Contract Number 260165

E-HUB
Energy-Hub for residential and commercial districts and transport

SEVENTH FRAMEWORK PROGRAMME

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Del 2.3 Technology specification for different E-HUB district scenarios

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1 Executive Summary

The E-Hub project, funded under the FP7 programme "Energy efficient Buildings (EeB)" aims at developing energy infrastructure concepts that are able to utilise the full potential of renewable energies available at district level.

An important element of such concepts involves smart control of energy producers[1] and consumers in a district. An important question is what kind of energy producing and consuming equipment is suitable for use in smart energy networks. The selection of suitable energy generation and distribution systems is the objective of the present study ('define possible district scenarios'). The optimisation process and the comparison with a conventional system, using the system impact calculation model, will be the subject of Deliverable 2.4 *E-Hub system impact calculation model.*

As the starting point serve the 6 model districts identified in Deliverable 1.1 '*Identification and systematic specification of a 'model district type'*. These model districts are summarized in the table below. The table shows that in fact 4 different districts have been identified and that district no. 2 is located in three different climate zones in order to take the effect of the climate into account.

Model district type	**Description**	**climate zone**	**District could be located in:**
MDT1	**Urban or suburban, mixed use** (i.e. residential, commercial and services), medium density mid-rise buildings from 1946 to present	(Central Europe)	Amsterdam Munich Freiburg
MDT2A	**Residential district**, suburban or exurban area, buildings aged from 1971 to present, medium/low density, mid-rise buildings	(South Europe)	Athens Palermo Malaga
MDT2B	**Residential district, as 2A**	(North Europe)	Helsinki
MDT2C	**Residential district, as 2A**	(Central Europe)	Amsterdam Munich Tweewaters Freiburg
MDT3	**Business district/office park** in a metropolitan or urban area with medium density high-rise and mid-rise buildings aged from 1981 to present	(Central Europe)	Amsterdam Munich Freiburg
MDT4	**Multifunctional development centre** with mixed use (i.e. residential, commercial and services), with medium density mid-rise buildings aged from 1981 to present	(Central Europe)	Amsterdam Munich Freiburg

Table 1: Table showing 4 different model districts, of which district no. 2 is located in 3 different climates

The size of the model districts, with a few hundred inhabitants, is not as large as a real district which typically has 5000-10000 inhabitants. However, the model districts are treated as a typical module of which a district can contain several. The size of the model district, illustrated in the next figure, is taken to size the energy system (e.g. central boiler or district heating network).

[1] Strictly speaking, energy cannot be produced (nor annihilated). Energy is used here as a generic term for forms of energy such as heat, cold and electricity which can be converted from e.g. fossil fuels or solar energy.

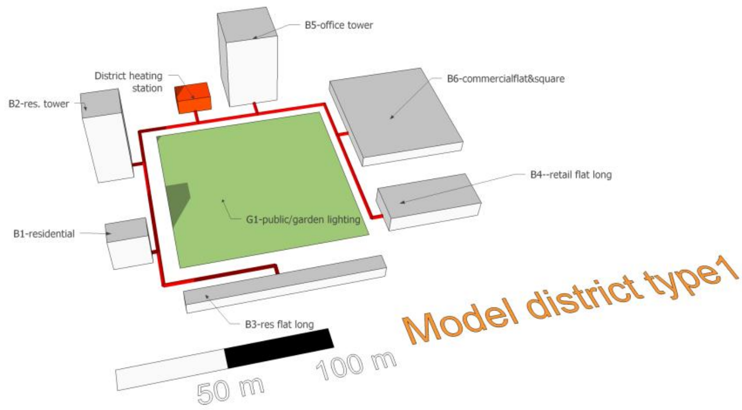


Figure 1: *3D model of model district MDT1 with district heating network and district heating station shown in red*.

The districts considered contain buildings in the current state of thermal insulation because the impact of applying E-hub systems on (far more abundant) existing districts is much larger than when considering new and more energy efficient districts.

In the present study the energy demand of the model districts was analysed in detail, in particular producing hourly data for the energy consumption using the eQuest software from the DOE (Department of energy) (See Annex A). However, assessment of the energy consumption was done mainly on the basis of the monthly energy profiles, as illustrated in the figure below for model district no. 1 (Munich). This is the subject of chapter 3.

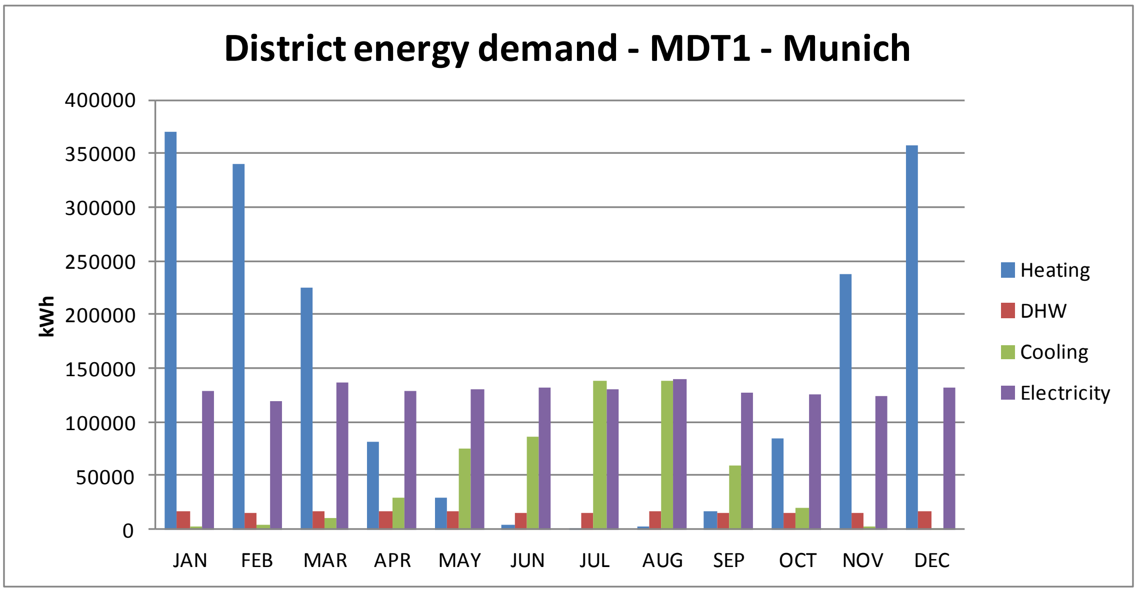


Figure 2: *Figure showing the monthly energy demand for heating, DHW, cooling, and electricity in kWh/month for model district no.1 (Munich). Electricity consumption includes the energy for building ventilation, lighting and auxiliary equipment*

In the next step, a number of real cases were studied which provided information on the performance and economic feasibility of different renewable energy and energy efficient systems. The cases studied are summarized in the table below. Detailed information can be found in Annex B.

Technology	Real case study
Photo Voltaic panels	Electricity production with 1.8 kWp poly-crystalline photovoltaic modules in Belgium.
	Electricity production with a 2.4 kWp poly-crystalline photovoltaic module in Belgium.
	Electricity production with a 1.2 kWp poly-crystalline photovoltaic module in Belgium.
Windturbines	Electricity production with a 660 kW wind turbine in Middelkerke, Belgium.
	Electricity production with a 1,650 kW wind turbine in Halle (Belgium).
	Electricity production with a 1,800 kW wind turbine in Eeklo (Belgium).
Solar collectors	Domestic hot water production with 37 m² of solar collectors combined with space heating with gas boilers
	Domestic hot water production with 51 m² vacuum tube solar thermal collector for an elderly home in Schoten, Belgium.
	Domestic hot water production with a 33 m² flat plate solar thermal collector for an elderly home in Mol with 28 apartments (Belgium).
	Domestic hot water production with a 82 m² flat plate solar thermal collector for an elderly home in Kortrijk, Belgium.
CHP (Combined heat and Power)	Heat production with a 100 kW wood pellet boiler in combination with a 200 kW condensing gas boiler for space heating of 26 dwellings in Belgium.
	ORC-CHP (Organic Rankine Cycle –Combined Heat and Power) in a residential district (380 dwellings)
	Heat and electricity production with a 5,5 kWe/12.5 kWth Combined Heat and Power installation (CHP) for the energy supply of 12 dwellings in Herenthout (Belgium).
	Micro-CHP in a residential building (94 dwellings) in Madrid
	Cogeneration plant in Genoa (Sampierdarena neighbourhood)
Absorption cooling	Absorption cooling with a cooling capacity of 3,200 kWth at the AZ Sint-Jan Hospital in Bruges, Belgium.
district heating	District heating of public buildings and private dwellings fuelled by local biomass in Liguria region (Italy)
Heat pump	Heat production with a 10.5 kWth direct expansion heat pump.
Underground heat and cold storage	Borehole heat exchanger field for the art museum in Ahrenshoop (Germany)
	Energy piles for an office building in Schwerin (Germany)
	Heat and cold production with two heat pumps of 195 kWth and an aquifer thermal energy storage system (ATES) for a hospital.
	Aquifer thermal energy storage to provide heat and cold at Cipal and Technologiehuis in Geel, Belgium.
	Aquifer thermal energy storage to provide heat and cold with a nominal power of 518 kWth at the site of NV Blairon in Turnhout, Belgium.
	Aquifer thermal energy storage to provide heat and cold with a nominal power of 570 kWth at Etap in Malle, Belgium.
Hydrogen storage	desktop study

Table 2: *Table showing the real cases studied using different renewable energy and energy efficient systems.*

From the analysis of the monthly profiles for the energy demand and the real cases, a best practice system is proposed for each model district. Each best practice system includes an ambitious but realistic share of renewable energy, taking into account district restrictions, climatic conditions, and characteristics of each renewable technology.

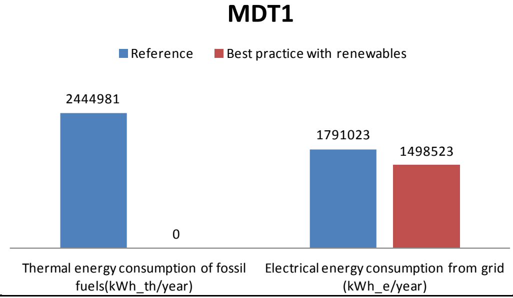
The best practice systems as well as the conventional systems (reference) for each model district are summarised in the next table.

Model district	Description	SYSTEM CONSIDERED	
		Reference	Best Practice including renewables
type 1	Urban or suburban, mixed use, Munich	Individual (R[2]) and central condensing boilers (NR), electrically heated storage systems (NR) and compression chillers (NR).	Central biomass fired boilers, compression chillers (NR) + Photovoltaics
type 2A	Residential, Athens	Individual (R) and central condensing boilers (NR), electrically heated storage systems (NR), individual split heat pumps for cooling (R) and compression chillers (NR).	Central gas fired condensing boilers, solar thermal panels for DHW (R), individual split heat pumps for cooling (R), compression chillers (NR) + Photovoltaics
type 2B	Residential, Helsinki	Individual (R) and central condensing boilers (NR), electrically heated storage systems (NR) and compression chillers (NR).	Central biomass fired boilers, compression chillers (NR) + Urban Wind Turbines
type 2C	Residential, Munich	Individual (R) and central condensing boilers (NR), electrically heated storage systems (NR) and compression chillers (NR).	Central biomass fired boilers, compression chillers (NR) + Photovoltaics
type 3	Business district/office park, Amsterdam	Central condensing boilers, electrically heated storage systems and compression chillers.	ATES (Aquifer Thermal Energy Storage)+ Large wind turbine(s)
type 4	Multifunctional development centre, Amsterdam	Individual (R) and central condensing boilers (NR), electrically heated storage systems (NR) and compression chillers (NR).	Combi-heat pumps (R), ATES (NR) + Urban Wind Turbines

Table 3: *Table summarising the reference system as well as a best practice system for each of the model districts.*

Assuming all renewable energy can be used within the district, the consumption of fossil fuels and electricity from grid, has been calculated for each of the model districts equipped with the best practice system. This energy consumption has been compared with the consumption of the reference installation. The results are shown in Table 4 below.

[2] (R) = residential buildings, (NR) = non residential buildings

<table>
<tr><th>Model district</th><th>Description</th><th>SYSTEM CONSIDERED</th></tr>
<tr><td>type 1</td><td>Urban or suburban, mixed use, Munich</td><td>
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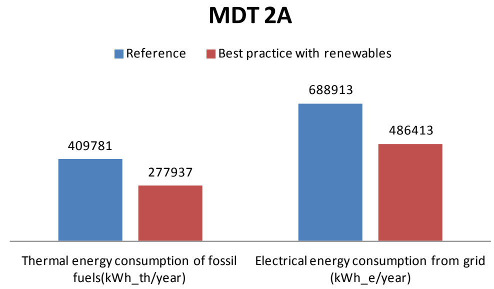
<tr><td>type 2A</td><td>Residential, Athens</td><td>
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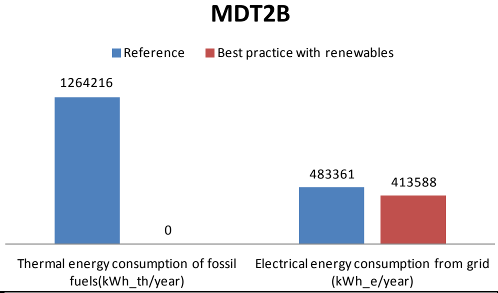
<tr><td>type 2B</td><td>Residential, Helsinki</td><td>
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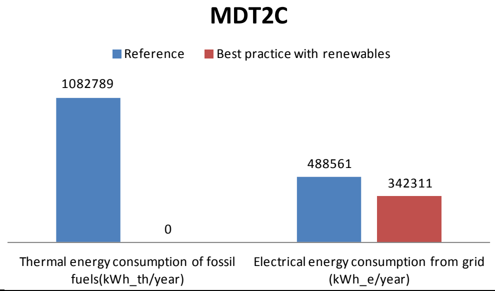
<tr><td>type 2C</td><td>Residential, Munich</td><td>
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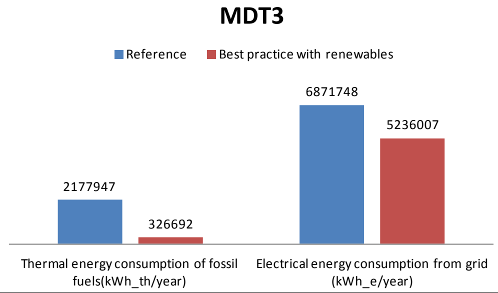
<tr><td>type 3</td><td>Business district/office park, Amsterdam</td><td>
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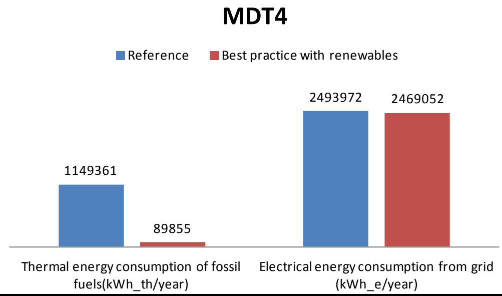
<tr><td>type 4</td><td>Multifunctional development centre, Amsterdam</td><td>
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Table 4: Estimation of the energy consumption when implementing best practice systems

First estimations show that it is feasible, in each district, to achieve a reduction in primary energy consumption (from fossil fuels and grid electricity) in the range of 20-40%, leading to a corresponding reduction of CO_2 emissions. This is just a conservative estimation because at this stage it is not possible to estimate the effect of application of a smart control system (which is being developed in WP4) intended to match the demand and supply of energy. The reason is that at this stage of the project, it is difficult to quantify the effect of a smart control system with any level of accuracy.

More detailed calculations of the extent, to which the introduction of renewables have an effect on energy, economy and ecology is the subject of Deliverable 2.4 *E-Hub system impact calculation model.*