3.1 Publishable summary

Introduction and objectives

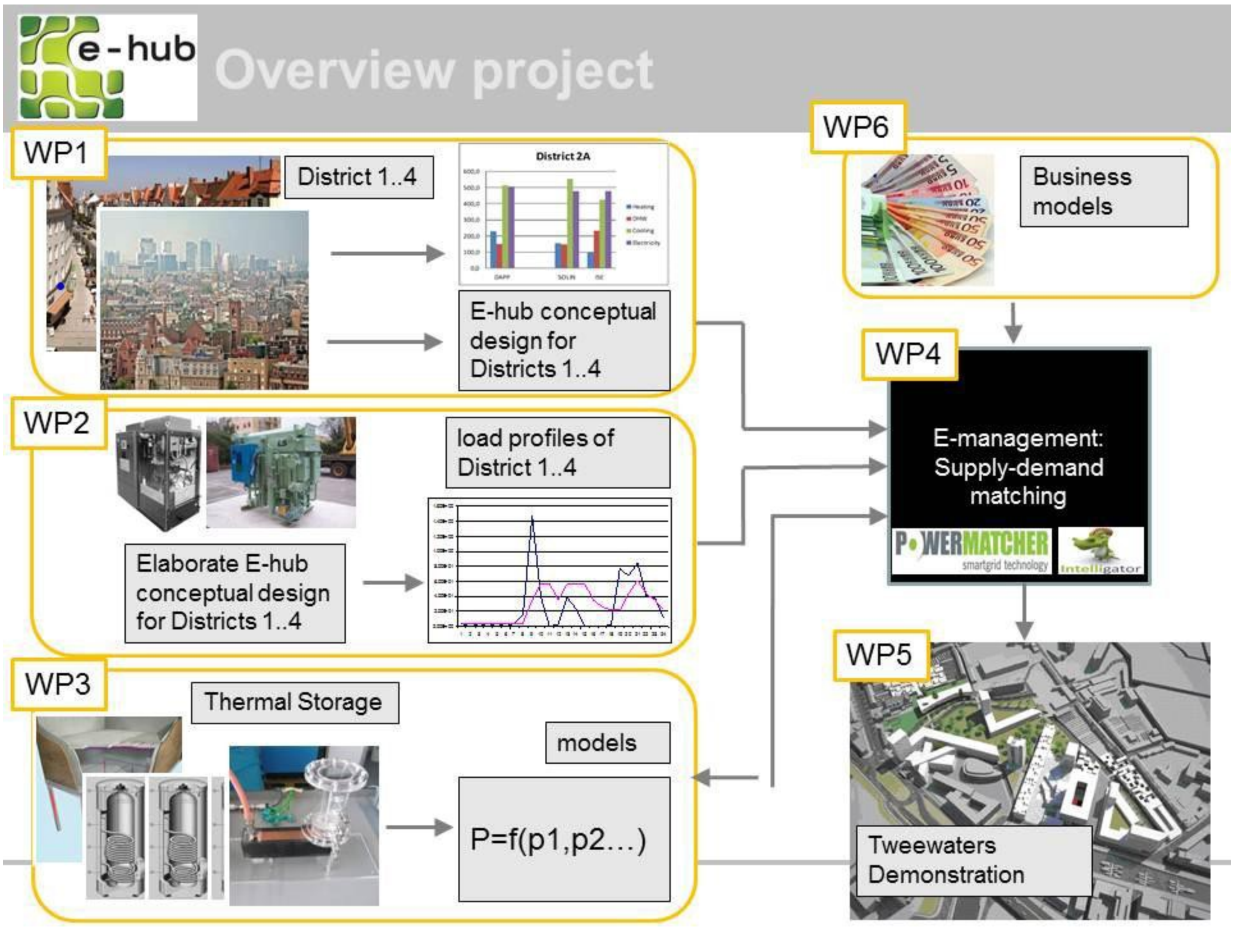
To achieve low energy or even energy neutral districts, the share of renewable energy must increase drastically over present levels. Accommodating a large supplier of renewable energy, such as a large wind turbine, in the existing energy infrastructure is hampered by the fluctuating character of the energy supply. As a result, renewable energy supply is either too large or too small to cover the instantaneous energy demand. Both smart energy management systems and energy storage are essential to meet this challenge.

The objective of the E-hub project is to maximise the amount of renewable energy in a district by matching energy demand and supply, by shifting the demand of heat pumps, refrigerators or washing machines. Excess renewable heat can be stored in advanced Thermo-Chemical Materials (TCM) or boreholes for prolonged periods with few heat losses. An important element is the acceptance of such an advanced energy system by energy suppliers and users alike. Therefore, developing new business models and service concepts that are attractive to all stakeholders is crucial.

The E-hub energy system will be demonstrated in the district of Tweewaters in Leuven, Belgium. In addition, four scenario studies will be carried out to assess the feasibility of an E-hub type of system in the districts of Amsterdam (NL), Freiburg (D), Bergamo (It) 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.

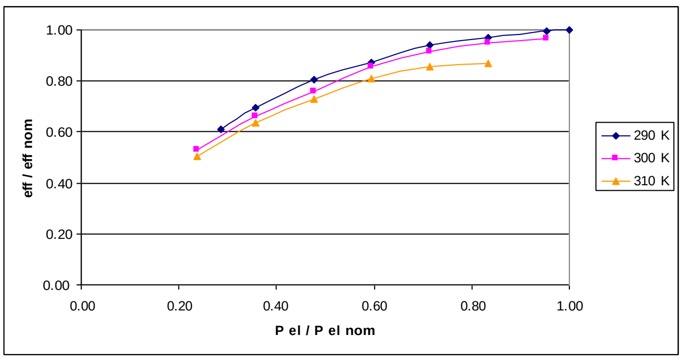


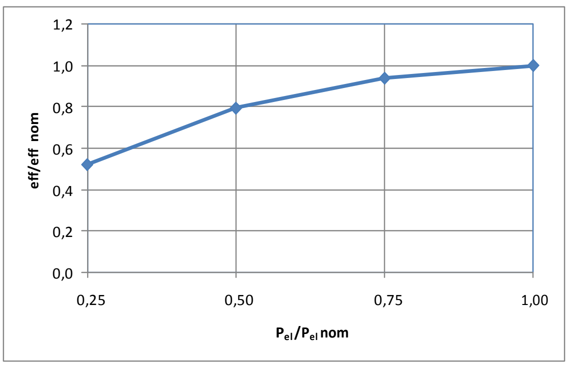
In work package 1, we identified a number of model districts (subject of Del 1.1 and Del 1.3, both completed), and annual energy demand figures for heating, cooling and electricity. The districts are shown in the table below. They will be the subject of simulations in later stages of the project, assessing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

Model district	Description	climate zone	District could be located in:
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 1971 to present, medium/low density, mid-rise buildings	(South Europe)	Athens Bergamo 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 medium 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. residential, commercial and services), with medium density mid-rise buildings aged from 1981 to present	(Central Europe)	Amsterdam Munich Freiburg

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), a fuel cell gas turbine hybrid system and a Stirling Engine (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 (left) and the electrical efficiency of a CHP based on an internal combustion engine. In spite of the difference in technology, the curves show a striking resemblance.





WP2 also produced, for each of the model districts, a proposal for heat and electricity generating equipment, based on the energy profiles of the district and the analysis of a number of real cases with renewable energy and energy efficient equipment. This system is called the ‘best practice‘ system.

Following a methodology developed in WP1, the kpi's (key performance indicators) of energy, ecology and economy were calculated for a number of alternative systems. This resulted in an optimised system, with a share of renewables of at least 20% of the total energy demand. The table below shows the characteristics of a reference system, the best practice system and the optimised system.

Model district	Description	SYSTEM CONSIDERED (D2.3)		OPTIMUM SYSTEM FROM KPI'S (D2.4)
		Reference	Best Practice including renewables	
type 1	Urban or suburban, mixed use, Munich	Individual (R[1]) and central condensing boilers (NR), electrically heated storage systems (NR) and compression chillers (NR).	Central biomass fired boilers, compression chillers (NR) + Photovoltaics	District heating + 593 kWp PV
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	Best practice + 129 kWp PV
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	District heating + 255 kWp PV
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	District heating + 200 kWp PV
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)	Best practice + 1898 m^2 Large wind turbines (swept surface)
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	TAF + 1294 m^2 Urban wind turbines (swept surface)

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 reactors that were tested at ECN (using $MgCl_2{\cdot}6H_2O$ as the thermochemical material) and TNO (using zeolite 5A).

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

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).

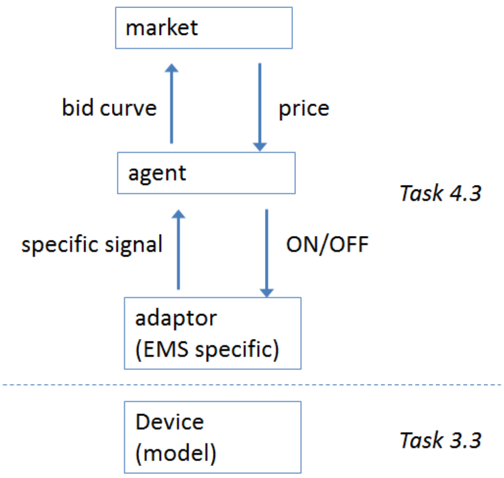
Models will be developed of heat and electricity generating and heat storage systems (Del 3.3, D3.4) so they can be used interactively in the simulation of the energy management system in WP4 (hence the two- sided arrow between WP3 and WP4 in figure 1).

Work package 4 is the pivotal part of the project. An overall ICT architecture was developed (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 a district. A first working prototype software called the Multi Commodity Matcher was developed by VITO before the project. Alternative approaches are being developed.

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.

The integration of models developed by different partners in WP3 is a major issue. All models should be integrated in a common simulation environment. This implies that the models be structured in a similar manner and that they all communicate through a common interface that will allow to run the different simulations in parallel. The interface between the different devices, represented by a model, and the agent based energy market is illustrated in the figure below.



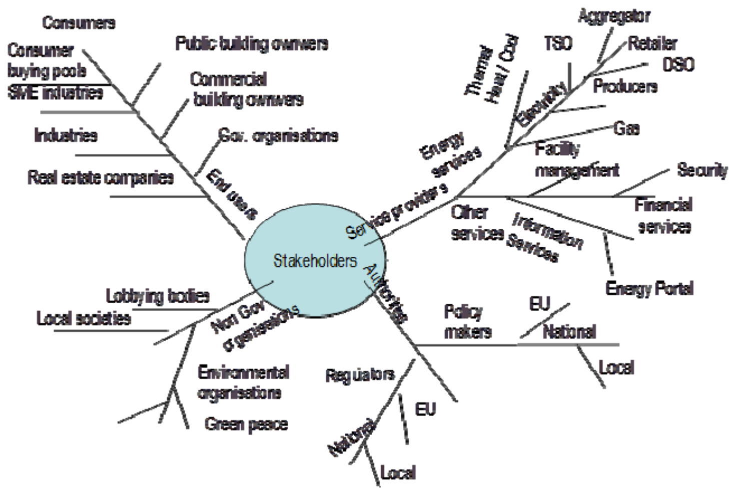
Work package 5 deals with the full scale demonstration in the district of Tweewaters. An artist's impression and a picture of the construction process are shown in the pictures below. On the foreground one can discern the large apartment building called the 'Balk van Beel' and in the background the silos 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 is looking 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. A report on stakeholders and value chains was produced and submitted as an extra deliverable Del 6.6.

Del 6.4 and 6.5 deal with implementation of the novel business models in demonstration and a number of 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 finite stocks of fossil fuels and an increasing demand for energy, energy prices are expected to rise in the future. Considering also increasing public awareness of the effects of greenhouse gas emissions and stricter regulation on the matter, future energy supply systems are expected to change considerably.

The share of renewable energy from wind, biomass and solar energy will grow substantially. Application of energy buffers and intelligent energy management systems are essential to match demand and supply of energy to deal with the fluctuating nature of renewable energy supply.

Energy, being an increasingly scarce commodity, is expected to be subject to a price differentiation, replacing the flat rate in use today. Energy will be more expensive in times of shortage 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. This system therefore is well prepared for future price differentiation.

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