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D2.1 – New requirements for technology packages at district level

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WP 2 **Leader: ZRMK**
Task 2.1 **Leader: LEAG**

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History

Version	Description	Lead author	Date
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1.2	draft with country data included	LEAG	3.8.2016

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The partners in the project are:

- Sweco Finland Ltd. (Finland)
- VTT Technical Research Centre of Finland Ltd.(Finland)
- Fraunhofer Gesellschaft zur Forderung der Angewandten Forschung EV - Fraunhofer Institute for Building Physics IBP (Germany)
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- Ertex Solartechnik GmbH (Austria)
- Gradbeni Institut, ZRMK DOO – GI ZRMK (Slovenia)
- Finnenergia Oy (Finland)
- Lokalna Energetska Agencija Gorenske Javni Zavod - LEAG (Slovenia).

1 Introduction

1.1 Publishable summary

For energy efficient refurbishment at district level, four aspects have to be observed.

(i) The local district energy systems due to their size operate with higher efficiencies than systems per building.

(ii) For distribution of energy at district level an efficient infrastructure must be present.

(iii) Technologies for distributed RES on building level needs smart balancing with district networks to overcome seasonal imbalances.

(iv) To attract users a legal framework (power tariff system etc.), rising awareness and new business models have to be developed.

To meet occupant needs and reduce primary energy consumption, energy efficiency technologies can be used in residential, public and commercial buildings for both new construction and retrofits. Goal of project MODER is to encourage district refurbishments, and to reach NZEB standards. In order to reach this goal, we have to include measures that have to be done on individual buildings (insulation, ventilation, shading systems…), and measures that can be done on a district level (heating, cooling, energy production, optimization of energy storage and usage).

There are many different systems and technologies that need to be used in refurbishment of individual buildings and whole districts in order to reach NZEB goal. Before we even start with the refurbishment we must know end user, grid operator and energy provider's requirements that need to be fulfilled. Those requirements can vary according to country or municipality legislation.

This document presents results from:

- study of new requirements for technology packages on district level,
- expanding technologies for NZEB refurbishment from a building level on the district level,
- identifying end users, grid operators and energy sources requirements across Europe with a goal of minimization of non-renewable energy consumption,
- preparing a list of technologies, end users, grid operators, energy sources and their requirements according to various conditions.

The starting point of the study was to identify main technical requirements especially in the field of new technologies at a district level.

By new technologies we are targeting modern technical systems for the rational use of energy (RUE) and utilization of renewable energy sources (RES) on a district level. We analysed and pointed out the criteria that need to be fulfilled in order to successfully install devices that enable refurbishment of buildings and districts in a NZEB manner, from different points of view (end users, grid and energy sources operators).

1.2 Purpose and target group

The purpose of the work was to

- Identify technologies and their requirements that are able to reduce primary energy consumption,
- upgrade EPBD in order to recognize smart solutions and technologies on a district level, and thus encourage and optimize refurbishment,
- gather requirements from end users, grid operators and energy sources,
- form conclusions.

Special attention was devoted to recognizing requirements of possible technologies in municipalities with case studies within project MODER, and requirements of technologies that are, and will be implemented in the District Energy Concept Adviser (D-ECA) software in work package 3.

The results will be published as a conference article or journal article.

1.3 Contribution of partners

The following partners have contributed to the deliverable:

- Jure Eržen, LEAG - author,
- Marjana Šijanec Zavrl, Samo Gostič, ZRMK - co-authors,
- Tarja Häkkinen, VTT - reported about Finnish technologies,
- Erik Alsema, W/E - reported about Dutch technologies,
- Dieter Moor, Ertex solar - reported about Austrian district technologies,
- Heike Erhorn-Kluttig, Fraunhofer - reported about German technologies, reviewed document
- Joska Stoltenberg, Finnenergia - reported about the district properties in Finnland

1.4 Relation to other tasks/deliverables

Identification of technology packages in WP2 is closely connected with WP 3. Information and solutions from WP2 will be used in WP 3 and later on in the project and district refurbishments in various cities and conditions. The following figure presents the relationships of the work-packages:

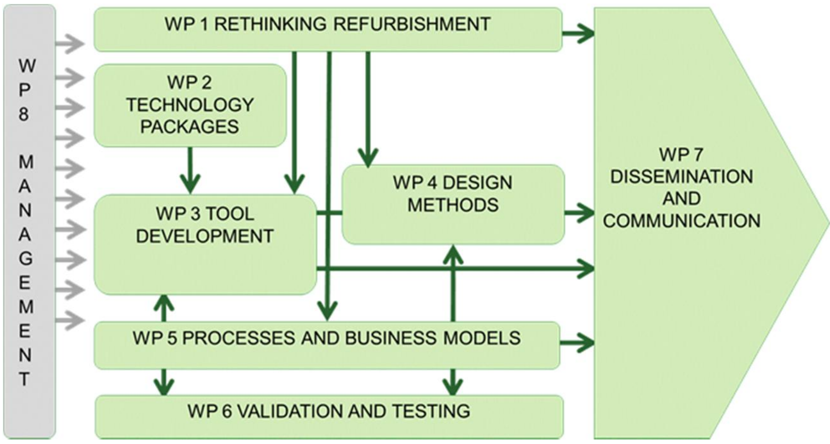

Figure 1 – Relationship of the work with other parts of the project

1.5 Terminology and definitions

RUE	Rational use of energy
RES	Renewable energy sources
DH	District heating
DC	District cooling
DH/C	District heating and cooling
CHP	Combined heat and power plant
GHG	Greenhouse gas
NZEB	Nearly zero energy building
NZEBR	Nearly zero energy building refurbishment
HVAC	Heating, ventilation, and air conditioning
EPBD	Energy Performance of Buildings Directive

2 Starting point and methodology

The starting point was to recognize requirements from different points of view and different technologies that are and will be used in NZEB refurbishment of districts.

There are many different systems and technologies that need to be used in refurbishment of individual buildings and whole districts in order to reach NZEB goal. Before we even start with the refurbishment we must know end user, grid operator and energy provider's requirements that need to be fulfilled. That requirements can vary according to country or municipality legislation. With the help of partners included in the WP2 we identified and supplemented main requirements for a refurbishment of a district.

In order to identify district technology requirements for NZEB, and their implication on various stakeholders (end users, grid operators, and energy sources), we have to derive from cost optimality studies that were planned in EPBD (Article 4). Cost optimal studies on building level in individual country represents a starting point for further development in order to encourage NZEB renovations and later achieving this on a district level as a whole.

For choosing of the best possible approach and systems we must know individual technologies' requirements and limitations. First we identified the technologies used on a building level, we gathered data from other projects and literature and later, focused on the technologies that could be used for a whole district (DH, CHP, etc.).

2.1 Structure of the legislation in the Europe union

The topic of the technology requirements and legislation grids and energy in buildings and therefore districts in Europe is vast. It includes requirements and legislation on building, district, town, municipality, and country level that refers to end users, grid operators and energy providers. Because of the different conditions between countries, municipalities and buildings, requirements and legislation varies, and cannot be uniformed.

2.2 European Union energy policy and national laws

European Union energy policy was approved at the meeting of the informal European Council on 27 October 2005 at Hampton Court. The EU Treaty of Lisbon of 2007 legally includes solidarity in matters of energy supply and changes to the energy policy within the EU. Prior to the Treaty of Lisbon, EU energy legislation has been based on the EU authority in the area of the common market and environment. However, in practice many policy competencies in relation to energy remain at national member state level, and progress in policy at European level requires voluntary cooperation by member's states.

In 2015, the Framework Strategy for Energy Union is launched as one of the European Commission's 10 Priorities:

1. SET Plan
1.1. EERA
2. Energy sources
3. Energy markets
4. IPEEC
5. Buildings
6. Transport
7. Flights
8. Industry
9. Consumer goods
10. External energy relations

How European Union energy policy is implemented in each EU country is defined by type of EU law used and by the type of the national law.

2.3 The supremacy of EU law

The doctrine of the supremacy of EU law is a principle that when there is conflict between European law and the law of Member States, European law prevails; the norms of national law have to be set aside.

Union law is divided into 'primary' and 'secondary' law:

- Primary law refers in particular to the Treaties that are the basis for all EU action.
- Secondary law is derived from the principles and objectives set out in the Treaties and includes regulations, directives and decisions.

Member States have primary responsibility for the correct and timely application of EU Treaties and legislation, and the Commission monitors the application of Union law.

The EU's primary constitutional sources are the Treaty on European Union (TEU) and the Treaty on the Functioning of the European Union (TFEU), which have been agreed or adhered to among the governments of all 28 Member States. The Treaties establish the EU's institutions, list their powers and responsibilities, and explain the areas in which the EU can legislate with Directives or Regulations.
The aims set out in the EU treaties are achieved by several types of legal act. Some are binding, others are not. Some apply to all EU countries, others to just a few.
Types of EU legal acts:

- Regulation is a binding legislative act. It must be applied in its entirety across the EU.
- Directive is a legislative act that sets out a goal that all EU countries must achieve. However, it is up to the individual countries to devise their own laws on how to reach these goals.
- Decisions is binding on those to whom it is addressed and is directly applicable.
- Recommendation is not binding. When the Commission issued a recommendation that EU countries' law authorities improve their use of videoconferencing to help judicial services work better across borders, this did not have any legal consequences.
- Opinions is an instrument that allows the institutions to make a statement in a non-binding fashion, in other words without imposing any legal obligation on those to whom it is addressed. An opinion is not binding.
- EU standards (prepared by European standardization organization CEN, and are not legally binding if it is not referred in the legislation).

General form of legislation and regulations on different levels:

- Constitution
- Laws and regulations on a national level
- Municipality regulations and directives (for example mandatory local energy concept).

The key European laws for reduction of energy consumption on a building level are the 2010 Energy Performance of Buildings Directive [2] and the 2012 Energy Efficiency Directive [3].

Other important directives related to buildings:

- Eco-design of energy related products directive [4]
- Use of renewable energies directive [5]
- Directive 2010/30/EU on by labelling and standard product information of the consumption of energy and other resources by energy-related products - REHVA labelling page [6]
- Construction products directive [7]

3 New requirements

3.1 Requirements on a building level

3.1.1 Goal

Goal of project MODER is to encourage district refurbishments, and to reach NZEB standards. In order to reach this goal, we have to include measures that have to be done on individual buildings (insulation, ventilation, shading systems…), and measures that can be done on a district level (heating, cooling, energy production, optimization of energy storage and usage).

By refurbishment of individual buildings toward better RUE and even with installing new RES (per building) the district as a sum of individual buildings progresses toward NZED (nearly zero energy district). But to truly take advantage of district level refurbishment either district level RES installations should be employed or some advanced business models implemented among stakeholders in the district.

In this section we focused on technology requirements and measures that may need to be meet and done in order to reach that goal on a building level. Short summary of requirements of certain technologies and measures used on a building level was made.

3.1.2 National cost optimal analysis

Requirements, technologies and actions needed for lowering energy usage for individual buildings have been thoroughly investigated, studied and presented on a national level. Corner stones of this work were the 2010 Energy Performance of Buildings Directive (EPBD) and the 2012 Energy Efficiency Directive (EED). However, many Member States performed economic analyses of their energy performance requirements already before these directives.

In the EPBD national cost-optimal minimum energy performance requirements have been calculated for individual new buildings and retrofits as well. EU countries were obliged to set minimum energy performance requirements for new buildings, for the major renovation of buildings and for the replacement or retrofit of building elements (heating and cooling systems, roofs, walls, etc.).

Furthermore article 9 in EPBD states that Member States shall ensure that:

(a) by 31 December 2020, all new buildings are nearly zero- energy buildings; and

(b) after 31 December 2018, new buildings occupied and owned by public authorities are nearly zero-energy buildings.

Member States have set a national application of the NZEB definition including a numerical primary energy indicator according to national, regional and local conditions. This indicator is expressed in kWh/m^2 per year, and has lower requirements than in the cost optimality study. If we wish to retrofit district in a NZEB fashion we must first look at the measures and requirements on a building level, and then possible technologies and measures on a district level.

3.1.3 Systems and measures for renovation and their requirements on a building level

Technical requirements and characteristics in different countries vary. Because our main goal is to identify requirements for district technologies and measures, we will on a building level only focus on most common measures and technologies that are a foundation for a low energy building, and also NZEB. We focused on energy savings measures, heating, cooling, ventilation and lighting.

Country	Regulative
Finland	The National Building Code of Finland
Netherlands	National Building Code for the Netherlands
Germany	German Energy Ordinance (Energieeinsparversordnung – EnEV)
Austria	OiB Guideline 6 - Energy saving and heat insulation
Slovenia	Efficient energy usage in buildings regulative (PURES), TSG-01-004:2010 (Efficient energy usage)

Table 1: List of national regulative for countries participating in project MODER

Building envelope measures

- Thermal insulation and renovation of the opaque building envelope

Installation of thermal insulation is the most common way of lowering energy usage in buildings. Different values of heat transfer coefficient [W/m^{2}K] are required for different parts of building envelope (walls, roofs, ceilings, floors…). Each country has their own requirements and specifications. In general insulation materials must not oppose any danger for health of people, and have to comply with EU standards and Construction product regulation (EU) No 305/2011.

- Replacement of existing and the installation of new energy-efficient windows/doors

Window and door specifications and requirements about their technical properties and installation in Europe vary. Common requirements concerning windows and doors stated in national regulative are: U-value [W/m^{2}K], solar transmittance of glass – g-value, visual transmittance of glass and air leakage. In national regulative across Europe we can find requirements about window size in certain type of buildings, their position and type. Lately some new technologies of dynamic glazing such as electrochromic, photochromic, thermochromic, liquid crystal and suspended particle device windows are being used, which could change some requirements.

- Shading systems

In collaboration with glazing we must often pay special attention to shading. There are many different types of shading systems (from regular blinds, venetian blinds, overhangs, light shelfs, etc.). In certain countries, orientations and types of buildings (especially public buildings like kindergartens, schools, etc.) have to meet requirements that apply to shading transmittance, stability, location of installation, regulation and mandatory usage.

- Avoidance of thermal bridges

Thermal bridges are common phenomenon in all types of buildings. There are many products and measures for renovation of thermal bridges that have to comply with national requirements.

- Airtightness

Airtightness is an important factor when planning a NZEB building. Sufficient airtightness is achieved with certain membranes and correct windows and doors choice and installation. When renovating airtightness can be improved with correct windows and doors choice and installation. When we achieve better airtightness we have to be careful, because especially in older buildings with thermal bridges problems with condensation and thus mould can appear. In newer buildings with high airtightness mechanical ventilation is needed.

The above mentioned retrofitting techniques are applied per single building and in respect to district energy retrofitting the only gain is utilising the 'economy of scope'. Using same solutions for similar buildings in the district, building products providers and contractors might lower their prices during bid negotiation process.

Heating, cooling and domestic hot water system measures

Systems for heating, cooling and domestic hot water preparation can be used, or replaced on a district and on a building level. Renovations of districts operate with many different types of buildings. There are privately owned buildings such as single family houses, multi-family houses, flats, privately owned company buildings, etc. On the other hand there are publicly owned (national, municipality) buildings such as: schools, hospitals, libraries, kindergartens, etc. As it was concluded in D1.1 – Barriers and needs for new processes and improved tools there are many barriers that could prevent cooperation of all building in the district. Therefore it is unrealistic to presume that all buildings will be able or will want to participate in district refurbishment. Furthermore in some cases district technologies (such as district heating system) won't be the best course to take. In any case there will always be systems on building level, at least parts of the distribution or/and delivery system and in many cases storage systems. Therefore we have to look at the systems and their requirements on a building level as well. There is a list of common measures and systems that can be done or used on a building level.

- Installation of:
    - individual stoves, that can be used on room level, apartment level and building level
    - constant, low temperature and condensing boilers
    - heat pumps for domestic hot water and/or central heating and cooling
    - combined heat and power units- seasonal heat storage - in combination with other systems like (solar panels)
    - compression, absorption or solar cooling
- Central control of the heating system
- Local control of heating and cooling systems
- Thermal insulation of the pipe system
- Frequency control of heating and cooling systems
- Building energy management systems (BEMS)

Most countries have requirements associated with minimum performance of boilers and air-conditioning systems. Examples include minimum boiler efficiency levels and in some cases like Germany ban of old inefficient boilers. There are requirements about efficiency, installation, usage, safety, etc. There are many different types of systems for generation of heat that are used in individual buildings:

- individual stoves (gas, oil, biomass), that are an individual source of heat and are most commonly used in addition to other types of heating systems.

- boilers (gas, oil, biomass). They and their distribution systems have to fulfil requirements about energy efficiency, max. heat losses, allowed energy source,…. Their main advantage is that they can meet individual needs, are simple and need no distribution of heat systems to other buildings.

- heat pumps are a common and effective system that enables harvesting of renewable energy sources. Main requirements for technical specifications of heat pumps apply to COP (coefficient of performance), sound levels and type of fluid. They can harvest energy from various sources (ground heat, deep geothermal, ground water, outside air, exhaust air, waste heat, shower water, solar thermal panels and various combinations).

- combined heat and power generation have different requirements about efficiency, energy source, maintenance and emission of gases.

- Seasonal heat storage systems are used to store heat usually produced from RES (solar) or from building cooling systems. According to type of storage various requirements about ground specifications and/or ground water (aquifers) need to be met. Seasonal heat storage is usually combined with heat pumps to upgrade the heat extracted from the storage system to temperature levels of 30-40 C.

- night storage heating systems, and other less frequently used technologies. Energy storage on a building level are rarely used because they are rather inefficient and expensive.

Ventilation and air-conditioning system measures

Member States' legislation, requirements and regulative have different interpretations of requirements and specifications. When installing new or replacing old systems of ventilation we have to take in-to account requirements about ventilation rates, airtightness, indoor air pollutants, mechanical and natural ventilation, indoor temperatures, sound levels, maintenance, humidity and air velocity. All this requirements depend on the type of building, country, and other factors. In some countries it is mandatory to use heat recovery systems, in some it is mandatory if mechanical ventilation is installed and in some it is not mandatory. Following ventilation systems are in use:

- Mechanical ventilation with heat recovery – central
- Mechanical ventilation with heat recovery – local
- Installation of a heat exchanger (for transferring heat recovered from waste air to supply air)
- Installation of a cooling generator and the upgrading of cooling systems
- Control of air-conditioning and ventilation
- Stack ventilation
- Solar chimney ventilation

Electricity use/generation measures

The EPBD introduced the definition of NZEB as a building with very high energy performance where the nearly zero or very low amount of energy required should be extensively covered by renewable sources produced on site or nearby. Some national NZEB definitions also include a requirement for the use of renewable energy sources. Requirements for energy production must comply with EU legislation (Directive 2009/28/EC, Directive 2004/8/EC). Aside from that each country has their own regulative and technical specifications and standards that have to be meet regarding installation, and connection to the grid.

- Energy-saving lighting and appliances

If we are trying to reach low primary energy consumption we have to use efficient lighting solutions. Lighting has to comply with valid standards and specifications. For buildings in some Member States there are requirements about maximum installed power, colour reproduction values, temperature, sensor usage etc. that vary according to type of building and its usage.

- Installation of equipment or construction of facilities for obtaining electricity from the sun, water or

wind
Grid connected systems are the most common type of PV system used in buildings. Electricity not used in the building can be exported to the local electricity supply network, with the agreement of the distribution network operator. Where a building's electricity demand exceeds the amount of electricity being produced by the PV system additional electricity can be purchased from the grid. Panels, inverters, possible batteries, turbines, and small hydro power plants and their connections needed to meet certain demands and requirements about their structure, fire and environment safety, noise levels, energy efficiency, installation, grounding, etc.

- Installation of equipment for the high-efficiency cogeneration of heat and power
There are many different types of cogeneration systems to choose from (gas, oil, biomass, hydrogen). Cogeneration is a highly efficient system (up to 90%) for heating and simultaneous production of electricity on site. Therefore its usage has to be considered and evaluated. Cogeneration systems are mostly used on larger systems and plants. When installing new systems in an individual building we have to comply with safety, technical, installation regulations, in order to meet end users and grid operator requirements (sound levels, usage and generation profiles, etc.).

3.2 Requirements on a district level

In general the process of refurbishing or building a nearly zero energy district (NZED) should start with measures and usage of certain technologies on a building level (as described in previous section). When individual buildings have certain predispositions (insulation, ventilation, window properties, regulation) we can start evaluating certain technologies on a district level for energy:

- usage (district heating/cooling systems, cogeneration, trigeneration and heat pumps, seasonal heat storage),
- harvesting on a district level (PV, wind turbines, small hydro power plants),
- storage, utilization and management (batteries, thermal storages, smart meters and systems).

This segment focuses on specific technologies used on a district level and their requirements that need to be meet. Similar as for the technologies and systems on a building level, there are many differences between national requirements in Europe.

3.2.1 Structural requirements for installation of certain technologies

In order to assure end users comfort, healthy living conditions and safety, we have to make sure that installed systems for generation of heat/cold (DHC, CHP) or generation, distribution and storage of electricity (CHP, PV, solar panels, wind turbines, batteries) meet national and regional requirements about location, distance from buildings, noise, energy efficiency, air pollution, and other specific requirements.

3.2.2 District heating/cooling

District heating/cooling is fairly old system for distribution of heat or cold generated in a centralized location to multiple consumers (households, industry or other parties). According to different ways of generation of heat and cold, there are several different types of DH/C systems (waste heat, oil, gas, coal, biomass, solar, geothermal, sewage, heat pumps, cogeneration and different combinations). Different systems of DH/C have to meet different requirements. In this segment we will look at different types of DH/C systems, and their main requirements. DHC systems have to meet requirements of heating/cooling systems in buildings that are designed according to national codes and principles. These codes and principles generally vary from country to country. In continuation there is a segment on DH/C systems and their requirements from grid operator's point of view.

Conventional district heating systems

District systems produce heat or cold at a central plant. Hot or chilled water is piped underground to individual buildings and can be used for space heating, air conditioning and as sanitary hot water. Therefore individual buildings connected to district system don't need their own systems (boilers or furnaces, chillers or air conditioners). There are a number of different energy sources that can be used for DHC, including industrial waste heat, geothermal, sun. They can be utilized with the help of solar collectors, heat pumps, conventional boilers, cogeneration etc. A low DH return water temperature enables the efficient use of temperature (Low-Ex) energy sources. This is because low temperature return water is able to absorb more thermal energy from these sources. For this reason, the temperature level of consumer installations should be as low as possible. The level is mostly dependent on specific rules and principles, which varies from country to country. The level of return temperatures from consumer installations may vary as much as from 80 to 30°C. The use of high return temperatures often precludes many of the low grade sources of heat available. As well, where co-generation is used, the temperature level is of utmost importance. The efficiency of any thermal power plant depends on the temperature level of the cooling water. In the case of combined heat and power generation, the DH water is the cooling water of the plant and in order to keep the total efficiency of the plant as high as possible the return water temperature of the DH system should be as low as possible. In any DH system, a priority regime of the heat sources connected has to be defined. This is in order to secure the operation of the most efficient and most cost-effective plant (such as CHP plants) and fuels (such as waste being treated in incinerators) during base-load periods. More expensive sources such as boilers, based on oil or gas, are often added for short-term peak loads only.

Main requirements of DH systems:

- high heat load density: As district heating networks are very capital intensive (300 - 1200 €/m), the heated area has to be densely built to minimize the required pipe-length

- economic viability: As a rule of thumb the heat load density for DH should be higher than 2 MWh per metre of planned network length to be commercially viable

- location of buildings: the buildings to be connected to the DH networks should be close to the existing network to minimize the connection pipe length. This will reduce both investment and operational costs. Careful planning is required because underground networks require space that is already partly occupied by other infrastructure (electricity, telecommunications, sewage, water, gas)

- location of heat sources: modern systems can be located in urban areas. This is important in order to minimize network length. Heat sources should be close to the customer (economy) but should take into account noise prevention and transportation logistics. Fuel and ash transportation routes should minimize any harm and risk to the population.

Depending on the type of fuel different requirements are needed. For instance biomass district heating systems require storage facilities, good traffic connection that enables transportation of biomass and other types of fuel to the boilers, etc. District heating that uses natural gas for the operation of the system requires no storage facilities.

Solar district heating

Solar district heating systems have to have sufficient solar collector area. Solar collectors can be centralized or spread over the district. The downside of solar district heating systems is the needed area of solar collectors. According to EN 12975-1, EN 12975-2, CEN/TS 12977-1, CEN/TS 12977-2 appropriate components must be used.
In central solar DH systems we have to use large storages (tanks, pit storage, borehole, and aquifers). All of the listed technologies have different requirements (specifically about on site soil properties, presence of groundwater) and specifications in which they present the best solution. In some cases extensive ground tests and investigations are needed.
SDH systems like all systems have some requirements about maintenance. On a regular basis they need to be checked for leakages, fluid quality, integrity of valves, expansion vessels, etc.

Central solar district heating plant: The solar collectors deliver heat to a main heating central. With large seasonal heat stores the solar heating plant can contribute more than 50 % to the total heat demand.

Distributed solar district heating plant: The solar collectors are placed at suitable locations and connected directly to the district heating primary circuit on site. Often these plants utilise the district heating network as a storage.

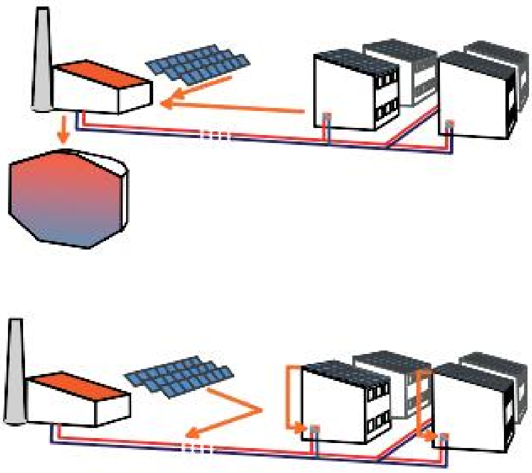

Figure 1: Two main types of solar district heating systems

Mixed systems of district heating

The majority of systems isn't capable or is not economically viable for generation and distribution of heat and/or cold if only one source of renewable energy is used. Therefore there are combinations of different RES (biomass, solar heat pumps, sewage heat usage) and combinations of RES with fossil fuels (CHP, gas or waste heat or cold).

- CHP systems

EU countries must also ensure that cost-benefit analysis for cogeneration is conducted when they plan to build or substantially refurbish:

- a heat or electrical installation with a total thermal input exceeding 20 MW
- an industrial installation generating waste heat with a total thermal input exceeding 20 MW
- a district heating and cooling network exceeding a total thermal input of 20 MW. In this case, the intention is to see if it is cost-effective to utilize waste heat from nearby industry.

The Energy Efficiency Directive demanded from each EU country to carry out a comprehensive assessment of the national potential of cogeneration and district heating and cooling (a main user of cogeneration) by December 2015.

CHP systems have to be designed and operate in order that is not harmful to the distribution network.

It is also possible to generate cold. So called trigeneration or combined cooling, heat and power (CCHP), is the process by which some of the heat produced by a cogeneration plant is used to generate chilled water for air conditioning or refrigeration. An absorption chiller is linked to the combined heat and power (CHP) to provide this functionality. Quadgeneration takes this process one step further with the addition of systems to purify carbon dioxide from the engine exhaust. Combined cooling and power (CCP) is where electricity and cooling are utilised alone.

- Heat pumps systems

Utilizes waste heat from sewage, industrial waste heat recovery or more common air, water and geothermal energy. Different heat media can be used for the production of heat. For the utilization of sewage waste heat, certain requirements have to be met (appropriate sewage network, sewage quantity, pipe specifications, sewage flow, different approvals, etc.).

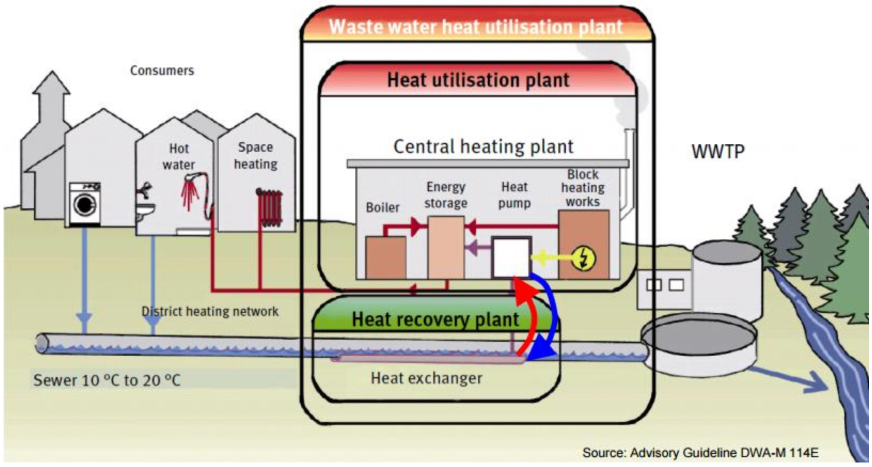

Figure 2: Sewage waste heat utilization

Bivalent systems are preferred, because monovalent systems need to be to larger than bivalent systems in order to provide a sufficient amount of heat at peak demand. Therefore there are bivalent systems where a heat pump provides the base load and boilers (gas, oil and biomass) cover peak requirements.

In general, requirements related to heat pumps refer to technical specifications about their:
- efficiency COP (coefficient of performance)
- installation requirements that depend on type of heat source
- protection from noise pollution levels
- protection from pollution
- type of refrigerant.

UTILIZATION OF DH WITH DIFFERENT SUPPLY TEMPERATURES

District heating schemes are operating with various temperature levels depending on the network and the connected building specifications. Required temperature levels vary between buildings and countries, and depend on the heating installations. New energy efficient buildings with floor heating installation need lower supply temperatures (35-40°C) to fulfil their heating requirement. On the other hand existing (especially old and not renovated) buildings require high supply temperatures and consequently have high return temperatures. Example: supply of 90-100°C and return of 40-60°C.

This fact gives the opportunity to utilize the return flow from existing areas (non-energy renovated buildings) in renovated buildings and hence utilize the capacity of existing DH networks to a greater extend with minimum investment costs. This solution also increases efficiency at the plant due to lower return temperature. Furthermore this reduces heat losses in the return line. In order to establish such a DH system different types of buildings (different supply temperature needs) need to be available. Pipelines need to be modified and in some cases micro boosters need to be installed. Generally this type of solution represents a great potential for lowering investment costs and utilization of the remaining heat in the return pipeline from the existing DH grid.

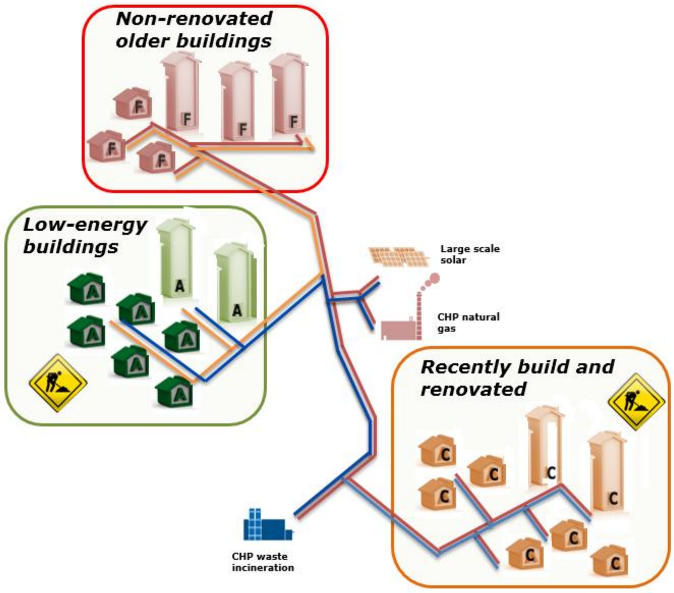

Figure 3: Utilization of return water in district heating networks

3.2.3 Hydro energy

Electricity for a small district can be obtained from a small hydro power unit. Small hydro power units can be divided into three categories: micro scale (less than 100kW), mini scale (100kW - 1MW) and small scale (1MW - 10MW) hydro.
Most common micro-hydro systems are so called "run of the river" systems. They allow the river flow to continue. From an environmental point of view this is preferable because seasonal river flow patterns downstream are not affected. Another advantage is that flooding of valleys upstream of the system (creation of accumulation lake or reservoir) is not required. Further on, power output of the system is not determined by the flow of the river, but instead the turbine operates when there is water flow. The output is governed by the flow. Therefore a complex mechanical control system is not required. The simplicity minimizes maintenance requirements and possibility of failures, and therefore lowers costs of construction.

Electrical energy from a micro-hydro system can be obtained either instantaneously or with the help of a storage system. In a case of installation into an instantaneous power demand system, the system provides 240 V AC power to the load via a turbine. In order to meet the peak power demand sufficiently large turbine in required. These systems require a large head and/or flow. On the other hand the turbine in a storage system is significantly smaller and operates at a constant power output. A micro-hydro generator provides a constant DC charge to a battery system, which then supplies power to the load via an inverter. For the battery system it is required that it is sized to the daily electrical demand.

In order to take full advantage of the electrical potential of small streams, a suitable conditions and requirements are needed. Factors that are important for the utilization of electricity produced in small hydro power units are:

- stream size (flow rate, output and drop),
- distance from the power source to the location where energy is required
- balance of system components — inverter, batteries, controller, transmission line and pipelines.

In the process of obtaining concessions for the use of water for power generation and the process of construction and operation of small hydroelectric plants it is usually required to make different entries, reports and related documents.

3.2.4 Solar energy

Solar energy is our biggest energy source and thus has the biggest potential for utilization. Because the utilization of solar energy for heating has already been discussed in the previous segment, we will focus on technologies for production of electricity – PV panels. The main requirement for the production of electricity is of course availability of sun radiation. But in order to install solar panels, produce, distribute and use produced electricity we have to meet all sorts of requirements, specifications and technical solutions. We have to meet the requirements about installation and grounding, produced electricity quality and suitability for the grid, safety (fire, stability) and last, the proper disposal of used systems. The economic and technical requirements for feeding solar electricity into the utility grid vary across the European Union, and even within Member States. For example in some countries technical connection requirements must be regulated by contract between plant operators and grid operators. Placement of PV panels can be centralized or decentralized (for example several rooftops).

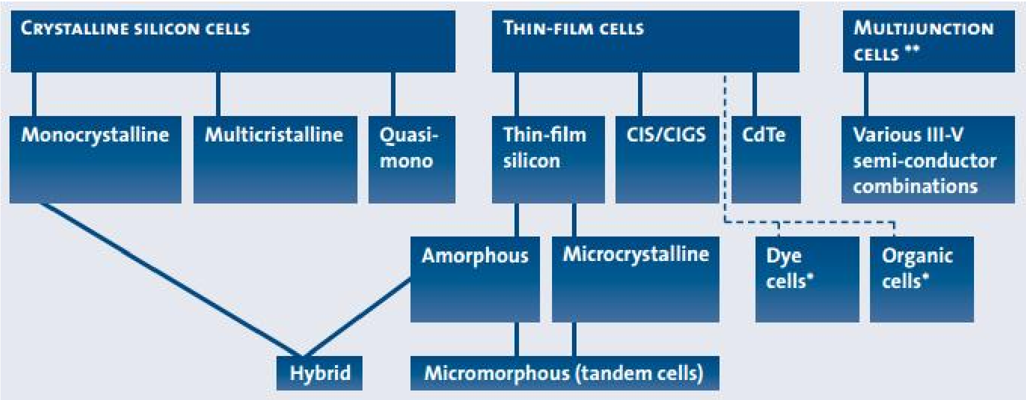

Figure 4: Basic types of solar cells

Solar generators are a combination of solar modules connected in series and in parallel: Depending on the voltage of a given solar module, up to 30 of them may be connected in series to form a string, so the electrical voltages of the individual modules will add up. In a large solar farms, it sometimes make sense to increase the DC voltage up to 1,500 V in order to be able to use smaller cable sizes. That can significantly lower the cost of cabling and at the same time, thermal losses are reduced. On the other hand, this kind of action means that junction boxes have to be equipped with fuses certified for these voltages (more expensive than those for lower voltages). We must also be careful with installation of inverters that too, must be approved for the higher DC

input voltages, and thus require power electronics that are designed for such purposes. Suitable transistors are even more expensive. All this means that we have to be careful with making and sizing of the solar power plant and its components. Major advantage of having a higher system voltage is the option of combining solar systems with wind energy generation systems. Such hybrid power plants could in some cases be the optimal solution, because they take up the same area and feed power into the grid via a joint switching station.
For the conversion of DC produced by photovoltaic systems into AC that can be fed into the grid we need a device called inverter. We have to be careful because not all inverters are suitable for every type of module (DC voltage window, with or without transformer, with or without grounding of the DC circuit).
The greater the output from a solar power plant into the grid, the more important the protection against grid failure is. The directive on medium voltage grid feed, which came into force in Germany in April 2011, takes this requirement into account. If grid stability is threatened, the grid operator can either disconnect a plant or use it to stabilize the grid. This may include maintaining grid voltage and grid frequency, balancing real and reactive power in the grid and phase shifting at the feed-in point.

Solar installations (especially large-scale systems) are vulnerable to wind-induced vibrations. Therefore mounting system must be capable of supporting the solar modules securely for a long period of time.

Solar power plants are planned, installed and financed as system solutions, and at the end of this chain comes the price per kilowatt hour of solar electricity, which competes with that of other technologies, return on investment is therefore determined by the efficiency of the entire system, from individual modules to inverters and grid feed-in.

3.2.5 Wind energy

Generation of electricity by harvesting wind power is a common practice all over the world. Most of the wind energy is produced in large systems and wind farms. Because of the safety requirements, noise levels, architectural standards and other factors large types of wind turbines are not suitable for urban districts. Therefore we will focus on small and micro turbines systems. This types of wind energy harvesting systems can be mounted on building's rooftops or other suitable locations.
Small and micro systems can be either connected to the electric grid or they can stand alone (as an off-grid systems). This enables small units, districts and rural areas ability to harvest energy from wind, and in some cases (low electricity demand) self-sufficiency.

According to the type of systems (connected or not connected to the grid) certain equipment is required.

Apart from wind turbine mounted on a tower, small wind electric systems also require balance-of-system components. The balance-of-system parts required will also depend on whether your system is grid-connected, stand-alone, or hybrid. Usually small systems come as a package that includes all off the parts needed for application of small systems. Grid-connected application, the balance-of-system parts may include the following:

- A controller
- An inverter (power conditioning unit that converts DC into AC required for feeding excess power into grid
- Electrical disconnect switch

- Grounding system

For a standalone system (no connection to the grid) there is a problem with the electricity storage. This is because power is often needed when wind is not there and vice versa. Therefore we have to use some kind of batteries that enable us to storage access power. So called smart grid systems tend to avoid this issue by distributing access power to other users and/or by smart appliances that are able to turn on when needed.

In general we have to meet the requirements of the end users (noise levels, safety, stability, aesthetic, etc.) and if connected to the grid - grid operators (power quality, type of connection), national and regional requirements and policies about energy production and environment.

3.2.6 Building permit

Building permit is the main permit document that has to be obtained for the start of most building and bigger renovation processes. The definition and situations in which a building permit is needed are defined by member states. Building permit is an important factor in the process of energy refurbishment of a district together with its energy systems, grids and systems for utilization of RES.

On a district level we have to look at the bigger systems such as DH. A survey amongst partners working on MODER project was made. It focused on necessity of having a building permit for building or renovating certain technologies and systems (DHC, CHP, HP, etc.). Larger systems such as DHC systems that need new grid – pipes, large facilities and boilers and heat pumps in general need a building permit all over Europe. In case of major renovation or new extensions or boilers building permit could also be needed. Results of the survey are gathered and presented in the appendix.

3.3 End users requirement

EPBD addresses not only efficient energy usage in buildings, but also dictates that measures to improve energy performance of buildings should also take into account climatic and local conditions as well as indoor climate. End user's needs and requirements vary according to type of building and national legislation. That said, minimal standards for buildings have to be met, in order to sustain proper conditions for people to work and live in.

It is important, that building and district refurbishment does not influence interior conditions in a negative way. Small scale refurbishments must ensure that the conditions are better or the same as before. When building permit is needed often conditions and specifications need to match requirements and conditions of a new building.

Refurbishments in the MODER project will focus on districts. They usually contain several different types of buildings: residential buildings and public buildings such as schools, kindergartens, etc. Industrial buildings have different and very specific needs according to the type of production, and are therefore not included in the scope of addressed districts in the MODER project.

General specifications and requirements for different types of buildings are presented and summarized in this section. We summed up technical specifications about HVAC, hot sanitary water preparation, appropriate daylighting, artificial illumination, sound levels, user profiles - occupancy time frame, safety precautions and possible other requirements. Needs and requirements vary accordingly, so the interval and minimum specifications are presented for each country with a partner working in WP2 (Austria, Germany, Finland, Netherlands and Slovenia).

Ambient conditions and requirements (air quality, thermal conditions, max. sound levels, daylight and illumination) need to be met regardless of the type of technologies and technical systems and solutions used for the refurbishment of buildings and district.

End users requirements together with indoor conditions are often in conflict with energy efficient refurbishment (size of windows, ventilation rates, temperature levels, etc.). Many problems and deteriorations of indoor conditions arise from partial, inadequate and inappropriate planning and renovation processes (insulation, replacement of windows, HVAC systems replacement and their regulation). This measures in general result in more airtight buildings. All this leads to many problems and situations in which the living conditions after renovation are less favourable then prior to renovation. Therefore we have to pay attention to all aspects of the renovation and make efforts to lower energy consumption, maintain appropriate indoor conditions and thus fulfil end users' requirements.

At the end (or better to say at the beginning), the end users expect (or require) from the district level systems to provide services better than from local sources. 'Better' is encompassing: cheaper (more efficient), more reliable, more flexible (regarding adjusting to fuel prices over time) and ease of operation and maintenance.

3.3.1 Thermal comfort

Thermal comfort is a very important part of indoor conditions. It plays an important role in health, wellbeing and productivity of users, and also energy usage. Thermal characteristics of indoor rooms and spaces of buildings are the main source of energy usage in buildings. They depend on lots of different specifications and characteristics (thermal transmittance, accumulation and area, of building elements, HVAC systems, their regulation, climate …).

EPBD and energy efficiency directive were the foundation for the development of a set of CEN standards. Standard EN15251 specifies indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment. EN 13779 and EN 13779 apply to the design and implementation of ventilation and room conditioning in non-residential buildings intended for human occupancy. They do not apply to industrial process buildings.

According to the EPBD, heating and cooling systems have to be dimensioned so they can provide sufficient heat and cool loads of the building, in order to ensure proper indoor conditions. Requirements vary according to building type and its usage. Main legislation for thermal conditions in Slovenia is the Regulative on ventilation and air conditioning of buildings. For some special types of buildings and their specific requirements, there are other regulations. For example the Regulative on technical specifications about rooms and systems in kindergartens.

Requirements that need to be fulfilled are stated in the standards, one of them is EN 15316 Heating systems in buildings. Standard applies to methods for calculation of system energy requirements and system efficiencies.

Because this is not the focus of MODER and because different technologies (if sized and installed correctly) can all assure appropriate conditions, we only present figures of a related study [23].

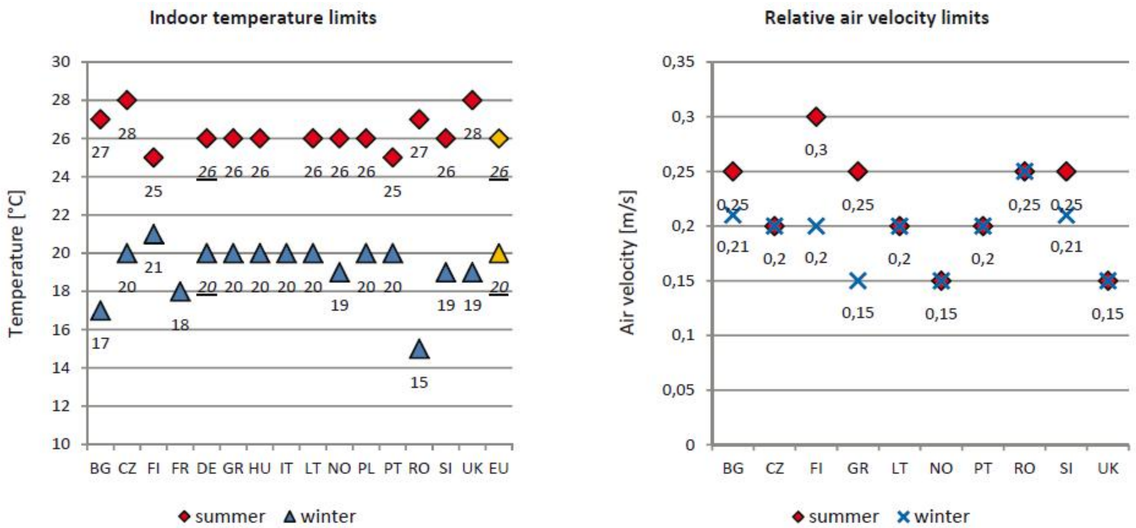

Figure 5: Appropriate indoor temperatures and air velocity limits in several European countries.

3.3.2 Meeting demands for sufficient ventilation of the buildings

Quality of indoor air is related to people's health, wellbeing, and ability to work and concentrate. We generally talk about Indoor Air Quality (IAQ) that includes parameters of ventilation rate, air flow rates, and exposure to various dangerous particles and organisms. And therefore proper ventilation needs to be ensured.

Ventilation systems need to have a proper regulation, and should be placed so that negative effects of cold air flows are minimal, and that they are accessible for maintenance and cleaning.

Ventilation systems and their parts that are installed outside, must be able to withstand weather conditions, and must not be harmful to the environment.

In order to ensure a healthy indoor climate and air exchange in buildings, sufficient ventilation (natural or mechanical) and its control is needed. That is why when preforming energy refurbishment, special attention must be paid not only to energy efficiency but to indoor comfort parameters and building codes as well.

3.3.3 Hot sanitary water requirements

Hot sanitary water generation is an energy demanding process. If we want to achieve NZEB goals we have to choose an energy efficient and appropriate solution. There are several technologies for preparation of hot sanitary water on a building and district level (heat pumps, solar collectors, fossil fuel boilers, district systems, etc.).

Regardless of the technology we use for the preparation of hot sanitary water, we need to meet certain country defined requirements and specifications. Most importantly sanitary and health standards need to be met, in order to ensure safe water usage. Therefore certain water temperatures are required.

Efficient energy usage in buildings regulative dictates specifications that need to be meet in buildings. Energy efficient water storage, pipes, regulation and usage must be used. Sanitary hot water should be prepared by using renewable energy sources.

- Central systems are preferred to be used. If that is not economically feasible local systems with heat pumps and systems with additional heaters that can heat water over 70˚C should be used.
- Solar collectors are preferred. If not possible, other renewable energy sources can be used.
- Heat pumps often have defined minimum COP
- South orientation and different scenarios inclination of solar collectors is defined
- Hot sanitary water grid needs to be installed in insulated environment

3.3.4 Indoor visual comfort requirements

In order to ensure proper living and working conditions, proper daylight and artificial illumination needs to be provided. Energy efficiency, quality of illumination, and end users requirements can be best met with proper daylight utilization. First we have to try to meet the end users requirements about illumination with daylight, and if that is not possible use efficient artificial lighting solutions. That said glazing size per floor area and transparency is often defined in national legislation together with allowed energy usage for lighting per floor area.

- Sufficient levels of illumination, daylight factor, unified glare ratio are stated in EN 12464-1.
- Visual connection with the outside
- Daylight utilization

3.3.5 Maximum sound levels

Similar as for previous parameters and indoor specifications maximum sound levels are often defined in national legislation and regulation. These values were gathered by partners working on MODER, because this is where certain district technologies and systems for energy generation (heat pumps, wind turbines, CHP, etc.) can prove as not appropriate because of the exceeding sound levels. Therefore sound levels in certain building types and countries were gathered (Table 2).

<table>
<tr><th></th><th>Finland</th><th>Latvia</th><th>Netherlands</th><th>Germany</th><th>Austria</th><th>Slovenia</th></tr>
<tr><td>Residential buildings</td><td>55 dB</td><td>7.00-23.00 - 35dB
23.00-7.00 - 30dB</td><td rowspan="2">33-35 dB for user areas; 30 dB for “bed area”.

(In fact there are separate requirements for: 1) sound level at the outside of the façade and 2) for the sound</td><td rowspan="2">Required resulting sound reduction level of external building components: depending on the ambient noise level (I to VI) 30 dB - 50 dB, max. sound pressure level from systems</td><td>Max. night values: Rural 40 dBA, urban 45 dBA. Max. day values: Rural 50 dBA, urban 55 dBA. (outdoor levels)</td><td>30 dB, max outdoor sound levels for systems 42 dB (night value)</td></tr>
<tr><td>Public buildings</td><td>48 dB</td><td>7.00-23.00 - 30dB
23.00-7.00 - 30dB</td><td>Max. night value: 50 dBA.
Max. day value: 60 dBA.
(outdoor levels)</td><td>40 dB, max outdoor sound levels for systems 47 dB (evening value)</td></tr>
</table>

Kindergartens	48 dB	7.00-23.00 - 35dB 23.00-7.00 - 30dB	reduction by the façade. Requirements differ by type of noise, I.e. traffic, railway or industrial noise, and by the function of the building or building part)	35 dB	Max. 40 dBA (outdoor level)	40 dB, max outdoor sound levels for systems 52 dB (day value)
Schools	48 dB	7.00-23.00 - 35dB 23.00-7.00 - 30dB			Max. 40 dBA (outdoor level)	40 dB, max outdoor sound levels for systems 52 dB (day value)

Table 2: Maximum sound levels

As seen from working with partners there are some requirements and specifications that need to be met, but have different interpretations. Some countries specify required sound levels, and some (Germany) specify needed sound reduction levels. This is a valid end user requirement and should be as such taken into account when planning district refurbishment and certain technologies.

3.3.6 Occupancy time frame

Occupancy time frame and usage patterns of buildings in a certain district are an important information when trying to reach a cost optimal refurbishment in NZEB fashion. Knowing the occupancy timeframes of buildings in a district enables us to define necessary connections between buildings, and energy distribution potential and thus choosing correct RES systems and their size. Survey about typical occupancy time frame for 4 types of buildings was done amongst participating partners.

Summary of occupancy time frame.

	Finland	Latvia	Netherlands	Germany 1: Start and end of use 2: Bdg Daily operation time 3: Daily operation time of the systems: A/C and cooling 4: Daily operation time of the systems: heating	Austria	Slovenia
Residential buildings	7:00, 8:00 - 15:00, 16:00	17:00 – 8:00	24 h	1: 0:00 - 24:00 2: 24 h 3: 24 h (ventilation) 4: 17 h	24 h	7:00, 8:00 - 15:00, 16:00
Public buildings	7:00, 8:00 - 15:00, 16:00	8:00 -17:00	7.00 - 18.00 (sometimes 7.00 - 23.00)	1: 7:00 - 18:00 2: 11 h 3: 13 h 4: 13 h	mainly 7:00 - 18:00	7:00, 8:00 - 15:00, 16:00
Kindergartens	6:00 - 18:00	7:00 - 18:00	7.00-18.00	1: 8:00 - 15:00 2: 7 h 3: 9 h 4: 9 h	Depending on federal state. Vienna: 6:30 – 17:30 (18:00)	7:00 - 17:00
Schools	7:30 - 16:30	7:00 - 18:00	7.00-18.00	1: 8:00 - 15:00 2: 7 h 3: 9 h 4: 9 h	Max. 7:00 – 18:00	7:00 - 17:00

Table 3: Occupancy time frame

3.3.7 Safety

Safety is a basic human necessity. Buildings and systems that enable us proper living conditions (indoor temperatures, ventilation, etc.) have to be build, placed, installed and used in a way that meets requirements in this aspects. Especially with heating, cooling, ventilation and RES utilization systems (PV panels, wind turbines, batteries, etc.) fire safety is a very important aspect. Systems have to match technical guidelines (incl. CE-sign) and regulative about fire safety. Buildings have to meet static, thermal and fire regulations, etc.

Country	Regulative
Finland	National Building Code
Latvia	National
Netherlands	National Building Code
Germany	Sound: DIN 4109-1 User profiles: DIN V 18599 -> internal gains are not only based on daily operation time, but also on relative absence. For residential buildings average internal gains for single-family houses and multi-family houses exist.
Austria	The OIB Guidelines 1 – 6 represent the basis for the technical regulations in the 9 federal states.
Slovenia	Regulation on limit values for environmental noise indicators, TSG-1-001:2010 (technical guideline for fire safety in buildings), Environmental protection law. TSG-1-005:2012 (technical guidelines for protection against noise in buildings)

Table 4: National regulative that apply to end user requirements

3.3.8 Compliance of electronical devices

End users can install and use electronical devices (heat pumps, cooling systems, pumps, burners…) that have to be made and labelled according to regulations and standards that apply in EU. End users are responsible for notifying grid operators about the installation of devices with certain connection load that could cause grid instability or deprivation of quality of electricity supply to other users. The threshold is determent according to grid specifications and legislation that applies in the area.

3.4 Grid operators requirements

3.4.1 Electricity

When talking about electricity grids, we are talking about at least two types of grids (transmission network and distribution network). Transmission network is a high voltage network (usually above 110 kV) that transfers electricity between cities, regions, and countries. Distribution network has lower voltage (110 kV – 0, 4 kV) and via transformer stations connects transmission network and end users. Because we are focusing on energy efficient renovation of districts we will focus on the requirements of distribution networks.

Electricity supply is one of the most important services in everyday life. Electricity supply has to be available when needed, safe, reliable, and of appropriate quality. This means that certain technical specifications must be ensured (prescribed voltages and frequencies). Distribution operator is therefore responsible for ensuring continuity of supply, commercial quality and voltage quality.

Voltage quality is defined with standard EN 50160, that applies to low and medium voltage electricity networks. We must also comply with other standards and directives that apply to insulation and safety of electronic devices. Special attention must be payed to new electronic devices that can cause disruptions in the network.

There are several regulations and directives that apply to electricity distribution networks and its operators:

- Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings [2]
- Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC Text with EEA relevance [3]
- Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management (Text with EEA relevance) [23]
- Commission Implementing Regulation (EU) No 1348/2014 of 17 December 2014 on data reporting implementing Article 8(2) and Article 8(6) of Regulation (EU) No 1227/2011 of the European Parliament and of the Council on wholesale energy market integrity and transparency Text with EEA relevance [24]
- Regulation (EU) No 347/2013 of the European Parliament and of the Council of 17 April 2013 on guidelines for trans-European energy infrastructure and repealing Decision No 1364/2006/EC and amending Regulations (EC) No 713/2009, (EC) No 714/2009 and (EC) No 715/2009 Text with EEA relevance [25]
- Directive 2009/72/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC (Text with EEA relevance) [26]
- Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC (Text with EEA relevance) [27]
- Directive 2005/89/EC of the European Parliament and of the Council of 18 January 2006 concerning measures to safeguard security of electricity supply and infrastructure investment (Text with EEA relevance) [28]

European Union is trying to incorporate environmentally-friendly design of energy consumption-relevant products. Directive 548/2014 from the commission for implementing the Ecodesign Guideline 2009/125/EG, applies to grid operators in the field of small, medium and larger distribution and power transformers. The Ecodesign Guideline defines a framework for the requirements for the environmentally-friendly design of energy consumption-relevant products. The objectives include improved energy efficiency and a general environmental compatibility and thus the reduction of CO_2 emissions. Underneath there is an example (Figure 6) of the technical requirements for a certain type of transformers. In this case – liquid filled distribution transformers.

Liquid-filled distributor transformers
Maximum load and no-load losses for liquid-filled distributor transformers with one Um ≤ 24 kV winding and one Um ≤ 1.1 kV winding.

	Tier 1 (from July 1, 2015)		Tier 2 (from July 1, 2021)	
Rated Power (kVA)	Max. load losses P_K (W)*	Max. no-load losses P_0 (W)*	Max. load losses P_K (W)*	Max. no-load losses P_0 (W)*
≤ 25	C_k (900)	A_o (70)	A_k (600)	A_o −10% (63)
50	C_k (1,100)	A_o (90)	A_k (750)	A_o −10% (81)
100	C_k (1,750)	A_o (145)	A_k (1,250)	A_o −10% (130)
160	C_k (2,350)	A_o (210)	A_k (1,750)	A_o −10% (189)
250	C_k (3,250)	A_o (300)	A_k (2,350)	A_o −10% (270)
315	C_k (3,900)	A_o (360)	A_k (2,800)	A_o −10% (324)
400	C_k (4,600)	A_o (430)	A_k (3,250)	A_o −10% (387)
500	C_k (5,500)	A_o (510)	A_k (3,900)	A_o −10% (459)
630	C_k (6,500)	A_o (600)	A_k (4,600)	A_o −10% (540)
800	C_k (8,400)	A_o (650)	A_k (6,000)	A_o −10% (585)
1,000	C_k (10,500)	A_o (770)	A_k (7,600)	A_o −10% (693)
1,250	B_k (11,000)	A_o (950)	A_k (9,500)	A_o −10% (855)
1,600	B_k (14,000)	A_o (1,200)	A_k (12,000)	A_o −10% (1,080)
2,000	B_k (18,000)	A_o (1,450)	A_k (15,000)	A_o −10% (1,305)
2,500	B_k (22,000)	A_o (1,750)	A_k (18,500)	A_o −10% (1,575)
3,150	B_k (27,500)	A_o (2,200)	A_k (23,000)	A_o −10% (1,980)

Figure 6: Requirements for distribution transformers [29]

Transmission system operators and distribution system operators also need to:

- set up and make public their standard rules relating to the bearing and sharing of costs of technical adaptations, such as grid connections and grid reinforcements, improved operation of the grid and rules on the non-discriminatory implementation of the grid codes, which are necessary for integration of new producers feeding electricity produced from CHP into the grid;

- provide any new producer of electricity produced from high-efficiency cogeneration wishing to be connected to the system with the comprehensive and necessary information required, including:

(i) a comprehensive and detailed estimate of the costs associated with the connection;

(ii) a reasonable timetable for receiving and processing the request for grid connection;

(iii) a reasonable indicative timetable for any proposed grid connection. The overall process to become connected to the grid should be no longer than 24 months, bearing in mind what is reasonably practicable and non-discriminatory;

- provide standardised and simplified procedures for the connection of distributed high-efficiency cogeneration producers to facilitate their connection to the grid.

Example Slovenia

The main distribution network operator on a country level in Slovenia is SODO d.o.o. On behalf of SODO, electricity distribution activities are carried out by several regional network operators (Elektro Gorenjska, Elektro Ljubljana…). EU regulations and directives that apply to electricity grids and their operators in Slovenia are gathered in Energy act (Energetski zakon Uradni list RS, št. 17/2014). Main technical requirements and specifications about the low voltage networks are gathered in Technical guidelines TSG-N-002:2013 (Low voltage electrical installations).

On the basis of EU directives and regulations, Slovenia implemented the liberalization of the energy market, with which the rules allowing the development of competition between market participants were set. In accordance with the provisions of the legislation, the agency is established as the national energy regulator and responsible for preparation and compliance of these rules.

The regulator's task is providing the circumstances for development of competitiveness and ensuring its operation by taking into account the requirements for sustainable, reliable and high-quality supply.

Electro energy object owners are responsible for preparation of operation manual that needs to be correlated with SODO. Operation manual has to include:
- general and technical information about the power plant
- connection specifications of the power plant to the grid
- people responsible for operation
- control scheme of the power plant.

Users with maximum demand greater than 41 kW have to include smart metering devices that can measure quantities in time steps shorter than 15 minutes, have to store measured data, and are able to transfer data to grid operator.

Before issuing an approval to connect end customers must provide the following mandatory technical data:
- Connection power
- Plan of end users devices
- Regime of electricity consumption
- For new connections - cadastral plan

Notwithstanding the above mentioned technical data end users according to system operator have to provide required information for each device if installing:

1. system connected loads greater that 20kW: method of connection, the rated power of the device, maximum device parameters, characteristics and duration of the operation of the plant
2. a rectifier or frequency-controlled devices: device type (type of control, ..), the method of smoothing, wiring diagram of routing information on the rectifier transformer,
3. compensating device: the scope of compensation, state compensation

Voltage drop in low voltage grids is one of the main criteria for grid planning. Allowable voltage drop in low voltage grids 400/230V is 0,5 % to 3 %.

For cases when municipality builds electricity grid in order to provide electricity to end users, we have regulation that regulates reimbursements of cost to municipalities for investment in the construction of electricity grid.

In the aspect of lowering impact on the environment noise levels and radiation have to be regulated.

Example Finland

TECHNICAL REQUIREMENTS (connection specifications, max allowed power, etc.)
The size of connection point is the specification of the electricity supply, nominal current by fuse or ordered power. Connection point and it's electrical installations shall be carried out, inspected and connected to the power network in compliance with the legislation concerning electrical safety and the related rules and regulations. Electrical installations and equipment shall not be used so that damages or disturbances are caused to the distribution network or other users.

DISTRICT OBLIGATIONS
Transmission system operator (TSO) in Finland is Fingrid. Local distribution is operated by 80 distribution system operators (DSO) with are natural monopolies. In electricity market legislation,

electrical power network operations have been regulated as operations subject to a permit from the Energy Authority.

POLICY OF SUBSIDIES REGARDING GRID DEVELOPMENT
Transmission system operator (TSO) in Finland is Fingrid. Local distribution is operated by 80 distribution system operators (DSO) with are natural monopolies. In electricity market legislation, electrical power network operations have been regulated as operations subject to a permit from the Energy Authority. The DSO may not refuse to develop the network as required by the Electricity Market Act

OTHER REQUIREMENTS
If there is no agreement to the contrary, the network service is faulty, if the quality of electricity does not correspond to the standards adhered to in Finland. The standard to be applied when these terms enter into force is SFS - EN 50160

REGULATIVE
Is accessible on Finlex Data Bank.

Example Latvia
TECHNICAL REQUIREMENTS (connection specifications, max allowed power, etc.)
Before issuing an approval to connect end customers must provide the following mandatory technical data:
- Connection power
- Plan of end users devices
- Regime of electricity consumption
- For new connections - cadastral plan
- Coordination with all the authorities

DISTRICT OBLIGATIONS
Main distribution network operator on a country level in Latvia is AS "Sadales tīkls", electricity distribution activities are carried out by several network operators. There is free electricity market in Latvia. Mandatory procurement components (green energy) is included

POLICY OF SUBSIDIES REGARDING GRID DEVELOPMENT
Expansion of grid takes place at the country level, which is subsidized by the budget. Local network extension is not subsidized-if not included in the country program.

OTHER REQUIREMENTS
Voltage drop in low voltage grids is one of the main criteria for grid planning. Allowable voltage drop in low voltage grids 400/ 230V is 4-5% %.

REGULATIVE
Building Energy Efficiency Law (09.01.2013), Energy Law (06.10.1998), Building Law (01.10.2014) Different specific regulations that need to be meet.

Example Netherlands
TECHNICAL REQUIREMENTS (connection specifications, max allowed power, etc.)
The size of connection point is the specification of the electricity supply, nominal current by fuse or ordered power. Connection point and it's electrical installations shall be carried out, inspected and connected to the power network in compliance with the legislation concerning electrical safety and

the related rules and regulations. Electrical installations and equipment shall not be used so that damages or disturbances are caused to the distribution network or other users.

DISTRICT OBLIGATIONS
Local distribution of electricty and natural gas is executed by 4-5 regional energy distribution companies. In most cases energy distribution is separated from energy generation. Rules for connection to the energy network are regulated at national level. The high voltage transport network for electricity is operated by a separate company (TSO), called Tennet. Likewise the main gas transport infrastucture is operated by one company (Gasunie).
District heating networks are operated by a large number of companies, both large and small. Within a certain district these companies are usually monopolists Heat generation and heat distribution may be combined in one single company. The operation and customer rights for heat supply is regluated by national legislation (heat supply law). In certain areas there may be an obligation to connect your (new) building to the heat network, except when can prove that you can operate at a better energetic and environmental performance than the heat supply option.

POLICY OF SUBSIDIES REGARDING GRID DEVELOPMENT
At present there is net metering regulation for PV systems operated by small consumer. This netmetering regulation garantuees the same tariff for PV ellectricity fed into the grid as the full end-user tariff paid for consumed electricity (including network costs and taxes). So if electricity is bought by households at 20 ct/kWh, the saqme rate will aplly to excess PV electricity fed back into the grid. This tariff is valid up to the level where yearly PV feedback and elctricity consumption are equal (i.e. yearly net consumption is zero). The net metering regulation does not apply for large consumers (>80 A connection) and it may be adapted after 2018.

Example Austria
TECHNICAL REQUIREMENTS (connection specifications, max allowed power, etc.)
Due to the federal legislation in Austria the situation is quite complex and many steps are mandatory. Before issuing an approval to connect end customers must conduct the following points:
- Apply for metering point (network operator)
- Provide project description, cadastral plan, schematic diagram of connections, static confirmation,…
- Grid access agreement
- Building permission
- Electrical permission
- Coordination with all the authorities

DISTRICT OBLIGATIONS
There are many network operators in Austria, listed Austrian network operators. There is free electricity market in Austria.

POLICY OF SUBSIDIES REGARDING GRID DEVELOPMENT
With the liberalization of the electricity market in 2001, the politically and financially independent institution E-Control has been established. The E-Control is Austrian´s competition regulator and takes care of the security and sustainability of energy supply. E-Control cooperates with the network operators to propose technical and organizational regulations for the energy networks and their expansion, maintenance and use.

OTHER REQUIREMENTS
Voltage and frequency stability in low voltage grids (network level 7: ≤ 1kV) are the main criteria for grid planning. They are regulated in ÖVE/ÖNORM EN 50160.

REGULATIVE
EIWOG
TOR - Technical and organizational rules for operators and users of networks
ÖVE / ÖNORM EN 50438

3.4.2 District heating and cooling systems

District heating and cooling is a system for providing heat and cold from one boiler room to many households.

High-efficiency cogeneration and district heating and cooling has significant potential for saving primary energy, which is largely untapped in the Union. Member States should carry out a comprehensive assessment of the potential for high-efficiency cogeneration and district heating and cooling.

Distributor must ensure security of the distribution system by providing sufficient capacity and reliability of the system and thus security of the supply to the distribution system.

District heating and cooling providers have to act according to valid regulations, directives and national legislation.

- Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings [2]
- Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC Text with EEA relevance [3]
- Regulation (EU) No 347/2013 of the European Parliament and of the Council of 17 April 2013 on guidelines for trans-European energy infrastructure and repealing Decision No 1364/2006/EC and amending Regulations (EC) No 713/2009, (EC) No 714/2009 and (EC) No 715/2009 Text with EEA relevance [25]
- Commission Delegated Regulation (EU) No 1391/2013 of 14 October 2013 amending Regulation (EU) No 347/2013 of the European Parliament and of the Council on guidelines for trans-European energy infrastructure as regards the Union list of projects of common interest [30]

Materials used in the infrastructure must apply to national and grid operator’s standards and specifications. Valid Euroheat & Power EHP/001 certificate may be needed.

Example Slovenia
Heat and other energy gases distribution may be carried out as an optional local service of general economic interest, or as commercial distribution. Such activity must be notified to the Energy Agency.

Where a distributor supplies or plans to supply more than one hundred households, district heating and cooling is provided as a service of general economic interest. They have to create system operation instructions and validate them at the Energy agency.

District heating and cooling shall be carried out as services of general economic interest when a sustainable and uninterrupted supply of heat and other energy gases is in the public interest

District heating and cooling systems must be primary energy efficient. Heat distributors must ensure that an annual production of heat is produced by fulfilling one of the conditions below.

- at least 50% of heat produced from renewable energy sources;
- at least 50% of waste heat,
- at least 75% of cogenerated heat,
- at least 75% of a combination of the heat referred to in the above three indents.

Heat distributors who operate with systems that exceed nominal power capacity of 10 MW, must also include:

- a control system for the operation of the district heating and cooling system, that takes care of optimum thermal and hydraulic operation of the system,
- Implementation of measures for optimization of DHC systems operation.

Some of the standards that apply to materials used in district heating systems:

- pipe lines: SIST EN 253, EN 15698-1
- bonded pipe systems: SIST EN 448
- pipe joints: SIST EN 489

DISTRICT OBLIGATIONS

Defined in obligatory documents - LEC (Local energy concept). DH systems have to use renewable energy sources, or highly efficient CHP.

POLICY OF SUBSIDIES REGARDING GRID DEVELOPMENT

District heating systems together with CHP systems are encouraged to be used on a national level. They have an advantage comparing to individual systems. Funds were granted for financing projects of district heating biomass (BDH). Financial incentives for investment in new systems and micro-BDH. BDH systems as well as expansion of existing systems BDH and construction of new boilers with wood boilers biomass as a source of the existing remote network.

OTHER REQUIREMENTS

District heating operators in Slovenia must assure:

- nominal pressure p_{nom} = 16,0 bar,
- nominal temperature p_{nom} = 16,0 bar,
- minimum differential pressure on distribution point p = 0,75 bar.
- maximum inlet temperature t_{max} = 130° C
- minimum outlet temperature t_{min} = 70° C

REGULATIVE

Energy act RS, num. 17/2014, Act for construction of objects, TSG-01-004:2010 (Efficient energy usage), efficient energy usage in buildings regulative (PURES), Regulation of air emissions from small and medium-sized combustion plants.

Example Finland

POLICY OF SUBSIDIES REGARDING GRID DEVELOPMENT

District heating systems together with CHP systems are commonly used in Finland. Biomass is replacing coal and natural gas. Legislation drives investments in new construction of new boilers with wood boilers biomass as a source of the existing network.

OTHER REQUIREMENTS

District heating operators in Finland must assure:
- nominal pressure p = 16,0 bar
- minimum differential pressure on distribution point p = 0,6 bar.
- maximum inlet temperature t max = 120° C

Example Latvia

TECHNICAL REQUIREMENTS (connection specifications, max allowed power, etc.)
Max fluid velocity depends on hydraulics characteristics of system. Some cities has new systems (21th century). Mostly systems are from 70's-80's

DISTRICT OBLIGATIONS
Defined in obligatory documents - LEC (Local energy concept). It has big municipalities. Small municipalities are using country energy concept.

POLICY OF SUBSIDIES REGARDING GRID DEVELOPMENT
District heating systems together with CHP systems are encouraged to be used on a national level. They have an advantage comparing to individual systems.
Funds were granted for financing projects of local heating biomass (BLH). the government attracts investors for the implementation of green technologies in the district heating system. Some municipalities received European co-financing for the implementation of green technologies.

OTHER REQUIREMENTS
District heating operators in Slovenia must assure:
- nominal pressure p = 16,0 bar
- maximum inlet temperature t max = 120° C
- minimum outlet temperature t min = 70° C

REGULATIVE
Building Energy Efficiency Law (09.01.2013), Energy Law (06.10.1998), Building Law (01.10.2014)
Different specific regulations that need to be meet.

Example Austria

TECHNICAL REQUIREMENTS (connection specifications, max allowed power, etc.)
The characteristics depend on the district heating network - in Austria, district heating networks are managed at local level by the individual heat supply companies. In Vienna for instance the primary network operates at 21.5 bar and temperatures up to 145°C. It´s the largest district heating system in Austria and is run by Wien Energie.

DISTRICT OBLIGATIONS
Defined in obligatory documents - LEC (Local energy concept). The newer district heating plants are constructed as biomass plants or as CHP-biomass plants.

POLICY OF SUBSIDIES REGARDING GRID DEVELOPMENT
Subsidies are assigned mainly to biomass district heating plants – new construction and expansion of heat distribution on the basis of biomass, geothermal or industrial waste heat.

OTHER REQUIREMENTS
There is no federal regulation providing a legal framework for the connection of district heating plants to the heating grid. Therefore, the connection to the grid is based on the individual contract with the district heating supply company. Detailed information on the connection process can be provided by the Austrian Association of Gas- and District Heating Supply Companies (FGW).

REGULATIVE

National Energy Efficiency Law (July 2014), and see above.

3.4.3 Natural gas

Similar to electricity network, gas network also has transmission and distribution networks. International and national gas transmission networks enable the transport of natural gas over long distances from production sources to large industrial consumers and distribution systems for general consumption. Natural gas distributions systems enable gas supply to consumers in towns and districts. They are geographically confined sites with distribution network, associated facilities and equipment necessary for safe and reliable operation.

Distribution of natural gas includes the transport of natural gas from connection to transformation network to end users connection. Distribution network is in the hands of operating companies. Their responsibilities are stated in regulations, directives and national legislation.

- Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings [2]
- Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC Text with EEA relevance [3]
- Commission Regulation (EU) 2015/703 of 30 April 2015 establishing a network code on interoperability and data exchange rules (Text with EEA relevance) [31]
- Commission Implementing Regulation (EU) No 1348/2014 of 17 December 2014 on data reporting implementing Article 8(2) and Article 8(6) of Regulation (EU) No 1227/2011 of the European Parliament and of the Council on wholesale energy market integrity and transparency Text with EEA relevance [24]
- Regulation (EU) No 347/2013 of the European Parliament and of the Council of 17 April 2013 on guidelines for trans-European energy infrastructure and repealing Decision No 1364/2006/EC and amending Regulations (EC) No 713/2009, (EC) No 714/2009 and (EC) No 715/2009 Text with EEA relevance [25]
- Commission Regulation (EU) No 312/2014 of 26 March 2014 establishing a Network Code on Gas Balancing of Transmission Networks Text with EEA relevance [32]

Distribution entity in EU can be organized as a public company, private company that has a concession with local community, or private – public company. Operator is responsible for distribution, operation, maintenance and development of the distribution network.

New grids are no longer a priority in LEC documents, because there are usually no new subsidies for construction of new pipes. Where pipes and connection to the buildings already exist heating with natural gas can present one of the solutions.

3.5 Energy sources requirements

Ability to utilize RES is specific for each district, because of different energy potentials (wind, sun, geothermal, etc.), different national and regional preferences, plans and obligations. In the survey we sent to partners working on MODER we asked about availability potentials, national targets for share of RES, national obligations for preparation of energy plans for municipalities and districts their efficiency and national regulative.

3.5.1 Availability potential

First step in process of planning the use of RES is identifying their potential on the site. In the project MODER we focused on 5 most common RES (biomass, solar, wind, geothermal, hydro). Because this types of information is very difficult to summarize we decided to state the addresses for individual country, where individual type of data can be obtained. Results of the survey are stated in the next two tables.

	Finland	Latvia	Netherlands
Biomass	/	Biomass Study	National potential: 160 PJ from NL and 640 PJ from imported biomass
Solar	Solar	Global horizontal irradiation potential	System yield 800-900 kWh/kWp/yr; national potential 300 PJ/yr
Wind	Wind power	Wind energy	Wind speed map National potential: 500 PJ/yr
Geothermal	Geothermal	Company Geothermal map	Resource map; National potential 200 PJ/yr
Hydro	Most of the resources are already in use. Focus on achieving better efficiency. Needs regulation to acquire more water systems to serve energy industries.	Water energy	Very little potential

Table 5. Availability potential references part1

	Germany	Austria	Slovenia
Biomass	https://www.unendlich-viel-energie.de/veroeffentlichungen/potenzialatlas-bioenergie-2020	Austria´s biomass potential till 20150, report	Map of wood potential
Solar	http://www.unendlich-viel-energie.de/media/file/319.Potenzialatlas_2_Auflage_Online.pdf	Global horizontal irradiation potential	Global horizontal irradiation potential
Wind	http://www.unendlich-viel-energie.de/media/file/319.Potenzialatlas_2_Auflage_Online.pdf	Wind potential	Average density of wind power 10m above ground level
Geothermal	http://www.unendlich-viel-energie.de/media/file/319.Potenzialatlas_2_Auflage_Online.pdf	Geothermal potential	Geothermal map
Hydro	http://www.unendlich-viel-energie.de/media/file/319.Potenzialatlas_2_Auflage_Online.pdf	After the intensive expansion of large hydropower plants between the 1960s and the 1990s, the focus is now on the expansion of small hydropower plants, on the revitalisation of older facilities and the expansion of pump-storage capacity. Hydro potential Micro-hydro unit	Potential for small hydro power plants

Table 6. Availability potential references part 2

3.5.2 National target on the share of RES by 2020 by Directive 2009/28/EC

Member states have in their efforts to lower energy usage and CO2 emissions agreed to oblige themselves to reach certain goals in share of energy produced from RES. This goal can be important for obtaining certain subsidies or approvals when trying to achieve NZEB standards on a district level. We gathered data from countries participating in the MODER project and EU as a whole.

Country	Target for share of energy from renewable sources in gross final consumption of energy, 2020
Sweden	49%
Latvia	40%
Finland	38%
Austria	34%
Portugal	31%
Denmark	30%
Estonia	25%
Slovenia	25%
Romania	24%
France	23%
Lithuania	23%
Spain	20%
Germany	18%
Greece	18%
Italy	17%
Bulgaria	16%
Ireland	16%
Poland	15%
United Kingdom	15%
Netherlands	14%
Slovak Republic	14%
Belgium	13%
Czech Republic	13%
Cyprus	13%
Hungary	13%
Luxembourg	11%
Malta	10%

Table 7: Target for share of energy from renewable sources [19]

3.5.3 National obligations regarding municipality and district energy plans

From an energy point of view on a municipality and district level aside from potential for exploitation of RES there are many other requirements and polices that can affect the refurbishment process and choice of system type for utilization of RES. This requirements, specifications and directions specific for municipality are often addressed in different documents (Local energy concepts – LEC, or SEAPs). Therefore survey amongst participating partners was made in order to identify presence and necessity of such documents in national and municipality legislation.

Example Slovenia
Key legislation - energy act (EZ-1-NPB1) states that local communities (municipality, or several of them), are obliged to form and adopt local energy concept – LEC, which regulates regional energy policies, priorities, development, RES usage and energy savings. Document should be accessible to the public, keep up to date and up to date with national policies and legislation.

Example Germany
In Germany there is no obligation to participate in the Covenant of Mayors and to develop a SEAP. However there are 57 German SEAPs listed on http://www.covenantofmayors.eu

Additionally there is a promotion activity by the Federal German Ministry for the Environment (BMUB) for communal climate protection projects since 2008 that has funded nearly 9.000 projects in about 3.000 communes so far.

Example Latvia
Regional energy concepts are obligatory in Latvia Their specifications about certain energy source vary, but have to comply with national targets.

Example Netherlands
Municipalities have an important role in the execution of the National Covenant on Energy (Energieakkoord) but no fixed obligation. The municipalities have an important with respect to both privately owned buildings and rented buildings. For this task they receive financial and technical support from the Association of Dutch Municipalities (VNG). One of the municipal tasks is the operation of a local Energy Advice Counter where citizens can obtain information on energy saving measures.

3.5.4 National obligations regarding energy efficiency of DHC systems

Example Slovenia
District heating and CHP systems are encouraged to be used on a national level. Prior to investments the possible use of DH system needs to be investigated. In energy act (EZ-1-NPB1) it is stated that district heating or cooling systems have to use at least 50 % of energy of RES or waste heat, or 75% from CHP systems.

Example Germany
Germany has chosen not to set direct obligations to energy suppliers but to go for support programmes and taxes instead (EED)

Example Netherlands
There are no specific obligations regarding efficiency of DHC systems. The cost for end-consumers may not be higher than in case of application of a decentral gas boiler system.

3.5.5 Regulative (national regional…)

Example Slovenia

There are several acts and regulations that apply to the field of energy in buildings, distribution, savings etc. in Slovenia. As said in the previous segment the key document is energy act (EZ1). A national energy concept is according to EU requirements being prepared. Local energy concepts and action plans regulate local community's approach to energy challenges in region. Technical specifications and requirements are defined in efficient energy usage in buildings regulative (PURES) and more specifically in TSG-01-004:2010 (Efficient energy usage).

Example Latvia

At least 40% energy has to be produced from RES.

4 Conclusion

Process of gathering requirements needed for the refurbishment on a district level with a goal of reaching NZEB standards turned out to be vast and very complicated. There are several reasons:

- Member States have different approaches to implementation of EU directives
- In order to achieve NZEB standards on a district level, we must first make the necessary measures to lower energy usage on a building level (by proper insulation, ventilation etc.). Therefore we must identify requirements on building and district technologies
- Various technologies can be used on a building and district level, or in combination (district heating system – energy storage systems). Therefore it is difficult to differentiate between the two.
- There are many different requirements on each level (end users, grid operators and energy sources), that are specific for a certain building, type of grid and use case. Therefore it is impossible to define everything overall but requirements must be case specific
- Country specific differences (legislation, policies, standards, requirements)
- District specific properties (RES potential, building type etc.)

We tried to identify key requirements that need to be meet on a building and district level from end user, grid operator and energy source's point of view. Key findings and requirements are stated in next segment.

4.1 Summary of requirements

4.1.1 End users

Several end user requirements have been identified that need to be met when renovating existing buildings, districts and their systems. We summarized general requirements that apply to indoor conditions (thermal comfort, ventilation, hot sanitary water, visual comfort), and made a survey about end user requirements (maximum sound levels, user profiles – timeframes, safety precautions) that can have an effect on the choice of the district energy supply system.
As expected there are some differences in requirements between the participating countries. Differences occur in definition of observed parameters (sound levels, occupancy and fire safety). For example Germany has defined user profiles, while not all other countries have done the same. It was identified that some technologies (heat pumps, wind turbines, etc.) can't be used in close proximity of certain buildings because of the end users requirements about noise and vibrations. Attention to national, regional legislation and end users requirements is needed when planning district refurbishment.

4.1.2 Grid operators

Grid operators have a crucial role in city's energy supply and distribution, and consequentially have to respect both end users and national and municipality restrictions and requirements. In this WP we focused on three main types of grid systems (DHC, electricity grid and gas pipelines). For each grid type we gathered main requirements that grid operators have to meet in participating countries. Survey was made with 6 topics; technical requirements, district's obligation regarding favourable technology and grid type, policies and subsidies for certain types of grids, other requirements, emissions and regulative that binds everything together.

District operators have to assure proper pressure, flow, temperature of fluid (water, steam) on the inlet and outlet, temperatures of sanitary hot water (legionella), etc. They also have to meet requirements for gas emissions, and other requirements stated in national and regional legislation (LEC, SEAP, etc.). Additionally, they have to provide information for building owners, energy providers and public in general.

Electricity grid operators have other requirements that need to be meet – electricity quality (frequency, voltage drops, etc.), connections to end users, distribution, regulating consumption and generation of electricity, EM radiation and sound levels).

Gas pipeline grid systems in EU are not favourable anymore. Less and less subsidies are appointed to gas pipeline grid.

4.1.3 Energy sources

Europe in general is trying to lower energy consumption and increase energy efficiency in buildings and systems that are needed in buildings (boilers, district heating systems, lighting etc.). We identified availability potential and requirements that need to be met for the utilization of certain types of energy for each country. We focused on RES, and more specifically on biomass, solar, wind, geothermal and hydro sources. National targets on the share of RES that need to be meet by 2020 were collected. Member States working on MODER in average have to reach 28 % of RES. The average for all of the EU members is 21 %.

Because specific countries, regions and districts have different requirements and policies, documents that regulate usage of RES such as LECs and SEAPs were identified. Survey showed that LEC are a common practice for regulation of municipality’s energy programs, Due to the focus on requirements of technologies that can be used on a district level, we gathered data about national obligations regarding energy efficiency or specifications of DHC systems. When building or renovating district heating or cooling systems in the EU, there are national requirements and obligations about their efficiency and/or RES share that need to be fulfilled.

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[23] Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management (Text with EEA relevance)

[24] Commission Implementing Regulation (EU) No 1348/2014 of 17 December 2014 on data reporting implementing Article 8(2) and Article 8(6) of Regulation (EU) No 1227/2011 of the European Parliament and of the Council on wholesale energy market integrity and transparency Text with EEA relevance

[25] Regulation (EU) No 347/2013 of the European Parliament and of the Council of 17 April 2013 on guidelines for trans-European energy infrastructure and repealing Decision No 1364/2006/EC and amending Regulations (EC) No 713/2009, (EC) No 714/2009 and (EC) No 715/2009 Text with EEA relevance

[26] Directive 2009/72/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC (Text with EEA relevance)

[27] Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC (Text with EEA relevance)

[28] Directive 2005/89/EC of the European Parliament and of the Council of 18 January 2006 concerning measures to safeguard security of electricity supply and infrastructure investment (Text with EEA relevance)

[29] New EU requirements for transformers. 2014. Available at: http://www.energy.siemens.com/apps/features/eco-design-calculator/assets/pdf/eu-requirements-for-transformers.pdf

[30] Commission Delegated Regulation (EU) No 1391/2013 of 14 October 2013 amending Regulation (EU) No 347/2013 of the European Parliament and of the Council on guidelines for trans-European energy infrastructure as regards the Union list of projects of common interest

[31] Commission Regulation (EU) 2015/703 of 30 April 2015 establishing a network code on interoperability and data exchange rules (Text with EEA relevance)

[32] Commission Regulation (EU) No 312/2014 of 26 March 2014 establishing a Network Code on Gas Balancing of Transmission Networks Text with EEA relevance

Appendix

Appendix 1

Building permit						
Type / technology	Finland	Latvia	Netherlands	Germany	Austria	Slovenia
Individual stoves	Yes for new large systems, no for maintaining	Permission is needed if project is financed by Europeanian, country or munitipality fund.	* For new buildings in general a building permit is needed. No permit is needed for a heating system as part of a building and replacement of systems. Minimum requirements apply.	* For new buildings in general a building permit is needed. No permit is needed for a heating system as part of a building and replacement of systems. Minimum requirements apply.	Yes (different federal laws).	Yes for new large systems, no for maintaining
District heating	Yes	Always need permission	Yes, for the whole district heating system. Otherwise see *	Yes, for the whole district heating system. Otherwise see *.	Yes	Yes
Combined heat and power generation	Yes	Yes	See *.	See *.	Yes	Same as for individual stoves
Heat pumps	Yes, depends on local building codes (if changes in facade)	Same as for individual stoves	** Special permit necessary if ground water is used in any way. Otherwise see *	Permit necessary for energy wells. Otherwise see *	Same as for individual stoves	Same as for individual stoves
Constant-temperature boilers	/	Same as for individual stoves	See*	See*	Same as for individual stoves	Same as for individual stoves
Low-temperature boilers	/	Same as for individual stoves	See* For large installations legionella safety is an issue.	See*	Same as for individual stoves	Same as for individual stoves
Seasonal, energy heat storage	/	/	Special permit necessary if ground water is used in any way. Otherwise see *	See*	/	No
Solar collector	Yes, depends on local building codes (if changes in facade)	Same as for individual stoves	See*	Yes - for storage facilities	Yes. In addition construction notification.	Same as for individual stoves

Waste heat usage	No	/	See*	See*	/	No
Shower water heat recovery	No	/	no	Yes, for the whole district heating system. Otherwise see *.	/	No
DCU - District Cooling Unit (local district cooling)	Yes	Always need permission	See*	/	Yes	Yes
Shading systems	Yes, depends on local building codes (if changes in facade)	Not needed	Yes, depends on local building codes (if changes in facade)	Yes, for the whole district cooling system. Otherwise see *.	No	No
Compression cooling	/	Same as for individual stoves	no	No	Yes	Same as for individual stoves
Absorption cooling	/	Same as for individual stoves	No	See *	Yes	Same as for individual stoves
Solar cooling	/	/	No	See *	Same as solar collectors.	No
Heatpump cooling	Yes, depends on local building codes (if changes in facade)	/	No	See*	Same as for individual stoves	Same as for individual stoves
PV pannels	Depends on local building codes	Same as for individual stoves	Yes, depends on local building regulation (if changes in facade or visible from street). May be forbidden in historical city district	See *	Yes	No
Wind	Yes	Yes	yes	See *	Yes	Yes
Hydro	Yes	Yes	yes	Yes	Yes	Yes
CHP		Yes	yes	Yes	Same as for individual stoves	Same as for individual stoves
Storage systems	No	/	See**	See *	Yes	No
Wind driven ventilation	/	Same as for individual stoves	Included in main building permit	See *	Same as for individual stoves	No

Exhaust ventilation	Included in main building permit	Same as for individual stoves	Included in main building permit	See *	Same as for individual stoves	No
Heat recovery ventilation	Must assembled in new buildings	Same as for individual stoves	Included in main building permit	See *	Same as for individual stoves	No
Stack ventilation	Included in main building permit	Same as for individual stoves	Included in main building permit	See *	Same as for individual stoves	No
Solar chimney	/	Same as for individual stoves	Included in main building permit	See *	Same as for individual stoves	No