3.1 Publishable summary

Introduction and objectives

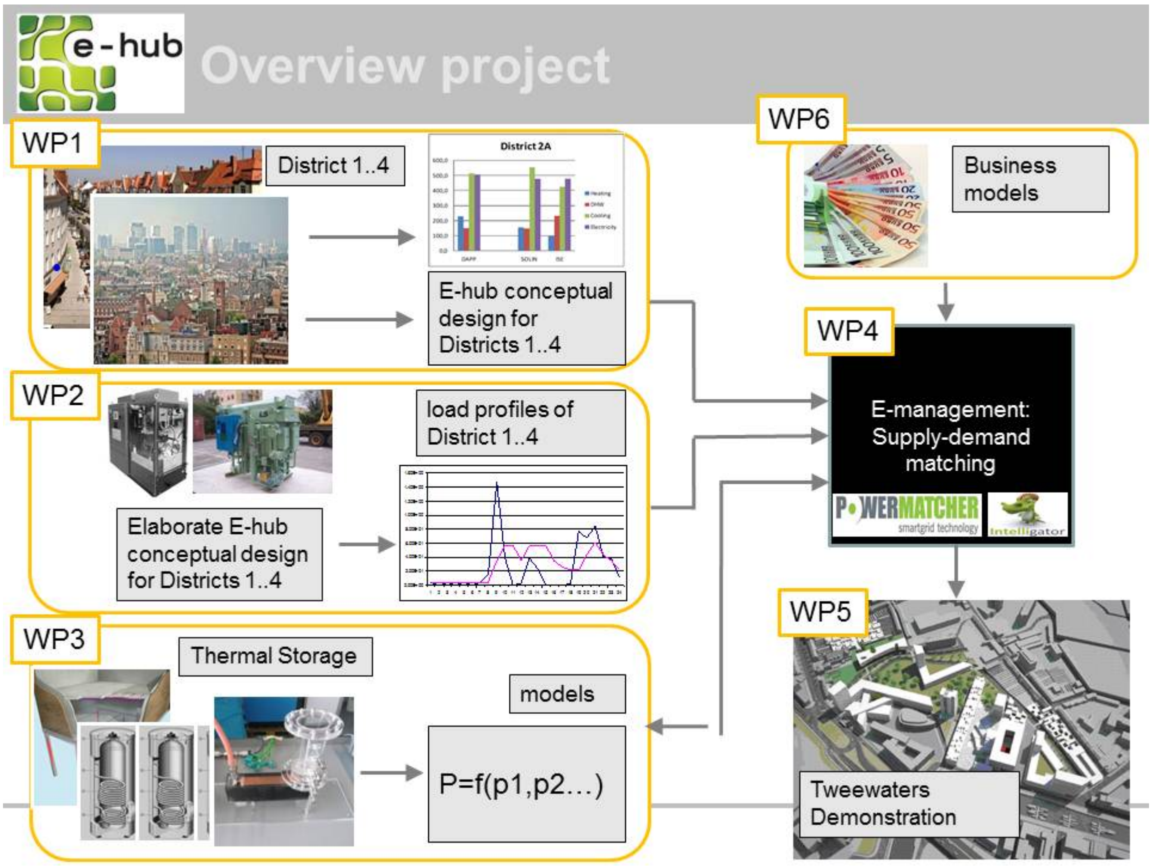
The contribution of renewable energy on district level is still modest and can presently be accommodated in the existing energy infrastructure without great problems. In cases where the contribution of renewables is of the same order of magnitude as the contribution of fossil fuels e.g. when using (large) wind turbines, a particular problem is the fluctuating character of the energy supply, with the effect that it does not match the energy demand. This may occur for instance when peak electricity production by PV cells occurs around noon, while the electricity demand is mostly in the morning and evening. It can also be a long term mismatch such as solar heat harvested in summertime, when the need for heat is mostly in wintertime.

The objective of the project is to maximise the amount of renewable energy at district level by matching energy demand and supply. Part of the solution is found in intelligent charging of electric vehicles or postponing the demand e.g. of heat pumps, refrigerators or washing machines. Excess renewable heat can be stored, e.g. in advanced Thermo-Chemical Materials (TCM) for prolonged periods without heat losses. An important element is acceptance of such an advanced energy supply system by the users. The development of new business models and service concepts that are attractive to both the suppliers and the users is crucial.

The E-hub energy system will be demonstrated in the district of Tweewaters in Leuven, Belgium. In addition, 4 scenario studies will be carried out to assess the feasibility of an E-hub type of system in different districts. (Amsterdam, Netherland; Freiburg, Germany; Milano, Italy and Dalian, China)

Overview of the project and results obtained so far.

An overview of the work in the different work packages and their relation is shown in the figure below.



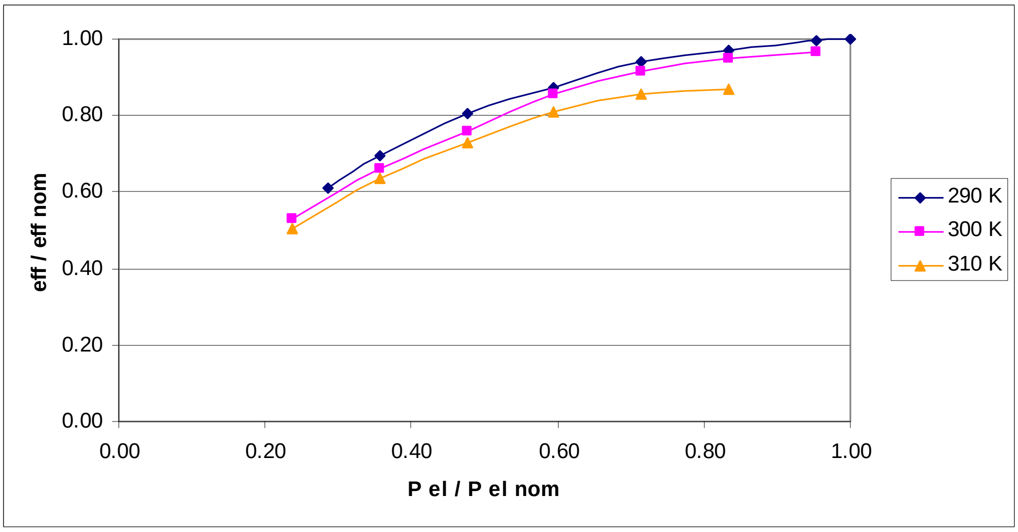
In work package 1, we identified a number of model districts (subject of Del 1.1 and Del 1.3, both completed), and annual energy demand figures for heating, cooling and electricity. The districts are shown in the table below. They will be the subject of simulations in later stages of the project, assessing the effect of a smart energy infrastructure.

Model distric	Description	climate zone	District could be locatec
type 1	**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
type 2A	**Residential district**, suburban or exurban area, buildings aged from to present, medium/low density, mid-rise buildings	(South Europe)	Athens Palermo Malaga
type 2B	**Residential district, as 2A**	(North Europe)	Helsinki
type 2C	**Residential district, as 2A**	(Central Europe)	Amsterdam Munich Tweewaters Freiburg
type 3	**Business district/office park** in a metropolitan or urban area with m density high-rise and mid-rise buildings aged from 1981 to present	(Central Europe)	Amsterdam Munich Freiburg
type 4	**Multifunctional development centre** with mixed use (i.e. residentia commercial and services), with medium density mid-rise buildings ag from 1981 to present	(Central Europe)	Amsterdam Munich Freiburg

Additional work in WP1 includes a first conceptual design of E-hub systems for each of the model districts (Del 1.2, completed) and an evaluation methodology to assess the impact of the E-hub energy infrastructure (Del 1.4, completed).

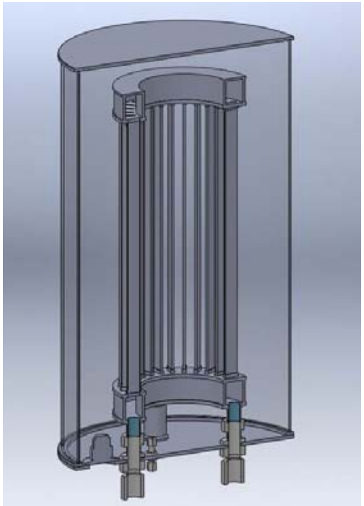
In an E-hub system, with smart control of energy consumers and energy producers, power and heat generating systems are expected to operate differently from stationary systems running at nominal conditions, as is currently the case e.g. in large electricity plants. Therefore, intermittent operation, start-up behaviour and operation at partial load are important aspects to consider.

Work package 2 deals mostly with conventional components of an E-hub system, making an inventory of existing technologies (Del 2.1, completed). In addition, real equipment was tested in the lab of TPG-DIMSET, evaluating the performance of a micro turbine CHP, an absorption cooler unit, an internal Combustion Engine (with a 1.2 litre Fiat engine) and a fuel cell gas turbine hybrid system (reported in Del 2.2, completed). The figure below illustrates the electrical efficiency of the micro turbine CHP at partial load for different ambient temperatures.



WP2 will also produce more detailed (i.e. hourly) load profiles of heating and cooling demand and electricity for each district which will be used in later stages of the project, in particular in WP4 to simulate the performance of an E-hub energy management system. Analysis of the load profiles and economic considerations will yield technological specifications for components in an E-hub system (Del 2.3). Finally, the evaluation methodology from WP1 will be used to calculate the system impact (Del 2.4)

The effort in work package 3 is devoted to the development of different types of thermal storage technologies, of which TCM (Thermo Chemical Material) is a particularly promising one (Del 3.2). The figure below shows the TCM reactor being tested at ECN and the new reactor being built at TNO.

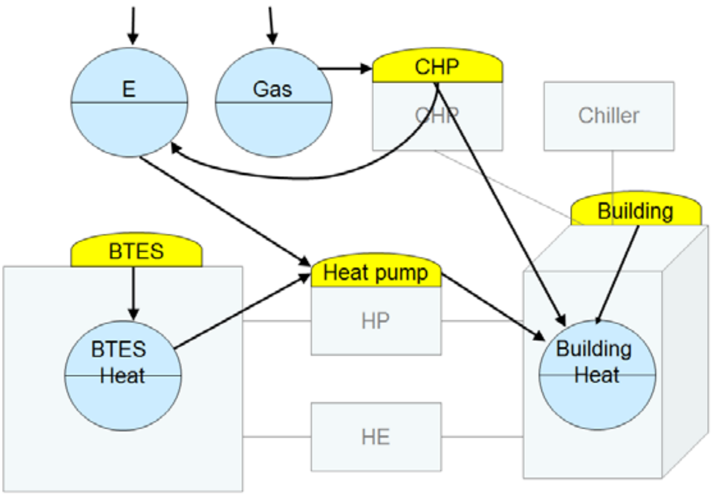


Other types of thermal storage involve thermo-active foundations (in combination with thermal road collector systems) and distributed storage in individual storage vessels (Del 3.1).

Models will be developed of heat and electricity generating and heat storage systems (Del 3.3, D3.4) so they can be used interactively in the simulation of the energy management system in WP4 (hence the two-sided arrow between WP3 and WP4 in figure 1).

Work package 4 is the pivotal part of the project. Overall ICT architecture definition is in progress (Del 4.1). Issues to be further addressed are the development of an intelligent control for storage, the energy management software and the integration of business models (from WP6) into the energy management system (all addressed in Del 4.2).

A particular challenge of the functional architecture is how to deal with the simultaneous optimization of heat and electricity generation in the face of competing technologies. This is for instance the case in the figure below, where heat can be supplied to the building with a CHP, consuming biomass or fossil fuel (and producing electricity) and by a heat pump, consuming electricity. Depending on the price of each commodity, a preference may be given to either equipment. A first working prototype called the Multi Commodity Matcher was developed by VITO before the project. First ideas on alternative approaches are being developed.



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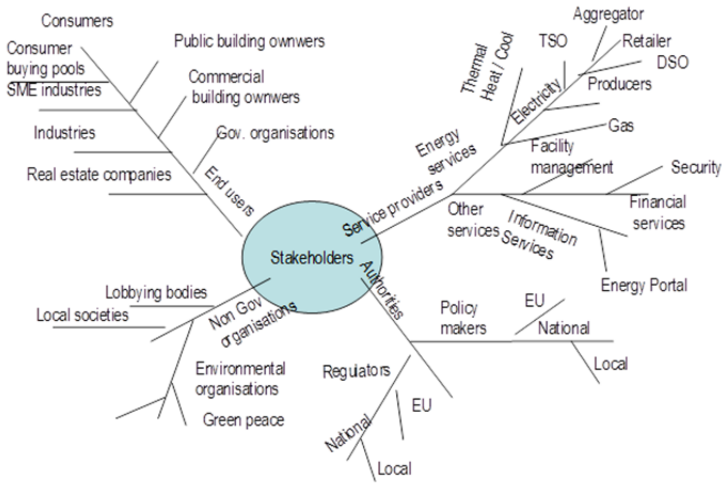
Task4.5 in WP4 deals with the simulation of the E-hub management system within the model districts that were identified in work package 1. In a very early stage of the project, it was decided to use Matlab-Simulink as the simulation platform. Input to the Matlab Simulink environment includes the characteristics of the model districts (load profiles), characteristics of the components used, models of the heat storage and the control strategy. The advantage of this early decision is that all partners know that the results of their work (e.g. numerical models) are pieces that should fit into the larger puzzle of the simulation platform.

Work package 5 deals with the full scale demonstration in the district of Tweewaters. An artist's impression and a picture of the construction process are shown in the pictures below. On the foreground one can discern the large apartment building called the 'Balk van Beel' and in the background the silos on top of which more apartments will be built.

Deliverables comprise reports on the application of the research work developed in the other work packages (Del 5.1, Del 5.3) as well as studies on user behaviour and user acceptance (Del 5.4-5.5).

Work package 6 will provide input related to business models. Both the Powermatcher ® and Intelligator© technology are based on a pricing mechanism to match the needs of electricity consumers with those of the electricity producers. This approach allows including a module called a 'business agent' that can influence the price in order to implement a certain business model (e.g. artificially increasing the price to decrease consumption in order to avoid expensive peaks in electricity consumption).

Del 6.1 will look into existing business models, while Del 6.2 and Del 6.3 look at innovative business models that are attractive to all stakeholders. A map of stakeholders in the district energy sector is shown in the figure below.



Del 6.4 and 6.5 deal with implementation of the novel business models in demonstration and case studies.

Finally, wp7 deals with dissemination and exploitation and it will produce a website, glossy brochures, conference papers and material for education and training.

Impact

Due to limited stocks of fossil fuels and an increasing global demand of energy, energy prices are expected to rise in the future. Considering also an increasing level of awareness with the public of the danger of greenhouse gas emissions and associated climate change, and stricter regulation on the matter, future energy supply systems are expected to change considerably.

The share of renewable such as wind energy, biomass and solar energy (solar collectors, Photo Voltaic panels) will grow in the future. However, renewable energy supply has a fluctuating nature and matching demand and supply of energy will be an increasing challenge. Therefore, intelligent energy management systems are absolutely essential for accommodating a large share of renewable energy in the existing energy infrastructure.

In addition, energy, being a scarce commodity in the future, is expected to be subject to different price levels, rather than the flat rate in use today. Energy may very well be more expensive in times of shortages of supply and cheaper in times of abundant supply. Powermatcher ® and similar software to be developed in the E-hub project already use a pricing mechanism, presently using artificial prices, to match the supply and demand of energy.

More information can be found on the project public website http://www.e-hub.org/