an organised manner and you will find the product you need more quickly. By shortening the time that the door is open, the goods will stay cold and wasteful energy consumption is reduced.

5. Do you pay attention to the food delivery, packaging and thawing conditions? ☐

Cool the foodstuffs before freezing them, for example, in the refrigerator or in the winter on your balcony or porch. This means you can reduce the amount of frost in the freezer. In summer, it is advisable to use a cooling bag to carry food home. Cover or pack the products. Uncovered products give out moisture, which increases the device's thawing requirements and thus also energy consumption. Thaw frozen products in the refrigerator, this gives you free cooling energy.

6. Do you pay attention to good maintenance? ☐

Thaw your freezer regularly. In the winter you can store frozen goods outside while the freezer thaws. Clean the external and internal surfaces and the seals of your device. Vacuum the condenser grill and compressor behind the device regularly.

7. Do you monitor the operation of the freezing appliance? ☐

Clear control panel markings and symbols help in using the device. It is important to read the manual to make sure that the appliance is adjusted correctly. Monitor the temperatures and electricity consumption of your refrigeration devices. If possible, ask your electricity company to loan you an electricity supply meter.

3.2. Food preparation appliances

Food preparation devices e.g., the stove, the microwave oven, the coffee maker and the electric kettle are commonly used in households. Although these devises consume a lot of energy, the user can effect on their energy consumption. For example, electric stove for cooking can consume 200-600 kWh annually depending on practices in use by a consumer.

The heating elements of cast iron cooking plates are in the insulation mass beneath the plate. In ceramic hobs, the heating elements are surrounded by the insulation material and are located under each cooking plate under the hob. Ceramic hobs may also have induction plates with induction technology, which produces electromagnetic fields between the induction coil and the pot. Induction technology warms the base of the pot, not the cooking plate. Conventional cooking plates may have special functions which ensure well timed adjustment of power or time. Follow these instructions to make sure that the stove does not consume energy on maximum power or stay on unnecessarily.

Ovens are either warmed from below and from the top or they are combination resistance ovens, which may also include convection oven functions and possibly steam oven functions. It is advisable to think about the features needed. It is sensible to choose an appliance that has low energy consumption.

Different energy efficient alternatives for food preparation appliances

Microwave ovens. A microwave oven is about 1/3 more energy-efficient than a traditional cooking plate when cooking for one or two people. Warming a ready meal in a microwave oven consumes about 10% of the electricity that would be consumed when using a traditional oven.

Induction stove. Induction stoves are energy-efficient and safe. They consume about 40% less energy than cast iron plates and about 20% less than traditional ceramic cooking plates. However, use of induction stove require special pots.

Convection oven. A convection oven does not require pre-heating. Convection function allows you to bake 2-3 oven trays simultaneously. Baking time is reduced by 15-50% depending on the number of trays. Baking takes place at a temperature that is about 20 °C lower than in traditional ovens, which saves about 30% of the electricity.

Small appliances. Small appliances e.g., kettles and coffee makers, are faster and more energy-efficient in use than traditional cooking plates. Small appliances, such as small grills and roasters, are energy-efficient and often also faster alternatives to the oven.

Checklist for energy efficient use of food preparation appliances:

1. Do you consider the size of portions when cooking? ☐

It is advisable to choose a cooking device and dish in accordance with the quantity and method of cooking e.g., to use microwave ovens for thawing, heating or baking small amounts. In general, the use of small appliances allows preparation of portions most energy-efficiently. It is more energy efficient to boil food in small amounts of water and only heat the amount that is needed for immediate consumption.

2. Do you use good quality pots and lids? ☐

Using good quality pots with thick bottoms and a lid is more energy efficient. The base of the pot may be a little bit larger than the hot plate. For speeding up the cooking process and improving distribution of heat it is necessary to cover the food with a lid.

3. Do you apply pre-heating of products? ☐

Many foods and pastries can be put in the oven when it is still cold, which saves about 10-20% of the electricity.

4. Do you take advantage of residual heat? ☐

By decreasing the power of the cooking plate in time it is possible to take advantage of residual heat. Even 30 minutes after the oven has been turned off, the temperature remains over 100 °C. Taking advantage of the oven's residual heat allows a saving of about 10% of electricity.

5. Do you make rational use of kitchen devices? ☐

It is advisable to avoid using the extractor fan when not needed. Although the extractor fan does not use much energy, it removes heat. It is preferable to keep pots and the cooking area clean.

3.3. Washing appliances (dishwashers, washing machines)

The most important environmental impacts of washing appliances are related to their electricity and water consumption. The appliance's water consumption has an effect on the electricity consumption. Most of the electricity used by the machine is used to heat the washing and rinsing water. New machines use less water; their electricity consumption depends on the washing program used.

Aspects to consider when choosing and installing washing appliances

It is wise to choose the most energy efficient appliance, as the class A+++ are at least 30% more energy efficient compared to the class A devices. The energy consumption on the label is the consumption for the basic program. For example for washing machines, the consumption on the label is based on programs "cotton 60 °C" and "cotton 40 °C", full and half loads. It is important to look for the consumption of different programs in the manual.

Washing appliances should be connected to the water supply system: washing machines are connected to the cold water supply, and dishwashers are connected to a warm or cold water supply. If the machine is connected to a cold water supply, it is worth keeping in mind that in the winter the incoming water's temperature is less than 10 degrees. This prolongs the washing time and increases electricity consumption. The energy consumption on the energy labels are based on an incoming water temperature of +15 °C.

In Finland, the warm water supply for a dishwasher is an energy-efficient alternative:

- The warm water supply shortens the washing time by as much as 35 minutes and decreases energy consumption by 20-60%. With quick wash programs the savings may be even higher.
- According to research, the incoming 60 °C water cools to 35-40 °C after entering the washer, as the cool dishes and machine absorb some of the heat.

Although the main principles of dishwashers and washing machines in operation are similar, differences appear in their energy efficient use.

Checklist for energy efficient use of dishwashers:

1. Do you consider the usefulness of the dishwasher? ☐

A machine wash uses less water than a hand wash when the machine is full. Newer machines use about 10 - 12 litres of water per program and about 1 kWh of electricity per wash.

2. Do you operate the dishwasher on the full load? ☐

Washing full loads is energy-efficient. It is wise to think about basket solutions for your dishes and also consider what size machine is needed. Small households should use small machines. Large machines use significantly more water and electricity than small machines.

3. Do you pay attention to sorting of dishes when loading the dishwasher? ☐

Be organised when loading the machine. Avoid rinsing the dishes before the wash under running water but instead choose the program on the basis of the dirtiness of the dishes. Coffee sets become clean with shorter programs, whereas dining sets that have sat in the washer for a couple of days need a more powerful program with pre-rinse.

4. Are you aware of energy consumption of different washing programs? ☐

It is advisable to check the program functions in the manual, as the names/ symbols may be misleading. The automatic program controls water consumption and wash temperature in accordance with the quantity and the dirtiness of the dishes. This affects electricity consumption and the duration of the program.

- The half load option, which reduces water consumption by 0.5 - 4 litres (10%). The half load option reduces electricity consumption by about 16%.
- Quick and light wash programs use lower wash and rinse water temperatures and/or the program is shorter than normal. Some programs skip the pre-rinse.
- Energy saving programs or eco-programs wash the dishes at temperatures of 50 - 55 °C. Reducing the water temperature from +65 °C to 55 °C reduces the energy consumption of the large machines by 25 - 55% and small machines by 40 - 50%.
- The programs run for 1 - 3 hours. The quick program is the shortest and usually the least energy consuming.

5. Are you aware of appropriate detergent dosing? ☐

Follow detergent dosage instructions. Too much detergent adds to the need for rinsing. Use 30 - 50 g (2 - 3 table spoons) of citric acid powder to get rid of deposits. Clean the waste filter regularly so the automatic programs run as energy-efficiently as possible.

Checklist for energy efficient use of washing machines:

1. Do you operate the washing machine on the full load? ☐

Washing full loads is energy-efficient. It is wise to consider what size machine is needed and choose a small load machine if small amounts of laundry are washed frequently.

2. Are you aware of water consumption? ☐

New washing machines use about 50 litres of water, 10–20 litres of which are warmed during the wash. Additional rinses increase water and electricity consumption, but often they are necessary to achieve good rinse results.

3. Are you aware of energy consumption of different washing programs? ☐

The electricity consumption of doing the laundry is affected by the washing temperature and the amount of laundry being done at once. Choose the washing temperature and program in accordance with the care instructions and dirtiness. The electricity consumption of washing a load of coloured laundry doubles when the temperature is increased from 40 to 60 °C or from 60 to 85 °C. A 60 °C program uses about 1 kWh of electricity. A low washing temperature should be used for laundry that is not very soiled.

- The names of the programs vary from manufacturer to manufacturer, so their contents have to be checked in the manuals. The energy and water consumption of quick and other short programs is usually a little lower than on basic programs, but the loads are usually only half of the full load. Also, the spin result is usually worse, which increases the electricity consumption of drying.
- Eco-programs are usually long and they are used to replace high temperature programs.

4. Are you aware of appropriate detergent dosing? ☐

Follow detergent dosage instructions. Too much detergent adds to the need for rinsing. Some machines have programs that use little electricity as they do not warm the water. In these cases, the detergent used is designed for a cold wash.

5. Are you aware of energy consumption of different spin cycles? ☐

Spin results have a great effect on the electricity consumption of drying laundry. High spin speeds leave little residual moisture in the laundry, which makes it dry quickly in the dryer and energy efficiently. Most small machines have spin speeds of at least 1 000 revolutions per minute (rpm), which leaves 60 - 70% of residual moisture in cotton. When the rpm of the spin increases from 1 000 to 1 600, the drying takes up to 25% less electricity.

6. Do you make rational use of washing machines? ☐

Clean the seals of the loading door after every load. Clean the detergent and fabric softener compartments and the lint trap regularly. Once in a while wash with as high a temperature as possible and use 100 g (1.3 dl) of citric acid powder to remove sediments.

3.4. Tumble dryers

Currently the market offers different types of tumble dryers: conventional and other more energy efficient dryers.

Aspects to consider when choosing and installing tumble dryers

In conventional dryers, air passes through the drum and needs to be constantly supplied and heated up. In small spaces, the environment may warm up so much that the machine does not get enough replacement air. When the temperature of the room increases over +30°C, the electricity consumption of these machines may double. The electricity consumption of air condensing dryers increases in poorly ventilated warm spaces, such as small bathrooms in apartment buildings.

Heat pump dryers use a closed circuit system where the air is efficiently recycled and energy is conserved within the drying system. Although having higher appliance costs, such advanced systems have several advantages in comparison to conventional tumble dryers - lower energy consumption by 40 - 50%; returns very small amounts of condensation back into the room; lower drying temperature by about 25% for all drying programmes.

It is sensible to choose an appliance that has low energy consumption. Energy consumption and drying time of laundry with different methods.

	Drying time	**Energy consumption**
Line-drying in dry indoor air	8 h	1.4 kWh (heat energy)
Dryer - air condensing dryer - dryer using a heat pump	 1 h 10 min 1 h 20 min	 2.1 kWh (electricity) 1.0 kWh (electricity)
Drying cabinet	1 h 30 min	2.2 - 2.8 kWh (electricity)

When paying attention to the energy efficiency of the appliance, it is advisable to take into account that the information on the energy label is based on 60% residual moisture in cotton laundry, which is achieved with spin of about 1000 rpm. The electricity consumption may be as much as 1 kWh smaller than that on the label if your washer has a more efficient spin.

Checklist for energy efficient use of tumble dryers:

1. **Do you consider the usefulness of the tumble dryer?** ☐

   Tumble dryers are suitable for homes or flats where it is difficult to dry clothes within a flat or outside the building e.g., in a yard.

2. **Are you aware of energy consumption of different drying regimes?** ☐

   Tumble dryers use about 2 - 5 kWh of electricity when drying cotton laundry at maximum power. Choose the dryer program to suit the final treatment. Dry the same types of materials together so that the dryer's moisture sensor can choose the correct drying time. If you are going to iron or mangle the laundry, you can leave it a bit wetter than if you were to put it directly into closets. The shorter drying time eases the final treatment and reduces electricity consumption. Drying laundry to iron dry consumes 30% less electricity than drying it to closet dry.

3. **Do you operate the tumble dryer in an energy efficient way?** ☐

   In order to save energy, laundry should be spun as dry as possible before drying. Drying full loads is energy-efficient. The heat given out by the dryer increases the room temperature rapidly, which lengthens the drying time and increases electricity consumption. Keep a window or a door open during drying to keep the room cool and provide the dryer with sufficient air.

4. **Do you make rational use of washing machines?** ☐

   Regular cleaning is important to allow air to circulate in the dryer freely. When there is a lot of lint in the machine, drying becomes slower and electricity consumption increases. Clean the lint trap and empty the water container after drying if the water does not go directly to the drain and clean the condenser/heat exchanger regularly as instructed in the manual. The blockages stop air flow, prolonging drying times and increasing the device's electricity consumption.

4. Energy saving in households: results from the EcoHousing project questionnaire on households

4. Energy saving in households: results from the EcoHousing project questionnaire on households

Everyone can save energy by changing their consumer behaviour, for instance by using heat and electricity produced from renewable energy sources, by using domestic appliances optimally and by choosing products that are durable and use less energy. The target of the "EcoHousing" project survey was to collect information on consumers' attitude towards energy saving in households, heating systems, lighting habits and criteria for purchasing electric household appliances in Finland, Estonia, and Latvia. The survey was also intended to find out what kind of consumer energy advice is needed and what should be done to improve energy efficiency at home[115].

4.1. Target and method of the survey

The survey was aimed to assess the attitude of respondents towards energy saving at home, heating and lighting practices, energy efficient household appliances, including criteria for purchasing, installing, use and maintaining at home. The research method was to collect national information from Finland, Estonia and Latvia. The survey was open from December 2011 until February 2012. In total, 1019 completed questionnaires were received by 590 respondents from Finland, 244 respondents from Estonia, 172 respondents from Latvia and 13 respondents from other countries (Table 4.1). This survey was carried out by convenience sampling and thus cannot be considered as being representative for the whole country.

[115] Kuusela M., Marjomaa T. (2013), Ecohousing market research survey for heating systems and home appliances. Result analysis from a survey in Estonia, Latvia and Finland, www.ecohousing-project.eu/wp-content/uploads/2013/04/Ecohousingmarketsurvey_Raport_13.pdf

Table 4.1. Method of collecting the data in Finland, Estonia and Latvia

Country	Number of respondents	Method of collecting the data
Finland	590	Online
Estonia	244	Online, paper version distributed and interviews by students
Latvia	172	Online, paper version distributed and interviews by students
Other	13	Online
Total number of respondents	1019	

Initial evaluation of the answers showed similar patterns in the countries of survey. Therefore, the results have been summarised from all the responses without country specific indication.

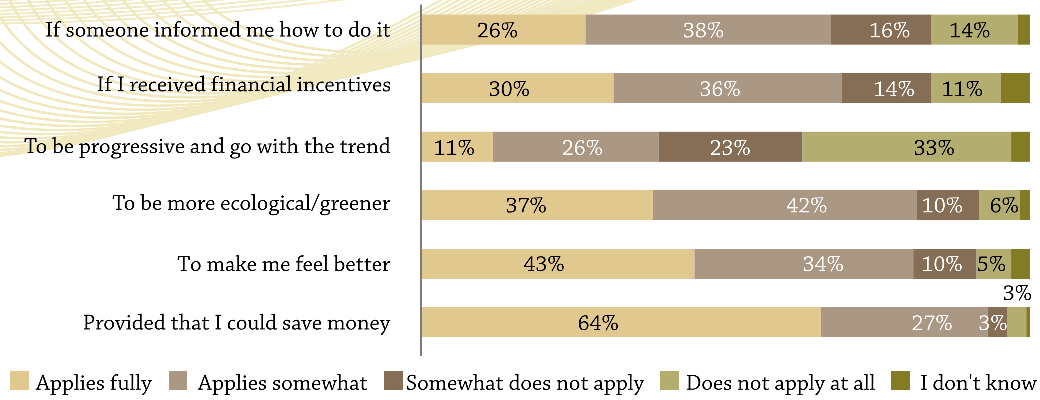
Approximately 40% of the respondents were female and 60% of the respondents were male. Half the respondents were between the ages of 31-60 years. The age group between 21-30 years made up 25% of all respondents. In general, the respondents were with a higher education. About half the respondents lived alone or in two-person households. Almost 50% of the respondents lived in detached houses and almost 40% lived in apartment houses. 25% of respondents lived in fairly small apartments (< 60 m^2), while 7 % of respondents lived in large apartments (> 200 m^2).

4.2. Attitude towards energy saving at home

Respondents were asked to indicate the main drivers that would motivate them to save energy at home. The results are summarised in Figure 4.1. It seems that the financial aspects are among the main drivers, as over 90% of the respondents would be more encouraged to save energy if it was also possible to save money. Almost 70% of the respondents would be more encouraged to save energy if they received financial incentives.

Figure 4.1. The motivation drivers to save energy at home.

Question: To what extent do the following statements apply to you? I would be even more eager to save energy…



The respondents' answers indicate self-esteem as an important motivating factor. Nearly 80% of the respondents would be keener to save energy in order to feel better as well as being more ecological/ greener. Only 37% of the respondents would be more eager to save energy in order to be progressive and go along with the trend.

Providing guidance can be an important factor to motivate people to save energy as approximately 2/3 of the respondents would be more encouraged to save energy if someone informed them how to do it properly.

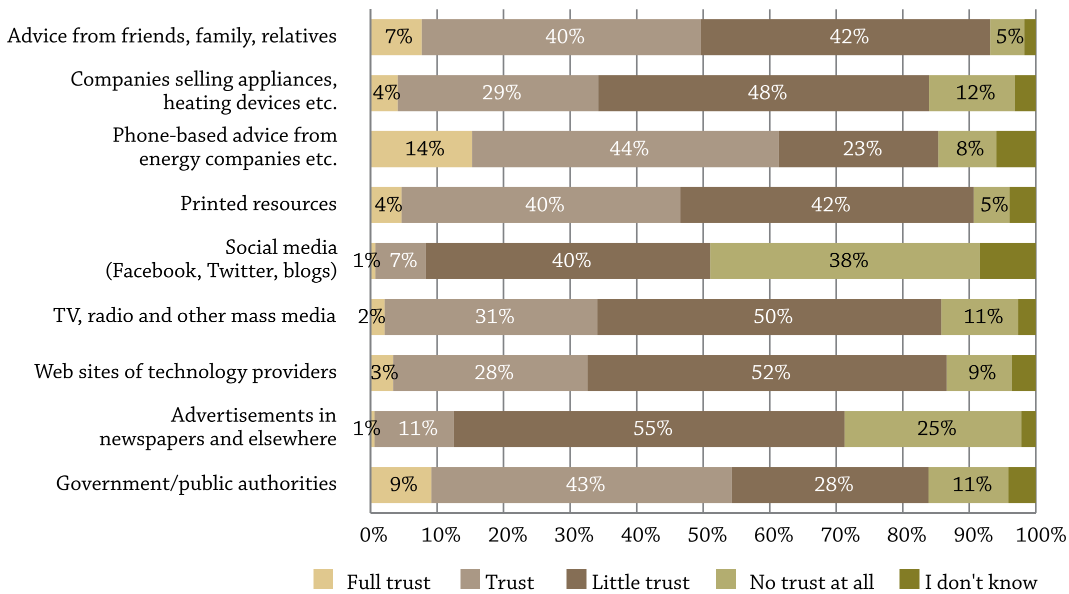
4.3. Trust in information sources providing energy-saving advice

There is a large variety of possible information sources to convey messages on energy saving e.g., personal communication, social and mass media, printed materials, energy and technology providers, public authorities. The positive impact will depend on the trust of consumers towards the particular advising source.

Results from the survey indicate high trust in personal communication on energy saving measures (Figure 4.2). The survey revealed that phone-based

Figure 4.2. Trust in information sources providing energy-saving advice.

Question: Which sources of energy-saving advice do you trust most?



consultations by experts are a good way to share general knowledge about energy efficient housing. Almost 60% of the respondents had full trust or trust in the phone-based advice from energy companies. About half the respondents trust the energy-saving advice given by friends, family and relatives. However, 1/3 of respondents trust companies selling appliances, heating devices, etc. Governments and public authorities as energy-saving advisers are trusted by more than 50% of respondents.

Printed information resources, except advertising materials, are trusted by 44% of respondents. Advertisements in newspapers and elsewhere are trusted only by 12% of respondents and 25% do not trust such information sources at all. TV, radio and Internet websites, including those of technology providers are trusted by at least 1/3 of respondents. Whereas, social media (Facebook, Twitter, blogs) was the least trusted. Moreover, almost 40% of the respondents do not trust these sources at all.

4.4. Heating and hot water preparation systems

Respondents were asked to answer what kind of room heating and water heating systems they have. More than half the respondents indicated using various renewable energy sources (RES) for room heating at home (other sources are electricity, district heating, oil, gas etc.). Almost half of households heat water by electricity, while boilers using RES are also common. The use of wood fuel takes precedence considerably from renewable energy sources.

Sauna heating.
Saunas are very common in Finland but it is also used in some apartments in Estonia and Latvia. About 60% of respondents indicated that they have a sauna. About 40% of saunas are heated with wood and the rest are heated with electricity. Usually, the sauna is heated once or a couple of times a week and it is switched on for 1-2 hours at a time. Saunas use a lot of electricity. It is important that it is switched on only for as long as it is in use.

Among the main motivating factors favouring the choice for wood fuel based facilities are, lower price for fuel and technology, environmental aspects and better comfort. Heat pumps and solar thermal collectors are used to a lesser extent. Heat pumps are a widely used solution in Finland, but in Estonia and Latvia they are less common. The majority of heat pump users use them for heating as a supplementary option (air-to-air heat pumps are the most common). In addition to the main purpose of heating, heat pump devices are used also for cooling.

Comfortable room temperature.
Heating should provide a comfortable room temperature in any weather conditions. Comfortable room temperatures can differ for individuals depending on their activity, health condition and age. The World Health Organisation recommends 21°C as a comfortable temperature in living rooms and 18°C in other rooms. For people with respiratory problems or allergies, a room temperature of at least 16°C is recommended. For elderly, ill, disabled people or infants, a room with 22°C is recommended. In order to adjust the temperature in each room, it needs to be possible to regulate the temperature separately for each radiator e.g., to equip radiators with thermostatic valves[116].

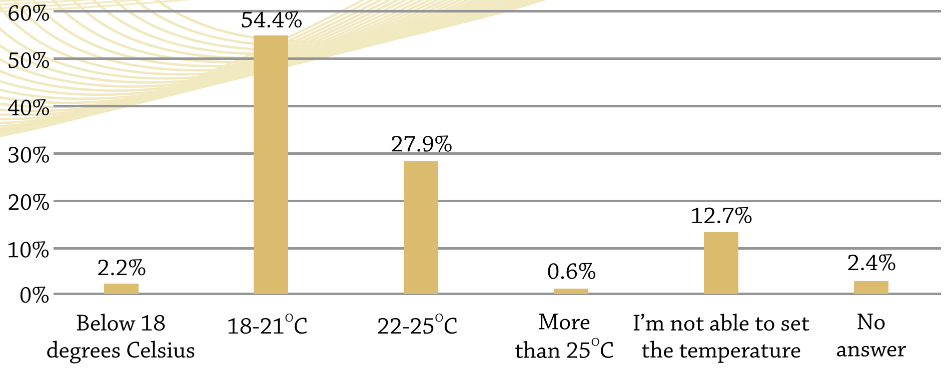
Respondents were asked to indicate the typical room temperature they set. Over half the respondents answered that the room temperature in their apartment or house is between 18-21°C or less. However, room temperatures between 22-25°C were also quite common. About 13% of respondents indicated that they are not able to select the room temperature on their own.

When being asked about their typical room heating practices, 56 % of respondents mentioned that they keep their bedroom cooler than other rooms. Almost

[116] Baltijas Vides Forums, Rīgas enerģētikas aģentūra (2011), Siltumsūkņu izmantošana ēku siltumapgādē, www.rea.riga.lv/files/Kastaniitis_publikacija.pdf

Figure 4.3. Typical room temperatures.

Question: What is the typical living room temperature you set for day time during the winter season?



35 % of the respondents set the temperature lower when leaving home for a longer period. Monitoring the functioning of thermostats and setting them in an energy-efficient way and the use of fireplaces for heating are other methods applied to maintain comfortable room temperatures.

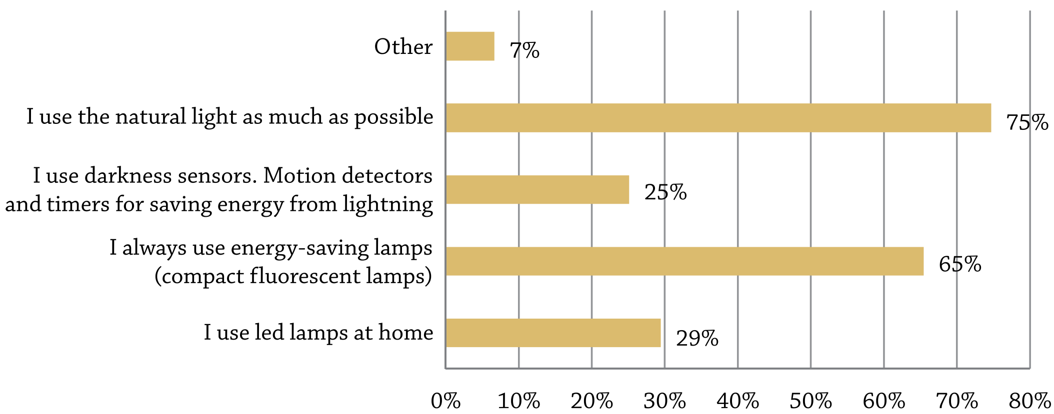
4.5. Lighting practices

There are many different kinds of lamps available today for homes, from energy-saving small fluorescent lamps to light-emitting diode (LED) and halogen lamps. It is easy to improve the energy efficiency of indoor lighting through good planning and the choice of the right types of lamps. In accordance with the EU legislation incandescent lamps and certain inefficient halogen, fluorescent and discharge lamp models are gradually being phased out[117].

When being asked about lighting practices at home, the majority of respondents indicated that they care about energy efficient lighting. About 75 % of respondents try to use natural light as much as possible. Twilight sensors, motion detectors and timers for saving energy are also used by 25 % of respondents. 65% of respondents use compact fluorescent lamps and 29% apply LED lamps at home (Figure 4.4).

Figure 4.4. Lighting practices.

Question: Which of the following statements best describes your lighting practices at home?



[117] European Commission - MEMO/09/368 (01/09/2009), FAQ: phasing out conventional incandescent bulbs, http://europa.eu/rapid/press-release_MEMO-09-368_en.htm

4.6. Domestic electrical appliances

There are various factors that can be considered when making decisions on the purchasing of domestic electrical appliances e.g., fridges and freezers, dishwashers, electric ovens and stoves, washing machines, dryers and smaller electric kitchen appliances. Respondents were asked to select 3 factors that most strongly influence their purchasing decision. About 70% of respondents admitted that good quality and energy-efficiency are the most important aspects influencing their decision when purchasing domestic electrical appliances (Figure 4.5). The results indicate that most consumers are ready to pay more if they get better quality and energy efficient solutions - only 20% of respondents have pointed out that a lower price is determinative.

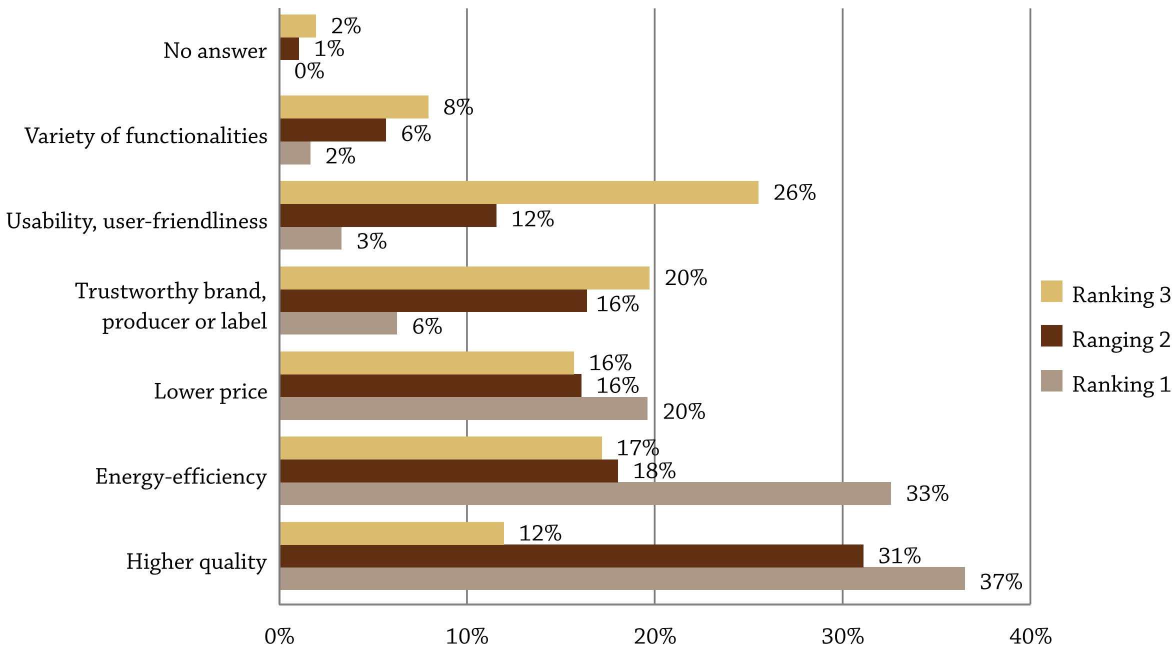
Almost all the respondents had a refrigerator; about 90% also had a freezer, washing machine and oven. Approximately 70 % of all responders also have a dishwasher.

Refrigeration appliances

From the respondents, 63% have a refrigerator with a freezer section, 41% upright freezer, 34% refrigerator without a freezer, 25% chest freezer and 12% of respondents use a cellar or other non-technological solutions for cool storage. With respect to energy efficiency classes about 62% of respondents have a refrigerator of "A" or better energy efficiency class. However, the placement and appropriate operation of the device contributes to the desired energy performance.

Respondents were asked "*What is the location of the refrigeration appliances in your home?*" A freestanding location in the kitchen or other warm room was most common in this survey, with 53% of answers, 45% of refrigerators were fitted into the kitchen units and 7% integrated in the kitchen furniture. About 16% of answers indicated a free standing refrigerator in a cool or unheated room.

Figure 4.5. Important criteria when choosing home appliances.
Question: What are the three important factors infl uencing your decision when purchasing a home appliance?



Consumers were asked if they had experienced problems with their refrigeration appliances. Almost 70% of respondents were satisfied with their refrigeration appliances, but some respondents have had problems such as frost inside the refrigeration appliance or water in the bottom of the fridge.

Evaluation of the answers received by the respondents indicates that devices are of quite high quality but they are not always installed according to the manufacturers' instructions. Almost 20 % of the respondents indicated that a heat-generating device is located next to the fridge or freezer.

Washing machines

Close to 60% of respondents have an "A" or better energy efficiency class washing machine in their household. Over 10 % of respondents use their washing machine once a day or more. The most common habit is to wash laundry 1-2 times a week, as 43% of the respondents do. About 30% of respondents use the washing machine 3-4 times a week. Washing full loads is energy-efficient and nearly 80% of the respondents usually wash full loads.

According to the TTS the electricity consumption of washing a load of coloured laundry doubles when the temperature is increased from 40 to 60°C or from 60 to 85°C. A low washing temperature should be used for laundry that is not very dirty. Over 40% of respondents indicated that the usual washing temperature they use is between 30-40°C. About 30% of the respondents said that they adjust the temperature depending on the laundry.

About 65% of the respondents were satisfied with their washing machines but some of the respondents have had some problems e.g., bad rinsing quality, prolonged washing programs, poor washing quality and water staying in the machine. 4% of the respondents said that their machine smells and looks dirty. According to TTS it is good to occasionally use the highest washing temperature possible as it is good for the washing machine, prevents bad odours and cleans it. About 25% of the respondents wash their laundry with the hottest possible water or run the machine with the hottest water together with citric acid or special cleaning powder. Typical cleaning operations are cleaning the filter and washing power drawer from time to time, as almost 50% of the respondents do.

According to the results, it seems that people know how to use their washing machines in energy efficient way but on the other hand there is a lack of awareness about proper maintenance of these devices.

Tumble dryers

Just fewer than 30% of respondents possess tumble dryers, of which every fourth device is of "A" class or better energy class. The most common habit is to use the dryer from one to four times a week. Drying

full loads is energy-efficient and the majority of respondents indicate that they dry full loads.

Consumers were asked if they have experienced problems with their tumble dryer. Over 70 % of the respondents were satisfied but some of the respondents have had problems such as bad drying quality, the drying taking much longer than expected, the room temperature rising too much and the dryer stopping for a while.

Several questions were asked about the maintenance and cleaning practices of tumble dryers. According to the answers of the survey and evaluation by TTS experts, it seems that energy advice is needed, especially for the correct and energy efficient use and regarding maintenance of the dryer.

Ovens

About 35% of respondents have an oven of "A" or better energy efficiency class in their household. The most common habit is to use the oven a couple of times a week as about 50% of the respondents do. Half the respondents indicated that their habit of using the oven varies a lot between cooking and baking. Every fourth respondent does not use the oven for small portions but uses a microwave oven instead when there is a need to defrost or warm a small portion of food. More than 1/3 of answers indicate that users take advantage of the oven's residual heat and switch the oven off in good time before removing the food from it, make more food at the same time, or try to fill the oven up every time they cook or bake.

Dishwashers

42% of respondents have a dishwasher of "A" or better energy efficiency class in their household. Only 17% of the respondents who have a dishwasher use it every day and 40% of the respondents use the dishwasher one to four times a week. Although a pre-wash of dishes is not necessary, 20% of the respondents always do it before the machine wash. Washing full loads is energy-efficient but only 60% of the respondents usually wash full loads of dishes. Almost 60% of the respondents indicated that the usual washing temperature that they use is between 50-55°C. According to the results it seems that energy advice is needed especially for correct loading of the dishwasher.

A little more than 40% of the respondents were satisfied with their dishwashers but some of the respondents have had problems such as poor washing quality, prolonged washing programs or stain-covered dishes. TTS' tests have shown that it is good to clean the waste filter regularly so the automatic programs run as energy-efficiently as possible. It is recommended to sometimes use the highest washing temperature possible as it is good for the dishwasher, prevents bad odours and cleans it.

5. Policy targets and national legislation in Finland, Estonia and Latvia

5. Policy targets and national legislation in Finland, Estonia and Latvia

5.1. Energy performance of buildings

Policy targets

Energy efficient construction and energy savings are among the national priorities in Finland[118], Estonia[119] and Latvia[120]. National policy documents e.g., strategies, reflect the current situation in the country and indicate the direction of further developments taking into account local circumstances with respect to increasing the energy performance of buildings. In order to monitor the progress achieved in energy savings, all Member States are obliged to submit their national energy efficiency action plans[121] regularly to the European Commission.

Finland

Presently, the policy related to energy performance of buildings in Finland is reflected in:

1) Long-term Climate and Energy Strategy, period of action: 2008 - 2020 and 2050 (2008, updated in 20.3.2013);
2) Action program "For an Energy-Smart Built Environment 2017" - ERA17 (2010);
3) Programme of the Finnish Government (2011);
4) Finland's Second National Energy Efficiency Action Plan (NEEAP-2) (2011).

The **Long-term Climate and Energy Strategy** sets the guidelines up to 2020 for reaching the targets for reducing greenhouse gases, energy procurement, renewable energy and energy efficiency in Finland. In addition to this, it sets out a vision until 2050. The strategic objective is to halt the growth in energy end-use and to stay at 310 TWh in 2020. However, it may be challenging to reach the goal as the prediction made in 2008 referred to lower energy consumption than it turned out in practice[122].

Initiated by the Minister of Housing, a group of experts have elaborated the **action program ERA-17 for an Energy-Smart Built Environment 2017**[123] setting an ambitious goal to reach the EU energy efficiency targets by 2017, (3 years earlier as the EU 20-20-20 target). The actions recommended in ERA-17 are aimed at energy-efficient land use, decentralised energy production, construction guidance, property use and ownership, and competence development. ERA-17 highlights the role of municipalities expected to take a leading role in promoting energy-smartness. Local energy-efficiency strategies must specify objectives for planning, land acquisitions, and energy production, as well as set energy-efficiency targets for municipally-owned buildings and buildings within local jurisdiction.

The **Programme of the Finnish Government**[124] sets out the main functions of the Government with respect to energy efficiency. Particular attention will be paid to public buildings and the apartment

[118] National Climate and Energy Strategy, Finland, www.tem.fi/index.phtml?l=en&s=2542

[119] National Reform Programme "ESTONIA 2020" (approved by the Government on 25 April 2013), http://valitsus.ee/en/government-office/estonia-2020

[120] Latvian energy long term strategy 2030 - Competitive energy for society (Energy Strategy 2030), www.em.gov.lv/em/2nd/?lng=en&cat=30169 // Latvijas Enerģētikas ilgtermiņa stratēģija 2030 – konkurētspējīga enerģētika sabiedrībai, www.em.gov.lv/em/2nd/?cat=30166

[121] Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on energy end-use efficiency and energy services and repealing Council Directive 93/76/EEC, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:114:0064:0064:en:pdf

[122] Kansallinen energia- ja ilmastostrategia (2013) // National Energy and Climate Strategy, www.motiva.fi/files/7315/Kansallinen_energia-_ja_ilmastostrategia_Valtioneuvoston_selonteko_eduskunnalle_20.3.2013.pdf

[123] ERA17 – For an Energy-Smart Built Environment 2017 http://era17.fi/en/, www.ymparisto.fi/download.asp?contentid=122035&lan=fi. According to the Action program, an energy-smart built environment refers to an energy-efficient, low-emission, high quality built environment that employs all necessary means to mitigate climate change.

[124] Programme of the Finnish Government, 22 June 2011, http://valtioneuvosto.fi/hallitus/hallitusohjelma/en.jsp

stock, addressing energy efficiency in construction and refurbishment. The quality of construction and design will be enhanced by emphasising the designers' qualifications and improving the education opportunities for people in the sector. Wood construction will be supported. With regard to the energy-efficiency calculation of buildings, a life cycle calculation approach, that takes into account the manufacture of construction materials and products, will be promoted. The favouring of options with the least harmful environmental effects will be adopted as a principle for public construction projects. New and innovative refurbishment practices will be promoted.

According to **Finland's Second National Energy Efficiency Action Plan**[125] renovation of the existing buildings stock will continue in 2010-2020. In 2012, the Ministry of the Environment produced a road map for improving the energy efficiency of new buildings with the aim of achieving nearly zero-energy construction. It is envisaged that all new public buildings will be nearly zero-energy buildings from the year 2019 and all new buildings will reach the same target in year 2021.

Estonia

The national policy in Estonia in the field of energy efficiency of buildings is reflected in:

1) Estonian National Housing Development Plan 2008–2013 (2008);
2) 'Estonia 2020' competitiveness strategy (2011, updated in 2012);
3) The second energy efficiency action plan of Estonia (2011).

The **Estonian National Housing Development Plan 2008–2013** describes the situation in the housing sector of Estonia, its problems, future perspectives, measures and activities required for achieving the targets. The main aims are ensuring access to suitable and affordable housing for the population of Estonia, high-quality and sustainable housing stock and diversified residential areas that are developing in a balanced and sustainable manner. The measures indicated are e.g., increasing the quality and energy performance of buildings, increasing awareness of energy efficiency measures, mapping the condition of the housing stock, improving the legal environment and raising administrative capacity.

The **'Estonia 2020' competitiveness strategy**[126] comprises a **National Reform Programme "Estonia 2020"**, action plan and reforms establishing targets for increasing competitiveness of Estonia for 2015 and 2020 in compliance with the objectives of the EU 20-20-20. With respect to energy efficiency of the existing building stock, it is planned to promote investments in energy efficient renovations in three building categories: public sector and local government buildings in public use, apartment buildings and private houses. Starting from 2013, stricter energy efficiency requirements for new and reconstructed buildings are applied. The state will lead by example, constructing new public sector buildings energy-efficiently.

The second energy efficiency action plan of Estonia[127] highlights Estonia's goals in energy conservation and efficiency, measures and programmes for achieving them. One of the most important targets is construction of nearly zero-energy buildings in all regional centres of Estonia. At least 10 publicly accessible nearly zero-energy buildings of various types with a total usable area ≥ 5 000 m^2 will be constructed in Estonia by 2015. Support schemes for the first public buildings that meet the requirements set for nearly zero-energy buildings will be applied. The support schemes will be used to finance additional investments that ensure compliance with the requirements for nearly zero-

[125] Finland's Second National Energy Efficiency Action Plan (NEEAP-2) 27 June 2011 // Suomen toinen kansallinen energiatehokkuuden toimintasuunnitelma NEEAP-2, 27.6.2011, www.buildup.eu/publications/20807, www.tem.fi/files/30406/NEEAP_2.pdf

[126] 'Estonia 2020' competitiveness strategy // „Konkurentsivõime kava „Eesti 2020", http://valitsus.ee/en/government-office/estonia-2020

[127] The second energy efficiency action plan of Estonia, www.buildup.eu/publications/20806

energy buildings in new public buildings to be built. Information activities are directed to encourage the private sector to construct nearly zero-energy buildings. In addition, guidebooks for the planning of low and nearly zero-energy dwellings[128] and office buildings[129] are already available.

Latvia

The necessity to increase the energy performance of buildings in Latvia has been admitted in several policy documents. The current policy in the energy efficiency of buildings is reflected in:

1) Guidelines for Energy sector Development for 2007-2016 (2006);
2) The Second National Energy Efficiency Action Plan 2011-2013 (2011);
3) Latvian energy long term strategy 2030 – competitive energy for society (2013).

The **Guidelines for Energy sector Development for 2007-2016**[130] highlight several priorities in the field of energy. Supporting of energy efficiency measures in energy end use sectors is mentioned among the priorities[131]. The Guidelines envisage a reduction of the average specific heat consumption of the buildings from 220-250 kWh/m^2/year to 195 kWh/m^2/year by 2016. Subsequently, the implementation of energy efficiency measures shall be continued, reaching the average specific heat consumption 150 kWh/m^2/year by 2020. The Evaluation report[132] (2013) on fulfilment of the targets highlights the intermediate results achieved by 2011 e.g., the average specific heat consumption of buildings is 200 kWh/m^2/year. It is envisaged that in 2014, the Ministry of Economics will elaborate new Guidelines for Energy sector Development for the period from 2014-2020.

The **Second National Energy Efficiency Action Plan 2011-2013**[133] (NEEAP) sets the objective to increase energy efficiency in the energy end-use sector and in energy transformation. The plan includes energy efficiency measures aimed at the rational use of energy and preservation of the environment. The document gives indicative targets up to the year 2020. It is admitted that the largest energy end-use sector in Latvia is the residential sector, which consumed 35.5% of all energy in 2010. The following energy efficiency improvement measures are indicated: to improve the thermal stability of apartment blocks and of social housing. An information campaign "Let's live warmer" for residents of apartment blocks to promote energy efficient refurbishment will continue to run. The third National Energy Efficiency Action Plan will be submitted to the European Commission not later than 30 June 2014.

The **Latvian energy long term strategy 2030 – competitive energy for society**[134] is the most recent policy document determining directions of actions for long term energy security, competiveness, energy efficiency and use of renewable energy sources. According to the Strategy, increasing the energy efficiency is a national priority. It is acknowledged that improving energy performance of buildings gives great potential for significant energy savings related to the heat supply in the housing sector. The aim identified in the Strategy is to achieve a reduction in heat energy consumption of existing buildings up to 100 kWh/m^2/year and to an average heat energy consumption of 50 kWh/m^2/year for newly built buildings by 2030.

[128] Kalamees T., Tark T. (2012), Madalenergia- ja liginullenergiahoone kavandamine. Juhend väikeelamute projekteerijale, ehitajale ja tellijale, www.kredex.ee/public/Uuringud/Madalenergia-_ja_liginullenergiahoone_kavandamine_Vaikeelamu.pdf

[129] Kurnitski J., et al. (2012), Madal ja liginullenergiahooned. Büroohoonete põhilahendused eskiis- ja eelprojektis, www.rkas.ee/files/Madal-%20ja%20liginullenergiahooned.pdf

[130] Enerģētikas attīstības pamatnostādnes 2007.-2016.gadam (2006), http://polsis.mk.gov.lv/view.do?id=2017

[131] Ministry of Economics of Republic of Latvia, www.em.gov.lv/em/2nd/?lng=en&cat=30173

[132] Informatīvais ziņojums "Par Enerģētikas attīstības pamatnostādnēs 2007. - 2016.gadam noteikto uzdevumu izpildi" (2013), http://polsis.mk.gov.lv/view.do?id=2017

[133] Second National Energy Efficiency Action Plan 2011-2013, www.buildup.eu/publications/20813 // Latvijas Republikas Otrais energoefektivitātes rīcības plāns 2011.-2013.gadam (2011), http://polsis.mk.gov.lv/view.do?id=3754

[134] Latvian energy long term strategy 2030 - Competitive energy for society, www.em.gov.lv/em/2nd/?lng=en&cat=30169

Overview on national legislation

The national legislation shall support reaching the policy targets set by the strategic planning documents in the countries. The chapter gives an overview on key documents related to energy performance of buildings.

Finland

In Finland, land use, spatial planning and construction is controlled by the **Land Use and Building Act** (2000). It has proved to be an important instrument to promote ecological sustainability, and set guidance for better energy efficiency of buildings.

The **National Building Code** (2010) contains technical regulations and instructions related mainly to the construction of new buildings. The Building code defines a low-energy building - specific heat loss of such building should not exceed 85% of the level of heat loss of the reference building. The reference building is defined according to requirements on U-values, ventilation heat recovery, air tightness of the building envelope, and total window area. A low-energy single family house is expected to consume not more than 30–50 kWh/m^2 per year for room heating in the climate of Jyväskylä.

Energy efficiency-related building regulations have been renewed recently. The objective of the new regulation **National Building Code D5 "Building's energy efficiency"** (2012) is to improve the energy efficiency of buildings by 20% compared to the present situation, as well as to promote the increased use of RES. The focus is on transition of buildings to the nearly zero-energy construction[135]. For example, an overall energy assessment taking into account all the energy used in the building, a coefficient for the form of energy, and the building type will be required for new construction.

Regulations for improving the energy efficiency of new buildings (2012). The aim of these regulations is to improve the energy efficiency of buildings by 20 % compared to the present state, and to increase the use of renewable energy sources. This change supports the gradual transfer towards nearly zero-energy construction.

E-number to determine energy class of buildings in Finland

The energy efficiency of buildings is surveyed by a value called E-number (kWh/m^2/y). To obtain the E-number, all purchased energy will be taken into account (including energy for heating, ventilation, preparation of hot water and energy consumption for lighting, home appliances etc.). This figure is then divided by the gross area of the building. The result is multiplied with energy coefficients for different forms of energy. The way of producing the purchased energy is taken into account when counting the E-number. The regulations tend to support the use of renewable energy sources and district heating by setting the coefficient lower than for fossil fuels[136].

New **Energy efficiency regulations for renovation work** (2013) define the minimum requirements for energy efficiency during renovation and alteration works (renovations that are subject to a licence, a change in use or the renewal of technical systems). This includes, extensive basic repairs, renovation of a building's façade and the renewal of technical systems that usually require a building permit or a planning permit for minor construction. The decision to start renovation work remains voluntary allowing to decide on the time, extent and the best methods for improving energy efficiency within the regulatory framework[137].

[135] Ministry of the Environment 2012; Builder's eco calculator 2012 (Rakentajan ekolaskuri 2012, www.rakentajanekolaskuri.fi/laskuri.php)

[136] Mikkonen L., Energy audit in Finland, http://nortech.oulu.fi/GREENSETTLE/Energy%20Audit%20in%20Finland.pdf

[137] Environment.fi website, www.ymparisto.fi

Energy performance certificates in Finland
An energy performance certificate is a tool that can be used to compare and improve a building's energy efficiency. It has been used in Finland since 2008 in new constructions as well as large buildings. Energy certificates must be displayed in public buildings of more than 1 000 m^2.

Estonia

In Estonia, construction is regulated by a **Building act** (2003, last amendments 2012)[138]. Requirements for construction work specify that insulation and heating, cooling and ventilation installations of a construction must ensure that the amount of energy consumed by the construction corresponds to the climatic conditions of its location and to the purpose of its use. The structural elements and utility systems of a building with indoor climate control must be designed to meet the minimum requirements for energy performance of buildings.

Regulations on minimum efficiency requirements (2012)[139] set minimum requirements for energy performance for an existing or a new building. The regulations also define low energy, nearly zero-energy and net zero-energy building. The ceiling value of the total energy consumption is set for buildings taking into account their purpose of use.

For new constructions:

1) 150 kWh/m^2 for apartment buildings;
2) 160 kWh/m^2 for small residential buildings;
3) 160 kWh/m^2 for office and administrative buildings, libraries, research facilities;
4) 160 kWh/m^2 for educational buildings;
5) 190 kWh/m^2 for kindergartens;
6) 200 kWh/m^2 for public buildings;
7) 210 kWh/m^2 for commercial buildings;
8) 230 kWh/m^2 for trading and service facilities;
9) 380 kWh/m^2 for healthcare centres and clinics.

For significant reconstruction:

1) 180 kWh/m^2 for apartment buildings;
2) 200 kWh/m^2 for educational buildings;
3) 210 kWh/m^2 for small residential buildings;
4) 210 kWh/m^2 for office and administrative buildings, libraries, research facilities;
5) 240 kWh/m^2 for kindergartens;
6) 250 kWh/m^2 for public buildings;
7) 270 kWh/m^2 for commercial buildings;
8) 280 kWh/m^2 for trading and service facilities;
9) 460 kWh/m^2 for healthcare centres and clinics.

For nearly zero-energy buildings:

1) 50 kWh/m^2 for small residential buildings;
2) 90 kWh/m^2 for educational buildings;
3) 100 kWh/m^2 for apartment buildings;
4) 100 kWh/m^2 for office and administrative buildings, libraries, research facilities;
5) 100 kWh/m^2 for kindergartens;
6) 120 kWh/m^2 for public buildings;
7) 130 kWh/m^2 for commercial buildings;
8) 130 kWh/m^2 for trading and service facilities;
9) 270 kWh/m^2 for healthcare centres and clinics.

Energy performance certificates in Estonia
According to the Building Act, an energy performance certificate is a document which is issued in respect of a building with indoor climate control that already exists or that is being designed and which states the rated energy demand or the actual energy consumption level of the building. The procedure for the energy certificate is described in the respective regulations[140].

[138] Building act (2003, amended in 2012) www.legaltext.ee/et/andmebaas/tekst.asp?loc=text&dok=X50072K4&keel=en&pg=1&ptyyp=RT&tyyp=X&query=ehitusseadus

[139] Energiatõhususe miinimumnõuded (2012), www.riigiteataja.ee/akt/105092012004

[140] Energiamärgise vorm ja väljastamise kord (2008), www.riigiteataja.ee/akt/129122010034

Latvia

The main legislative act regulating the energy efficiency of buildings in Latvia is **the Law on the Energy Performance of Buildings** (2013)[141]. The objective of this law is to promote the rational use of energy resources, improving the energy performance of buildings, as well as to inform society regarding the energy consumption of buildings. The law prescribes the minimum energy performance requirements of buildings to be put into service and of buildings to be designed, reconstructed or renovated. The requirements for the energy certification of buildings and the inspection of heating systems and air conditioning systems are also laid down here.

Several Cabinet of Ministers Regulations have been issued under this law:

- Regulations on Energy certification of buildings (No. 383, 2013)[142];
- Regulations on Independent experts in the field of energy efficiency of buildings (No. 382, 2013)[143];
- Regulations on Methods for calculating the energy efficiency of a building (No. 348, 2013)[144].

Depending on energy consumption, buildings will be divided into energy performance classes from "A" to "F". Class "A" buildings are the most energy efficient ones and are classified as nearly zero-energy buildings. They have to correspond to all of the following criteria: energy demand for heating does not exceed 30 kWh/m^2/year; the total primary energy demand for heating, preparation of hot water, mechanical ventilation, cooling, lightning does not exceed 95 kWh/m^2/year; technological systems of high efficiency are applied that ensure at least 75% of heat recovery from ventilation during the heating season; renewable energy sources are used to satisfy at least partly the energy demand and there are no low efficiency combustion installations fuelled by fossil fuels.

Requirements for the energy certification of buildings in Latvia

Energy performance certificate (EPC) is required for a building (dwelling house, public building) to be designed, reconstructed or renovated, in order to accept it for service or sell it. EPC is required also for a building unit in a building to be designed, reconstructed or renovated, in order to sell this building unit, if an individual energy carrier or thermal energy is anticipated for it. A purchaser, tenant or lessee may also request an EPC for a building to be put into service, in order to sell, rent or lease it. A purchaser, tenant or lessee may request an EPC for a building unit to be put into service if its heating area exceeds 50 m^2 and if this building unit has an individual energy carrier or thermal energy. EPC is requested for a public building in the State or local government ownership to be put into service, the heating area of which exceeds 250 m^2. EPC has to contain information on the energy performance class of the building and the reference markers according to which the building owner, tenant or lessee could compare the energy performance of the building. The energy performance certificate issued for an existing building is valid for 10 years, and for new and reconstructed buildings a temporary EPC must be issued that is valid for 2 years.

Energy efficiency of residential houses is also tackled in the Cabinet of Ministers Regulations No. 907 on Inspection, technical maintenance, regular repairs and minimum requirements for energy performance of a residential building (2010),[145] prescribing that if the average thermal energy consumption of multi-apartment buildings over the last 3 years exceeds 230 kWh/m^2/year (requirements might become more stringent since 2014), then the manager of a dwelling house has to plan measures improving

[141] Ēku energoefektivitātes likums (2013), http://likumi.lv/doc.php?id=253635

[142] Noteikumi par ēku energosertifikāciju (MK noteikumi Nr.383, 2013), http://likumi.lv/doc.php?id=258322

[143] Noteikumi par neatkarīgiem ekspertiem ēku energoefektivitātes jomā (MK noteikumi Nr. 382, 2013), http://likumi.lv/doc.php?id=258321

[144] Ēkas energoefektivitātes aprēķina metode (MK noteikumi Nr.348, 2013), http://likumi.lv/doc.php?id=258128

[145] Noteikumi par dzīvojamās mājas apsekošanu, tehnisko apkopi, kārtējo remontu un energoefektivitātes minimālajam prasībām (MK noteikumi Nr. 907, 2010), http://likumi.lv/doc.php?id=218831

the energy performance of a building, including renovation. The highest savings of thermal energy as compared to the funds required for implementation of such measures have to be ensured.

5.2. Use of renewable energy sources

Policy targets

Taking into account different starting points, renewable energy potential and the economic performance of each country, the renewable energy targets to be reached by 2020 are set for EU Member States[146].

Finland

The national policy for the use of RES in Finland is reflected in:

1) Long-term Climate and Energy Strategy, period of action: 2008 - 2020 and 2050 (2008);
2) National action plan for promoting energy from renewable sources pursuant to Directive 2009/28/EC (2010).

Long-term Climate and Energy Strategy, period of action: 2008 - 2020 and 2050[147]. The Strategy reflects the goal to increase the share of renewable energy to 38% by 2020. Fulfilling this obligation will require a considerable increase in the use of e.g., wood based energy, waste fuels, heat pumps, biogas and wind energy. This strategy also includes the municipal climate strategy campaign, whereas the municipal participation in this campaign is voluntary. Municipalities are invited to estimate the existing situation and make an inventory, compile the forecast for the development of greenhouse emissions for the next 20 years and set the target for decreasing the emissions. The municipal plan for reducing emissions is to be compiled and implemented.

Finland's national action plan for promoting energy from renewable sources pursuant to Directive 2009/28/EC[148]. The Action plan sets the target at 47% for RES in heating and cooling in 2020 (for comparison, in 2005 the share of RES in heating and cooling was 40%). The estimated share of renewable energy in the building sector is 68% in 2020 (the share of renewable energy in the building sector in 2005 was 39%). Revised energy regulations in buildings takes into account the energy consumption and energy efficiency. This also perceives the self-sufficient renewable energy from solar panels, local wind mills, heat pumps and heat accumulating fireplaces.

Estonia

National policy documents for the use of RES in Estonia include:

1) National Strategy on Sustainable Development "Sustainable Estonia 21" (2005);
2) National Development Plan of the Energy Sector until 2020 (2009);
3) National Renewable Energy Action Plan (2010).

The **Estonian National Strategy on Sustainable Development "Sustainable Estonia 21"**[149] defines the prospects for the development of the state and society until the year 2030. It is stated that it is important to increase the use of renewable energy sources and at the same time minimise pressure on other areas e.g., nature.

The **National Development Plan of the Energy Sector until 2020**[150] sets the objective to ensure a continuous, efficient, sustainable energy supply at a

[146] European Commission. Climate Action. The EU climate and energy package, http://ec.europa.eu/clima/policies/package

[147] Long-term Climate and Energy Strategy, period of action: 2008 - 2020 and 2050, Ministry of Employment and Economy, 6.11.2008

[148] Finland's national action plan for promoting energy from renewable sources pursuant to Directive 2009/28/EC (2010), 30.6.2010; Suomen kansallinen toimintasuunnitelma uusiutuvista lähteistä peräisin olevan energian edistämisestä direktiivin 2009/28/EY mukaisesti, www.tem.fi/files/29773/Suomen_kansallinen_toimintasuunnitelma.pdf

[149] Estonian National Strategy on Sustainable Development "Sustainable Estonia 21", www.envir.ee/orb.aw/class=file/action=preview/id=166311/SE21_eng_web.pdf // Eesti säästva arengu riikliku strateegia "Säästev Eesti 21", www.riigiteataja.ee/akt/940717

[150] Estonian National Development Plan of the Energy Sector until 2020, www.legaltext.ee/et/andmebaas/tekst.asp?loc=text&dok=XXXX051&keel=en&pg=1&ptyyp=RT&tyyp=X&query=energiamajanduse

justified price and sustainable energy consumption in the country. It describes the situation in the energy sector of Estonia, its future perspectives on energy markets, and the required measures and activities for achieving the targets.

The **National Renewable Energy Action Plan**[151] summarises the national renewable energy policies, forecasts the final energy consumption and sets renewable energy targets and forecasts until 2020. The overall target for Estonia is to reach 25% of renewable energy in final consumption. Other targets are that e.g., 18% of the demand in heating and cooling shall be met by RES and 5% of electricity demand shall be met by electricity generated from RES.

Currently, the Estonian Ministry of Economic Affairs is preparing an Energy strategy for up to 2030, with an outlook to 2050[152].

Latvia

Efficient use of renewable energy sources is reflected in several policy documents in Latvia:

1) Guidelines for Energy Sector Development for 2007-2016 (2006);
2) Guidelines for Renewable Energy Use 2006-2013 (2006);
3) Latvian energy long term strategy 2030 – competitive energy for society (2013).

The **Guidelines for Energy sector Development for 2007-2016**[153] prescribes that the use of RES has to be promoted in the energy and transport sectors. Priorities are the efficient utilisation of biomass for electricity and heat production, the use of biogas in cogeneration processes and the use of wind energy and hydropower.

The **Guidelines for Renewable Energy Use 2006-2013**[154] reflects the aim to increase the share of RES in the energy balance. Several indicative targets have been set for 2010 with respect to electricity production from RES, biofuels, etc. Evaluation report[155] (2013) states that due to several reasons (e.g. increase in total energy consumption) the indicative targets have not been fully reached, thus remaining a future challenge.

Also the **Latvian energy long term strategy 2030 – competitive energy for society**[156] defines the aim to promote the use of RES for production of electricity and heat as well as the use of RES in transport. The strategy reflects the target of reaching 40% of renewable energy in final consumption in 2020. The Strategy highlights the principles for promoting the use of RES in various sectors and applications. Applying state support for investments in the energy sector, efficient use of energy, ensuring appropriate taxation and emission trading policy should result in reaching an even more ambitious target - 50% share of energy from RES in gross final consumption of energy by 2030.

National legislation

Finland

In Finland, the **Law for Operating Aid for Electricity Produced by Renewable Energy Sources** (2010, amended 2011)[157] promotes the production of electricity by using RES by applying a feed-in tariff system for electricity production in the wind turbines, biogas power plants, wood chips or wood fuel -fired power plants.

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151 International Energy Agency, www.iea.org/policiesandmeasures/pams/estonia/name,36461,en.php

152 International Energy Agency, www.iea.org/w/bookshop/add.aspx?id=451

153 Enerģētikas attīstības pamatnostādnes 2007.-2016.gadam (2006), http://polsis.mk.gov.lv/view.do?id=2017

154 Atjaunojamo energoresursu izmantošanas pamatnostādnes 2006.-2013. gadam (2006), http://polsis.mk.gov.lv/view.do?id=2091

155 Informatīvais ziņojums par Atjaunojamo energoresursu izmantošanas pamatnostādņu 2006. – 2013.gadam izpildi, http://polsis.mk.gov.lv/view.do?id=2091

156 Latvian energy long term strategy 2030 - Competitive energy for society (Energy Strategy 2030), www.em.gov.lv/em/2nd/?lng=en&cat=30169 // Latvijas Enerģētikas ilgtermiņa stratēģija 2030 – konkurētspējīga enerģētika sabiedrībai, www.em.gov.lv/em/2nd/?cat=30166

157 Law for Operating Aid for Electricity Produced by Renewable Energy Sources // Laki uusiutuvilla energialähteillä tuotetun sähkön tuotantotuesta 1396/2010, 01.01.2011; partly 25.03.2011, www.finlex.fi/fi/laki/alkup/2010/20101396

The Government Decree on General Conditions for Granting Energy Support (2002)[158] states that support can be granted for investments into projects that promote the production and use of renewable energy.

Estonia

The **Electricity Market Act** (2003, amended in 2013)[159] amongst others regulate electricity production from renewable energy sources - water, wind, solar, wave, tidal and geothermal energy sources, landfill gas, sewage treatment plant gas, biogases and biomass. Biomass is considered as the biodegradable fraction of products, waste and residues from agriculture (including vegetable and animal substances), forestry and related industries, as well as the biodegradable fraction of industrial and municipal waste. According to the Act, indicative targets for the consumption of electricity produced from renewable energy sources as a proportion of the total consumption for the next ten years and the measures taken to achieve these indicative targets have to be periodically reviewed. The Act foresees simplified conditions for connecting to the network of a generating installation which has a capacity of less than 15 kW and which uses a renewable energy source. The Act prescribes the conditions for support for the producers of electricity from RES.

Latvia

In Latvia, the **Energy Law** (1998, amended in 2012)[160] regulates the energy industry as the economic sector. It covers the acquisition and use of energy resources for the production of energy, the conversion, purchase, storage, transmission, distribution, trade and use of energy. The purpose of this Law is, amongst others, to facilitate the use of local[161], renewable and secondary energy resources[162]. According to the Law the renewable energy sources are wind, sun, geothermal, wave, tidal, and water energy, as well as aerothermal energy (thermal energy accumulated in the air), geothermal energy (thermal energy located under the surface of the mainland) and hydrothermal energy (thermal energy located in surface waters), waste landfill sites and sewage treatment plant gas and biogas, and biomass.

The **Electricity Market Law** (2005, amended in 2013)[163] regulates the production, transmission, distribution and trade of electricity as a free circulation commodity. It determines the requirements for electricity market participants and the participants of the electricity system. It also determines the competence of the involved authorities in the monitoring and regulation of the electricity market. The law prescribes the incentive measures for production of electricity by using RES. Recent amendments prescribe the payment system for households delivering electricity produced from RES to the common electricity grid. Starting from 1 January 2014, the payment system will be based on the net calculation of electricity produced and consumed only for households producing electricity from RES for their own consumption.
Based on the Law, several Cabinet Regulations have been issued e.g.:

- Regulation No. 262 "Regulations Regarding the Production of Electricity Using Renewable Energy Sources and the Procedures for the Determination of the Price" (2010, amended in 2013)[164] determining, amongst others, the criteria according to which a producer who

[158] Government Decree on General Conditions for Granting Energy Support // Valtioneuvoston asetus energiatuen myöntämisen yleisistä ehdoista, 25.7.2002/625, www.finlex.fi/fi/laki/ajantasa/2002/20020625

[159] Electricity Market Act, www.legaltext.ee/et/andmebaas/tekst.asp?loc=text&dok=X60045K9&keel=en&pg=1&ptyyp=RT&tyyp=X&query=elektrituruseadus // Elektrituruseadus, www.riigiteataja.ee/akt/128062012025

[160] Enerģētikas likums // Energy Law, http://likumi.lv/doc.php?id=49833

[161] Local energy resources are renewable energy resources and fuel stocks assessed in Latvia that may be utilised for direct use or the acquisition of energy

[162] Secondary energy resources are energy resources resulting from any type of technological processes as a by-product, also non-utilised energy in the technological process that is suitable for further utilisation

[163] Elektroenerģijas tirgus likums // Electricity Market Law, http://likumi.lv/doc.php?id=108834

[164] MK noteikumi Nr. 262 "Noteikumi par elektroenerģijas ražošanu, izmantojot atjaunojamos energoresursus, un cenu noteikšanas kārtību", http://likumi.lv/doc.php?id=207458

produces electricity from RES may acquire the right to sell the produced electricity as the volume of electricity to be mandatorily procured and the formulas for calculating the selling price of the volume of electricity;

- Regulation No. 221 "Regulations Regarding Electricity Production and Price Determination Upon Production of Electricity in Cogeneration" (2009, amended in 2013)[165] prescribes the procedures for the mandatory procurement of electricity produced in a cogeneration unit and for the settlement of mandatory procurement costs for electricity produced from different energy sources, including RES.

5.3. Energy labelling of products

Energy performance of products is an important factor for achieving energy efficiency and energy savings. In the European Union, several policy instruments are used to pull the market towards energy efficient products i.e. by requirements for an eco-design[166] and energy labelling[167]. The requirements are laid down for various product groups that use energy and also energy-related products[168].

Energy labelling of products is a tool to raise the awareness of consumers. The requirements for each product group are issued as European Commission Regulations. The list of Regulations can be found on the Internet homepage of the European Commission[169]. The European Commission's issued Regulations are directly in force in all EU Member States.

National legislation

Finland

In Finland, the requirements for energy labelling and ecodesign are laid down in the **Ecodesign Act** (1005/2008) and the **Ecodesign Decree** (1043/2010)[170]. Both instruments were updated in late 2010 to reflect the most recent EU requirements. Although there are no national implementing regulations associated with these EU Regulations, some national information and advisory projects have been started in Finland to ensure compliance.

Estonia

In Estonia, Regulation No. 25 on **Energy-related product labelling, information supply and overall conformity assessment specifications** (2012)[171] are published by the Ministry of Economic Affairs and Communications.

Latvia

In Latvia, Regulation No. 480 **on Procedure for labelling of products related to consumption of energy and other resources, as well as advertisement and monitoring** (2011)[172] transpose the EU requirements on energy labelling of products.

[165] MK noteikumi Nr. 221 „Noteikumi par elektroenerģijas ražošanu un cenu noteikšanu, ražojot elektroenerģiju koģenerācijā", http://likumi.lv/doc.php?id=189260

[166] Eco-design principle aims at reducing the environmental impact of products, including the energy consumption throughout their entire life cycle

[167] Energy labelling is classification of products by their efficiency

[168] European Commission, http://ec.europa.eu/energy/efficiency/labelling/labelling_en.htm

[169] Energy Labelling legislation of household appliances, http://ec.europa.eu/energy/efficiency/labelling/doc/overview_legislation_energy_labelling_household_appliances.pdf

[170] Valtioneuvoston asetus tuotteiden ekologiselle suunnittelulle asetettavista vaatimuksista, www.finlex.fi/fi/laki/alkup/2010/20101043

[171] Energiamõjuga toote tähistamise, teabega varustamise ja vastavushindamise üldised nõuded, www.riigiteataja.ee/akt/127032012018

[172] Noteikumi par kārtību, kādā tiek marķētas preces, kas saistītas ar enerģijas un citu resursu patēriņu, kā arī to reklāmu un uzraudzību, http://likumi.lv/doc.php?id=232553&from=off

6. Roles and responsibilities of key stakeholders

6. Roles and responsibilities of key stakeholders

This chapter highlights the roles and responsibilities of stakeholders related to energy performance of buildings, use of renewable energy sources and promotion of energy efficient products in Finland, Estonia and Latvia.

Finland

Ministry of the Environment is responsible for the coordination of development and implementation of legislation and regulations related to the use of land and energy performance of buildings. The functions of the ministry include the general development and guidance of land use planning and building activities. The ministry promotes, steers and monitors regional planning.

Ministry of Employment and the Economy is in charge of the promotion of energy efficiency including development of legislation; elaboration of indicators to evaluate the development of energy efficiency in various sectors; co-ordination and support for the research, development and application of renewable energy.

The Ministry of Trade and Industry is involved in the implementation of ecodesign and energy labelling requirements in the country.

Municipalities co-ordinate, plan and control activities at regional and community level. The municipal board of construction grants construction permits based on the land use plan of the community. For the purpose of building guidance and control, the local authority must have a building inspector. This position can be shared between several municipalities, if this is appropriate in terms of carrying out the functions. The building inspector supervises that construction work is carried out in accordance to the construction permit as well as the requirements of good building practice. On top of that, the statutory functions regarding building control are appointed by the local authority and assigned to a committee of external experts.

Regional energy advisory offices and energy companies provide consultancies and answer questions related to the energy performance of buildings.

Agencies. Motiva Oy is the national energy agency in Finland. In addition, there are seven regional energy agencies. Energy agencies give advice on the energy efficiency of buildings and use of renewable energy sources in heating and electricity production. Tukes, the Finnish Safety and Chemicals Agency is the monitoring authority regarding the energy labelling of electric appliances.

Retailers are responsible for placing the energy labels onto home appliances when selling them in shops.

Estonia

The Ministry of Economic Affairs and Communications elaborates and implements the state's economic policy and economic development plans in various fields, including energy, housing and building, as well as supervising the implementation of eco-design requirements for energy related products.

Municipalities issue construction design specifications taking into account spatial plans or other documents governing the use of the land. Design specifications are prepared and issued on the basis of an application by an interested party no later than within 30 days from the day the application is submitted.

The competence of the local authority is to oversee construction in their administrative territory:

1) verification of conformity to established requirements of building design documentation and of as-built drawings of construction works;
2) issuance of building permits;
3) issuance of occupancy and use permits;
4) verification of conformity of construction works to established requirements;
5) organisation of the evaluation of construction works in order to verify the conformity with requirements.

In order to obtain a building permit, a person shall submit an application and building design documentation. In addition, presenting of the energy performance certificate might be required. The energy performance certificate is issued by the design contractor.

Several **local and regional energy agencies and centres** are established in Estonia: Tallinn Energy Agency; Tartu Regional Energy Agency; Climate and Energy Agency of Estonia, Smart House/Intelligent Building Competence Centre in Rakvere.

Fund KredEx was established in 2001 by the Ministry of Economic Affairs and Communications with the purpose of improving financing possibilities of enterprises, enable people to build or renovate their homes and develop energy-efficient ways of thinking. Through the years, KredEx has become a considerable link between the Estonian financing institutions and loan applicants.

Before building commences, the **owner of the construction work** shall appoint a person who is authorised to act to oversee the work. This person shall not be the person who designed the construction work or the person building it. The owner shall ensure a valid energy performance certificate according to the requirements.

Latvia

The Ministry of Economics is responsible for the general supervision and co-ordination of activities in the field of energy performance of buildings in Latvia. It has to develop and implement the policy for the energy performance of buildings, implement measures in order to provide recommendations regarding the inspection of boilers and air-conditioning equipment and for the improvement of efficiency to the consumers. With respect to renewable energy sources, the Ministry of Economics e.g., issues permits for energy production from RES and decides on granting the merchant the right to sell the produced electricity within the scope of mandatory procurement. The Ministry of Economics is responsible for supervising the implementation of labelling requirements with respect to electric appliances.

Municipalities may provide assistance for the performance of an energy audit, as well as for the refurbishment of buildings, according to the procedures and in the amount specified in regulatory documents. Refurbishment has to be implemented in accordance with the recommendations indicated in the energy audit report, observing the most efficient principle for the payback of investments, the principles of sustainability, maximum energy savings and the utilisation of environment-friendly technologies. For municipality owned buildings, municipalities have to ensure that the energy certificate of the building or the temporary energy certificate of the building is located in a place visible to visitors.

There are 3 **regional energy agencies** (Zemgale Regional Energy Agency[173], Vidzeme Regional Energy Agency, Kurzeme Regional Energy and Development Agency[174]) and one **local energy agency** (Riga Energy Agency[175]) in Latvia. The main objectives of

173 Zemgale Regional Energy Agency, http://zrea.lv/en/about_us/about_us

174 Kurzeme Regional Energy and Development Agency, http://www.krea.lv

175 Riga Energy Agency, www.rea.riga.lv

the agencies are to promote energy efficiency and use of RES in public and private sectors as well as to ensure the general availability of information on these issues. Riga Energy Agency has established an Energy efficiency information centre to consult inhabitants on energy efficiency issues.

In Latvia there are 2 **certification institutions** issuing certificates for energy auditors. Only a natural person, who has received a certificate certifying the competence in the field of energy performance of buildings, has the right to carry out an energy audit. In Latvia, there are approximately 90 certified energy auditors. The register of certified energy auditors is available on the Internet homepage of the Ministry of Economics of the Republic of Latvia[176].

A **building owner** has to ensure the conformity of a building to be put into service with the minimum requirements of the energy performance of buildings. Energy certification of a building or building unit to be put into service and a building to be designed, as well as the inspection of the heating system and air conditioning system has to be ensured too. A building owner is entitled to receive co-financing from the EU funds, the State or local government for the energy certification of the building, as well as for improvement measures of the energy performance of the building.

With respect to multi-apartment houses, increasing the energy performance of the building is the free choice of the flat owners in the building. The **community of apartment owners** may take the decision for the refurbishment of the buildings either at a general meeting of apartment owners, without convening a general meeting of apartment owners – by means of a questionnaire, or upon mutual agreement of another kind. A general meeting of apartment owners shall have a quorum, if apartment owners representing more than half of all residential properties participate therein. A decision of the community of apartment owners shall be binding for all apartment owners, if apartment owners who represent more than a half of the residential properties of the residential house have voted "for"[177].

[176] Register of certified energy auditors in Latvia, www.em.gov.lv/em/2nd/?cat=30272

[177] Dzīvokļa īpašuma likums (2010) // Law on residential properties (2010), www.likumi.lv/doc.php?id=221382

7. Economic instruments

7. Economic instruments

This chapter gives an overview on economic instruments applied in Finland, Estonia and Latvia to promote the increase of energy performance of buildings and use of renewable energy sources (RES) in small scale applications e.g., households and public buildings.

In **Finland,** the public sector uses various financial incentives to encourage energy-efficient construction in both the renovation of housing stock and new constructions. Annual energy subsidies from State funds for refurbishment of residential buildings are targeted to measures improving energy efficiency, reducing emissions, changes in heating methods and application of RES[178].

In **Estonia,** investments have been made into the refurbishment of public sector buildings, increasing their energy efficiency[179]. For renovation of multi-apartment buildings there are 2 types of financing schemes – a provision of preferential renovation loan and a grant scheme.

Support for increasing the energy efficiency of buildings in **Latvia** started in the 1990s. These were separate project initiatives implemented by the State and municipalities, based on international or bilateral cooperation agreements. Such projects have been implemented in Riga, Valmiera, Jelgava and other municipalities of Latvia. A more significant effect was observed with the availability of funding from the EU Structural funds and the Climate Change Financial Instrument, promoting energy efficiency and the use of RES in small scale applications.

[178] Finland: Second National Energy Efficiency Action Plan, www.buildup.eu/publications/20807

[179] National Reform Programme „Estonia 2020", http://valitsus.ee/en/government-office/estonia-2020

7.1. State support programs

In **Finland,** the State supports both home ownership and rented housing. Subsidies, guarantees and grants are provided to promote the construction, renovation or acquisition of housing. Renovation and energy subsidies are granted partly by municipalities and partly by the Housing Finance and Development Centre of Finland (ARA)[180] to improve the energy efficiency of residential buildings. In 2012, the State budget allocated 10 million EUR for energy grants to support the utilisation of RES instead of fossil energy sources in the heating of dwelling houses. Additionally, 2 million EUR were targeted particularly for small houses. Grants are awarded for conducting energy audits, external repair work, improving the ventilation and heating systems, and for application of RES. The grant covers up to 25% of the approved eligible costs.

Support for the implementation of environmentally friendly investment and settlement projects is available through funding from the Ministry of Employment and the Economy. The so-called Energy support program[181] provides grants to municipalities, enterprises and organisations for implementation of projects related to the use of RES, energy-saving and increasing the efficiency of energy production. In 2012, depending on the type of project, subsidies of the total project eligible costs have varied from 10% e.g. for production of equipment for the production of wood chips and industrial wood residues, and up to 30% for solar energy projects. Support of 50-60% of eligible project costs can be granted to projects related to energy audits of the municipal sector, micro enterprises and small and medium size enterprises. For energy saving and efficiency-related investments this support can be a maximum of 500 000 EUR of the total investment costs of up to 3 million EUR.

[180] The Housing Finance and Development Centre of Finland, www.ara.fi

[181] Ministry of Employment and the Economy of Finland, Energy support, www.tem.fi/energia/energiatuki

In **Estonia,** the State support program for renovation of multi-apartment buildings was implemented during 2003-2009. The supported activities under this program were energy audits, preparation of building design documents and technical supervision (50% co-funding rate) and renovation of multi apartment buildings (10% co-funding rate). The program was administered by Estonian Credit and Export Guarantee Fund (KredEx)[182].

In 2011, an investment support programme for the reconstruction of public sector buildings was started in Estonia and is coordinated by State Real Estate Ltd. State agencies and local authorities are the target group of this program. Within the program it is planned to reconstruct 480 public sector buildings with an aggregate usable area of 1.27million m^2. The total volume of this support scheme until 2012 amounts to 146.5 million EUR[183].

In **Latvia,** the financial support for increasing the energy performance of buildings from national or municipal budgets has been comparatively small mostly due to limited budget availability. In the period from 2009-2010 a State support program for increasing the energy performance of dwellings was coordinated by the Ministry of Economics. The available funding was 993 165 EUR. Activities supported were energy audits of multi-apartment buildings, technical inspections, preparation of project documentation (80% co-funding rate) and renovation of multi-apartment houses (20% co-funding rate). In addition to this, some municipalities e.g., Daugavpils, Liepāja, Rēzekne, Rīga, Ventspils have provided financing for carrying out energy audits in multi-apartment buildings[184].

7.2. EU structural funds

Environmental projects in Finland from the EU grants are funded through the European Regional Development Fund (ERDF) and the European Social Fund (ESF).

In **Finland,** five regional programs (Southern, Eastern, Western and Northern Finland, and Åland) are used to provide ERDF funding. Amongst others, ERDF funds support environmental protection, climate change mitigation and adaptation actions, sustainable use of RES and other environmental resources. The ESF supports, among others, the development of environmental expertise and networking; social innovations e.g., new types of employment and practices[185].

In **Estonia,** funds for increasing the energy efficiency of residential buildings from the ERDF have been allocated under the “Operational Program of the Development of the Living Environment”. Under this program, grants have been given for preparations for renovating apartment buildings - energy audits, building design documents and technical expertise. The support scheme (2003-2015) is managed by KredEx. The amount of financing - 50% of the costs, but not exceeding the established maximum amounts per year. Applicants can be apartment associations, building associations and communities of apartment owners[186].

The mechanism for the provision of long-term loans with a low interest rate for the renovation of multi-apartment buildings has been implemented in Estonia (2009-2015). For this purpose, 49 million EUR in total (majority from ERDF and the Council of Europe Development Bank) have been allocated to the KredEx fund. A renovation loan may be granted to apartment associations, building associations or communities of apartment owners out of which at least 80% of the apartment owners are natural

182 “KredEx” is a state owned financial institution founded in 2001 by the Ministry of Economic Affairs and Communications with a purpose, among other things, to foster construction and renovation of buildings increasing their energy efficiency, www.kredex.ee

183 The second energy efficiency action plan of Estonia, www.buildup.eu/publications/20806

184 Informatīvs ziņojums “Par ēku renovācijas finansēšanas mehānismiem”, www.mk.gov.lv/lv/mk/tap/?pid=40267991

185 Ministry of Employment and the Economy of Finland, Leverage from the EU 2007-2013, http://www.rakennerahastot.fi/rakennerahastot/en

186 The second energy efficiency action plan of Estonia, www.buildup.eu/publications/20806

persons. Social housing owned by a local municipality is regarded on equal terms with apartments owned by natural persons. The preferential renovation loan comprises a fixed interest rate of not more than 4.4% over 10 years. Financial intermediaries – Swedbank and SEB bank – evaluate applications for renovation loans. These loans can only be issued to finance the renovation works of apartment buildings built before 1993. Only renovation works described in the energy audit may be financed e.g., insulation of construction elements, replacement of windows, exterior doors, reconstruction of utility systems (heating, ventilation), installation of facilities for the use of RES in apartment buildings (excluding the mounting of heat pumps in district heating areas for apartment buildings using district heating systems). Energy savings of at least 20% have to be achieved in apartment buildings of < 2 000m^2 and at least 30% in apartment buildings of >2 000m^2 of closed net surface area[187].

In **Latvia,** one of the most important financial instruments supporting increasing energy performance of buildings is ERDF. Within the frame of this funding scheme a program, "Improvement of the thermal stability of apartment blocks"[188] was started in 2009 and is to be continued while funding is available. The Investment and Development Agency of Latvia is supervising the implementation of the program. Co-funding is available to buildings whose construction commenced before 1993 and put into operation by 2002. The program supports the preparation of project documentation, preparation of the energy audit, carrying out construction supervision and project supervision, technical inspection, as well as construction works e.g., insulation and replacement of the construction elements of a building's external envelope, renovation or reconstruction of the heating supply, hot water distribution system and installation of the recuperation system (since 2012). The maximum amount of aid financed from the ERDF for one project must not exceed 49.8 EUR/m^2. The amount apartment owners can recover is 50-60% of the total eligible project costs.

Requirements for energy savings to be achieved.

In order to ensure the refurbishment quality in terms of energy efficiency, requirements were set for energy savings to be reached. Annual heat savings must be at least 20%. In addition, after renovation the energy consumption for heating must not exceed 120 kWh/m^2/year (for 1-2 storey high buildings) and 100 kWh/m^2/year (for 3 and more storey high buildings).

By October 2013, there were 276 refurbishment projects completed; implementation of projects is ongoing. The map of projects implemented/ ongoing is available on the Internet homepage of the Ministry of Economics of Republic of Latvia[189]. In order to promote the activity, a wide communication campaign "Let's live warmer!" *(Dzīvo siltāk!)* has been carried out, encouraging apartment owners to get involved in management of the communal property and improvement of building insulation[190].

Another ERDF support program, "Measures to improve the thermal stability of social dwelling houses" (2008-2010) had the aim to improve the energy performance of municipal social dwelling houses in Latvia. Financial support (75% co-founding share) was granted for preparation of project documentation, carrying out supervision of construction, for implementation of measures reducing energy consumption of a building e.g., insulation, changing of windows and doors[191].

187 JESSICA, Joint European support for Sustainable investment in city areas. Financing energy efficiency renovations in the Latvian housing sector. Final report (2012), http://ec.europa.eu/regional_policy/archive/funds/2007/jjj/doc/pdf/jessica/20-jessica-study-latvia-en.pdf

188 Daudzdzīvokļu māju siltumnoturības uzlabošanas pasākumi (Improvement of the thermal stability of apartment blocks) – Latvia, http://www.buildup.eu/links/34852

189 A map of refurbished multi-apartment buildings in Latvia, www.em.gov.lv/em/2nd/?cat=30321

190 The campaign "Let's live warmer!" ("Dzīvo siltāk!"), www.em.gov.lv/em/2nd/?lng=en&cat=30267

191 Sociālo dzīvojamo māju siltumnoturības uzlabošanas pasākumi (2. kārta), www.liaa.gov.lv/lv/es-fondi/isteno/socialo-dzivojamo-maju-siltumnoturibas-uzlabosanas-pasakumi-2-karta

7.3. Green Investment Scheme

Green Investment Scheme is a financing mechanism where finances from the international trading of greenhouse gas emission units[192] are channelled to sustainable energy investments (e.g., increasing energy efficiency, using of RES) that lower emissions of CO_2 and other greenhouse gases[193] or for awareness raising about energy efficiency. This financing mechanism could be used by regional and local governments, enterprises, NGOs as well as the general public.

Both Estonia and Latvia had excess emission units to be sold, while **Finland** participated in the international emissions trading scheme as a buyer of the assigned amount of units.

Since 2010, reconstruction grants[194] provided from the funds obtained from international emissions trading have been made available through the Green Investment KredEx scheme in **Estonia.** Grants for apartment associations and communities of apartment owners were available for reconstruction of apartment buildings. Depending on achieved energy savings, different amounts of total eligible project costs could be obtained. In addition, was a requirement that the microclimate in all renovated projects corresponded to EVS-EN 15251. Having an energy audit is a prerequisite for applying for the grant. Supported activities are, insulation of apartment buildings, reconstruction of utility systems e.g., heating, ventilation; replacement of windows, etc. All project construction tasks need to be completed by November 1st, 2014 at the latest. The grant will be paid upon the completion of all construction tasks.

Latvia participated in the international emissions trading with more than 30 million assigned amount of units, selling these units to Austria, the Netherlands, Portugal, Japan and Spain, thus allowing a gain of approximately 200 million EUR for co-financing of investments in sustainable energy projects[195]. The Ministry of Environmental Protection and Regional Development[196] and the Latvian Environmental Investment Fund[197] have been responsible for supervising the implementation of this financial instrument known in Latvia as the "Climate Change Financial Instrument". During 2009-2013, sixteen calls for projects were opened supporting e.g., increasing energy performance of buildings, construction and reconstruction of low energy consumption buildings and/or application of renewable energy technologies, introducing efficient lighting infrastructure in public territories. Depending on the call for projects applicants could be State institutions, municipalities, commercial entities, natural bodies (households). In total 2082, projects have been implemented until September 2013. Implementation of a few projects will continue in 2014-2015.

The co-funding rate for project beneficiaries has varied from 35 to 85%. In most of the projects beneficiaries are liable for fulfilment of obligations for the agreed reduction of CO_2 emissions. If the envisaged annual reduction of CO_2 emissions is not achieved in 2 years after completion of the project, the beneficiary has to make improvements, financing them from his own resources. In case of repeated non-compliance after 4 years, the received co-funding might be considered as ineligible and shall be returned to the State.

[192] International emissions trading (established under the Kyoto protocol) allows the countries to sell their excess of CO_2 units on an open market

[193] Greenhouse gasses are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulphur hexafluoride (SF_6), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs)

[194] KredEx. Reconstruction grant, http://kredex.ee/apartment-association/toetused/rekonstrueerimise-toetus/

[195] More information at: Latvian Environmental Investment Fund, http://www.lvif.gov.lv/?object_id=299

[196] Ministry of Environmental Protection and Regional Development, www.varam.gov.lv

[197] Latvian Environmental Investment Fund, www.lvif.gov.lv

Examples of municipal projects co-funded by the Climate Change Financial Instrument in Latvia

- Application of complex solutions increasing energy performance of the building of multifunctional centre "Strēlnieki", Bauska municipality e.g., insulation of the building, renovation and insulation of roof, substitution of old windows, installation of ventilation system with heat recovery, installation of a wood pellet boiler.
- Increasing energy performance of several school buildings in Rēzekne municipality.
- Modernisation of boiler houses and substitution of fossil fuels with biomass, installation of heat pumps and solar thermal collectors in Jelgava municipality.

7.4. Other support instruments

In **Estonia,** according to the Public Procurement Act, the contracting authority has an obligation to give preference to environmentally friendly solutions, if possible. The guidelines to consider **energy conservation criteria in procurements** and other competitive tendering procedures are accessible on the sustainable procurement webpage of the Ministry of the Environment[198].

7.5. Further prospects

Finland

As outlined in the Government Programme, the long-term goal is a carbon-neutral society, which can be achieved by following the roadmap towards 2050, involving an increase in energy-efficiency and the use of renewable energy and drafted on the basis of various strategies. Work on the roadmap will begin in 2013. Finland's target for 2020 for use of renewable energy is 38% of the final energy consumption. While the EU has set the obligation of a 10% share of renewable energy in transport fuels for 2020, Finland has set a higher national target of 20%[199].

Estonia

The objective of investments is to carry out energy efficient renovations in three building categories: public sector and local government buildings in public use, apartment buildings and private homes. It is stated that investments into the energy efficiency of apartment buildings must be continued and State measures for promoting the energy efficiency of private houses must be expanded[200].

Latvia

It is envisaged that in the forthcoming years, the support programs for improving the energy efficiency of existing buildings will continue, particularly in the multi-apartment sector. New types of potential instruments and support mechanisms are planned to be developed for increasing energy efficiency in residential buildings[201]. The recently developed "Energy Strategy 2030" determines the directions of actions in the long term perspective in energy security, competitiveness, energy efficiency and the use of renewable energy. It also prescribes the review of State aid mechanisms for energy generation from RES[202].

[198] Instructions for environmentally friendly public procurements for various types of products in Estonia, www.envir.ee/KHRH

[199] Europe 2020 – Strategy, Finland's National Programme, 2012, http://ec.europa.eu/europe2020/pdf/nd/nrp2012_finland_en.pdf

[200] National Reform Programme "ESTONIA 2020", 2012, http://ec.europa.eu/europe2020/pdf/nd/nrp2012_estonia_en.pdf

[201] Progress Report on the Implementation of the National Reform Programme of Latvia within the „Europe 2020" strategy, 2012, http://ec.europa.eu/europe2020/pdf/nd/nrp2012_latvia_en.pdf

[202] Convergence Programme of the Republic of Latvia 2012-2015, http://ec.europa.eu/europe2020/pdf/nd/cp2012_latvia_en.pdf

Annexes

Annexes

A1. Renewable energy sources in Finland, Estonia and Latvia

Renewable energy sources (RES) play quite an important role in Finland, Estonia and Latvia. In 2011-2012, the energy supply from RES comprised 33% of the total gross final energy consumption in Latvia, 25% in Estonia and 30% in Finland[203]. In **Finland,** the most significant RES include bioenergy – wood and wood-based fuels, hydropower, wind power, ground heat and solar energy[204]. In **Estonia**, energy demand is satisfied through domestic production (mainly oil-shale) and imported supplies (natural gas, gasoline and diesel oil). For application of RES, biomass has the highest potential. Hydropower is applied on a smaller scale while the application of wind power is rising[205] and the market for heat pumps is also growing.

In **Latvia,** the two most commonly used RES are biomass and hydropower while solar, wind energy and biogas are used to a lesser extent[206].

In small scale application, i.e. in households, commercial and public sectors, the utilised energy sources comprise both fossil (oil products, coal, natural gas) as well as renewable energy sources (biomass, biogas, ambient energy sources e.g., heat pumps). Heating in small scale application is also provided through district heating and by electric energy. Energy balance for the household sector in Finland, Estonia and Latvia is presented in Figures A.1.1-A.1.3.

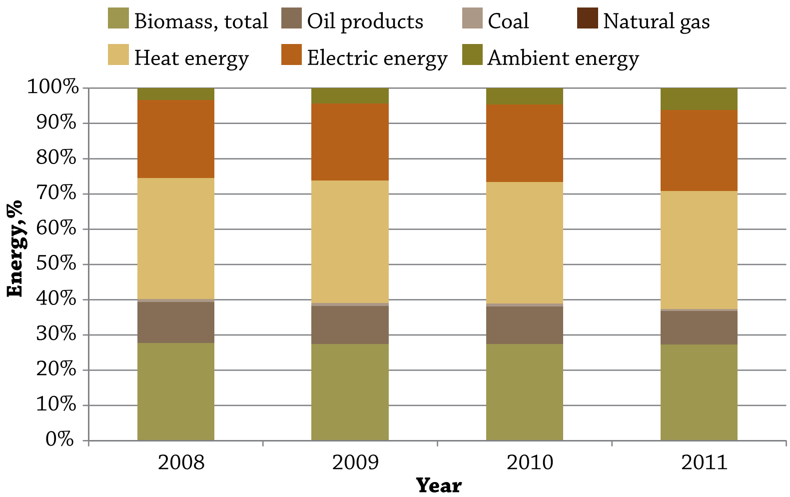


Figure A.1.1. Energy balance for the household sector in Finland (Source[207], own compilation)

[203] Statistics Finland, www.stat.fi/til/ehk/2012/04/ehk_2012_04_2013-03-22_fi.pdf

[204] The Ministry of Employment and the Economy, www.tem.fi/en/energy/renewable_energy_sources

[205] Kingsbury A., Zochowska M. (2011), Renewable energy and bio-fuel situation in Estonia, GAIN Report Number: ES1104

[206] The Ministry of Economics. Renewable energy, www.em.gov.lv/em/2nd/?lng=en&cat=30170

[207] Statistics Finland, www.stat.fi/index_en.html

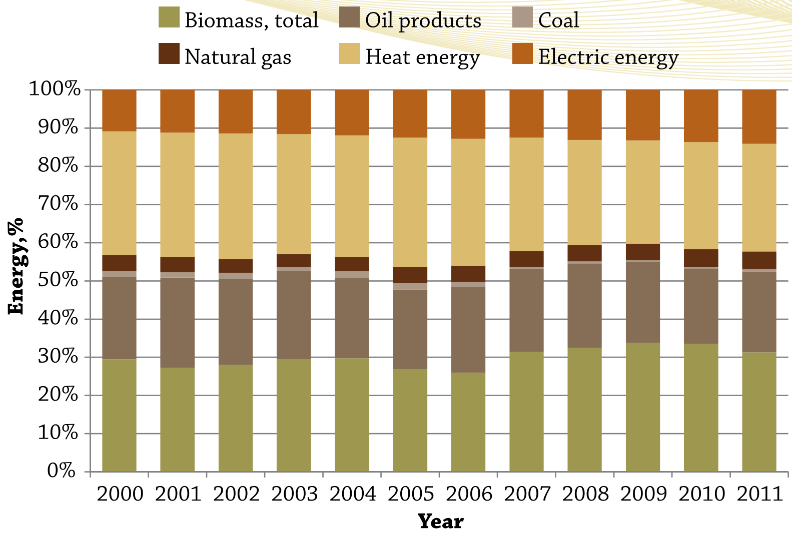


Figure A.1.2. Energy balance for the household sector in Estonia (Source[208], own compilation)

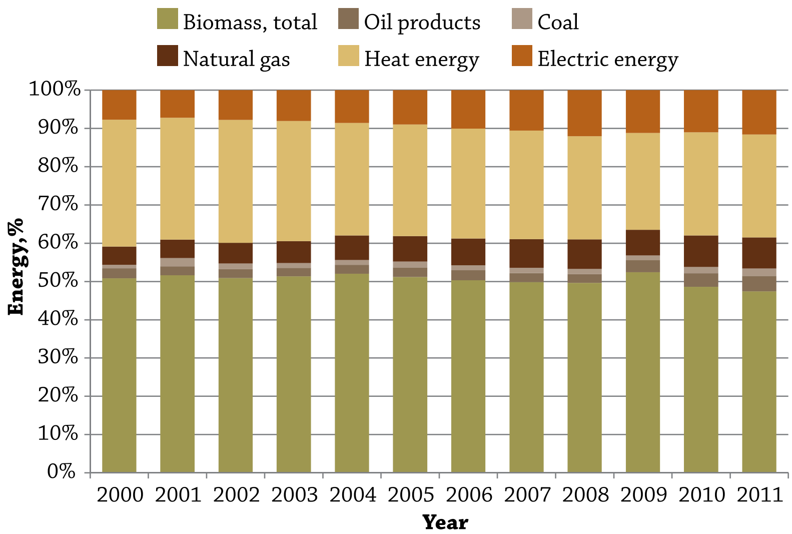


Figure A.1.3. Energy balance for the household sector in Latvia (Source[209], own compilation)

A high share of biomass fuel is used by the household sector in all three countries: 50% in Latvia, 30% in Estonia and 27% in Finland. The remaining energy demand is secured by oil products, coal and natural gas, or supplies from district heating (heat energy) and electric energy. In Finland, the share of ambient energy supplied by heat pumps has increased (from 3% in 2008 to 6% in 2011).

Energy balance in the commercial and public sectors is compared in Estonia and Latvia (Figure A.1.4-A.1.5). Compared to households, the share of biomass is considerably smaller - with 10-20% in Latvia and only 0.5-3% in Estonia. Notably, a high share of electric energy, with 30% in Latvia and 50% in Estonia, is used by the commercial and public sector. With the diversification of energy sources, application of a biogas with 0.5% has been accounted recently in Latvia.

[208] Statistics Estonia, www.stat.ee/en

[209] Central Statistical Bureau of Latvia, www.csb.gov.lv/en

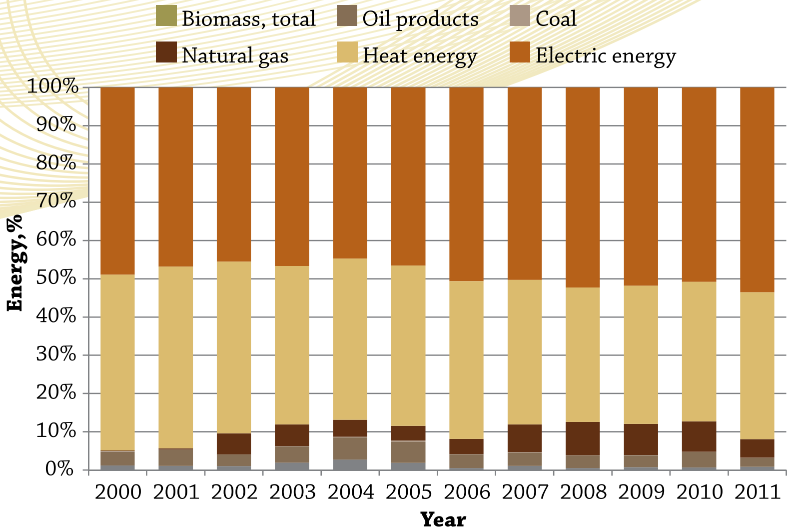


Figure A.1.4. Energy balance for the commercial and public sectors in Estonia (Source[210], own compilation)

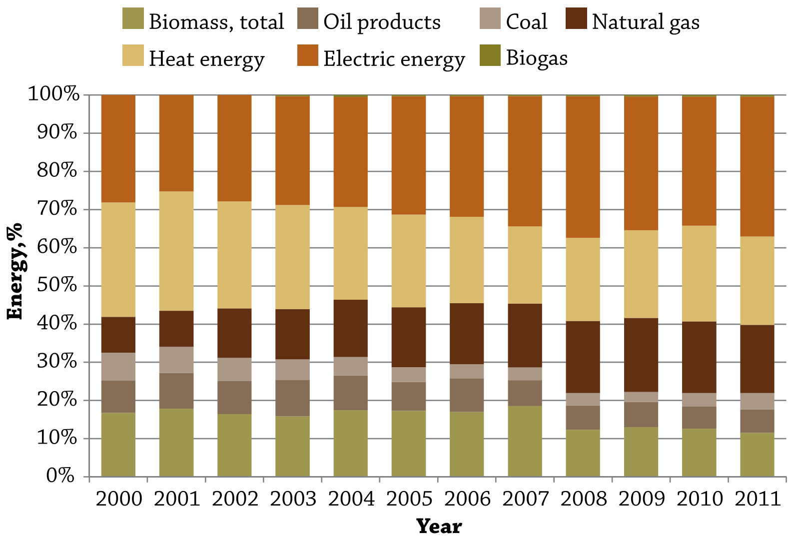


Figure A.1.5. Energy balance for the commercial and public sectors in Latvia (Source[211], own compilation)

[210] Statistics Estonia, www.stat.ee/en

[211] Central Statistical Bureau of Latvia, www.csb.gov.lv/en

A2. Devices for measuring and saving energy in households

When looking for possibilities to measure energy consumption, to save energy in a household or monitor the indoor climate, a set of small, smart devices can be very helpful.

Energy meter

Several electric household appliances continue to use a small amount of power (usually up to a few watts per hour) when left on stand-by mode or sometimes even when switched off. These "phantom loads" are related to many electric household appliances e.g., TV, radio, video recorder, computer, and can be avoided only by unplugging the appliance. An energy meter can help to detect the individual electricity consumption of each device. At first, the electric appliance needs to be plugged into the device and then connected to electricity. The energy meter will indicate the electricity consumption of the TV, refrigerator or washing machine or any other electric device consuming electricity. It can also show the related electricity costs, so new, more energy efficient appliances can be considered to replace those consuming more energy.

Thermo-hygrometer

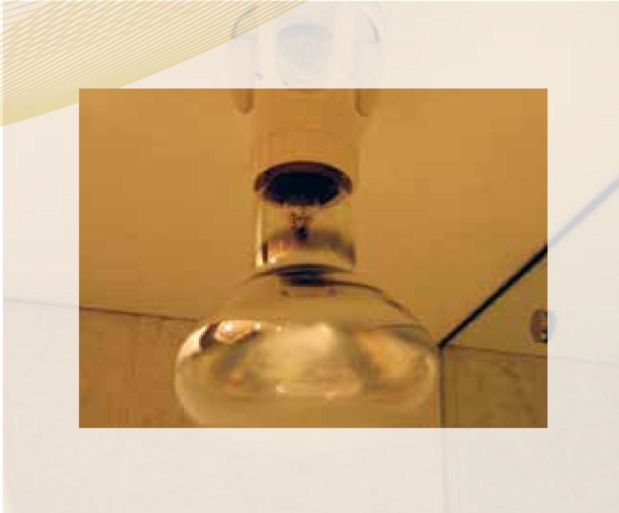
A thermo-hygrometer indicates the amount of moisture in the air and the indoor temperature. There are individual preferences for heating comfort. Usually, people feel comfortable if the temperature e.g. in the living room is 21°C, 18°C in the bedroom and with a relative humidity of 40-60%. High humidity levels (>60%) can promote the growth of mould[212]. If relative humidity is <30%, occupants might experience eye irritation[213].

[212] Illinois Department of Public Health Guidelines for Indoor Air Quality, www.idph.state.il.us/envhealth/factsheets/indoorairqualityguide_fs.htm

[213] Wolkoff P., Kjaergaard SK. The dichotomy of relative humidity on indoor air quality. Environ Int. 2007 Aug;33(6):850-7. Epub 2007 May 17. Review., www.ncbi.nlm.nih.gov/pubmed/17499853

Infrared thermometer

With the help of this pocket size instrument it is possible to detect the thermal bridges e.g., spots around windows or doors and other areas where the house is losing heat. The infrared thermometer can do this by detecting the thermal radiation which is emitted by the object being measured and calculate its temperature. The accuracy of measurements is +/- 1 or 2°C. Infrared thermometers can also be used for other non-contact temperature measurements.



Motion sensor for a light bulb

Where people regularly enter and leave premises (e.g., corridors, staircases) it is often worth considering a motion sensor. The lamp-base motion sensor can simply be screwed into a socket. The sensor reacts to movement and automatically switches lights on and off. Different light conditions for the unit to operate can be selected.

Remote controlled lighting

A system of remote controlled light bulbs allows the brightness of the lighting in a house to be reduced, and thus reducing energy consumption. It is possible to control all lamps at the same time or control each lamp individually. Energy efficient light bulbs save between 65 and 80% energy for the same light output than a conventional incandescent light bulb. Remote controlled lighting allows even more savings.

Photos: Irina Aleksejeva

A3. Measuring temperatures of the operation of ovens and boilers, by Mart Hovi, Estonian University of Life Sciences (EULS), Estonia

In order to understand the operation of a thermal-device, it is important to know the quantity and quality of energy distribution in the input and output. Energy balance consists of the fuel energy in the input and output's useful energy and energy loss, all of which is measurable. Determination of the temperature is the simplest and most accurate measurement of thermal measuring. A lot of information is acquired by measuring the temperature. Usually, rooms and boiler rooms have a room thermometer that shows the temperature of combustion, if it is measured from the room's air. Furthermore, this kind of thermometer is a good indicator of when the room should be heated.

The most common thermometers are fluid-filled glass thermometers and bimetal thermometers. Capillary tube thermometers are also widely used nowadays to control the air distribution of modern fireplaces. It is advisable to base most of the temperature measurements on electrical phenomenon, as nowadays the metering and control functions have been delegated to computers. Resistance thermometers and thermoelectric thermometers have a simple structure. There is a specific category of radiation measuring instruments for example pyrometer, IR-thermometer and thermovision appliances.

The surface temperature of a boiler or oven is uniquely related to the heat output of the device. A high surface temperature of a boiler may indicate a heat loss that in most cases remains within a few per cent, due to the use of good thermal isolation techniques and materials. However, the surface temperature is important in the heat output of an oven heat as it is a heating device. It is easy to get a quick overview with a thermal camera, which is capable of recording all surface temperatures of the objects in sight. However, one must be careful as light-coloured objects may give a misleading indication. The surface temperature of objects with black coloured surfaces are in accordance with thermo photography, yet, glossy surfaces indicate a lower temperature on thermal photography than the actual surface temperature.

Temperatures are closely connected with a boiler's energy balance. Part of a boiler's heat balance analyses the nature of different losses. It is important to know which components compose heat-loss, in order to heat efficiently. There are five main types of losses. To begin with, there is heat loss, which is caused by the high temperature of combustion gas. Secondly, there is chemically incomplete combustion heat loss: unburned or half-burned gaseous fuel particles in the combustion gas. For example, carbon monoxide, hydrogen and other carbon compounds. The third example of loss is seen in the use of solid fuel and is manifested as particles of fuel and coal in the ash. The fourth type is convective and radiative heat that beams from the surface of the device. The fifth example is the high temperature mineral or ash, which is removed from the process. It is recognised that some of the aforementioned losses are only due to using solid fuel. Most of these are measurable by thermometric devices. Low combustion temperatures in the furnace, inadequate combustion space and poorly organised supply and distribution of air cause the heat loss of chemically incomplete combustion.

Figure A.3.1. Combustion gas thermometer in a carbon cup

Photo: Alo Allik

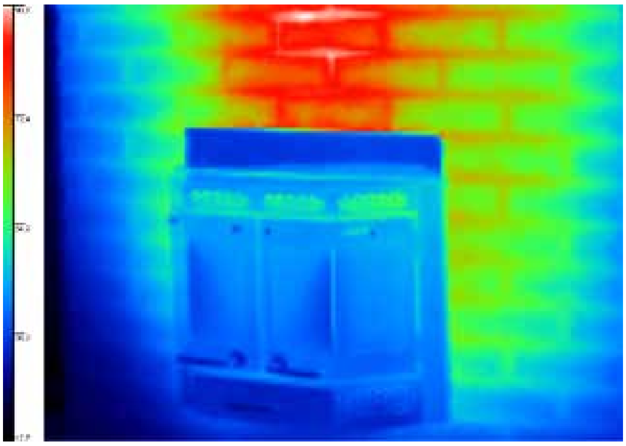


Figure A.3.2. Thermo graphical photography of a placed heating device

Photo: Mart Hovi

Several users of heating devices have positive experiences using the combustion gas thermometer displayed in Figure A.3.1. Some examples are mentioned below.

1. Matis Luik, an ergonomics lecturer at EULS, has been using a combustion gas thermometer for a few years and is satisfied with the results. Combustion gas thermometers help to manage the amount of air in a metal oven as desired. First, the temperature is fairly high but after half an hour it stabilises at 200 degrees.

2. An EULS researcher of energy utilisation, Alo Allik, uses one carbon cup thermometer to observe the performance of several fireplaces. All maintenance doors have the exact same measurements. He says that the installation of a thermometer was exceptionally easy: the diameter of the thermometer's stem was measured with a caliper and a corresponding hole was made in the carbon cup. Alo's observations show that the thermometer shows a temperature in the flue over 100 degrees after completing the heating. The measurements coincide with the theory that the temperature on combustion gas decreases in the flue from fireplace to chimney.

3. Thermal energy lecturer Mart Hovi manages the operation of a boiler with the alteration of primary and secondary air, so that the temperature of combustion gas stays in the optimal range. If the temperature is too high, it causes losses and if it is too low it can cause condensation that can lead to the formation of pitch. The impact of the cleanliness of a boiler's heat exchange surfaces on the temperature of the combustion gas is clearly recognisable in both ovens and boilers. A device with radiation protection and gas directing functions that was installed onto the ceiling of a furnace had a visible impact on the combustion gas temperature. The tabulators that improve a heating surface's convections significantly decrease the temperature of the combustion gas.

In conclusion, it is important to get to know the way equipment works. Furthermore, the interpretation of received information needs careful attention. Measuring the temperature is the most effective method compared to measuring quantity, composition or pressure. Temperature measurements are accurate and easily automated by modern computing.

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