Project no. 314277

STEEP PROJECT

Systems Thinking for Comprehensive City Efficient Energy Planning

Seventh Framework Programme

Theme Energy

D3.1. Low carbon technologies study: current technologies, best practices of their applications and roadmaps

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Dissemination Level		
PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

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1. INTRODUCTION

1.1 Purpose of this document

This document is part of STEEP project *Task 3.1 – Knowledge Exchange and Validation Initiatives*, and together with its Annex, forms *Deliverable 3.1 'Low carbon technologies study: current technologies, best practices and their applications and roadmaps'.* As such, the intention of this document is to present information gathered by the project's technical partners regarding different technologies in the areas of Energy, Transport and ICT. Where relevant and possible, best practice applications have been identified for the different technologies, which can then be used to input into the generation of plans for the implementation of technologies in the different cities.

This document includes several sections with information on the different technologies, which intend to facilitate further knowledge exchange not only within project partnership but also with the different stakeholders participating in the different cities. To compliment this document, presentations for each particular technology in PowerPoint format have been also been developed to facilitate presentation of concepts to the stakeholders in a simple and direct way. Those presentations are compiled as an annex to this document.

1.2 Structure and content of the deliverable

After this introductory section, three technical sections each describe different technologies in the fields of Energy (section 2, prepared by TECNALIA), Mobility (section 3, prepared by ATAF) and ICT (section 4, prepared by CSE). Within these technology descriptions, different issues, best practices applications and trends are included. The descriptions are compiled as" which intend to serve as a resource for both project partners and different stakeholders in the city when information about a particular technology is needed or its application within the city needs to be discussed.

The fifth section of this document, prepared by ACCIONA, presents an overview of the current status and prospective use of energy technologies in the European context, in order to give a general overview that can be used for short communications on potential energy options. The final section presents a detailed description of innovative technologies resulting from European Research projects in Nano, Materials and Products (NMP), Energy Efficiency Best Practice programme (EEBPP), ENERGY and ICTs, in which ACCIONA has participated, and which are useful as a source for detailed technical information on particular technologies for the STEEP Project.

These technical sections intend to serve as a vehicle for discussions with the stakeholders participating in the knowledge exchange activities in the coming months,

and as a first input to facilitate preparation of the energy master planning process and the possible application of the analysed technologies in the STEEP cities.

The annex to this deliverable compiles the PowerPoint presentations, which were also prepared by the expert organizations summarizing information for each of the technologies.

2. TECHNOLOGIES FOR ENERGY

This section presents the developed for knowledge exchange on the different technologies and approaches in relation to energy.

The prepared by TECNALIA have been prepared so as to allow separate pages to be printed and distributed separately to respond to request of information, feed discussions and workshops, etc.

The following technologies have been covered, together with and an additional introducing the concept of industrial ecology in relation to cities:

PHOTOVOLTAIC (PV) SOLAR TECHNOLOGY

SOLAR THERMAL TECHNOLOGY (NON-CONCENTRATING)

DISTRICT ENERGY

GEOTHERMAL ENERGY

HEAT PUMPS, GEOTHERMAL AND HIDROTHERMAL ENERGY SOURCES

COGENERATION

THERMAL ENERGY STORAGE (SHORT AND LONG TERM)

WASTE HEAT RECOVERY FROM INDUSTRY

2.1 Photovoltaic (PV) solar technology

Introduction

The photovoltaic effect (the physical phenomenon responsible for converting light to electricity) is exploited by Photovoltaic solar technologies in order to generate electricity. Light shining on a semiconductor generates electron-hole pairs that are separated spatially by an internal electric field created by introducing special impurities into the semiconductor on either side of an interface known as a p-n junction.

Negative and positive charges are created on one and the other side of the interface and a voltage is created by the separation of the resulting charge. When the two sides of the cell are connected to a load, current flows from one side to the other side of the cell. The conversion efficiency of a solar cell is defined as the relation between the power generated and the incident solar irradiance. There are several aspects that affect the efficiency of a solar cell like the properties of the material of the absorber and its design. (Renewable Energy Sources and Climate Change Mitigation. Special Report of the IPCC. 2012)

Advantages and disadvantages of the technology

Advantages;
-The solar energy is renewable and the total solar irradiation of the sun to the earth surface is about 5.6.1012 TJ per year.
-The conversion of solar energy has no emissions during operation, only the visual impact.
-It allows applications in many orders of magnitude, from some milliwatts to several megawatts. Combining cells to reach different capacities.
-Direct and diffuse radiation can be transformed to electricity.
-Silicon is the second most abundant element on earth and is not toxic.
-Integration in buildings is possible.

Disadvantages;
-Low convertible energy density.
-Electricity production depends on weather conditions and irradiation.
-There is no good storage facility developed yet.
-The purification of the silicon is an energy intensive (and expensive) process. This increases the embodied energy of the product.
-Large areas are necessary.

Current photovoltaic technologies

Cells can be classified as wafer-based crystalline (single crystal and multicrystalline silicon) or thin film.

Singlecrystalline silicon cells (or monocrystalline): The active material is made from a single crystal without grain boundaries, those cells have the highest efficiencies (for commercial cells between 13-18%).

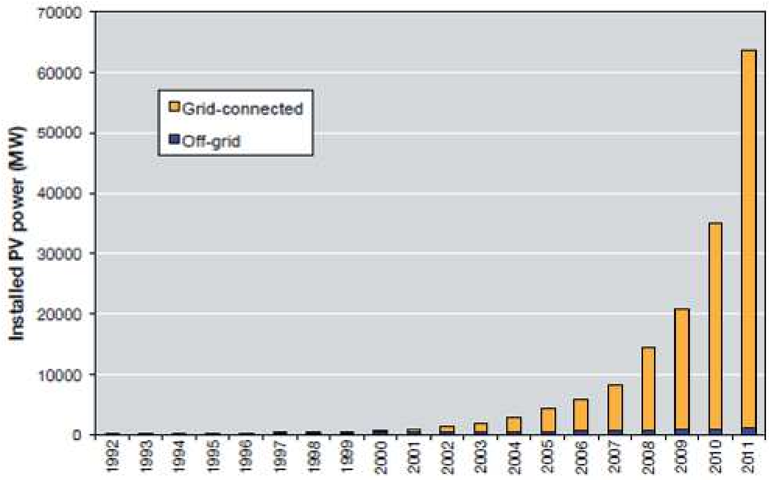
Multicrystalline (polycrystalline) silicon cells: The cell material consists of different crystals with different orientation. The domain boundaries or grain boundaries lead to electron-hole-recombination losses. Thus, this type of cells has a lower efficiency, but it is cheaper in production. This kind of cell has an efficiency of about 11-16%. *Ribbon silicon technologies* use the available silicon more efficiently. The wafers are directly crystallized from the silicon melt. Thus no sawing losses occur. Ribbon cells have an efficiency of about 10-14%.

Thin films: those modules are constructed by depositing extremely thin layers of photovoltaic materials on a component usually made of glass, stainless steel or plastic. Individual 'cells' are formed by then scribing through the layers with a laser. This technology is a good opportunity for cost reductions and is commercially used in amorphous silicon (a-Si), cadmium telluride (CdTe), and copper-indium-gallium-diselenide (CIGS). Those types of cells have in general a lower efficiency, for example amorphous silicon has a final efficiency between 6-9%.

Best practices of their application

There are two general types of PV systems, isolated and grid connected. Isolated systems generate electricity independently from the electricity grid and grid connected systems are connected to the grid reducing the electricity generation that would otherwise be generated by other technologies that compose the electricity grid mix. Grid-connected systems use an inverter to convert electricity from direct to alternating current, and then supply the generated electricity to the electricity grid. Grid-connected systems costs are lower because the grid is used as a buffer and energy storage is not required. Off-grid installations in return need a storage battery and a regulator to compensate the imbalance between the generation and the demand and to protect the battery from important discharges and overcharges respectively.

The next figure shows the time evolution of the ratio of off-grid and grid-connected systems in the Photovoltaic Power Systems (PVPS) Programme countries.



Cumulative installed grid-connected and off-grid PV power in the reporting countries (Source. IEA-PVPS T1-21:2012)

The principal applications for PV systems are;

Off-grid domestic systems provide electricity to buildings and areas where the cost of connection to the electricity network is high. There is a significant opportunity for application in developing countries providing electricity for lighting or refrigerating.

Off-grid non-domestic installations are usually used for power supply for remote services such as lighting, water pumping, etc.

Off-grid centralized PV mini-grid systems, this kind of systems are increasingly used as an alternative power supply system for diesel generators usually used for isolated areas, where buildings are not separated too much between each other.

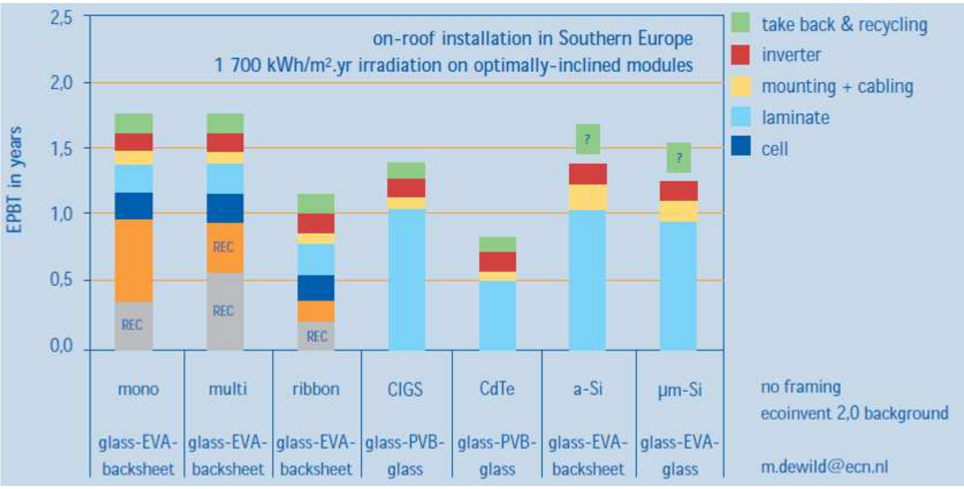
Centralized PV mini-grid systems can be cost-effective solutions for reducing the diesel generators due to some advantages linked to the technology like higher performances or less storage needs. Although they may have a diesel generator set as an optional balancing system or operate as a hybrid PV-wind-diesel system.

Grid-connected distributed systems are systems integrated into buildings or in the built environment that provide power to a grid connected customer or directly to an electricity grid configured to supply energy for a number of customers. There are several types of mounting structures for building integrated PV systems, including integration in facades and roofs and integration in some construction materials and components like glasses or tiles.

Grid-connected centralized systems are usually ground mounted large scale installations that are used as centralized power generation. The mission of those systems is to supply big amounts of electricity continuously.

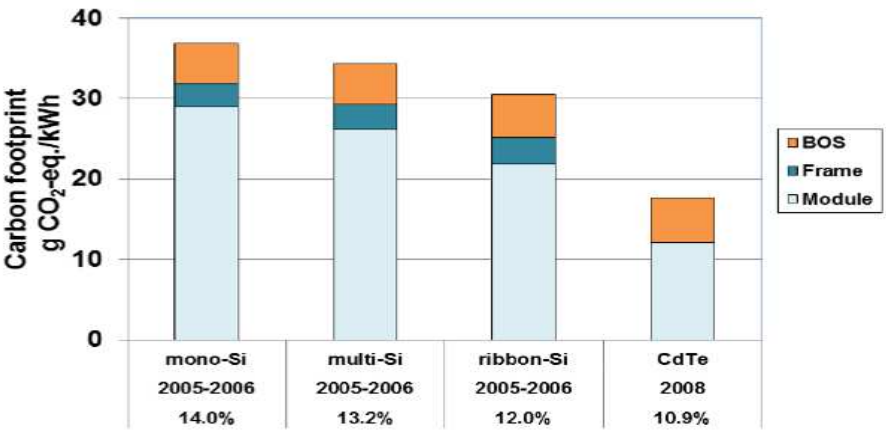
Environmental performance

The figure below shows the Energy Pay-Back (EPBT) Time of rooftop PV systems from different PV technologies in southern Europe (irradiation of 1700 kWh/m2/yr).



(Source: M. de Wild-Scholten (ECN), Sustainability: Keeping the Thin Film Industry green, presented at the 2nd EPIA International Thin Film Conference in Munich on November 12, 2009.)

With regard to the Greenhouse gas (GHG) emissions from the life-cycle of the PV, the figure below shows the results of rooftop mounted PV systems for different PV technologies. The estimates correspond to Southern European irradiation of 1700 kWh/m2/yr, performance ratio of 0.75 and life expectancies of 30 years with no degradation for either the modules or the BOS.

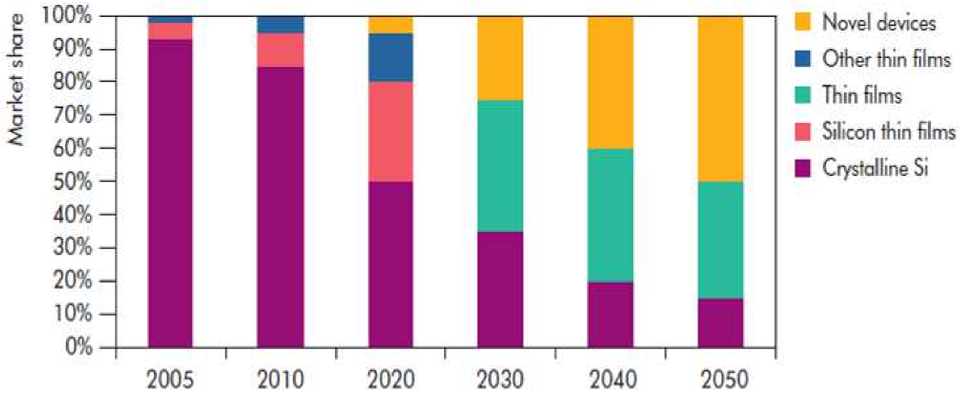


(Source: Methodology Guidelines on Life-Cycle Assessment of Photovoltaic Electricity, IEA PVPS Task 12, Subtask 20, LCA Report IEA-PVPS T12-03:2011)

Those values are similar to the values presented by the NREL (National Renewable Energy Laboratory) in the harmonization document for solar PV systems where crystalline silicon modules have an associated impact near 40g CO2/KWh.

Trends in photovoltaic applications

Today more than 80% of PV modules are wafer-based crystalline silicon type but this technology will decline in the medium term, requiring development of thin film technologies and novel technologies in the longer term. The next figure shows how the PV market will change up to 2050.



(Source: Frankl, Menichetti and Raugei, 2008)

Three main types of PV devices can therefore be distinguished, the existing, the emerging and the novel technologies.

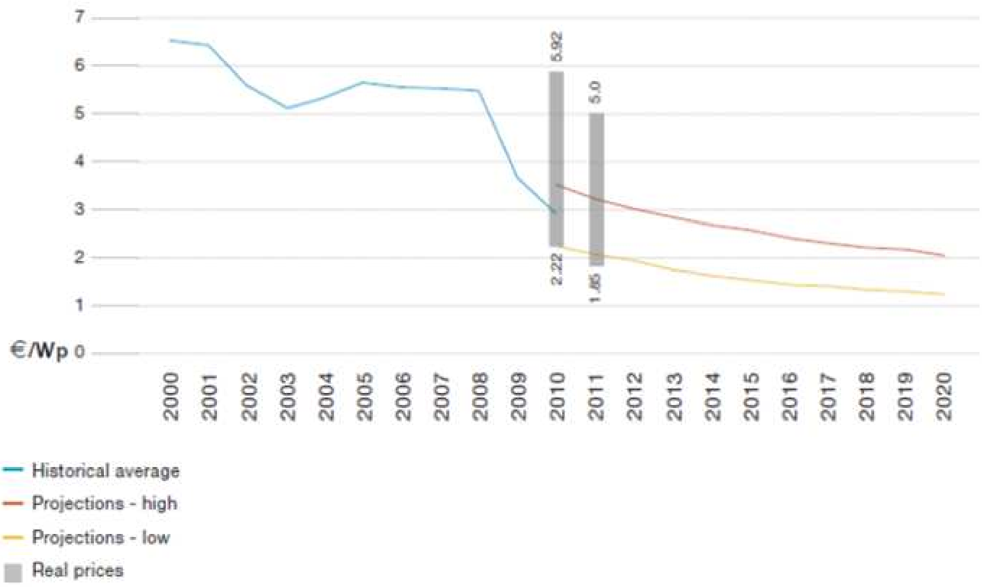
One of the main problems with the *existing photovoltaic technologies* is that the production of silicon solar cells is linked to high energy and economic costs. Therefore, improvement strategies are now focused on the reduction of the amount of silicon needed per KWp (improving cell efficiencies) and the increased recycling of this material.

The *emerging photovoltaic technologies* are focused on using low-cost materials and processes that include technologies such as dye-sensitized solar cells, organic solar cells and low-cost versions of existing inorganic technologies. Those technologies are still under development and are supposed to be available during the next decade.

The *novel PV technologies:* This kind of technology is focused on obtaining very high efficiencies by optimizing the use of the entire solar spectrum more than on reducing costs.

In spite of the high potential, the technology is linked to risk due to the considered new materials, and conversion concepts like the intermediate-band semiconductors, hot-carrier devices, spectrum converters, and others.

The current investment cost for PV systems is high but is expected to decrease during the next years with the increasing penetration in the market of thin film modules, with the development of the production processes and with the massive integration in building that will reduce costs. Next figure show the forecast presented by the European Photovoltaic Industry Association for the costs of a peak power (Wp) generated by photovoltaic technologies.



(Source EPIA (2011) Solar photovoltaics competing in the energy sector)

The studies developed by EPIA suggest that the PV prices will decrease through to 2020 with average prices falling by around 3-5% each year.

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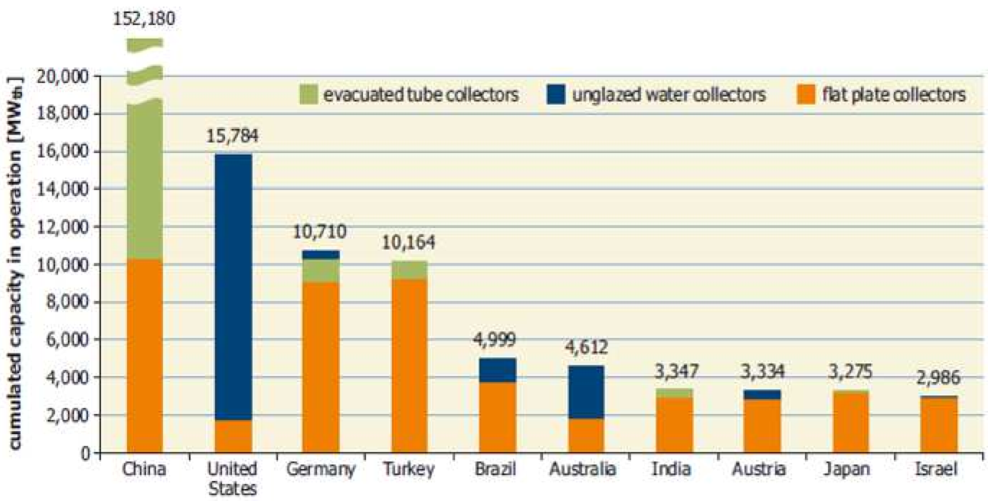
2.2 Solar Thermal Technology (Non-Concentrating)

Introduction

The solar thermal technology has been used traditionally to produce heat from solar radiation with the aim of covering the buildings energy requirements for water heating. Today the technology has improved and a wide range of applications are possible including technologies for electricity generation and for solar cooling. Therefore, it can be considered a technology with a high potential of contribution in meeting climate change objectives considering that the proportion of thermal energy in the final energy demand is very important. Reports developed by IEA show that in 2009 the energy demands for heat represent 47% of total energy use.

Next figure shows the distribution of type of collectors for the 10 leading countries by the end of 2011.



(Source: Weiss, Werner and Franz Mauthner (2013), Solar Heat Worldwide - Markets and Contributions to the Energy Supply 2011, Solar Heating and Cooling Programme)

Advantages and disadvantages of the technology

Advantages;

-Solar heating systems are compatible with almost all the heat support systems.

-The main costs of the technology are incurred in the initial investment due to the minimal operational costs. Therefore the price volatility of oil, gas or electricity has little influence.

-Solar thermal technology creates regional and local jobs because the different phases of the value chain cannot be delocalized.

-The solar resource is virtually unlimited.
-There embodied energy of the installation is lower than in the case of other renewable technologies.

Disadvantages;
-Despite being abundant, the solar resource is dispersed in time and space. The demand of heat does not always correspond to the availability of the resource.
-The existing difficulties in the store of large amounts of heat from one season to another.
-Limitations with the availability of land and roof/façade space.
-High variability of costs depending on the location, due to the different climate conditions.

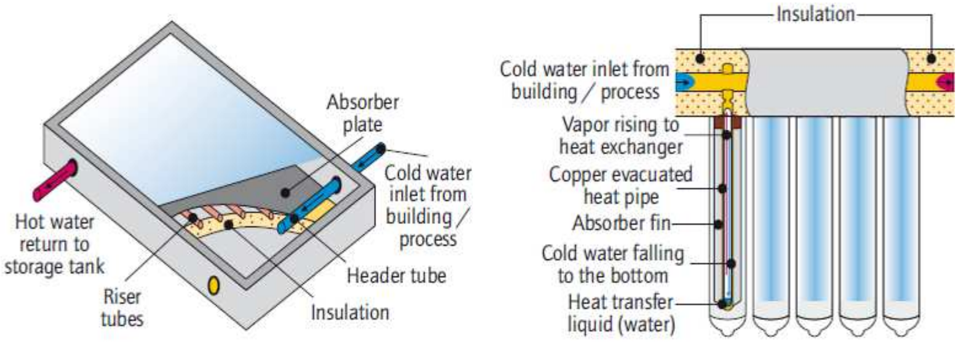
Current solar thermal technologies

Solar heating technologies use the solar collector to transform solar irradiance into heat. The incoming solar irradiance is absorbed by an absorber that maximizes solar absorption (usually in dark color and selective material). This heat is transferred with the help of a carrier fluid to a storage tank.

The storage tank is well-insulated in order to keep the heat available until it is needed. The type of the collector is selected depending on the service to be provided and the range of the needed temperature. Here are described the main type of collectors:

- Flat plane collectors;

Two types of collectors can be distinguished into that category, the glazed flat-plate collector and the unglazed solar collector. The glazed flat-plate collectors have a single or double-glazing that covers the absorber and helps in reaching the temperature needed for residential solar water and space-heating systems. The figure below shows the typical components of a flat-plane collector. The Unglazed Solar Collectors are also used for water heating but are mainly used in swimming pools where lower temperatures are required.



Flat plate collector (left) and evacuated tube collector (right). (Source: Victoria Sustainability).

- Evacuated-Tube Collectors;

Transparent glass tubes with vacuum inside in order to limit the heat losses. This makes it possible to achieve high temperatures used mainly for industrial applications and for cooling, but it is also used in situations with low irradiation conditions.

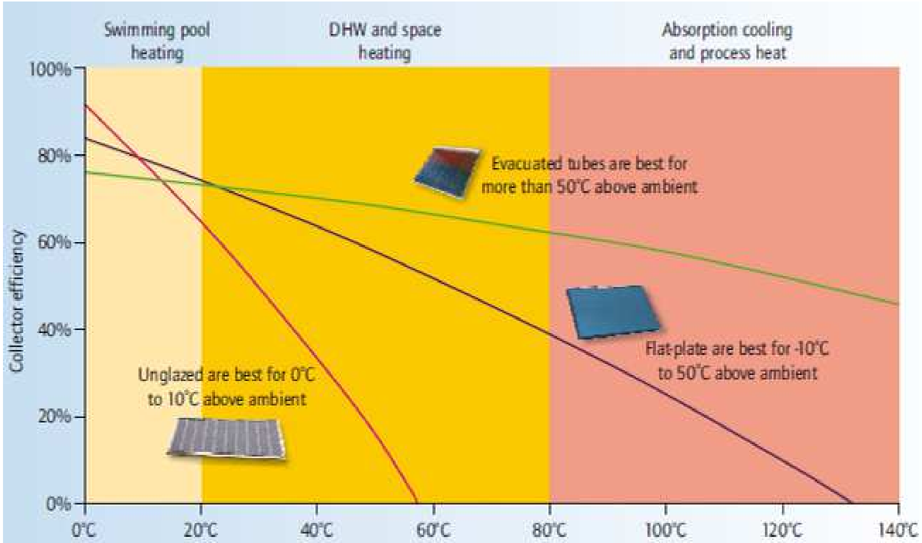
There are two main types of evacuated tube collectors, the direct flow tubes and the heat pipe tubes. In the first one the vacuum is located between two glass tubes fused together and coated with a selective surface.

But the most common evacuated-tube collectors are the heat pipe tubes where the liquid does not pass directly through them, they use heat pipes with fused absorber plates, for their core and the heat is transferred from the heat pipes to the transfer fluid of a hot water or space-heating system.

- Solar air heating system;

These systems heat air with the energy captured from the sun. There are two different types of solar air heating systems the glazed and the unglazed air collectors. The first one is usually used for space heating, recirculating building air and the second one is used to heat ambient air instead of recirculated building air.

Next figure shows for each solar technology, the variation of the efficiency due to the temperature difference between the ambient and the collector.



(Source: IEA. Solar Heating and Cooling Technology Roadmap)

It can be observed that the decrease of the efficiency is more sensitive in the case of unglazed flat plane collectors than in the glazed collectors and that the behaviour of the evacuated tube technology is even better.

Best practices applications

This document only includes active solar heating and cooling applications i.e. it doesn´t consider the application of the solar resource for passive strategies of buildings.

In this context, the principal applications for solar systems are;

Systems with natural (thermosiphon) or forced (pump) circulation

These are the main types of systems for building applications. Systems with natural circulation use the weight difference between the cold and the heated water to circulate the liquid to the storage system. Those systems need to be installed in places with no risk of frosts. On the other hand, the forced circulation systems need pumps to move the liquid into storage, therefore are more complex systems and more expensive. They do however separate the collector from the storage, therefore allowing bigger storage capacity than the natural systems and can be used for DWH and space heating.

Within the use of solar technology for individual buildings, there are several types;

Systems for domestic water heating that are usually small systems with small collector areas that need auxiliary systems for the amount of heating demand that cannot be covered with the collectors.

Solar combi-systems for water heating and space heating that are bigger systems usually with forced circulation and bigger collector areas and storage systems but also need an auxiliary system.

Solar systems for swimming pools use the unglazed technology in order to increase the temperature of the water with reduced costs.

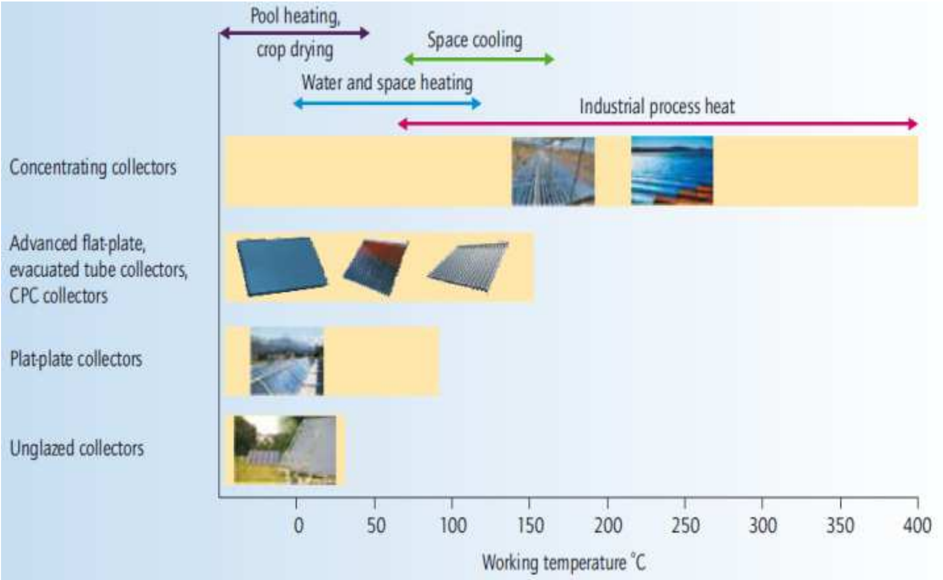
Large scale solar systems are often used for different cases such as multiple-occupancy buildings or the case of the heating supply for districts. This solution can be a good option for low cost heat supply for districts with high building densities.

Solar industrial process; Heat from solar systems is also used to cover a percentage of the needs of heat in industrial processes with temperatures 100ºC <. Most of the systems are currently at the experimental stage and are small in scale.

Desalination and water treatment are promising applications for solar thermal energy due to the large amounts of medium-temperature heat needs of the process. These kinds of plants are usually needed in areas with high availability of solar resource.

Cooling application; solar heat can also be used to cover cooling demands for example in buildings. In this case the heat of the solar system is used to cover the heat needs of the absorption cycle to provide cooling. The final COP of the entire system is low but the technology allows cooling in isolated areas where more is needed, during the day and when it is sunny. In this kind of system flat plane collectors with high efficiencies and evacuated tube or parabolic collectors are mainly utilized.

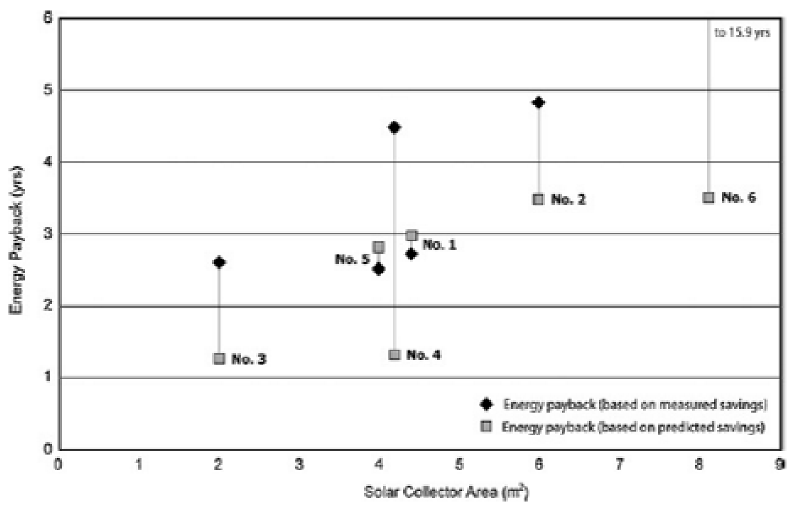
The figure below shows the different application of each solar thermal technology depending on the temperature.



(Source: IEA. Solar Heating and Cooling Technology Roadmap)

Environmental performance

The environmental impact associated with solar thermal technology is very low because there is no need for fossil fuel, and the impact is limited to the electricity needs of pumps, others devices and to the maintenance requirements. Besides the limited environmental impact of manufacture, the impact of the decommissioning of the solar thermal system is also low. The life-cycle impact of a solar thermal installation in GWP is around 60gCO_2eq/KWh. Regarding the Energy Payback Time of the solar thermal systems, there is a high variability between the predicted and the expected values and between different installations. This figure shows the results for a domestic solar water heating installation.



(Source: Patxi Hernandez and Paul Kenny, 2012)

In the same way the Net Energy Ratio values can vary between 5.7 and 16, there is also a large variation depending significantly upon climatic conditions

Trends in solar thermal applications

The installed power of the solar thermal technology is expected to increase considerably during the next ten years. The study presented by the IEA regarding the 'Roadmap for Solar Heating and Cooling Technology', envisages that the production of solar heating and cooling will increase by 16.5 EJ for heating and 1.5EJ for cooling before 2050. Hot water and heating applications will contribute with 8.9 EJ, heat for industry applications with 7.2 EJ, and heating for swimming pool applications with 400PJ.

Research and development priorities of the technology will be related to:

- *material research* like the integration of plastics in solar systems and the improving of the coating surface,
- *new components* to integrate solar systems in the building envelope such as the roof and multifunctional facades,
- *improved storage technologies* such as 'seasonal storage' to increase the potential of solar district heating or the use of phase-change materials or thermo-chemical processes,
- improvement in the *systems that use solar energy for air conditioning,*

The current investment cost for solar thermal system is different depending on the type of technology and application. The costs of DHW with thermosiphon and forced circulation are between 50-110 euro/MWh for Southern Europe and between 80-190 euro/MWh for Northern Europe, cost for combi-systems 140-230 euro/MWh [ESTTP based on data from ESTIF and EUROSTAT].

These costs are expected to decrease during next years, by 2030 hot water systems will cost between 50-80 euro/MWh, combi-systems will cost 100-240 euro/MWh, and large-scale applications will cost 30-50 euro/MWh.

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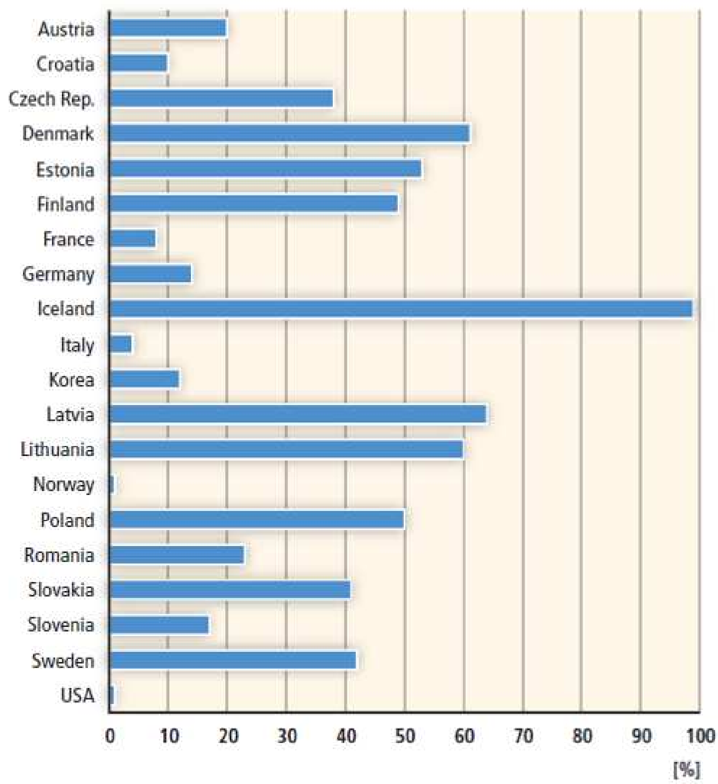
2.3 District energy

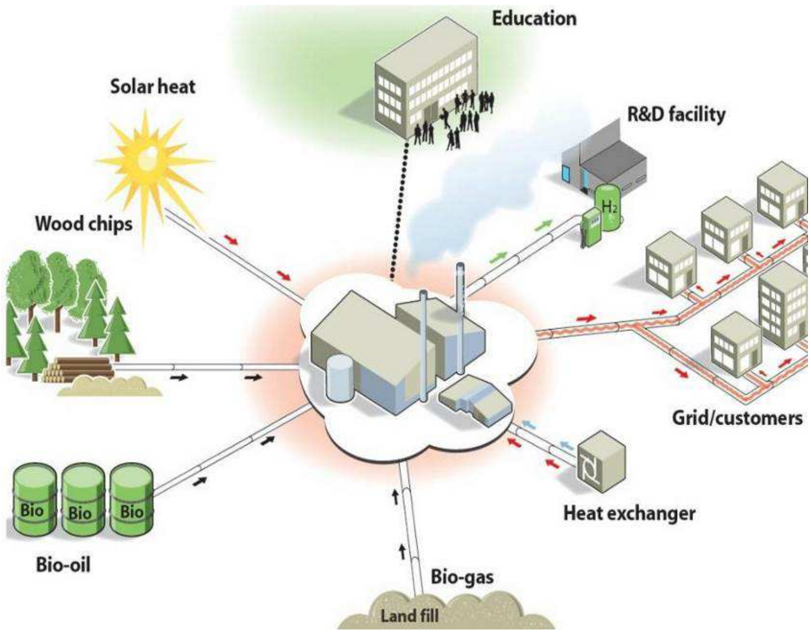
Introduction

District energy involves heating and cooling energy distribution and supply by circulating hot water or low-pressure steam through a district network with underground pipes. These kind of systems are mostly used to provide energy for multi-building space heating and water heating requirements but sometimes are used also for air conditioning by adding a heat pump or an absorption chiller. District energy systems have been used in Europe since the 14th century, and nowadays are more extended in Northern European countries. In Finland and Denmark and Iceland for example, district heating is the dominant heat source.



Share of total heat demand in buildings supplied by district heating schemes for selected countries (Source: Euroheat&Power, 2007).

A DH system has three main elements: the heat sources or the generation plant, the distribution system and the substation and customer interfaces.



District heating scheme. (Source: Akershus Energy AS)

Thermal generation: Centralized heat production in a large installation that generates thermal energy required to meet the demand of all users.

Distribution pipe network: is formed by isolated pipes distributed usually in underground drains in order to minimize heat losses.

Substations: It consists on a heat exchanger that is used for the correct operation of the heat transmission between the distribution network and consumers.

Advantages and disadvantages of the technology

Advantages;

- It saves useful space in buildings because it's not necessary to have energy generation systems.

-District heating allows exploiting sources which would be difficult or impossible to use in building specific applications (deep geothermal, wood wastes, residual heat from industries, etc.) and efficient technologies such as cogeneration.

- Enables the efficient use of low-grade energy sources (interesting for some renewable resources)

-Usually enables cost savings for users (Bill reduction)

Disadvantages;

-High Investment cost to be discounted in a long period.

-The efficiency of the system depends on some critical parameters like the distribution temperature (influence in transmission heat losses),
-Dependence on the energy demand of the buildings. Higher efficiencies are obtained with high demand buildings.
-Dependence on the density of the district. High number of users connected to the network must be guaranteed.

Current technologies

There are different options for the classification of the District Heating technology.

The first classification depends upon the *heat transport fluid*. There are three main types; the DH systems that distribute heat as steam, water or air. Steam and water are the most used, water is used in most modern systems because it provides efficiency advantages compared to steam. However, steam has much higher thermal density than water.

The second classification depends on the type of demand that need to be covered. The different possibilities are; heating, cooling and heating and cooling.

A final classification can be based on the *type of resource*. District heating system allows a wide range of energy sources; Conventional technology (boilers, etc.), renewable resources (solar thermal, geothermal, heat pumps, etc.) and also recycled energy sources like residual heat from industry or cogeneration,

Best practices of their application

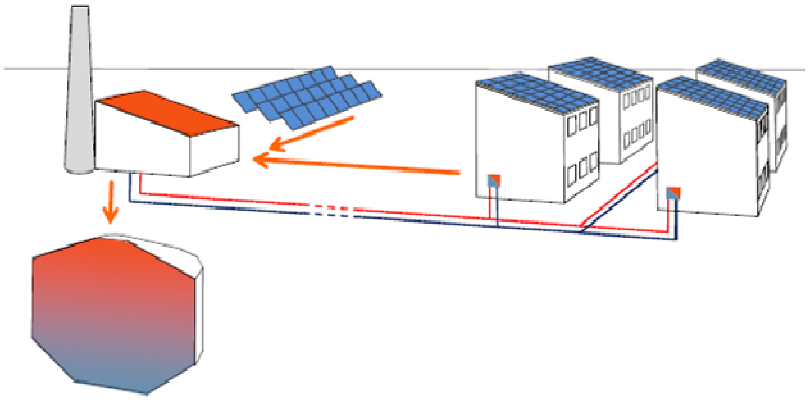
As mentioned before, the application of district energy networks is related to several factors like the type of demand that needs to be covered. Therefore, district energy supply can be used for heating only, cooling only, or for both heating and cooling for a large scale district or a smaller scale (e.g. a group of buildings).

Due to the difference between the availability of the resource and the demand (especially with renewable resources) it is necessary to establish some form of storage system. Those storage systems can be short (or long term, such as the 'seasonal' storage systems that allow the consumption of energy generated months before.

There are two main applications of district heating systems depending on the type of system;

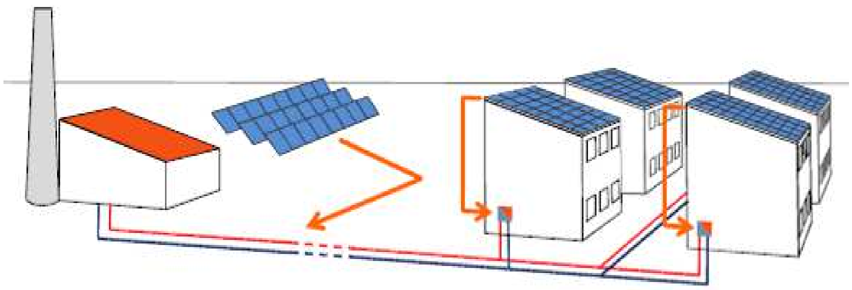
Central systems: In central systems with renewable resources, the renewable system is typically mounted close to the heating plant and feeds into the main heating plant of the DH system.

Alternatively, the renewable installations can be mounted on buildings. In this case the heat is transferred to the main heating plant and is stored in a large long-term storage unit connected to it.



Central solar district heating system. (Source: Solites)

Distributed systems: In this case the renewable system is located near the district and is connected directly to the district heating primary circuit. The network of the DH is often used as storage.



Distributed solar district heating system. (Source: Solites)

Environmental performance characteristics

Due to the flexibility of using different technologies for the energy generation in district heating systems, a wide range of low-carbon technologies can be used for sustainable energy supply to buildings. Besides, the replacement of less efficient equipment in individual buildings with a more efficient heating system will allow the reduction of the environmental impacts associated with the energy consumption of buildings.

The environmental impacts associated with a district heating system vary significantly depending upon different parameters. For example, the emissions associated with low temperature district heating system and geothermal energy generation is between 14

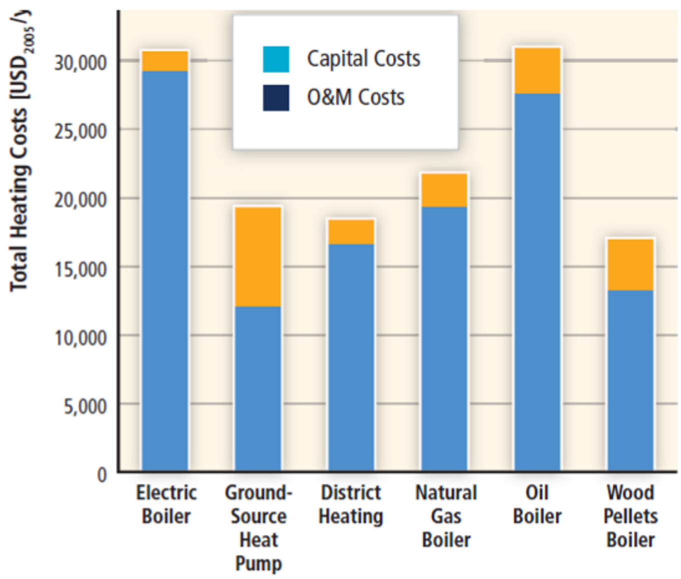
and 58 g CO2eq/kWh and with a geothermal heat pump is between 180 y 202 g CO2eq/kWh.

Trends in district heating applications

In the following years the energy demand of buildings will be reduced considerably due to the new design and energy efficiency measures. This will have direct influence on the total energy consumption of the districts, i.e. the energy density will be decreased and therefore the profitability of supplying district heat will be reduced.

On the other hand, in next years an important effort will be made in order to decrease the costs linked to district heating networks. There are anticipated improvements in the pipes, in the substations and in the reduction of the gap between supply and demand through thermal storage and system optimization.

Costs of the heat supplied by a District heating system vary between countries, selected energy resources, scale of production and other factors. It is therefore difficult to estimate costs. The figure below shows the comparative average annual heating costs (USD_{2005}), in a typical Swedish 1,000 m2 multi-family building with a heat demand around 700 GJ/yr for district heating and for other energy technologies. In this case the cost is around 25 USD_{2005}/GJ th.



Comparative average annual heating and unit costs USD_{2005}), including climate, energy and carbon taxes, as seen by the end user in a typical Swedish 1,000 m_2 multi-family building with a heat demand around 700 GJ/yr. (Source: IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation)

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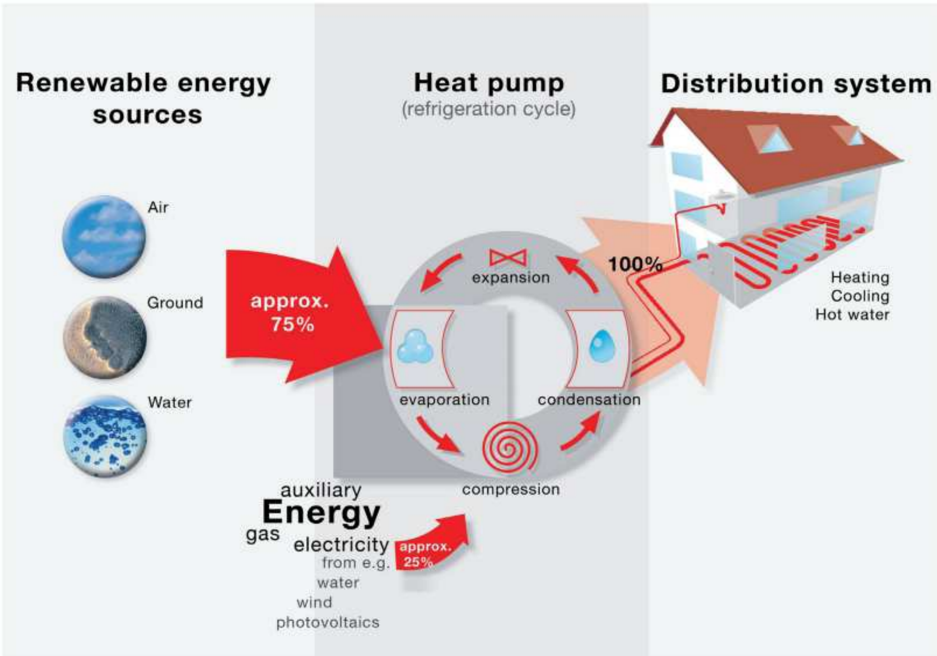
2.4 Heat Pumps, Geothermal & Hydrothermal energy sources

Introduction

Heat pumps are highly efficient technologies that are able to transform energy with a low temperature level (low energy) extracted from sources such as air, water, soil, or bedrock, to a higher temperature. The obtained energy is used for providing space and water heating but also for cooling when the heat pump is reversed.



Operation principle of a heat pump (Source: EHPA/Alpha Innotec)

In order to increase the temperature level, an external energy consumption is required in the heat pump.

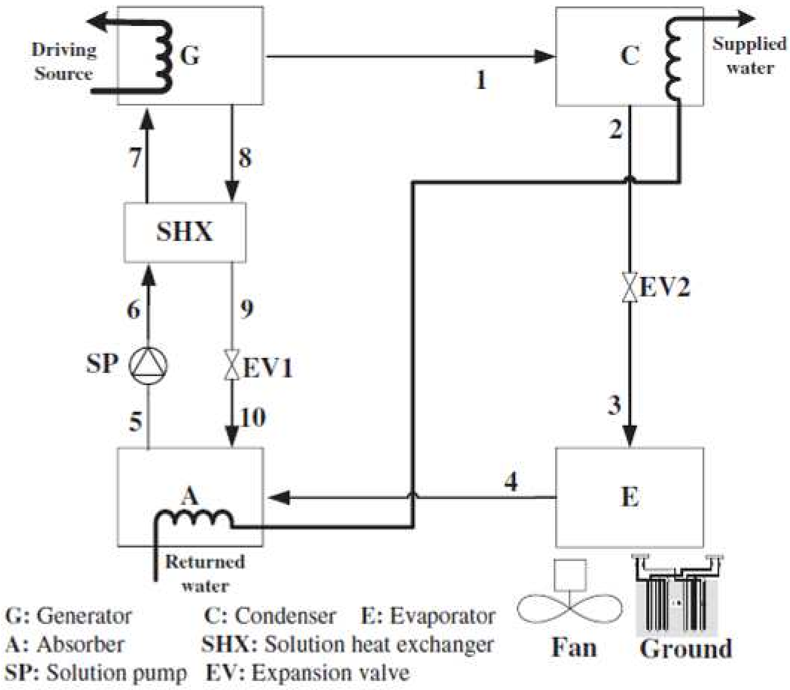
The most critical factor that affects the efficiency of the heat pump is the temperature difference between the two sources. The highest this is, the lower the efficiency. That is why the ground-source heat pumps and the seawater heat pumps have higher COP than the air source heat pumps.

The principal types of heat pumps include *vapour compression heat pumps* and *absorption heat pumps*:

-*Vapour compression heat pumps;* Are the most commonly used heat pumps and are usually driven by an electric motor. They are mostly used in cooling systems but can

be used both for heating or cooling. Sometimes the excess heat from cooling is used to meet a simultaneous heat demand elsewhere. The main components of the vapour compression heat pumps are the evaporator, the compressor, the condenser and the expansion valve. The degree of efficiency of heat pumps (COP) is defined as the ratio of heat output to energy input, such as electricity to the compression motor. Compression heat pumps can reach in some cases a COP up to 6.

-Absorption heat pumps: In absorption heat pumps, the compressor is replaced by an absorber and generator, in which a mixture of refrigerant and absorber circulate.



Schedule diagram of a single-stage ammonia-based air/ground source absorption heat pump. (Source: Wei Wu, Xiaoling Zhang, Xianting Li, Wenxing Shi, Baolong Wang. Comparisons of different working pairs and cycles on the performance of absorption heat pump for heating and domestic hot water in cold regions, Applied Thermal Engineering, 2012)

Absorption heat pumps for space conditioning are often gas-fired, while industrial installations are usually driven by high-pressure steam or waste heat. The obtained efficiency is lower than in the case of vapour compression heat pumps, in the modern absorption heat pumps can reach heat efficiency of up to 1,5. That is why the use of this system only makes sense with waste energy or renewable energies.

Advantages and disadvantages of the technology

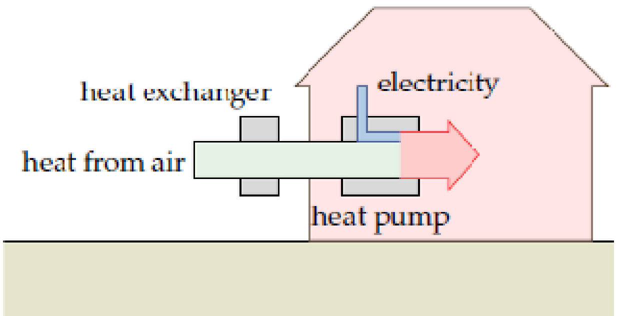
Advantages;

- No seasonal variation in the case of ground source heat pump (GSHP) and water source HP
- Immunity from weather effects
- Compatibility with both centralized and distributed energy generation
- In the case of the GSHP, the resource availability is in all around the world
- Geothermal heat use can cover several types of demand at different temperature levels.
-The seawater has less seasonal temperature variation than the air
-The seawater has lower freezing temperature than riverwater
- The seawater maintains 5-10ºC temperature difference from the atmosphere
- They achieve efficiencies greater than 100%

Disadvantages;
- Linked to high capital costs
- Resource development risk
- Use of electricity for heat generation
-Depending on the temperature required, geothermal heat can only be used where there is demand reasonably near to the resource, because the transport of heat has some limitations.
-In the case of the air-source heat pumps there is a higher temperature variation during the day and in different seasons.

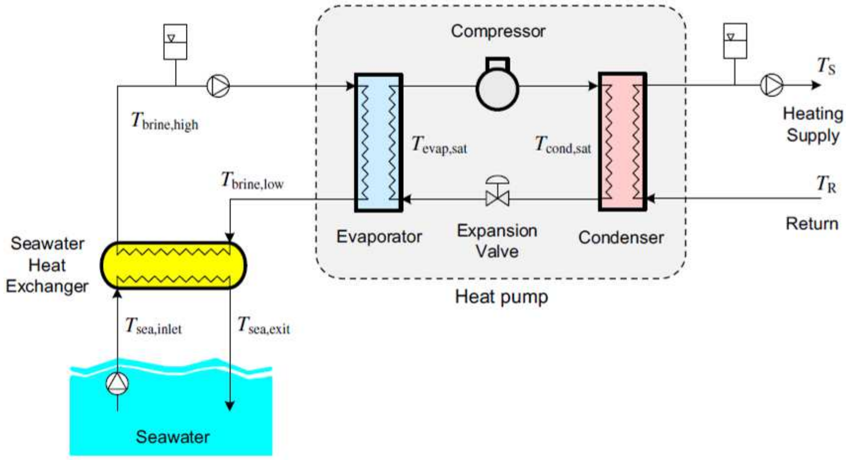
Current technologies

The use of the ***air source heat pumps*** is more extended, most air conditioners are heat pumps. The next figure shows the schematic diagram of the use of an air source heat pump for building energy supply.



Air source heat pump (Source: Sustainable Energy - without the hot air)

Regarding the ***hydrothermal energy with HP,*** two main types can be distinguished, the HP that uses fresh water (included in the GSHP section) and those that use seawater. The seawater HP systems are gaining popularity in coastal areas and much research has been undertaken during the last few years in this field. Next figure shows the schematic diagram of a seawater heat pump system.



Schematic diagram of the single-unit seawater-source heat pump system. (Source: Young-Jin Baik, Minsung Kim, Ki-Chang Chang, Young-Soo Lee, Ho-Sang Ra. Potential to enhance performance of seawater-source heat pump by series operation. Renewable Energy, 2014)

Finally, the ***geothermal heat pumps*** use energy available as heat contained in the earth's crust that can be discharged and used for electricity or heat/cold generation.

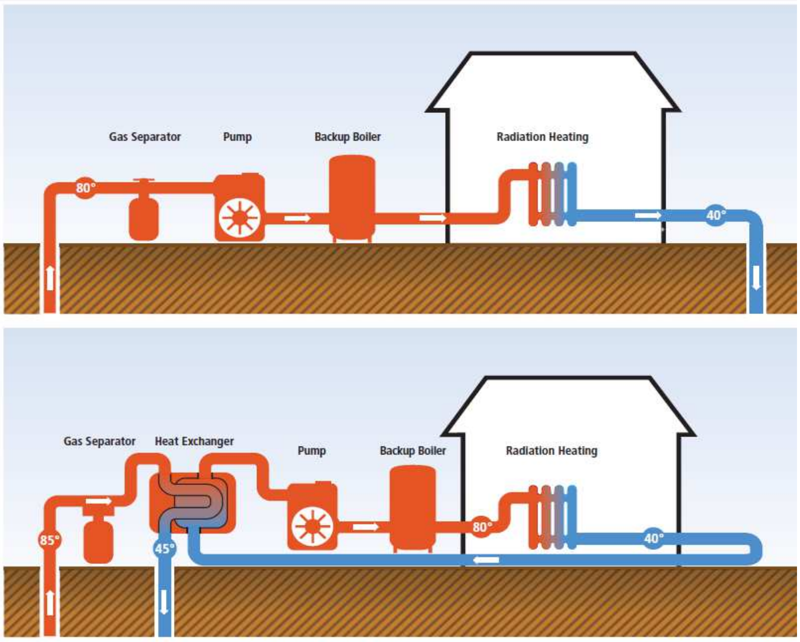
Low temperature geothermal resources are abundant and can be extracted in most locations around the world. This energy can be used directly for the heating and cooling supply of buildings, districts, industries, etc. but also can be used indirectly with the help of ground source heat pumps (GSHPs).

On a daily basis, at depths higher that 0,8m it can be considered that the temperature of the ground does not fluctuate significantly. The system is comprised of three systems: The Geothermal heat pump, the Earth connection, interior heat distribution system.

An earth connection transfers the fluid between the heat pump and the ground. The earth connection can be double loop and single loop.

-*Single loop configuration*; The heat pump fluid flows directly through the ground heat exchanger, which avoids the need for a ground loop to heat pump heat exchanger. They also avoid the circulation pump for the ground loop, instead relying on a slightly higher compressor.

-Double loop configuration; is the most common system configuration, and it has a ground loop which is separated from the heat pump. Heat is transferred from the water to the refrigerant via a heat exchanger. Two types of double loop configuration exist: 'closed' and 'open'.



Two main types of district heating systems; to open loop (single pipe system), bottom, closed loop (double pipe system). (Source: IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation)

Closed-loop systems use heat exchangers to transfer heat from the geothermal water to a closed loop that circulates water through the radiators. The heat transfer fluid has not direct contact with the ground. There are four classes of closed loop system depending on the configuration of the loop; vertical, horizontal, spiral, and pond. In the vertical configuration there is an increasing tendency for integrating geothermal pipes into the building's foundation due to the cost savings. This is known as thermo-active foundations and are mainly used in piles and foundation walls.

Open-loop systems directly utilize the geothermal water extracted from a well to circulate through radiators. In these systems, the water is passed directly through the heat exchanger of the heat pump before being discharged back to the source.

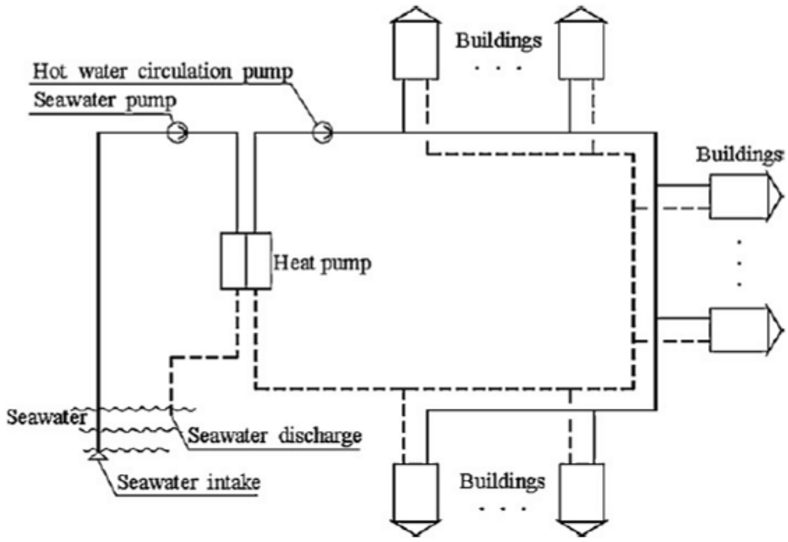
Best practices of their application

One of the most effective applications of the heat pumps are in satisfying the energy supply for residential and commercial buildings both at building and at district scale and the use of the heat pumps for industry applications.

In residential buildings, the energy can be used for space heating/or water heating, for both space heating and cooling, for space heating, cooling and water heating or for water heating only.

Another interesting appliaction of heat pumps is the use of the technology in combination with some renewable technologies such as solar thermal systems, which - in combination - can optimise system performance.

In the case of the seawater source heat pumps, good practice suggests their use in combination with district energy networks:



(Source: Shu Haiwen, Duanmu Lin, Li Xiangli, Zhu Yingxin. Energy-saving judgment of electric-driven seawater source heat pump district heating system over boiler house district heating system, 2010)

With regards to the industrial application of heat pumps, they are mainly used for: space heating, heating and cooling of process streams, water heating for washing, sanitation and cleaning, steam production, drying/dehumidification, evaporation, distillation and concentration. In some cases the waste heat (usually from condenser heat from refrigeration, cooling water, effluent and others) of the industry is recycled within the main process. The heat pump technology is also linked to storage tanks when talking about industry applications because the heat source is not usually constant.

Regarding the GSHPs, geothermal water has been used for various applications, in earlier time was mostly used for bathing, cooking and for therapeutic purposes but today, direct use of geothermal energy can extended for different applications such as heating buildings, individually or for districts, for raising plants in greenhouses, drying crops, several industrial processes, etc.

In a publication by the IEA (IEA. Geothermal heat and power. Technology roadmap) can be seen that the most installed geothermal heat use application is the ground source heat pumps with the 49% of total geothermal heat, the next-largest geothermal heat usage are spa and swimming pool heating (about 25%), next is district heating (about 12%), and other applications make up less than 15% of the total.

Despite those current percentages, there is potential for the deployment of the geothermal energy as an energy supply source in district energy networks. An interesting application could be to use geothermal energy in a district network with a cascade configuration for applications with different temperature requirements. For example it could start with a district heating system, followed by greenhouse heating.

Environmental Performance

The heat pump is a high energy efficiency technology and linked to the obtained energy savings (due to the replacement of a less efficient technology with the HP) is also obtained a GHG emissions reduction. In the case of vapor compression heat pumps, the environmental impacts depend a lot upon the electricity mix.
For example, in direct heating applications without the need of a heat pump, emissions of CO2 associated to heat supply are typically negligible. For example, in Iceland the CO2 content of thermal groundwater used for district heating is around 0.05 mg CO2/kWhth. In other cases, these values are higher (as presented by Kaltschmitt - 2000) and show that the lifecycle GHG emissions of a low-temperature district heating system is typically between 14.3 and 57.6 g CO2eq/kWhth and for a GHP these values are between 180 and 202 gCO2eq/kWhth.

Trends in the technology applications

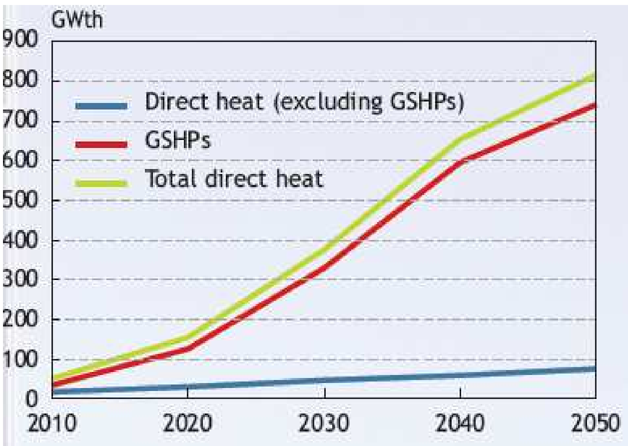
A wide deployment of heat pumps as a main source of heating would imply a massive increase in electricity consumption, with strong economic and environmental external costs. Thus, the main priority in research of heat pump technology is the increase of the performance, developing more efficient components and reducing costs. Another focus will be the optimisation of the component integration within the systems for specific applications and optimisation of the control of those systems with the help of the intelligent control strategies.

The combination of heap pumps with other technologies is also a field that need to be improved in order to obtain efficient hybrid systems for multifunctional applications. Finally, although few heat pumps are currently installed in industry, while the environmental regulation becomes stricter, the heat pump technology can become a good option to reduce emissions and improve efficiency. The table below shows the costs associated to the GSHP.

Heat application	Investment cost USD_{2005}/kW_{th}	LCOH in USD_{2005}/GJ at discount rates of		
		3%	7%	10%
Space heating (buildings)	1,600–3,940	20–50	24–65	28–77
Space heating (districts)	570–1,570	12–24	14–31	15–38
Greenhouses	500–1,000	7.7–13	8.6–14	9.3–16
Uncovered aquaculture ponds	50–100	8.5–11	8.6–12	8.6–12
GHP (residential and commercial)	940–3,750	14–42	17–56	19–68

Investment costs and calculated levelized cost of heat (LCOH) for several geothermal direct applications (Source: IPCC Special Report)

These values are expected to decrease due to some technology improvements especially in the performance of the GSHPs and other improvements in some key components such as compressors and heat exchangers. In Europe, by 2030, costs of GSHP are expected to decrease by 10%, to USD 74/ MWhth.
Linked to that cost reduction, the use of geothermal energy is expected to increase as presented in the World geothermal Congress 2010 where was presented that the total expected capacity for the direct use of geothermal energy in 2050 is estimated at 815 GW_{th}.



Geothermal direct use and GSHP capacity growth scenarios
(Source: Bromley et al., 2010.)

The figure shows that the main cause of this increase is the geothermal energy with GSHP application.

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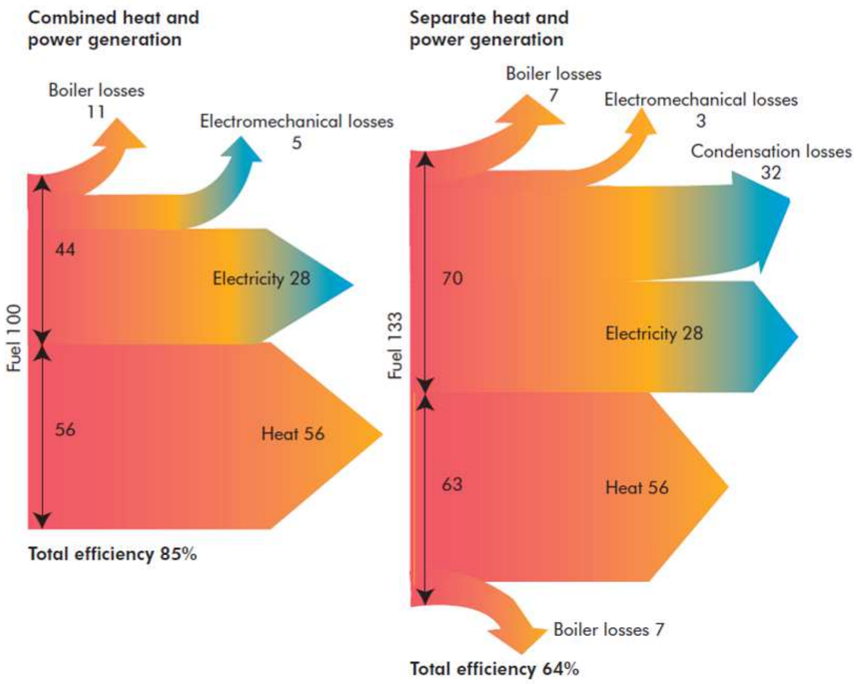
2.5 Cogeneration

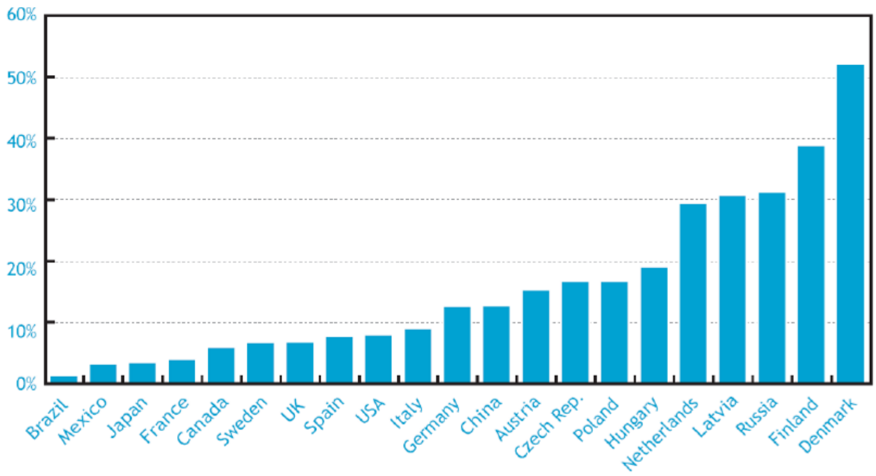
Introduction

Co-generation plants (also referred to as combined-heat and power plants), are plants which are designed to produce both heat and electricity. There is a simultaneous utilisation of heat and power from a single fuel source. This fact allows the conversion of the 75% - 80% of the fuel input to useful energy and up to 90% in the most efficient plants. In the case of the small decentralised CHP plants, in contrast to centralised traditional generation plants, they can be located near to the consumption points. This helps increase the efficiency of the energy supply due to the lower transmission and distribution losses.



Comparison of energy flows from CHP and separate production of heat and power. (Source: IEA Energy technology perspective 2008. Scenarios & Strategies to 2050)

In any case, the increase in efficiency linked to the CHP generation depends a lot on the technologies and fuel used for the energy supply and the replaced heat and electricity generation technologies. The next figure shows the share of the power generated by CHP plants across different countries.



CHP share of national power production. (Source: IEA, CHP: Evaluating the Benefits of Greater Global Investment.2008)

Advantages and disadvantages of the technology

Advantages;

-Is a proven energy-efficient technology.
-Can accelerate the integration of renewable energy technologies.
- Is more efficient that producing the same amount of heat and electricity in two separate plants.
-Almost any fuel is suitable for CHP providing flexibility.
-Opportunity to sell the excess electricity back to the grid.

Disadvantages;

-Depends on the variations in the regulation of each country
-Higher environmental impacts than some renewable technologies.
-It is needed a simultaneous energy demand of electricity and heat
-The micro-cogeneration technology still needs to improve in issues related to maintenance, etc.

Current technologies

The main classification of cogeneration plants can be done considering the original objective of them. When the fuel is used to produce electricity and the remaining heat is recovered, it is called ‘topping cycles’. The ‘bottoming cycles’ on the other hand use waste heat from a process to drive a cycle and produce electricity.

Different technologies can be used for the simultaneous heat and power generation:

- *Backpressure turbine:* Electricity and heat is produced in a steam turbine, in a conventional steam Rankine cycle and the power to heat ratio is normally about 0,3-0,5.

- *Extraction condensing:* in the extraction condensing plants some of the steam used for electricity generation is extracted from the turbine to generate heat.

- *Combined cycle power plant:* The gas turbine is connected to the steam turbine in order to produce both heat and electricity. In many cases the heat from the exhaust gases of a gas turbine process is recovered for the steam turbine process and converted also to electricity in the steam turbine.

- *Internal combustion engines:* Also called reciprocating engine. Heat can be recovered from lubrication oil, from engine cooling water and from exhaust gases and converted chemically bound energy in fuel to thermal energy by combustion.

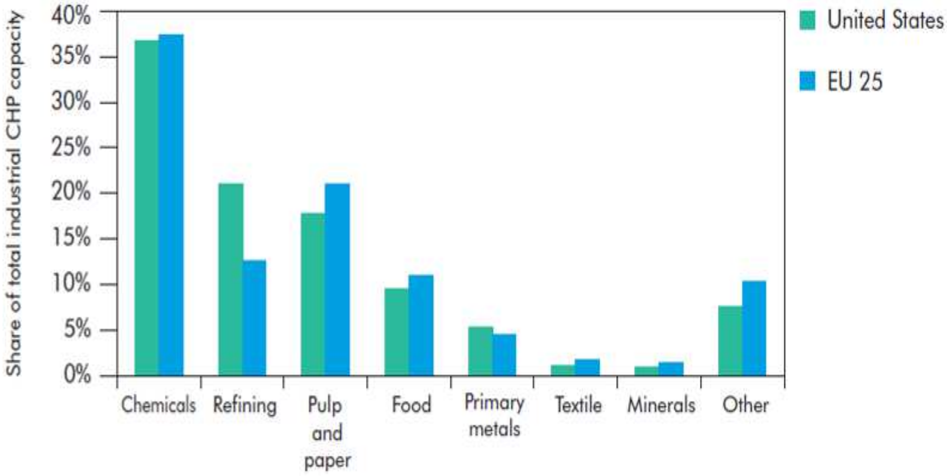
- *Organic Rankine Cycle (ORC):* Is based on the same technology as the Rankine cycle, but in this case the working fluid is an organic compound.

Among the mentioned technologies, others are being explored in order to expand the range of applications for CHP mainly in buildings. Technologies like reciprocating engines including stirling engines, gas turbines, fuel cells, micro-turbines and fuel-cell/turbine hybrids.

Best practices of their application

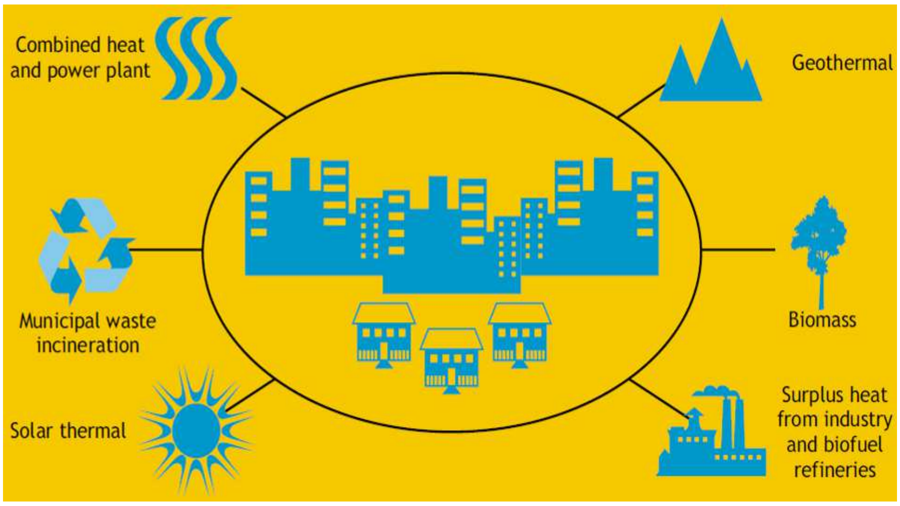
The CHP technology can be applied in different energy generation plants for centralized electricity and heat production as it is shown in 7.3. But this technology can also be applied to almost all manufacturing industries by employing the heat) in a more efficient way, reusing it directly in the same process.

Despite the wide range of possible industries, 80% of the total capacity of the CHP plant is concentrated in the chemical, food, refining and pulp and paper sub-sectors.



Distribution of industrial CHP capacity in the European Union and United States. (Source: IEA, 2007f)

The use of *CHP technology in combination with the district heating and cooling* infrastructure is also interesting because the last one works as a flexible platform for different energy generation sources in which the heat produced in the CHP plant can be distributed to the end consumer. DHC with CHP can provide a double benefit of reducing cost and impacts in many cases of both electricity and heat supply. In fact, more than 50% of the electricity production in Europe is generated in CHP plants that are connected to heating networks.



DHC network as a flexible platform for CHP and renewable heat sources. (Source: Froning, 2009)

Another interesting application of the *CHP technology* is to use them *as backup for renewables.* With the help of thermal storages or auxiliary boilers, CHP plants can meet a constant heat demand while they respond to a fluctuating electricity demand. This aspect represents an opportunity for balancing electricity production from variable renewables that otherwise would need to use other fossil based technologies with higher associated environmental impacts.

Environmental performance characteristics

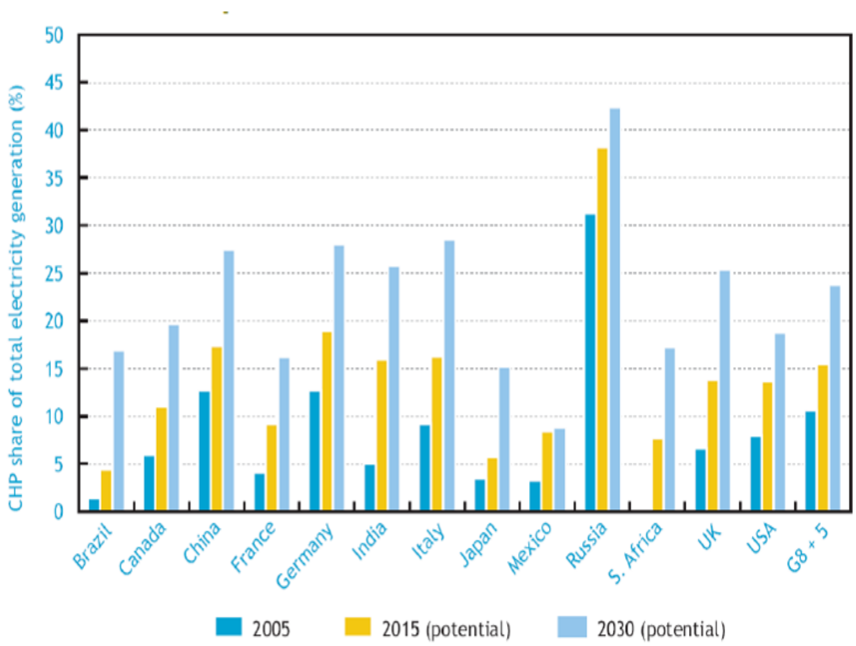
In many cases, the CHP technology can help in reducing the environmental impacts associated with energy generation but the environmental impacts related to CHP plants depend a lot more upon the type of technology and the type of fuel that is used. Moreover, it has to be considered what kind of energy technologies are replaced by the heat and the electricity produced. Finally, due to the simultaneous production of heat and power, the allocation of the generated impacts between the two types of energies in this kind of studies of multi-output processes is also an aspect that affects a lot in the final result, i.e. the impact associated to each generation type depends on the rules used to define the distribution of the impacts between the generated heat and power.

Trends in cogeneration applications

Cogeneration is a relatively mature process when it is used in combination with current technologies. There are a number of technological developments that are being explored specifically for building applications, such as fuel cells and microturbines that are still in their infancy in terms of market deployment.

The technology can be easily integrated into different energy networks such as the DHC or the smartgrids and also offers good technological solutions for renewable technologies.

Penetration of cogeneration technology varies significantly depending on the country. In the figure below it can see that most of the countries are predicted to increase their share of electricity generated by CHP plants and that Russia and China have an important improvement potential due to their current lower energy efficiencies.



CHP potentials. (Source: IEA, CHP Evaluating the Benefits of Greater Global Investment, 2008)

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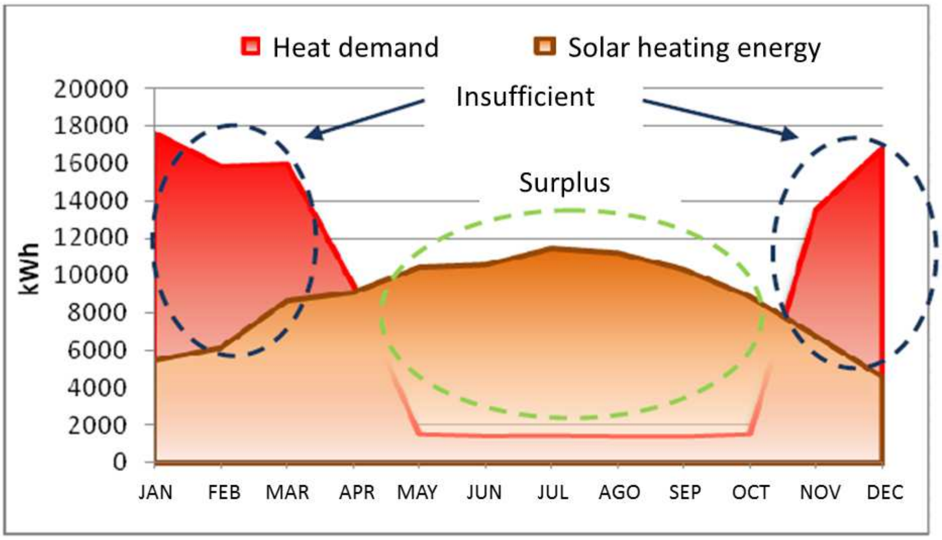
2.6 Thermal energy storage (Short and long term)

Introduction

Thermal storage technology is essential to ensure reliability and efficiency of many energy technologies. One of the main problems in the energy supply especially in the case of the renewable technologies is the temporary gap between the availability of the resource and the demand. The storages allow filling this gap and that is why it is a key factor to improve the renewable rate in the energy mix.



Temporary gap between availability of the solar heat resource and demand. (Source:Tecnalia)

Advantages and disadvantages of the technology

Advantages;

-Thermal energy storage offers the option to improve output control for some energy technologies.

- Able to reduce the mismatch between supply and demand

-Some storage materials (such as water) have universal availability and low cost.

Disadvantages;

-The energy stored decreases with the time due to the heat losses.

-Some storage technologies are still in the development stage.

-Some technologies are expensive.

Current technologies

There are two main forms of this technology: short term and long term heat storage systems. In terms of long-term storage, there can be a seasonal storage system that allows the use of energy some months after it is generated.

Solar District Heating plant with seasonal thermal energy storage, Munich (Source: Solites)

Four main types of thermal energy storage technologies can be distinguished:

-*Sensible heat storage systems;* where the heat capacity of a material is used. The most common material to store the heat is the water due to the low costs.

-*Latent heat storage systems;* where the storage capacity of a material's phase-change is used.

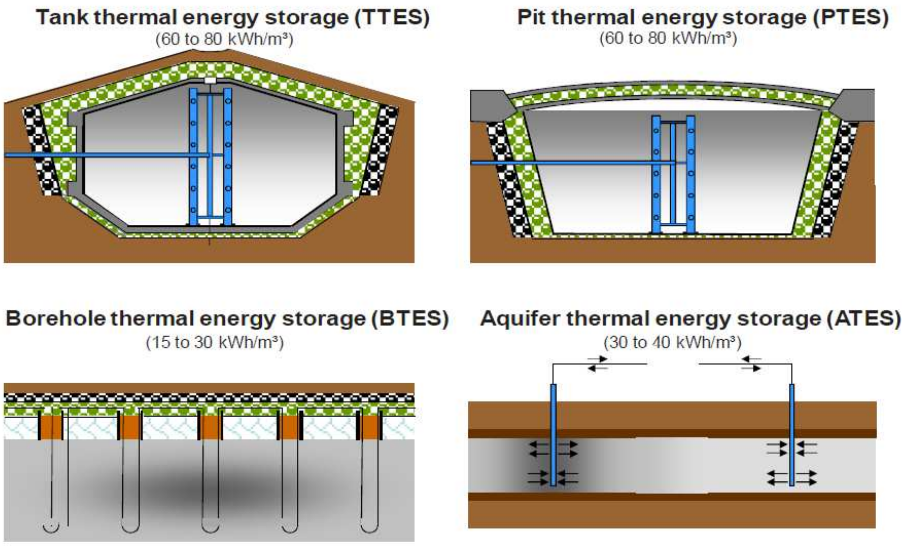
-*Sorption heat storage systems;* the heat is stored in materials using water vapor taken up by a sorption material. If the material is solid it is called adsorption and when is a liquid it is called absorption.

-*Thermochemical heat storage systems;* the heat is stored in an endothermic chemical reaction.

Best practices of their application

Thermal storages have been in use for many years, in combination with most of the building energy supply technologies. But regarding seasonal thermal energy storages, these can be used in combination with renewable technologies (especially solar thermal) and the district heating and cooling networks. There are different options in the energy storage for district applications; tank thermal storages, pit thermal energy

storages, borehole thermal energy storage and the aquifer thermal energy storage that uses a natural underground layer as a storage medium.



The four technologies for storing solar thermal energy seasonally. (Source: Solites)

PCMs also have a wide range of applications but regarding energy in buildings, it is interesting that the use of encapsulated PCMs in building materials, (for example integrating the PCMs in the building walls) provides a possibility to convert a building's 'envelope into an active heating and cooling system. Depending on the application there are different materials and different options for the encapsulation of the PCM; the cheapest material is water, but unfortunately the freezing point is 0°C what is not optimal for most of the thermal storage applications for buildings. This is why the most utilized PCM are salt solutions.

Environmental performance

Thermal energy storage does not save energy nor avoid emissions directly but it allows the continuous supply of low carbon thermal energy for different applications and this is a key factor for the deployment of renewable technologies into the energy mix. This means that the storage systems are essential to move towards a low carbon energy system.

Trends in the applications

Taking into consideration that heat demand can represent up to 60-70% of total amount of energy consumption in a residential building, heating systems based on the Seasonal Thermal Energy Storage concept are currently the most promising

technology. They that would allow meeting the decarbonization targets at the same time as providing continuous low carbon energy supply.

The main breakthrough in this context is the combination of Seasonal Thermal Energy Storage (STES) systems with heat pumps. STES systems are already applied in a few pilot plants in the north of Europe, but not with a heat pump. In these systems conventional boilers are used as auxiliary system for solar thermal energy. The potential of this combination is extremely high in comparison to using boilers. It is possible to increase energy efficiency by 20%, reduce primary energy consumption by 35% and reduce economic cost for users by 25%.

Cold storage for building applications is also attracting an increased level of interest. The application of PCMs in HVAC systems is an example of where cold storage can help shift the peak loads and reduce the installed capacity. In this field there are some experimental prototypes of latent heat storage tanks capable of working with organic phase-change materials.

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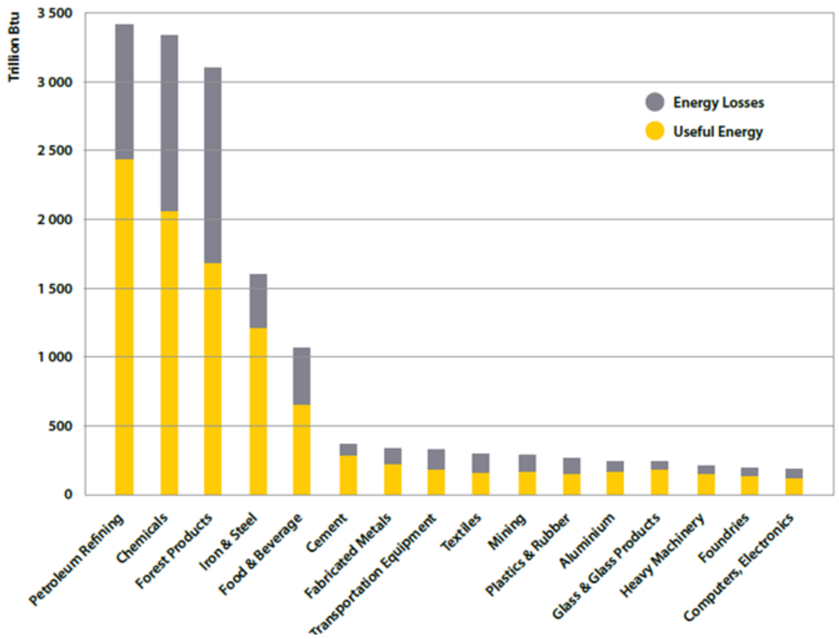
2.7 Waste heat recovery from industry

Introduction

Energy efficiency in Industry has improved significantly in the last decade, and one of the greatest opportunities for reducing energy use is Waste Heat Recovery.

Waste heat is heat generated in a process (by fuel combustion or chemical reaction) and then thrown to the environment even if it could be reused. It is estimated that 20-50% of the energy used is lost in industrial processes (e.g. boilers or furnaces) in the form of hot exhaust gases, heat losses from radiation and within the cooling water.



Energy use and energy losses in industry sectors in the US (Source. SPIRE Roadmap)

Waste heat recovery involves transfer of heat that occurs by three different mechanisms: radiation, conduction or convection. Solutions are frequently cross-sectorial and waste heat can be used directly in the plant, in neighbor industries, to produce electricity or in district heating.

Advantages and disadvantages of the technology

Advantages;

-Reduce industry's energy use and CO_2 emissions
-Economic benefits in industry due to the reduction of fuel consumption and CO_2 taxes.
-Reduce environmental impacts of final products

-Increase energy efficiency and environmental impacts of secondary processes consuming recovery heat

Disadvantages;

-Economic and technical risks:
-Payback period must be 3 years <
-Profit of heat recovery investments depends on the fuel price evolution
-Process plant adjustment due to the heat recovery and availability of space
-Misfit between supply and demand of recovered heat

Current technologies

Heat cannot be fully recovered. The strategy of how to recover this heat depends on the quality and quantity of this heat.

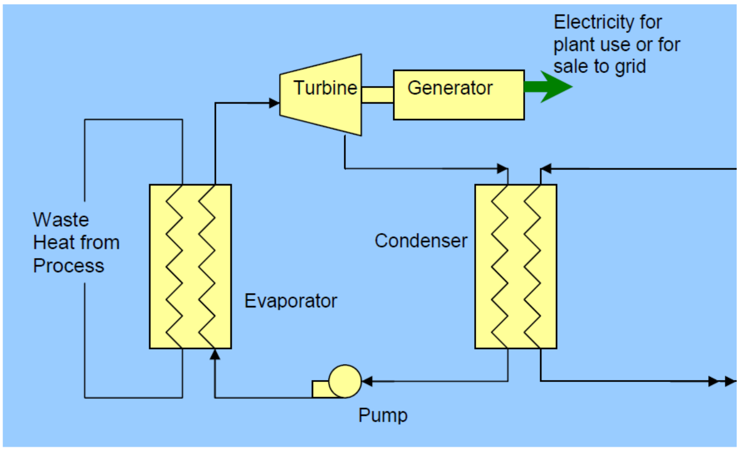
-*Direct Use of waste heat.* Regenerators use the waste heat in the same process.

-*Heat exchanger.* Equipment to transfer heat from one stream to another fluid without mixing them. Heat exchangers can have different configurations: parallel flow exchanger, cross-flow exchanger, plate exchanger, tubular exchanger, etc. Waste Heat Recovery Unit (WHRU) is a heat exchanger to recover heat from waste heat.

. *Economizer*. Waste heat from the exhaust gas is used to preheat the inlet stream in a boiler.

. *WHRU & Heat Pump*. In this case, WHRU will work as the Evaporator system of the Heat Pump.

. *WHRU & Rankine Cycle*. In this case, the heat in the evaporator will be used to generate steam that then will produce electricity in a Turbine. Steam Rankine Cycle is the most efficient system to recover heat when the temperature is above 350 °C. With lower temperatures, efficiency decrease significantly.

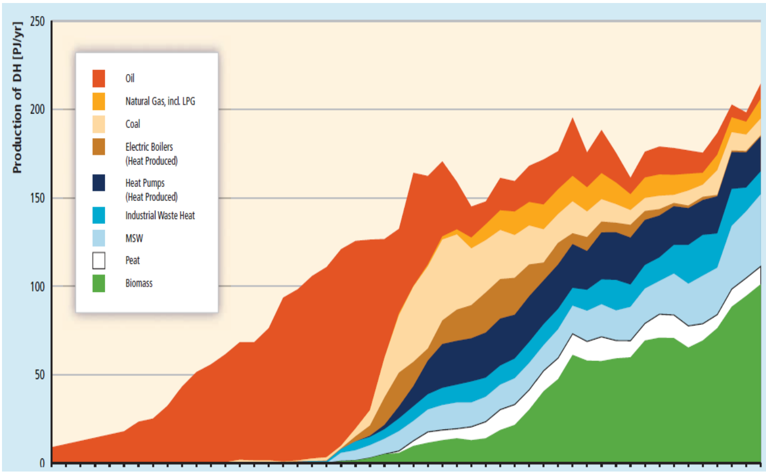


Waste Heat Recovery with Rankine Cycle (Source. Waste Heat Recovery: Technology and Opportunities in U.S. Industry, BCS 2008)

. *WHRU & Organic Rankine Cycle (ORC).* ORC is the same system than Rankine Cycle but operates with organic fluids with a lower boiling point and higher vapour pressure. ORC allows working with lower heat temperatures.

Best practices of their application

On a city level, waste heat recovery from industrial processes can be used to substitute a percentage of thermal generation from fossil fuels in District Heating systems. District energy involves heating and cooling energy distribution and supply by circulating hot water or low-pressure steam through a district network with underground pipes.



Sweden's district heat production, by fuels and energy sources, 1960 to 2009 (Source. IPCC – SRREN, 2012)

Environmental Performance

With a direct use of waste heat streams, critical attention must be paid to contaminants and dangerous substances. Furthermore, when designing WHRU an important concern will be to use materials that will resist corrosion and high temperatures.

Waste Heat Recovery is a viable strategy to increase energy efficiency in the industrial sector and to improve the environmental footprint of industrial companies and final products. The employment of Waste Heat Recovery systems will contribute to achieve resource efficient and low carbon economy as defined in the Europe 2020.

Moreover, the replacement of heat production from fossil fuels by waste heat recovered will allow the reduction of the environmental impacts related to the District Heating Systems.

When assessing sustainability, an important issue will be to take into consideration that industrial processes must be the most efficient, even if waste heat can be reused.

Trends in technology applications

One important disadvantage of the Waste Heat Recovery is the misfit between supply and demand of recovered heat, this means that some of the R&I efforts are related to the development of energy storage systems.

Furthermore, in order to increase the viability of Waste Heat Recovery systems there is a need to focus on the following areas:

-Reduce the equipment size

-Reduce the initial investment and the operating expenses

-Improve energy efficiency of waste heat recovery systems

-Develop and employ modelling and simulations methods

-Work on sustainable technologies and sustainable working fluids

-Integrate monitoring and control techniques

-Employ the waste heat recovered as energy input for a different process, for a different industrial plant (*Industrial symbiosis*), for district heating, etc.

-Develop components and materials to resist high temperatures

-Develop systems to recover heat from low temperature streams

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3. TECHNOLOGIES FOR MOBILITY

This section presents the developed for knowledge exchange on the different technologies and approaches in relation to mobility.

The prepared by ATAF are presented in separate pages to facilitate that they be printed and distributed separately to respond to request of information, feed discussions and workshops, etc.

The following technologies have been covered:

- INTEGRATED TRAFFIC PLANNING AND MANAGEMENT SYSTEM
- ICT SYSTEM FOR PUBLIC TRANSPORT MANAGEMENT
- ELECTRIC MOBILITY

3.1 Integrated traffic planning and management system

Introduction and reference framework

The current trend in traffic management and planning is more and more concentrated in implementing integrated systems supported by ICT.

Traffic and mobility are in fact very complex elements, influenced by a plurality of factors, infrastructural, legislative and normative, cultural and behavioural, and often also by casual events.

To achieve a balanced mobility system in the city several components are necessary, linked in a unitary and coordinated vision.

In the past, ICT has given a strong contribution to develop different systems for traffic management, devoted to single applications, such as traffic lights control, variable message panels, limited traffic area access controls, parking management and many others. These systems have been in these years widely applied in the cities and can be considered quite consolidated technological solutions.

Now the trend of the technological development and of traffic management models is mainly targeted at:

- Integrating as much as possible the different phases of traffic management, namely the planning and the control moments, basing them on the same set of information and making them more flexible and interactive with each other. This can give the opportunity to define control strategies more adaptive to different traffic situations and to modify the adopted strategies according to the real conditions.
- Integrating as much as possible all the information and centralizing them in a unitary data repository, making anyway the information available according to the web philosophy independently from the physical location of the consumer. This availability is a key point for increasing the potential of the cities in planning and managing traffic and mobility.
- To disseminate as much as possible the information about mobility toward citizens, both through services and real time applications. This at the purpose of allowing the better modal choice and obtaining a better modal shift.

In this way all the actors of the mobility planning / regulation / monitoring chain can create a unitary and coherent set of data and models, and all these phases become more integrated.

Technology description

The system is mainly composed of:

- a software application layer that integrates all the information coming from the different traffic management systems

- a series of models operating in real time, capable of modelling the network and the traffic states.

The core component of this system is represented by the so called "Traffic Supervisor".

The Supervisor's main goals are:

- to give operators a unitary view of the real time situation of traffic and mobility on the city territory
- to improve the capacity of traffic regulation by integrating several sources of information in a more complete set and providing advanced tools for real time modelling and strategy definition
- to collect and elaborate real time information about mobility to be provided to citizens

The supervisor works on a geo-referred graph representing the road network that is the basis for collecting and elaborating all the information. It's important to underline that the Supervisor must share with the planning environment all the information and data that define the characteristics of the local mobility, namely:

- the O/D matrix and the relevant geographical segmentation of the territory
- the different modal networks (roads, bus service, train and metro, etc.) and the associated parameters
- the data representing the traffic regulation elements (such as traffic lights modelling, LTZ, etc.)

The supervisor collects real time data from all the system over the territory devoted to mobility management and control and systems that can provide information to travellers. In particular it can interface the following categories:

- Traffic flows acquisition system
- UTC - Urban Traffic Control system
- VMS system and/or public transport management system
- Parking management system
- Environmental parameters acquisition system
- AVM system for different kind of public transport services
- LTZ access control system
- Video-surveillance system
- System for emergency management
- Information system for municipal ordinance management (for acquiring information about temporary traffic modifications and planned events)
- Car sharing and bike sharing management systems
- Eventual other existent systems

Recently an innovative technique for traffic speed data acquisition has been developed based on:

- FCD (floating car data) for the acquisition of data from travelling vehicles and the reconstruction of the average speed on the arches of the graph.

Some Supervisors can also integrate this kind of function, which, to be affordable, require a high number of vehicles equipped in such a way as to be tracked. For this reason, and for the intrinsic higher modelling difficulty, this technique is not yet widely used.

All these systems must be interfaced with the supervisor through specific physical connections and software interfaces.

Data acquisition occurs in real time so that the real traffic situation is systematically updated. All the acquired information is linked to the graph and represented for the operators on a clear cartographic basis on which the graph is mapped. On this basis all the static and dynamic data are reported and can be visualised or deleted according to the operator's instructions.

The supervisor's database works as an integrated data repository for all the collected data, coherently referred to the graph and the cartography.

The supervisor, on the basis of the collected data, provides three main classes of functions:

- o Regulation
- o Interfacing the planning environment
- o Travellers' information

In particular the system implements the following functionalities:

- Data filtering and normalisation
- Data management and retrieval according to several modes
- Reconstruction of the state of the traffic and recognition of critical situations
- Elaboration of strategy to face critical situations and on-line management functions
- Construction and dynamic management of sceneries
- Management of traffic events
- Dispatching of commands to peripheral systems
- Graphical representation of data and MMI interface
- Data processing and report production
- Interface toward infomobility systems.

Regulation

On the basis of the collected information, the supervisor implements the real time chain constituted by two sequential cycles:

- Strategic cycle
    - O/D matrix estimation
    - Evaluation of the optimum (equilibrium demand /offer) through a dynamic assignment model
    - Evaluation of a reference traffic condition based on the actual traffic state and transport offer
- Operative cycle
    - Traffic variable are evaluated basing on real time traffic measurement acquiring and traffic state is reconstructed and estimated
    - A control strategy is defined comparing reference state (as above defined) with the current conditions
    - Commands to the subsystem for the actuation are provided
    -

The first cycle runs over a longer time period, while the second one operates in real time, in the sense that all the operations are carried out at the moment it is useful to intervene with corrective actions.

The supervisor can also work in a predictive mode, on a short time horizon.

So critical situations (saturation of specific arches or a general high occupation rate, etc.) can be detected and the supervisor can synthesize corrective actions to be implemented mainly using information to be sent to VMS and modifications to the traffic light regulation, to improve the situation. All the strategies defined by the supervisor are submitted to the operator for approval or modification before being dispatched to the remote systems.

With the same criteria the supervisor is able to manage traffic events that can occur both as programmed or unexpected events.

An important feature of the supervisor models is that they can learn from experience; in fact the set of data accumulated and processed are used to tune the assignment model and the other models used to synthesize the actions to be applied.

Interfacing the planning environment

All the data used can be shared with the planning environment: real observed traffic conditions, reconstructed network states, O/D estimations. This can take place through data exchange according to defined formats and protocols. This helps in tuning the planning models and in carrying out predictive simulations based on sets of real data. For this reason it's very important that the planning environment and the

traffic supervision environment are integrated sharing all the basic modelling elements.

Travellers' information

For its nature the Supervisor must have the complete set of static data regarding private traffic and public transportation and has a constantly updated vision of the traffic state. So it represents the natural data repository for info mobility applications. This is the reason why supervisors often integrate these kind of applications. They can provide both static and dynamic information such as:

Bus journey data
Traffic conditions
Events such as traffic accidents, etc.
Car park occupancy levels

Data are made available through specific protocols to info mobility platforms.

The characteristics of the info mobility platform can be very different from case to case, but they generally provide applications for computers and for mobile and smart phones. Some of them can support facilities like trip planners, or in some cases can be integrated to acquire the GPS position of Smartphones, so that the information provided to the users are profiled against their real needs.

Advantages and disadvantages of the technology

Advantages;

- When used effectively, these tools represent a powerful means to improve the traffic management and to increase traffic planning capabilities.
- The dynamic modelling function allows the implementation of adaptive and time-varying strategies, improving significantly the regulation performances, especially in unexpected or transitory situations.
- Real time optimization of traffic can result in a significant saving of fuel and emissions, as it increases the average speed of traffic.
- The availability of a complete and coherent data repository is a great advantage for all the planning purposes and can also be a significant impulse in integrating urban and traffic planning.
- The same availability gives the possibility to provide efficient valuable services to citizens.

Disadvantages;

- Given these characteristics, this technology is suitable for those realities that have existing automated systems for traffic and mobility data collection / monitoring and that have developed some kind of traffic modelling for planning (as simulation tools or similar applications).
- Similar tools are very complex, and the full exploitation of their potential requires high professional skills and resources to be constantly devoted.
- Implementation and operation is quite expensive
- The real effectiveness of these technologies is largely based on the quality of the applied models. A lot of attention and effort must be spent in the set up phases for acquiring data and carry out the work for tuning the model.

Best practices for application of the technology

The application of this kind of technologies is particularly suitable for large urban areas where several traffic automation and management systems are present. Moreover, the economic and organizational effort needed to implement and operate these kind of systems is justified where critical traffic conditions exist. This is the case in many European cities, where the urban structure is old and streets are narrow, with low capacities, and large areas are occupied by historical centres with valuable architectural heritage. In these cases the capability of efficiently using the existing infrastructures is a key point to prevent congestion and the related effects.

The implementation requires a high degree of customization for:

Interfacing the other systems
Setting up and tuning the model
Initializing all the territorial and mobility data
Adapting the product to the specific user needs and situations.

For this reason a key element to success is the accurate specification and design of the application and achieving consensus on the project, as often many of the systems to be interfaced belong to different administrative Bodies, companies etc.

At last, a prerequisite not only for the implementation of the system, but for its day to day operation, is the availability of a skilled team of traffic engineers and technicians capable of maintaining the system and exploiting its potential.

A recommendation that should be done is to make available data according to the open data philosophy. Integrated Traffic Management Systems are intrinsically in line with this perspective and constitute an occasion to make a significant step forward on

this way. In fact they collect a large amount of real time data that are at a significant extent dispatched to citizens and users using different infomobility platforms. In the same way data can be made also accessible to external applications for different kind of uses and this represent a significant added value. In particular through a traffic supervisor system several classes of data could be made available, such as the traffic conditions, the parking places occupation, the air quality parameters, the events occurring in the city and so on. They could be used both at public information purposes (given the due mechanisms of reliability of the provided data) and for studies and analysis.

Environmental Performance

When speaking of ICT, it is difficult to evaluate their environmental impact as a lot depends upon how the technology is utilised.

Traffic planning and management systems can be very effective in that they can:

Decrease the level of congestion
Decrease the average travel time and/or the travelled distances

More effective planning policies can also

- Modify the mobility demand

It must be taken into account that congestion is not a linear phenomenon, so that even a little increase in the average traffic speed can produce significant savings in the fuel consumption.

Costs and technology trends in integrated traffic planning and management systems

The current trends in innovation are focused mainly on the following topics:

- To radically expand the capability of acquiring traffic flows and speed data at limited costs enhancing the FCD techniques
- To improve the quality and the effectiveness of the traffic models
- To find more sophisticated algorithms and methods for synthesizing regulation policies.

These trends are pertinent to the specific field of transport technology.

As previously mentioned, these kind of systems are quite expensive both in their implementation and in their operation.

Being the result of a tailored engineering work based on the specific conditions, there is no way to accurately predict the costs of such technology, as they are the result of many different factors. It is estimated that implementation costs will run into the hundreds of thousands of Euros for system acquisition and implementation (direct acquisition cost, without taking into account the internal costs of work). This cost could significantly increase up to several hundred thousands of Euros (or more) when we speak about large and complex supervisors interfacing several systems over large areas. They will also generate significant maintenance costs.

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3.2 ICT System for Public Transport Management

Introduction

Public Transport must be the backbone of mobility in large urban areas. An efficient Public Transport service is of course based on several factors, but technology is gaining more and more importance. In particular, ICT systems can play an important role in qualifying the service as they can have different and synergic functions, being at the same moment:

- A powerful tool for managing the service from the organizational point of view
- A provider of real time information to travelers

Specific ICT systems to manage the Public Transport operation are currently available in the market in two main applications. The: first is technology addressed to Public Transport operator, for the management of all the processes related to service executions The second application is addressed to the users, for delivering to them the relevant information.

Technology description

ICT systems For Public Transport Management are distributed systems composed by three main integrated subsystems:

- The so-called AVM (Automatic Vehicles Monitoring) system
- An electronic ticketing system
- An infomobility system

AVM

The AVM can manage different kind of services (bus, trams, on demand) given that customisation could be required.

The AVM is a distributed system with a complex central software application connected to on-board computers (BC) installed on the vehicles to be monitored and with local peripheral systems located in the depots. AVM systems can control a very high number of vehicles. Each controlled vehicle is equipped with a board computer including a GPS and a GPRS/UMTS connection that collects information and dispatches them to the centre. The BC can also send and receive short messages to/from the centre and some systems also include voice connections with the centre. The most modern BCs are equipped with touch screen and graphic capabilities. Moreover, they are equipped with

an emergency pedal. In some cases they are also connected on the CAN bus with the vehicle instrumentation and can also collect mechanical and diagnostic information. The whole system works in real time.

We have to underline that there are different kind of AVM systems, ranging from the simpler ones that only track vehicles (called AVL), to the more complete, which perform an exhaustive set of functions to manage the service.

Given that our main focus is on large urban areas, we will refer to the second ones that fit with the requirements of a large and diversified Public Transport service.
The main functions of an AVM are:

- The management of the driving personnel and the vehicles
- The real time management of the service, ensuring its regularity and the compliance with the schedule and the management of not foreseen events
- The collection of all the data related to the delivered service and the production of complete reports

The working cycle of an AVM system is the following:
Each day the centre releases the whole schedule of foreseen services for the day and the related shifts for vehicles and drivers. The depots units download through Wi-Fi connections (or other) the relevant data to each one of the buses, coupling the line with the bus and the driver. During the service, at short time intervals the BC sends the bus's position to the centre so that it can be compared with the intended schedule, defining the state of the service (on schedule, delayed, ahead of schedule etc.). The information is sent to each BC and visualised for the driver.

On the basis of the current position and on a series of additional data (such as the recorded average speed on the roads, the historical data, etc.) the time for the next transit to all the scheduled stops of the line is updated.

This is completed by each vehicle on each service, so that from the centre it's possible to have an overall picture of the service. The vehicle position is defined with a very high precision through corrective algorithms. Moreover, at each bus stop, the door opening is detected and the bus position is corrected with the current bus stop. At the centre, different operators can follow the service visualising on their monitors on a map or on a linear representation the state of the service for each line they control. When irregular situations occur they can intervene to recover the situation or simply to improve the regularity of the service. They can do this by sending instructions to the

drivers to modify the scheduled service (for example cutting a run, or anticipating a departure from a terminus, etc. Each driver is able to change or routes among the unexpected events mechanical breakdown is also included. During the service the driver can keep in touch with the centre exchanging the needed information.

At the end of the vehicle shift, when coming back to the depot, all the information stored on the BC is uploaded to the local depot unit and then routed to the central system that processes them and maintains all the data into the service data base.

In this way the AVM records the precise time-space diagram for each line and vehicle and can produce a complete report of the delivered service for the use of the operator itself or the Transport Authority.

AVM can exchange all the real time information about the service with other systems such as a mobility supervisor or other infomobility systems.

At last we can mention the fact that AVM systems can be complemented also with on board video surveillance systems, based on cameras that, through the BC, transmit video streams to the centre and can also record locally images at security purposes.

E-ticketing system

Another important component of an ICT system for Public Transport Management is the e-ticketing system. It provides travellers with the possibility to buy paperless tickets mainly based RFID or magnetic cards support for season tickets or even single trip tickets.

The purchase of tickets can also be provided with additional media such as

- SMS
- App for smart-phones.

Sometime mixed paper-paperless solutions are adopted.

RFID / magnetic cards and tickets can be often bought by vending machines making part of the overall e-ticketing system, located in important places to access the PT service.

On-board, validators are installed, capable of reading the selected support technology. They are generally interfaced with the BC AVM unit that transmits to the centre also the ticketing data. Often the validators (directly or through the BC) are equipped with GPS units; this allows implementing automatically fares based on different zones and other smarter pricing policies.

The controllers are equipped with portable devices capable of reading the tickets. For SMS and app solutions, the transaction is directly managed by the centre and the controllers interface between this and smart-phones or similar devices.

All the data is transferred in real time to the centre, where specific software manages all the accountings and also aggregating data for use in monitoring and planning purposes.

E-ticketing systems can also be used jointly by different operators. If the system is conceived to manage at the centre clearing operations. This represents a very important asset for fostering intermodality and interchange and represent an appreciated qualitative improvement of the service.

Infomobility applications

The AVM system is a natural provider of valuable real time information about the state of the Public Transport service, possessing all of the real time data on each vehicle over each line.

So, generally, the AVM systems give real time information to travellers on a series of devices that are directly connected to the system itself. These devices generally are:

- On board announcement systems connected to the BC, which announces all the next stops
- At bus stops, different kinds of e-panels show the time to the next transits for each of the lines travelling through the stop.

Real time information can also be dispatched to travellers via the internet or through mobile devices. AVM systems are interfaced (directly or through other systems such as the traffic supervisor) with special purpose infomobility platform: they can deliver information on portals but also on roads mainly via:

- SMS; giving the next transit at PT stops identified with a code that is sent by the traveller to the centre with an SMS
- Smart phone; through a specific app that automatically identifies the stop by the smart phone GPS.

Additional real-time information can also be provided regarding traffic delays, interruptions etc.

Advantages and disadvantages of the technology

Advantages;

- AVM systems, when integrated in the operator company's information system, can lead to a significant increase of efficiency in managing the daily operations and can lead to significant savings.
- AVM increases the regularity and quality of the service.
- E-ticketing can allow the implementation of sophisticated and intelligent fare - systems and policies. In particular, policies related to travelling zones are easily applicable, as well as integrated tickets among different transport operators, fare levels depending on cumulative use, etc.
- AVM and e-ticketing can be very efficient tools in monitoring the delivered service and to control the compliance with the service contract.
- AVM and e-ticketing provide important information about the real delivered service and the real use of the service by the travellers. This data is of paramount importance both for planning and for pricing policies.
- Real time information is always valuable for passengers and can increase the use of Public Transport.

Disadvantages;

- These kind of integrated systems are quite expensive, not only for implementation but also for operation. Their economic convenience is difficult to be fully and precisely evaluated, as several benefits are not directly related to economic parameters.
- Given the impact upon the organisational structure of the company as a whole, their implementation must be carried out with attention to creating a cooperative environment in the company and involving all the stakeholders in the process.

Best practices for application of the technology

AVM systems have been diversified to such an extent o that we could say "there is an AVM system suitable for any need and any subject", but the kind of systems we are speaking about are complex ones. They are suitable for large urban areas with a high number of vehicles and articulated services.

As a pre-requisite the company should have a good computer-aided service programming tool for the management of the driving personnel and the vehicles.

A lot of care should be taken in the preparatory phases, from the conception to the implementation and testing of the system.

The system must be embedded within the information system of the company and has a strong impact on a large number of organisational processes. For these reasons the level of customisation is always very high and the software must be subject to accurate specification, taking into account not only technical but organisational aspects as well.

A key success factor is the involvement of interested personnel and the various company department sat the conception stage. Many of the failures of similar applications are due to the resistances of these stakeholders. For example, vehicle drivers may perceive these technologies merely as a method to control their work. One of the ways to achieve this consensus and to create a cooperative environment is adequate training; for drivers, controllers, supervisors and for the operating centre operators.

The same can be said for e-ticketing systems that also have a very important strategic dimension, as fares are one of the most important leverage for approaching the market and determining the modal share. One of the intrinsic complications of these kind of systems is the fact that often they involve different operators, with different schemes, procedures and information systems. Moreover, there is the need to overcome the preconceived caution and often scepticism of operators; who may be uncomfortable in sharing information of this kind and in creating interoperability. So, if the target is to implement an intermodal and/or multi operator system it's very important to have clear and influential leadership on the project and strong political commitment by the local decision makers.

As all the monitoring systems, an integrated public transport management systems collects a lot of data that could theoretically been made available for other applications. In fact they often include an infomobility platform to dispatch the real time information. But in this case the real possibility to make data available as open data is quite restricted to:

- static data such as the network and the timetables
- The next transits at stops as dynamic real time data (information generally already provided to travellers).

In fact the rest of the data are partly not interested for general users (such as diagnostic data) or restricted as proprietary data subject to contractual conditions. For this reason, to achieve the target of having the availability of data, the matter should be included in the contractual terms between the Local Transport Authority and the Public Transport Operator.

Environmental Performance

As for other ICT, it is very difficult to evaluate the environmental impact. The only think we can say is to give an idea of what are the mechanisms that can operate in improving the quality of environment.

ICT systems for Public Transport Management can influence globally the urban environment only if they gain a higher modal shift for Public Transport against private polluting modes.

This result can be achieved mainly through:

- Better pricing policies
- Integration of different transport services
- Qualitative improvement of the service in terms of regularity and time-keeping
- Better information to passengers
-

Even if the effects are difficult to be precisely defined, we should remember that even a low percentage of increase in the modal split toward Public Transport, in large urban areas means thousands of trips, and the related environmental benefit can be very high.

Costs and technology trends in electric vehicles

The innovation trend in ICT hardware is very fast. The next generation of systems will benefit from even more powerful on-board equipment. The future developments seem to be in two main directions. The first to make accessible this kind of applications also to small realities, simplifying the solutions and using widely diffused hardware and communication techniques. In this sense the use of smart phones as on board units is already a reality. On the other side, to implement more sophisticated management tools capable of a better optimisation of the operations.

Finally, in terms of e-ticketing, the use of smart phones coupled with techniques like NFC will radically change the payment methods for Public Transport.

Within the transport sector, the innovation speed is limited by the application environment, so that not all the theoretically available technologies find a quick application. The sector is therefore technologically more stable than the general ICT sector.

All these systems are largely customised and their cost is largely dependent on the desired characteristics. So it’s difficult to get an overall evaluation.

A significant part of the cost is related to vehicle equipment; the cost of hardware is decreasing and now the cost to equip a vehicle can range from a few thousand Euros up to 10 or even 12 thousand euros.

The implementation of AVM software and of the other integrated systems is expensive, in the order of hundreds of thousands of euros or even more for large and complex systems. It must also be considered that they also generate significant maintenance costs.

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3.3 ELECTRIC MOBILITY

Introduction and reference framework

Electric mobility can be still considered a challenge for urban mobility. There are currently several vehicles available on the market, which are very good from the technical point of view but their adoption is still very limited in urban environments.

Cities often want to support the diffusion of electric vehicles but they find a lot of barriers and difficulties.

As an example, in Italy electric vehicles are less than 0,05% of circulating vehicles, even if the number of enrolled electric vehicles is increasing, in reverse trend with the overall vehicles enrolment. The situation in 2012 was the following:

Country	Electric vehicles sold in 2012 (units)	% over the overall enrolled vehicles
Japan	15.937	0,60%
United States	14.592	0,10%
China	8.733	0,06%
France	6.067	0,30%
Norway	3.883	2,80%
Germany	1.294	0,04%
Great Britain	1.167	0,06%
Italy	524	0,04%

(Source : AGIENERGIA, July 2013)

It is clear that, when speaking about the diffusion of electric mobility we can't speak only about technology, but we have to also consider the policies which foster its diffusion and the related problems with this.

Technology description

Electric mobility consists of two elements:

- Electric vehicles
- Charging systems.

Moreover, there is now a wide diversity of electric vehicles:

Full electric (FEV – they need to be recharged)

Hybrid (HEV – they have 2 engines, one of them electric, charged by the thermal one; they can't be charged through charging facilities)

Hybrid rechargeable (HRV – are hybrid vehicles, whose batteries can also be connected to charging systems).

Electric vehicles are also diverse in terms of their use, i.e. cars, vans or buses. Today the market offers hundreds of different electric vehicles models and types. Today the market offers hundreds of different electric vehicles models and types that can be bought with no barriers.

One of the main characteristics of electric vehicles is their individual variance. Various vehicles have very different performances; the data reported by the manufacturers however doesn't necessarily reflect the reality, as they are defined over standard driving cycles not so realistic in real driving.

Referring to electric cars, the current maximum distance that can be travelled is about 100 or 120 oms in real driving conditions, but it can significantly change according to several factors.

The problem of limited distance is not as significant for hybrid cars, so that they are often preferred for use requiring long journeys.

A key element of the electric vehicle technology is represented by the batteries: they are economically significant and heavily influence the maximum distance. There are several technological solutions for the batteries:

- Lead-acid
- Nickel - metal hybrid
- Lithium-ion
- Zebra

Lead-acid batteries have now been replaced by the other technologies, but still remains a solution for low level vehicles as they are relatively cheap. Nickel-metal hybrid and Lithium-ion batteries have high specific energy and high specific power, but costs are still high. Nickel-Cadmium and Lithium-ion technologies can support a very high number of charging cycles. Zebra batteries have the advantages of being nontoxic (are based on nickel and salt) and have high specific energy but quite low specific power; additionally they work at high temperature and maintain the charge for a few days. One promising solution for the future is the lithium-sulphur battery, which can hold as much as four times more energy per mass than lithium-ion batteries. This could enable electric vehicles to drive longer on a single charge and help store more

renewable energy. The down side of lithium-sulphur batteries, however, is they have a much shorter lifespan because they can't be charged as many times as lithium-ion batteries. Research is very active in this field, with the focus on new generations of batteries that could ensure a very high level of autonomy.

The last important element of electric mobility is represented by the charging systems. The availability of charging systems in the cities is a key point for the diffusion of electric vehicles, especially in this stage of the technological development when the autonomy is quite limited. Charging systems can be very different, ranging from the simple domestic wall socket available in any garage to sophisticated 'quick charging systems'.

The main difference between the systems is the time required for recharging the batteries. It is a direct consequence of the supplied energy that is of the available power. For this reason the fast charging systems work at high voltage and need specific safety and installation measures. Moreover they are particularly costly.

Normal on-street charging stations are equipped with multiple sockets and sensors that cut the flows when the vehicle is not charging.

The following table compares different charging systems.

Charging time	Power supply	Voltage	Max current
6–8 hours	Single phase - 3.3 kW	220 VAC	16 A
2–3 hours	Three phase - 10 kW	380 VAC	16 A
3–4 hours	Single phase - 7 kW	220 VAC	32 A
1–2 hours	Three phase - 24 kW	380 VAC	32 A
20–30 minutes	Three phase - 43 kW	380 VAC	63 A
20–30 minutes	Direct current - 50 kW	380 - 500 VDC	100 - 125 A

Charging systems can be installed both in private environment and on public roads. For the latter, the recent trend is to install "smart" charging systems: they can be accessed by any user through a smart card or other similar devices, and can manage the accounting and payment of the used energy.

Advantages and disadvantages of the technology

The use of Electric vehicles is highly contested and the balance between advantages and disadvantages is still under discussion. A long list of fact should be considered

Advantages;
Advantages are focused on few but very important points:

- The main advantage is clearly the reduction in emissions with respect to thermal engines, and the saving in fuel consumption.
- Electric vehicles are silent, so that also acoustic pollution is significantly reduced.
- The required maintenance is theoretically low with respect to the one required by thermal cars
- The operating costs are much lower than the ones to drive a thermal car (this is particularly true for FEV rather than for hybrid ones).

Disadvantages;
On the other side, disadvantages are numerous:

- Purchase costs that are significantly higher than for conventional cars.
- Limited autonomy; sometime it's a real problem, but some other is mainly a psychological barrier, as most of the daily trips in urban areas are significantly lower than the EV autonomy. This problem is more significant for buses as often they need to be recharged during the service, forcing a change of vehicle with additional operational costs.
- Scarce availability of charging points, as in cities charging infrastructures are limited in number and often concentrated. Garage owners who can charge in their own facilities are few in the centre of the cities.
- Long time for charging, not compatible with long inter-urban trips. Fast charging is available but is very expensive due to technology itself and to infrastructural works for safety.
- The low operational costs can recover the high differential in purchasing costs only over a high driven mileage.

Best practices for application of the technology

At the moment the use of EV is of course limited to urban areas. The best application strategy at the moment is introducing its use in:

Company fleets (particularly public) for urban services. This is a good application as the daily mileage is limited and during the night the vehicles are not used. The case of Reggio Emilia is exemplary in this sense.

Some bus lines, mainly in the historical areas, where a higher operational cost can be justified for the value of environment.

In some case the application of a limited number of electric vehicles in car sharing fleets can be implemented, even if the operational costs for the service operator is much higher than the for thermal cars.

For private citizens the adoption of electric cars should be in some way supported with economic incentives; in the other case they can't be competitive under a pure economic point of view. Moreover they are not so flexible to cover all the potential uses a private can do; they remain mainly city cars, with limited annual mileage and economic return is always problematic.

An additional problem for the private use is the availability of charging stations. Private garages are mainly available in the peripheral areas of the cities; in the centre, that is the most appropriate environment for the use of EV, this situation is rare, so that on roads charging stations are necessary. This represents a significant problem for a wide diffusion of EV, as charging stations occupy spaces and have a quite invasive visual impact, especially in city centre. All these facts explain the very limited diffusion of electric cars for private use.

Cities willing to foster the diffusion of electric vehicles should follow the mentioned strategy, starting their introduction from more "protected" environment as the ones mentioned. They should then provide on-road infrastructures for charging, enlarging gradually their number and geographical coverage.

Anyway a real wide diffusion of electric vehicles can be conceived only when the most important barriers will be overcome, that is when they will have a significantly higher autonomy of the charging times will be comparable to the ones for refilling the thermal cars. Of course the way to achieve this result can be very different - better batteries, recharging stations, etc.

As an important point to support the adoption of electric vehicles is the availability of information about the distribution of charging points. A monitoring system can provide this information and make data accessible by external applications according to the open data philosophy. It should be noticed that advanced monitoring systems can provide not only the location of the charging stations but also their occupancy state. In this way the potential user can be addresses to the nearest free charging point.

Environmental Performance

Environmental benefits of using electric vehicles are well known. FEV are zero-emission vehicles, and also HEV and HRV in any case show a significant saving in emissions.

But electric vehicles are convenient also considering the whole energy balance. Several estimations have been made of electric vehicles energy efficiency, taking also into

account the overall energy production chain. The energy efficiency for an electric car is about 32% against 28% of a conventional car.

For hybrid cars the efficiency is highly influenced by the kind of use is done.

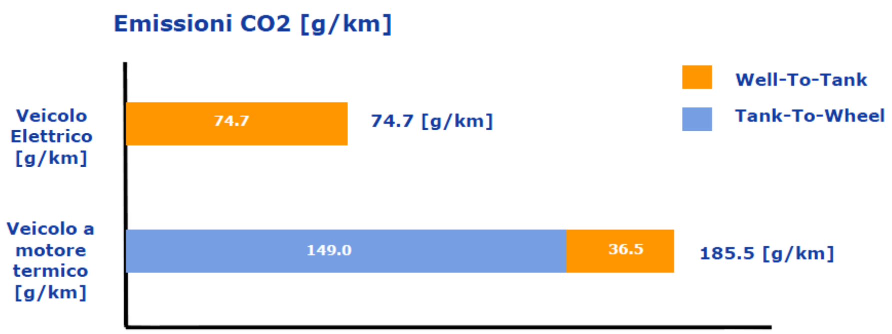
A significant benefit comes from the saving in emissions. Of course FEV are zero emissions vehicles "on-site" but the source emission for the electric energy production should be considered. It's of course very different in consideration of the different energy sources used in producing electricity, so that a clear data in this sense cannot be given. In any case, being the overall energy cycle more efficient, a saving in emissions is always achieved.

A discussion paper from the OECD - International Transport Forum, Electric Vehicles Revisited - Costs, Subsides and Prospects, compares the TTW (thank-to-wheel) CO_2 emissions for EV and thermal vehicles in grams/km for three different car models; the difference is quite evident.

	4-Door Sedan	5 door-compact	2-Seat Light Commercial Vehicle
WTW* grams CO2 per km Internal Combustion Engine	142	126	167
WTW* BEV grams CO2 per km EV	12	10	15

(OECD - Discussion paper International Transport Forum, Electric Vehicles Revisited - Costs, Subsides and Prospects)

Another study carried out by ENEL, the Italian main Electric Energy Supplier on the basis of the American Study "Well-to-Wheels Analysis of Advanced Fuel/Vehicle Systems — A North American Study of Energy Use, Greenhouse Gas Emissions, and Criteria Pollutant Emissions", Argonne National Laboratory, gives different and less optimistic figures, but anyway very significant, as shown in the next picture.



(ENEL - Italy, internal elaboration based on Well-to-Wheels Analysis of Advanced Fuel/Vehicle Systems, Argonne National Laboratory, USA)

It's clear that a wide spread of electric vehicles would result in a very significant improvement for environment.

Costs and technology trends in electric vehicles

Technology improvements are waited in the field of batteries, where significant researches are going on for producing long lasting and high charge batteries that can give a high level of autonomy to the car.

Another important area of research is for improving the charging process, both with the production of faster charging stations and with the definition of a fast process of battery change (for allowing fast change for example on motorways).

Of course car producers are going to improve their products, according to their needs, improving the general performances of the vehicles.

For what concern the costs, we must say that there several evaluation of convenience for the use of EV, and they always show very different numbers. The reality is that the convenience is heavily affected by the way of use of the vehicle the duration of batteries, etc., and all these parameters can lead under different hypothesis, to very different conclusions.

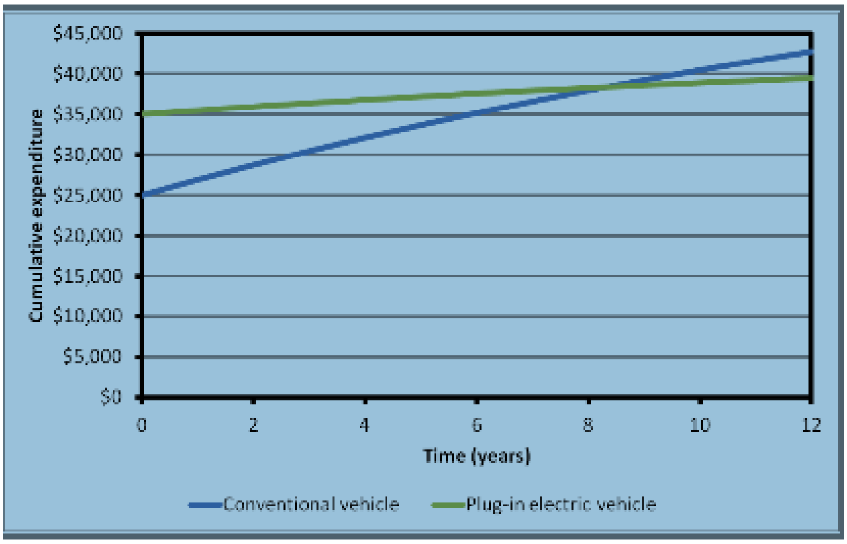
For sure we can say the purchase of electric vehicles is much more expensive than of equivalent thermal ones. The difference can range from a 30% to 50%, even if this difference should decrease with the higher production volumes for EV.

Maintenance costs are generally considered lower, from half to one third of diesel and petrol cars. But this if we don't consider the cost of batteries that must be changed indicatively every 5 years. A recent US study (Total costs of Ownership Model for Current Plug-in Electric Vehicles, Electric Power Research Institute - EPRI, 2013) demonstrates that the real advantage starts after the first after the first 30000 miles (as now the majority of new cars have maintenance schedule whose price is fixed by the producers), so that the real advantage is limited.

Driving is of course inexpensive with respect to thermal cars (the cost is roughly one third to one fourth), and the level of convenience radically depends on the ration between the cost of electricity and petrol, that is significantly different from site to site.

In any case the minimum estimated mileage for achieving the economic convenience over a time period of 5 years is no less than 20.00 km/year.

The same EPRI study defines the payback period for not-subsided EV with respect to the average conventional at about the 8.th year (of course taking into account two couples of EV and conventional American cars, with their costs and average driven mileage)

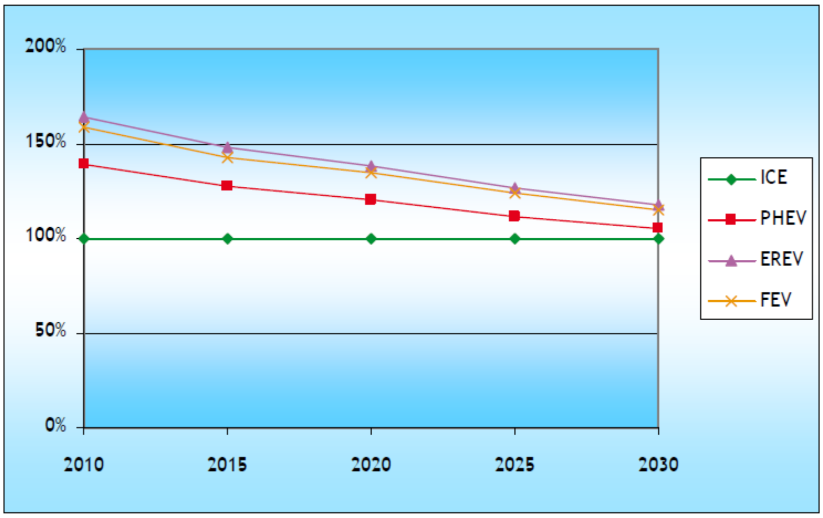


(Total costs of Ownership Model for Current Plug-in Electric Vehicles, Electric Power Research Institute – EPRI, 2013)

An European study carried out by CE Delft-ICF-Ecologic (2011) has computed the total cost of ownership (TCO) for different kind of electric vehicles (FEV and hybrid) compared with conventional ones (that is considered the conventional basis at 100%).

TCO for FEV is 60% higher and for hybrid is 40%. The values of TCO are expected to become comparable in 2030 about.

Illustration of the TCO of medium petrol vehicles - compared to the TCO of a comparable ICEV (ICEV=100%) - with fuel and electricity taxes but without vehicle taxes or subsidies



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4. ICT

This section presents the fiches developed for knowledge exchange in relation to ICTs.

The fiches, prepared by CSE, are presented in separate pages to facilitate that they be printed and distributed separately to respond to request of information, feed discussions and workshops, etc.

The following concepts and technologies have been covered in the fiches :

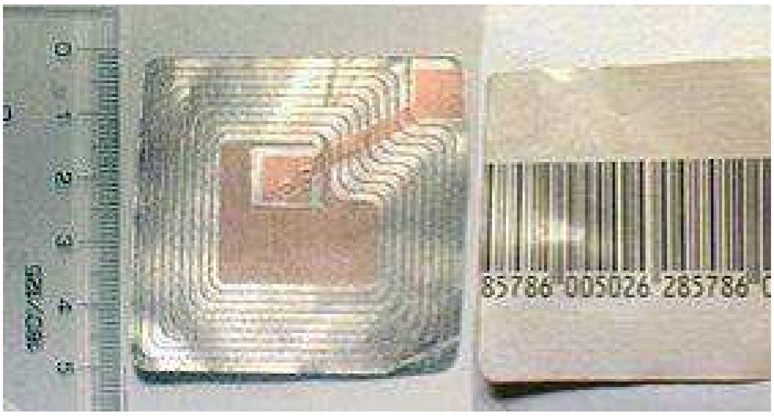
- INTERNET OF THINGS
- MOBILE APPLICATIONS
- OPEN DATA
- SMART GRID AND SMART METERS

4.1 Internet of things

Introduction

The internet of things (IoT) is a term coined by Kevin Ashton to describe a possible future in which most everyday objects have a unique identity, and a ubiquitous network is available.

To understand the internet of things, it is helpful to have an understanding of the component technologies which are enabling its development. The internet of things is not itself a technology, but instead a hoped for set of emergent benefits and synergies which are predicted to become possible as a consequence of the evolution of a platform of supporting technological components.



A flat RFID tag – a tag like this could be inserted into a book or other document to link its identity to a digital copy, for example.

Identities

A key prerequisite of an internet of things is the notion that all things are uniquely addressable; as such they must have an identity.

Radio-frequency identification (RFID):

RFID tags are very small chips (the size of a grain of rice), which can contain a small amount of information, for example a unique serial number. They can be externally powered by induction from the RFID reader, and so require no batteries. These could be used to place identity information into things which are too small or endure conditions too harsh to support an actively powered microprocessor. For example, many car tyres now contain RFID tags which allow their manufacture to be traced all the way up the supply chain to the factory.

Internet Protocol v6 (IPv6)

The next version of the internet protocol uses 128-bit addresses, allowing for 2128 distinct network addresses to be routed. Because of the number of possible things

which could be connected to the internet of things, a very large address space will be needed, and so the 32-bit address space provided by IPv4 is unlikely to serve.

Communications

The internet of things also depends on the widespread availability of a network connection. This need not be a connection to the internet itself, but may instead be a lower-power short-range technology, which connects to the internet through a bridging system; popular protocols include

-802.11 or Wi-Fi, which is a very widely used if somewhat inefficient protocol designed to support internet protocol (IP) for communications between relatively powerful machines.

-ZigBee, a low power mesh networking technology

-GSM, the rather old-fashioned second-generation mobile phone network

Both ZigBee and GSM, for example, are used in the current UK design for Smart Grids. GSM is employed for connectivity to the wider internet, whilst ZigBee provides a local mesh network for communications between smart devices in the home, like different smart meters, in-home displays and so on.

Sensors

A wide variety of sensors can be used to collect information in many different aspects ranging from environmental variables, events, signals, etc. The use of a particular sensor will depend on the variable that wants to be measured.

Computational resources

The internet of things is expected to produce vast troves of data, as a consequence of the continuous monitoring of many different sensors. To make use of this data, commodity computing platforms are required, and the current growth Cloud computing makes this possible. Services like Amazon's Elastic Compute Cloud (EC2) offer nearly unlimited computing resources to be delivered at short notice to any network user, without the large setup and management costs associated with building a datacenter.

Relationship to Smart Cities

Energy

A Smart Grid is an example of a system made possible by the internet of things. In the current state of the art, the 'things' identified within a smart grid are entire houses, because sensors are only deployed at the smart meter. However, future smarter grids may employ socket or appliance-level metering, or use more computational power to infer appliance-level data from the whole-house signal. Fine grained information about how devices use energy could help people to make better decisions about when and how to use technology efficiently. Another facet of the smart grid is the possibility of

appliance or socket level demand response systems (discussed in the Smart Grids article), which again depend on key IoT principles.

Transport

Internet of things can allow integration of sensing and applications to develop a range of applications for smart cities, such as smart parking, climate and traffic advice for drivers, etc.

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4.2 Mobile applications

Introduction

A mobile application is a software application that has been designed to run on smartphones, tablets and other mobile devices.

Mobile applications usually provide limited and relatively isolated functionality (for example a game or mobile web browsing), and represent a move away from the integrated software systems typically found on desktop computers. The fact that they are so specific in nature allows consumers to tailor the content and function of their mobile device to suit their own needs.

Technical description

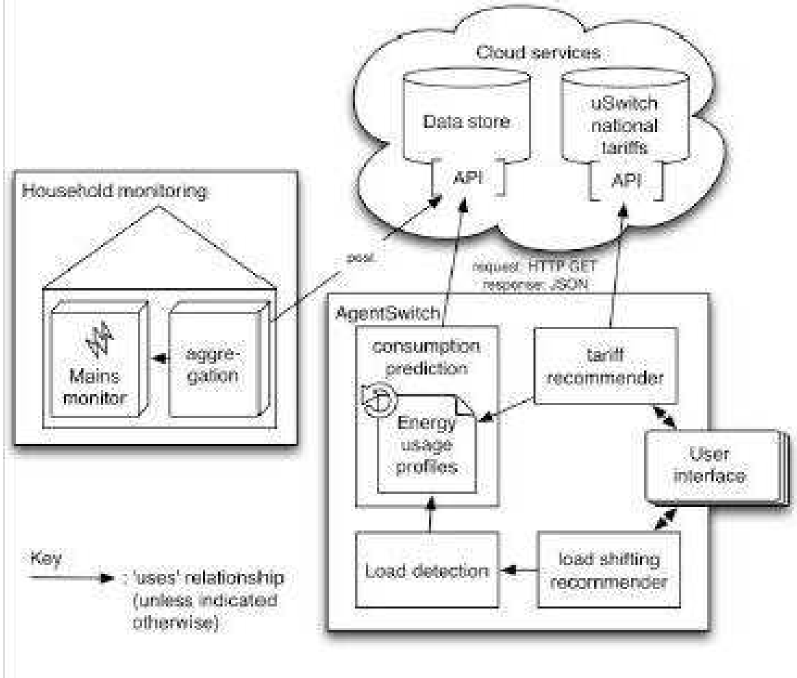
There is a direct link between the development and use of mobile applications and the availability of data. Whilst there are few existing applications focused on the management of energy, the roll out of smart meters, advances in machine learning and the advent of low cost sensing technologies present an opportunity for innovation in this sector.

One of the areas that has already attracted attention from researchers is the idea that mobile applications can be used to provide feedback to consumers on their personal energy consumption patterns based on data collected through smart metering. Increasing the transparency of energy consumption, for example by providing a visual representation of the energy being consumed by individual appliances within a household in real time, can be used to encourage consumers to alter behaviour. Previous studies have suggested that the provision of this type of information can lead to a reduction in the total energy consumption of a household of between 5% and 15%, and can be particularly effective where cost information is also provided. Some studies have suggested that introducing an element of gamification into an application, or linking it to social networking tools, could help to engage users.

Alternatively, the provision of feedback in this way could be used as a tool to shift the demand for energy to both reduce peak loading for suppliers and to cut consumer bills (assuming a deregulated market and that variable tariffs are available). Applications such as these may aim to do this by influencing consumer behaviour (for example by encouraging householders to run expensive appliances such as dishwashers overnight when the price per unit of electricity may be lower), or may control the appliances automatically, without the need for regular input from the user.

One example of a mobile application of this type is called AgentSwitch, which has been devised by a team of researchers from the Universities of Nottingham, Southampton and Oxford. AgentSwitch utilizes historic electricity consumption data to provide a

range of smart services including the provision of recommendations on energy tariffs, load detection and usage shifting. The application is driven by a third party real-time energy tariff API, a set of algorithms for usage prediction, an energy data store, and appliance-level disaggregation. Communications.



AgentSwitch system and infrastructure

Mobile applications can also be used to engage users with other energy-related issues, for example they may use to allow interaction with, or provide information relating to, the energy consumption of local buildings or infrastructure, or to encourage the use of sustainable modes of transport.

Advantages and disadvantages

It is difficult to provide generic advantages and disadvantages for mobile applications as they have the potential to vary so widely in form and function and there are few well developed examples (related to energy) currently in existence.

The nature of mobile devices means that they can provide a consistent and relatively immediate method of communication between individuals and/or objects. At the smallest scale, this could provide a user with a greater level of control over his or her energy consumption than could be achieved through other means. Mobile applications can also be used as a particularly effective public engagement tool through which to target younger audiences who might otherwise be difficult to reach.

User profiling is already used by many price comparison websites for utilities and other goods/services, however it usually relies on the consumer providing certain information themselves. It could be argued that manual data input is more error-prone, particularly where parameters may be difficult to estimate, and that tedious input processes might cause users to lose interest. Mobile applications provide an opportunity to minimize the amount of manual data input required by automating the data collection process, and they could also allow for recommendations to become more personalized.

On the other hand, where profiling is based on sparse data (for example on data collected during only the first few weeks or months of usage, without exposure to seasonal variation), then estimating a user's typical consumption behaviour will usually require the use of statistical modelling processes based on a set of assumptions, which in practice may not accurately reflect reality. Providing users with an opportunity to provide feedback on these assumptions, for example to justify instances of higher consumption within the existing dataset, may allow for more accurate profiling.

In addition to this, the focus on consumption feedback has recently come under criticism for its 'one size fits all' approach to demand side management, which does not take into account people's differences in motivation and can be considered to reduce energy issues to an optimization problem. It has been suggested that this approach does not sufficiently take into account the factors of convenience and comfort which contribute significantly to everyday behavioural practices.

Applications that include load detection as part of their function may be subject to some technical limitations. Detecting deferrable loads requires the disaggregation of the data, often based on statistical modelling, however low data granularity and a lack of training data can make it difficult to determine exactly which appliance generated a particular load.

The development of useful mobile applications is reliant on the availability and quality of appropriate data, and the issue of data confidentiality is not always fully addressed or made transparent to users by software developers.

Best practice application, uptake and costs

The development and use of mobile applications for energy management and planning is still very much an emerging field, and few tangible results are available to demonstrate their effectiveness or to define best practice at this time.

The cost of developing a mobile application is likely to vary considerably depending on its design and its purpose. For example, a mobile application that requires extensive

infrastructure in order to function is likely to cost more than one that is simply linked to one individual smart meter.

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4.3 Open data

Introduction

Open data can be defined as data that can be freely accessed, reused and redistributed by anyone and for any purpose. At most, use of the data may be subject only to the requirement to acknowledge its source or to share the results of its manipulation.

Open data would not usually contain any information that could be classed as 'personal' and should not contravene any laws on data protection. It should be easily accessible at no more than a reasonable cost for reproduction, and should be provided in a modifiable format.

Types of data that may be useful as open data may include the following:

-Geodata: maps, topographical surveys and data about the location of buildings or roads

- Environmental data: atmospheric pollution levels, weather data

-Transport data: bus and rail timetables, real-time travel information

-Statistics and finance: census data, public expenses

Advantages and disadvantages

The arguments for and against open data tend to depend strongly on the type of data involved and its potential uses.

One of the most commonly cited advantages of open data is its potential for increasing the transparency of government operations. The provision of data into the public domain in this way can promote public accountability (for example in relation to the spending of public money) and potentially improve the delivery and quality of

public services. Opening up data can also help drive innovation in business and services that can deliver both social and commercial value.

Another practical driver behind open data is the idea that the data that is released can be controlled and officially verified, which helps to mitigate against the risk of external parties processing and releasing their own data from unofficial and unverified sources. Increasing the number of people that use a particular dataset is also likely to increase the likelihood of any discrepancies in the data being identified and subsequently corrected.

Conversely, when data is released in its raw form it might not be considered to be fully and meaningfully accessible to the public where some level of technical expertise is required to interpret it. Some argue that that this provides already privileged groups with further advantage, and that public money should not be used to fund the time and skills necessary to convert data into a standardised format for release as open data where the benefits of its availability are unlikely to be evenly distributed across society

Best practice application

-**Conditions of use should be clearly defined.** It is important that proper licensing is in place at a national or international level in order to ensure that the data is open in the right way, and that it stays open. Potential issues relating to the re-use of the data, including attribution, ownership rights and privacy concerns should be clearly set out. Feedback on the quality of the data provided should be encouraged.

-**Data should be released in a format that is easy to use.** Creating and conforming to data standards allows for wider potential use of the data by ensuring that it is released in a format that can be easily used by a range of stakeholders with varying levels of skill in data manipulation and programming. For example, using standardised open formatting with an open license can simplify the merging and correlating of different datasets.

-**People need to be aware of the datasets that are available to them and need to be motivated to make use of them.** The availability of training should be considered in order to ensure that the skills and capacity within the local community are sufficiently developed to realize the potential of open data. It is often more straightforward to motivate people to make use of open data when it can be focused on local issues, such as local service provision, social enterprise and job creation. Data providers should consider which data people might find useful, rather than simply what is available. Organizations such as business associations, charities and NGOs should actively seek to obtain the data that is useful to them by engaging proactively with data providers.

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4.4 Smart Grid and Smart Meters

The smart grid is a catch-all term covering several technologies; metering and monitoring systems made possible by commodity computing and a pervasive data network (in some sense a reification of the internet of things), and local small-scale power generation.

Smart metering

A smart meter is a network connected electricity or gas meter. These can provide consumption information to the grid in near real-time, and in some cases may be provided with information about the wider world by the grid, such as a live fuel price or the current carbon factor of the electricity being generated.

Smart metering helps with accurate billing and supports more complex time-of-use tariffs, and also provides a lot of high-resolution information about fuel usage which may be used to better predict load profiles and manage distribution and generation infrastructure.

Furthermore, providing live and informative feedback to householders about their electricity consumption may help to enable behaviour changes which reduce demand. This kind of feedback is often provided by giving customers an in-home display along with their smart meter; an in-home display is a screen which shows real-time information about a house's consumption and rate of spending. An academic study based on existing trials showed that homeowners' electricity consumption on average is reduced by approximately 3-5% when a smart meter is paired with an in-home display.

Demand response

Demand response technologies allow appliances which use fuels to be automatically controlled by the grid, either through a pricing mechanism or more directly. There are three types of demand response - emergency demand response, economic demand response and ancillary service demand response. These may provide benefit by shifting peak loads, allowing more efficient utilization, reducing the need for generation and distribution capacity, and ensuring continuity of critical services during outages. Demand response systems can also be used in concert with distributed micro generation, switching between local and grid power in response to price information.

For example, refrigerators can typically be switched off for a period of time with no ill effects, so the grid could shed load during periods of high demand by instructing refrigerators to switch themselves off if possible. Similarly, a householder might program their washing machine to perform the washing when the grid offers a certain price for electricity.

Because generators are started in merit order (cheapest first), peak demand is satisfied by the most expensive sources, driving the wholesale price up to the marginal cost of the most expensive watt. Reducing peak demand by shifting load will therefore reduce both the wholesale price during operation, and also the operating costs for the entire system by reducing the required generation capacity.

Current demand response schemes are mostly implemented with larger commercial users such as supermarkets who have shiftable loads which are large enough to justify the transaction and setup costs associated with setting up the scheme.

Various academic studies predict average energy savings ranging from 2% to 16%, depending on the degree of real-time pricing and the elasticity of demand, and up to a 44% reduction in peak demand, although this scenario depends on sharp price increases at peak times together with the deployment of comprehensive automation.

Local generation and storage

Generation and storage technologies are also considered as part of the smart grid, including solar PV, combined heat and power, and energy storage. Smart grid proponents hope that a more distributed generation grid will provide superior efficiency, as well as resilience to equipment failures and the possibility of lower network overheads, and that advanced energy storage technologies will be able to smooth out intermittent supply and variable demand.

Electricity storage

Electricity storage is useful for handling peak loads without having to start up new plant. The total installed capacity of storage is not currently significant and is mostly embodied in large pumped-storage installations (for example the UK has about 30GWh of pumped storage capacity, and a typical peak demand of around 57GW).

However, a variety of other storage technologies are hopeful candidates for future expansion, including compressed air storage, fuel cells, and flywheels. One possible pathway involves the use of Electric Vehicles as grid-connected local storage when they are not being driven, as peak usage typically occurs when people are in their homes (in the evening and morning), and electric vehicles would likely be connected to the grid overnight to charge.

Heat storage

A lot of power demand is for space heat, especially in colder countries. In concert with heat pumps, heat storage systems like deep boreholes may provide the opportunity for increased efficiency in the provision of local heat. Although heat storage cannot be made available to a smart grid, local generation and storage of heat is often considered in this space as it is a demand-side option for reducing grid load.

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5. EU Energy Efficiency research current status and prospective

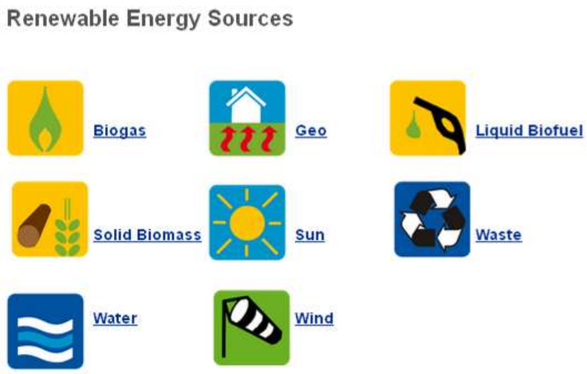
This section contains information about CONCERTO INITIATIVE´s technologies, interesting for the participant cities as a wider overview of energy applications to be discussed on a wider and less detail context.

With the same purpose, it also includes some general indications of technological prospective with a wider perspective than those trends shown in the previous sections for particular technologies.

5.1 Current status

CONCERTO is a **European Commission initiative** within the European Research Framework Programme (FP6 and FP7). The EU initiative under of the European Commission's Directorate General for Energy started in 2005 and has co-funded with more than 175 Million € 58 cities and communities in 22 projects in 23 countries.

According with that demostrative experience, CONCERTO Innitiative offers a list of **innovative technologies that are <u>ready to be applied</u>** and that look forward the use of renewable energies sources for cities, energy efficiency measures, sustainable building and district development. This source is considered of great interest for STEEP project because of its specific focus on buildings and urban communities. The technology´s information is divided into RENEWABLE ENERGY SOURCES and LOW CARBON TECHNOLOGIES:



List of renewable energy sources included in CONCERTO
(Source: http://concerto.eu/concerto/environmental-technologies.html)

List of Low-carbon technologies included in CONCERTO
(Source: http://concerto.eu/concerto/environmental-technologies.html)

ACTIVE THERMAL MASS STRATEGIES

For making use of environmental energy in an efficient way, it is beneficial to use heat or cooling energy with moderate temperature levels. For example, the lower the heating output temperature has to be, the more efficiently a heat pump can work. Another example is free cooling by using ground water directly.
However, more moderate temperature levels mean that larger surfaces for the heating (or cooling) exchangers are needed that provide the heating (or cooling) to a room. Floor heating is a good example and has been integrated into buildings since many decades already. Modern concepts can activate the whole concrete slab and also connect the circuits alternatively to the cooling device.
Beside the benefits to the energy performance, there can also be another, an architectural advantage to this system: no extra space for radiators or convectors is needed resulting in greater flexibility in using the space. A disadvantage is the thermal inertia of such systems, which engineers try to reduce by intelligent controls.
Within CONCERTO Hoje-Taastrup is a site where so-called thermo activated building systems (TABS) have been implemented.

BIOMASS BOILER

Compared to an oven or an open fireplace where one would feed in wooden logs manually and where the combustion process cannot be controlled well, a modern pellet or chip boiler has an automatic transport device for constant supply and often a lambda-sensor for achieving an optimal combustion of the biomass. There are boilers on the market now that even can handle crop or reed.
Compared to conventional gas or oil boilers biomass boilers are still less reliable in operation due to mechanical construction parts. To store the biomass extra space is needed. Often operating costs are higher because of requirements for cleaning and removal of ashes.
Though the efficiency factor is usually less compared to a gas or oil boiler the evident advantage is using renewable energy, thus making it more efficient in terms of primary energy or CO2 emissions.
Not only solid material is burned in biomass boilers, there are also systems using biogas or liquid biofuels as well. However these are seldom used for direct heat production, but rather for driving generators in CHP or polygeneration.

COMBINED HEAT AND POWER CHP (COGENERATION/POLYGENERATION)

When generating electrical power from fossil fuels, disposing of the arising heat by cooling towers has been common for a long time. In the 70ies the first power companies started to make use of the waste heat by feeding it into district heating networks. This use of both power and heat from a combustion process is called cogeneration or combined heat and power (CHP). The overall efficiency factor can be as high as 90 percent, whereas a typical standalone power generator has an efficiency of about 30 percent.
In recent years small CHP-units have become available for non-residential as well as residential buildings. Cost effectiveness depends on the annual operating hours and those often depend on sufficient demand for heating energy.
Polygeneration is defined as a process providing at least three outputs. In the building sector often the combined generation of power, heat and cooling (tri-generation) is called polygeneration, but an output can also be a compound instead of energy.
CHP based on fossil fuel or biomass is implemented at a large number of CONCERTO sites.

DISTRICT HEATING OR COOLING

The first use of a district heating system dates back as far as the 14th century and was found in a French village, where the heat from a warm spring was distributed. The first commercial heating network dates back to 1880. People realized that replacing a lot of boilers by just one central boiler would reduce the danger of fire and the emission of exhaust fumes.
In the 20th century power companies realized that they could make use of the waste heat from power-generation and sell it to the inhabitants of a district area. Since reducing greenhouse gas emissions and improving energy efficiency to stop climate change became an issue, district networks have achieved a new dimension of importance. A large power generator is more efficient than numerous small ones and fluctuations can be compensated for much better, because consumption is distributed to a much larger number of users.
The same principle can be applied to providing cooling energy for a district. As in many regions of Europe active cooling of residential buildings is not necessary or common, district cooling networks are rather rare.

GEOTHERMAL PLANT

Geothermal plants utilize the deep geothermal energy, which provides temperatures being able to be used directly without employing a heat pump.
Electrical power plants use temperatures larger than 100 degrees Celsius to generate steam directly and drive a turbine to produce electricity. Boreholes have to be at least 2000 m deep, therefore investment costs are high and there still remains an uncertainty of drilling to the right spot. But when a favourable location has been found, geothermal plants can be profitable.
Recently some projects led to a negative image because drilling was suspected to be the reason for earthquakes and for ground movements.
For using geothermal energy for direct heating the temperatures have to be between 35 and 100 degrees Celsius. The heat is fed into a district-heating network by a heat exchanger. Boreholes usually are between 1000 and 2000 m of depth.

HEAT PUMP

Heat pumps extract energy from a heat carrier (air, ground or water for example) and raise the temperature to a level on that buildings can be heated. For this purpose, a compressor is required, which is often driven by an electric motor, sometimes by a gas motor.
It is also possible to reverse the heat pump scheme for cooling buildings.
The so-called coefficient of performance (COP) indicates the efficiency of a heat pump. It indicates how many

kWh of heat can be harvested from one kWh of electricity (or gas). The COP should be at least 3, good values are above 4.
The higher the input temperature is and the lower the output temperature has to be, the more efficiently a heat pump will work. Therefore a heating system with low supply temperatures of 30 to 50 degrees Celsius suit the use of a heat pump well.
The heat pump is a central measure in the CONCERTO projects, the list shows all projects using heat pumps of different kinds.

HYDRO POWER STATION

Making use of hydropower is one of the oldest technologies that mankind invented. In earlier times the movement of the water was transferred to mechanical energy by millwheels, nowadays it is converted to electrical energy. The principle stayed the same, the material has changed and the form of the wheels has become a lot more efficient due to research and simulation capabilities.
A special form of hydropower is used in pump storage power stations or tidal power stations.
In many European countries the sites of high potential have already been developed. Here old power stations can be replaced by modern efficient ones to generate a larger amount of electricity than before. Additionally by use of modern, small and efficient power stations smaller potentials at new locations can be utilized.
Predestinated are mountainous regions like Austria and Switzerland, the typical hydropower countries. However, within CONCERTO there are also projects in the Netherlands, Germany or Italy for example.

INFORMATION TECHNOLOGIES (IT)

This term refers to different IT applications that concern buildings, districts or distribution grids. In some CONCERTO sites there will be special user information systems, that make energy consumption or comfort parameters visible by separate screens or by the stationary computers the people are working at.
In other projects a special energy management software is installed to monitor and reduce energy consumption and to optimize the operation of facilities. The CONCERTO site Helsingor/Helsingborg makes use of a special comfort metering system to assure the user's comfort in selected buildings.
In Delft for example a tenant information system is installed.

LARGE SCALE STORAGE

The problem with solar energy is that at times of ample supply (summer, day) not much energy for heating is required resulting in surplus supply. On the other hand, at times of high demand (winter, night) a smaller amount of solar energy is available. Small storage systems used in houses with solar collector units can store energy for about two or three days, but when wanting to bridge longer periods between supply and demand, the storage system has to become larger.
Therefore larger storage tanks are either integrated into single buildings or - if used for several buildings together - they are put outside, often underground in order to reduce heat losses through the tank's surface. These large storages can be connected to a district heating grid, receiving energy from several collectors in the area and delivering energy to all connected buildings.
Large heat storages can be found in various systems already, storages for cooling are still rather rare.
For example, at the CONCERTO site Neckarsulm (Germany) a large-scale thermal storage has been implemented.

MECHANICAL VENTILATION AND HEAT RECOVERY

Heat losses in buildings mainly consists of transmission heat losses through the envelop of the building and ventilation heat loss, where warm air leaves the building through open windows, ventilation systems or unintended leaks in the building envelope. With well-insulated buildings the proportion of the ventilation

heat loss increases significantly.
Mechanical ventilation is able to regulate the airflow, and by use of a heat recovering unit can extract heat from the exhaust air and provide it to the supply air. Current products reach a recovering factor of up to 90 percent. Experiences from different research projects have shown, that air tightness of the ducts and the ventilation unit itself has to be considered to ensure efficient use and to achieve high recovery rates.
In CONCERTO mechanical ventilation and heat recovery is used in both, residential and commercial buildings.

NATURAL VENTILATION OR PASSIVE COOLING

In air-conditioned buildings a large part of the total primary energy rated demand results from ventilation and cooling. When aiming for a minimized energy balance of a building, alternatives to conventional HVAC-systems have to be considered.
However, there are certain minimum air change rates in buildings that have to be adhered to to ensure minimum levels of hygiene as well as user's comfort and health. Integrated concepts using the wind force for natural cross-ventilation or invoking airflows by thermal buoyancy do grant the minimum air-change rate without (or with low) consumption of electric power.
Additionally the nocturnal outside air temperatures during the warm or hot months in most European climatic zones offer the potential to cool down a building during the nighttime. In order to utilize this potential efficiently the thermal mass of the building has to be activated for storing the cooling energy until the next hot day. This can be achieved by exposed concrete ceilings, walls or floors. In light weight buildings PCM (phase change materials) are used to increase their thermal capacity.

NEW MOBILITY

Apart from the building sector it is the transport sector that contributes a large amount to the overall energy consumption and pollution in a district or a region.
On the one hand the efficiency of vehicles has to be increased. E-Mobility can play an important role as efficiency of the electric motor is much higher than of the conventional engine and onsite there is no pollution by exhausts. But the balance of greenhouse gas emission only turns out positively if the electricity itself is produced from renewable energy or with high efficiency at least. Conventional cars with less weight and more efficient engines and hybrid cars will also help to reduce green house gas emissions.
It is not only the efficiency of the vehicle itself, but urban planning can strongly influence the way that people use individual and public transport systems. Furthermore, with the help of information technology the existing traffic can be made more efficient e.g. by intelligent car-park routing systems or automatic speed limits.

OPTIMIZED LIGHTING

Besides heating, cooling and ventilation it is the artificial lighting that contributes to the energy consumption in buildings. When assuming the common European power mix, electric power has the highest primary energy factor. Therefore it is mandatory to consider lighting as well, when aiming for more efficient buildings.
A prerequisite for reduced energy consumption by artificial lighting is an architectural concept that facilitates an optimal use of daylight. Therefore orientation of the building, position and size of the windows and position of the work stations and other activity zones are to be taken into account. Innovative façade systems can help to drive more daylight into the room.
Concerning the light bulbs themselves, huge improvements have been made in the past years.
Soon the standard light bulbs will be banned from the European market, the state-of-the-art fluorescent lamps will be followed by LED-lamps, which reduce the energy consumption of the illuminant once again.
Smart solutions in office workplaces help to reduce electricity consumption further. They measure the

available daylight and the presence of the user and accordingly dim the artificial lighting down or shut it off. However, LEDs are not only used within the buildings. Many communities replace their conventional street lighting systems with new efficient LED lamps.

PHOTOVOLTAICS

Converting sunlight into electrical power by solar cells was first used in 1958 for powering satellites. Meanwhile solar cells have become available for many everyday applications from charging cell phones, powering calculators or parking meters, to generating electricity on roofs of buildings or at large ground-attached facilities for producing power at a larger scale.
Unfortunately, the efficiency factor of solar cells is quite low, so that only a small amount of the offered solar energy can be converted. Amorphous cells reach 5 to 13 percent, polycrystalline cells 13 to 18 percent and monocrystalline cells 14 to 24 percent.
Furthermore photovoltaics produce direct current whereas the grid works with alternating current, so that when feeding power to the grid an inverter is needed. Usually a connection to the grid is obligatory, as storing electricity is still expensive and quite inefficient. Most European countries grant a gratification for feeding power to the grid.
In CONCERTO projects you will find building mounted photovoltaics (on the roof of or integrated into the building's walls) as well as large-scale plants on the ground.

SORPTION COOLING

Conventional chillers are run by compressors and thus by electrical power. The term sorption cooling refers to two methods of generating cooling energy from heat. These methods offer the possibility to provide cooling by renewable energies, at the time when cooling is needed the most - during hot, sunny days.
The first principle is an absorption, where the cold medium is absorbed by another fluid and desorbed at higher temperatures.
The second principle is called adsorption. Here a fluid is adsorbed by a solid material and this process provides heat. Desorbing the solid material (active coal, zeolite or silica) will use up heat and so cooling is possible.

THERMAL COLLECTORS

Thermal collectors utilize a simple method: a black surface absorbs solar radiation and becomes warm. The simplest collectors are so-called swimming-pool collectors, which only consist of black flexible tubes. Water of a pool is circulating through those tubes for heating up: no heat exchanger is needed.
Systems for domestic hot water preparation are more complex and due to reasons of hygiene need a heat exchanger. Two types of collectors are applied for the field of domestic hot water and heating: flat bed collectors and evacuated tube collectors, with the evacuated tube collectors being more complex in construction, but also more efficient. Special coverings of the tubes (made from nano materials) help to absorb a larger part of solar radiation and increase efficiency of collectors.
Not all thermal collectors use a fluid as energy carrier. Thermal air collectors can be integrated into ventilation concepts to save energy.
Thermal collectors are also used in large-scale power plants. Here they consist of large concentrating systems for turning a fluid in a tube into steam and thereby driving a turbine to produce electricity.

WIND TURBINES

Similar to hydropower, using the power of wind has an old tradition in human history. Sailing boats and windmills made use of the wind's force in early times, transforming it to mechanical power.
Nowadays wind power receives a lot of interest because wind turbines transform wind directly into valuable

electric power. Around the year 2000 there has been a big boom in installing wind turbines all over Europe, but economically exploitable locations are now becoming rare. Additionally, in some countries policy makes the process of obtaining planning permission very complicated.
Right now a lot of construction is being done offshore. Problems of construction in the sea seem to have been overcome, but economic performance still is to be proven in the upcoming years. Building-related or integrated solutions exist, but are still rare. Vertical axis wind turbines (VAWT) are easier to construct and don't require tracking of the wind direction which makes them interesting for small-scale applications

OTHER INNOVATIVE TECHNOLOGIES

CONCERTO projects stand out due to the innovative approach they are taking towards sustainability, using a mix of renewable energy sources and low carbon technologies on an integrated community level. The measures are various and not all of them can be attributed to a specific category. Here you will find technologies that don't belong to any of the other categories mentioned.

Source: concerto.eu

5.2 Prospective

The document *ENERGY FUTURES The role of research and technological deveopment* (European Communities, 2006) explores by several technics and resources the future of European research in the field of energy Efficiency. Main sources used are SAPIENTIA, WETO-H2, EURENDEL´s Delphy survey and VLEEM. Additional projects supported by the European Union also explore the future of Energy Efficiency research and are included in this report: CASCADE-MINTS, HYWAYS, EUSUSTEL, ENCOURAGED, RELIANCE, SOLID-DER or ERMINE. The conclusions of this work could be summarize in three:

- Energy system change slowly: building sector, power generation and energy intensive manufacturing require innovations that will need many years to be implemented
- There is a high cost of not doing research in the field of enery in terms of innovation and CO2 emissions
- Real paradigm shift is needed

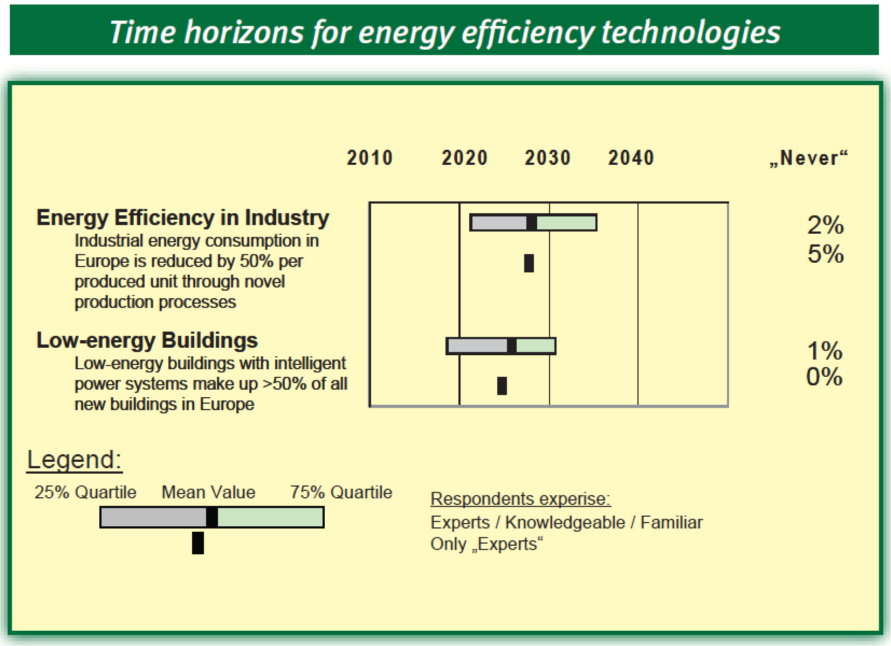
Next table stablish a learning velocity and characteristics for main energy efficiency technologies.

Technology learning characteristics

Capital Costs			
	Mostly Learning by doing	**Balanced Learning**	**Mostly Learning by research**
Fast Learning	Hydrogen internal combustion engine passenger car	New Nuclear (4th gen.)/ Building integrated PV	Fuel Cell/Wind turbines offshore/Post-combustion CO_2 capture (Supercritical pulverised coal)/Pre-combustion CO_2 capture (Integrated gasification combined cycle)
Medium Learning	Nuclear (2nd and 3rd gen.)/ Cogeneration from gas/ Post-combustion CO_2 capture (Gas turbine combined cycle)	Hydrogen from Biomass Pyrolysis/Hydrogen from Nuclear High-temperature Thermochemical Cycles/ Hydrogen from Water Electrolysis and dedicated Nuclear power plant/Pre-Combustion CO_2 capture(Coal Partial Oxidation)/Large Hydro/ Supercritical pulverised coal/Electric passenger car/	Hydrogen from Coal Partial Oxidation/Hydrogen from Solar High-temperature Thermochemical cycles/ Oil fired Open cycle gas turbine/Wind turbines Onshore/Solar Thermal power plant cylindro-parabolic/Biomass thermal/ Biomass gasification plus combined cycle/Hybrid passenger car
Slow Learning	Hydrogen from Gas Steam Reforming (large scale)/ Lignite conventional thermal/Coal conventional thermal/On board reformer cost (Natural gas fuel cells passenger cars)/Hydrogen storage cost (hydrogen fuel cell passenger cars)	Gas turbine open cycle	Hydrogen from Water Electrolysis (baseload electricity from Grid)/Pre-Combustion CO_2 capture (Gas Steam Reforming)/ Integrated coal gasification/ Oil conventional thermal/ Gas conventional thermal/ Gas turbine combined cycle/Small hydro (<25MW)/ CO_2 sequestration

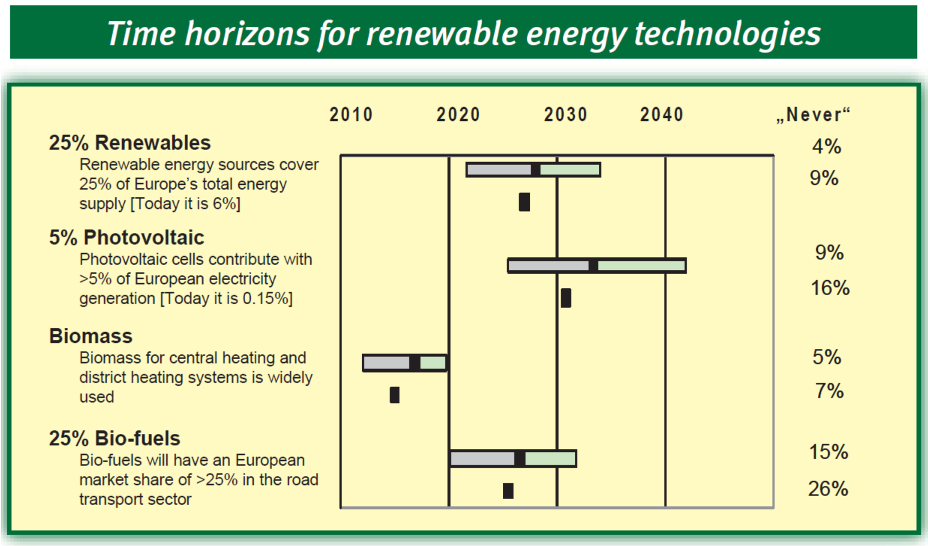
Table 1 Technology learning velocity & characteristics (Source: EURENDEL. From *ENERGY FUTURES The role of research and technological deveopment* (European Communities, 2006)

The Delphy survey of EURENDEL find a great consensus about that doubling the energy efficiency in industrial production is considered to be likely before 2030 (65% of the responses). Also is a big consensus on the prediction that the 50% of all new buildings in Europe will be low energy buildings before that date (75% of the responses).



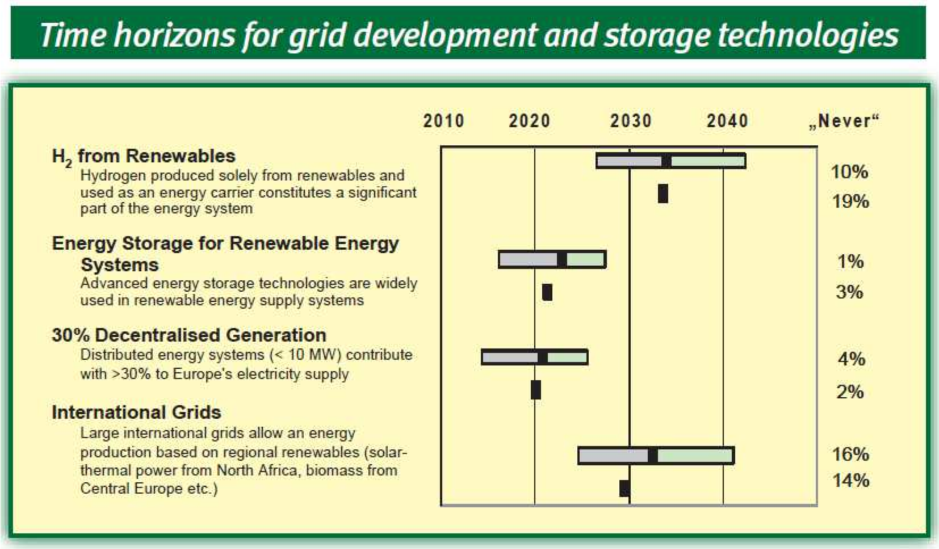
Time horizons for energy efficiency technologies (Source: EURENDEL. From *ENERGY FUTURES The role of research and technological deveopment* (European Communities, 2006).

On other hand, the analysis of the time horizon for renewable energy technologies shows that the majority of experts believe that 25% of Europe´s total energy demand can be met by renewable energy sources before 2030. But that expectation is considered dependent on the existence of appropiate support to the new technologies. Photovoltaic technology can play a significant role in Europe´s energy future. A 5% contribution to energy mix is considered possible between 2030 and 2040.



Time horizons for renewable energy technologies (Source: EURENDEL. From *ENERGY FUTURES The role of research and technological deveopment* (European Communities, 2006).

Energy storage technologies are consiered an important gap on energy market and a key component on renewable energy implementation. The Delphy EURENDEL´s survey shows the risk of the under-investment in energy storage percibed in the current support schemes. The hydrogen system is considered a major storage option. But other storage alternatives such as batteries, flywheels or super-capacitators are also considered highly relevant. Is still needed to identify a suitable long term growth path for the large new infraestructure need required in the expansion of the hydrogen economy.



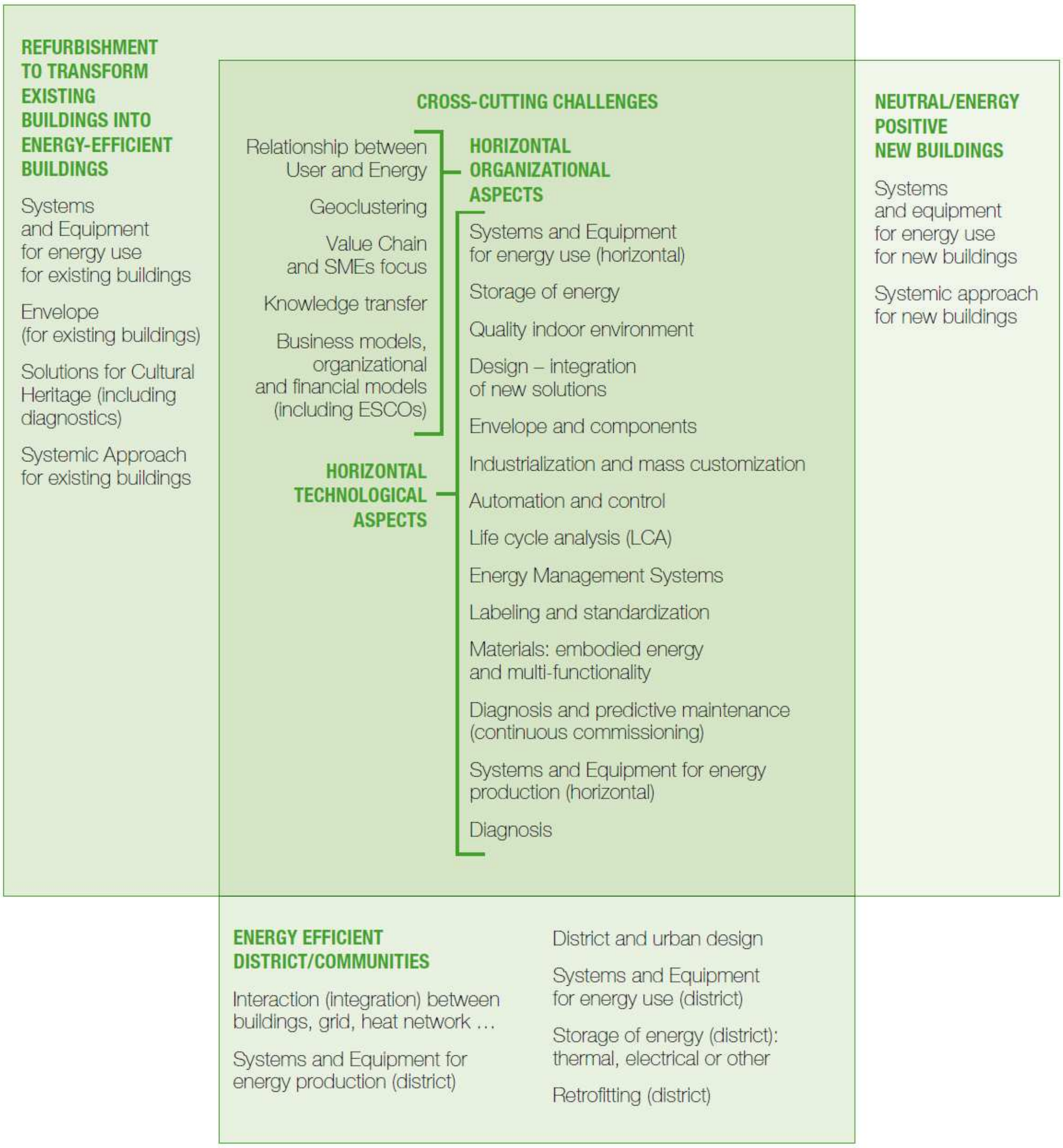
Time horizons for grid development and storage technologies (Source: EURENDEL. From *ENERGY FUTURES The role of research and technological deveopment* (European Communities, 2006).

The ENERGY-EFFICIENT BUILDINGS PPP. MULTI-ANNUAL ROADMAP AND LONGER TERM STRATEGY (2010) prepared by the Ad-hoc Industrial Advisory Group of the E2B Platform sets key challenges for a long term energy efficiency strategy in the construction sector, establishing the requirement of new knowledge and technologies to overcome current limitations to look forward energy independence and against climate change risks. Is considered that building industry´s transformation has to be achieved. The gaps are on systemic approaches for refurbishment, building design and quality of installations:

- Definition of energy-efficient solutions for renovation. Necessity of holistic approach for the integration of building components.
  (PROPOSAL: systems composed of insulation and thermal storage materials, and renewable energy harvesting)
- The outcome of research into understanding barriers and drivers for non-technical (e.g. behaviour) and technical aspects, such as the development of

multifunctional solutions (e.g. eco-efficiency, comfort, aesthetic value...), would speed up the transformation of the market.

- Cost savings can also help greatly in supporting the development of the energy efficiency market. R&D together with deployment has to reduce drastically the cost of certain technologies (market of hundreds of thousands of units), such as heat pumps, photovoltaics or emerging lighting solutions... There is also a large potential for an increase of performance from the economic and CO2 point of view.
- Low carbon technologies have to move from a several-hundred-thousand to a multi-million-unit-per-year market.
- Financing issues also need to be tackled, jointly implementing new business models and services with a life cycle perspective.



R&D Challenges (Source: E2B Multi-Annual Roadmap 2010)

In the **EUROPEAN COMMISION: REARCH & INNOVATION** web page, in the section of Energy, there is a compilation of the principal reasearch fields and technological developments, including the list of funded projects.

The following tables present a brief summary of the fields or technology that can be applicable to STEEP project cities. (Source: http://ec.europa.eu/research/energy/eu/index_en.cfm?pg=research)

Area	Technology	Applications (buildings-cities)	Status	EU Support	Research Project Examples
SOLAR ENERGY	PHOTOVOLTAIC	- grid-connected power generation - off-grid power is growing for remote areas and developing countries.	The key technology developments needed for PV over the coming years are: - To increase the efficiency and reduce the material intensity and costs of crystalline-SI modules; - To increase the efficiency and lifespan of thin film modules; and - To guarantee sufficient public and private R&D funding for the development of third-generation novel devices (ultra-high efficiency and ultra-low cost cells).	The Commission supports photovoltaics development since many years by funding research projects and facilitating cooperation between stakeholders. Since 2002 (start of FP6) more than EUR 110 million of funding has been provided to more than 30 R&D and demonstration activities, covering a diverse range of technologies including: Crystalline silicon cells; Thin-film cells and modules; Organic and Dye-sensitised solar cells; Concentration photovoltaics; Novel concepts for photovoltaics; Advanced system technologies; Socio-economic aspects and enabling research. European Photovoltaic Technology Platform: http://www.eupvplatform.org/	**APOLLON** - Multi ApprOach for high efficiency and inteLLigent cONcentrating PV modules (Systems) http://www.apollon-eu.org/ **UPP-SOL** - Urban Photovoltaics: Polygeneration with Solar Energy http://www.uppsol.eu/ **BIPV-CIS** - Improved Building Integration of PV by using Thin Film Modules in CIS Technology (BIPV-CIS) http://cordis.europa.eu/projects/rcn/73972_en.html More info: http://ec.europa.eu/research/energy/eu/index_en.cfm?pg=projects

Area	Technology	Applications (buildings-cities)	Status	EU Support	Research Project Examples
SOLAR ENERGY	CONCENTRATED SOLAR POWER	Solar power can be achieved through different techniques such as parabolic trough, parabolic dish or power tower systems. CSP can also provide combined heat and power, particularly in desalinisation plants. Mediterranean regions, with frequent sunshine, are ideal places for the deployment of CSP technologies.	CSP power plants have already been built in Spain with the financial support of the European Commission. They are proving to be efficient and cost-effective. The costs of these technologies still needs to decrease to further facilitate their entry into the market. Therefore, additional large-scale coordinated research efforts are still necessary.	The research projects that benefited from EU funding focused on: validating the full-scale applications of different technological approaches and their economic viability (i.e. solar towers, parabolic troughs, dish/engine systems); raising operability and reducing costs of CSP, through designing and testing new components for solar dishes and developing innovative storage media (i.e. large insulated tanks filled with molten salt); researching hybrid solar technologies; production of hydrogen using CSP; supporting horizontal activities for strengthening the European infrastructure for solar science.	**DIGESPO** – Distributed CHP generation from Small Size Concentrated Solar Power http://www.digespo.eu **MED-CSD** – Combined solar power and desalination plants: techno-economic potential in Mediterranean Partner countries http://www.apollon-eu.org More info: http://ec.europa.eu/research/energy/eu/index_en.cfm?pg=projects

Area	Technology	Applications (buildings-cities)	Status	EU Support	Research Project Examples
WIND ENERGY	No research objectives for Buildings or District applications				

Area	Technology	Applications (buildings-cities)	Status	EU Support	Research Project Examples
BIO ENERGY		- Electricity generation - Transport fuels - Biomaterials and biochemical	In the EU, according to the EurObserv'ER Biofuels Barometer 2008, biofuels represented 7.7 Mtoe in Europe in 2007. After four years of implementation, the European biofuels directive has made it possible to reach biofuel consumption of approximately 2.6% of the energy content of all the fuels used in road transport. The Industrial Initiative on Bioenergy in the context of the SET-Plan aims to ensure at least 14% bioenergy in the EU energy mix by 2020. At the same time it wants to guarantee GHG emission savings of 60% for bio-fuels and bio-liquids under the sustainability criteria of the new RES directive. Hurdles to be overcome by research: - Resources - Low energy content - Conversion technologies - Need for extensive research and technological development	Research and Technology Development (RTD) plays a key role in bioenergy and the EU has supported bioenergy-related RTD under several successive Framework Programmes, covering the whole chain from feedstock production to end-use. Since starting in 2007, the current Framework Programme (FP7) has been focussing on biofuels and renewable electricity production from biomass. Between 1998 and 2002 the priority was given to research into thermal processes. In the framework of the Intelligent Energy Europe Programme the EC is financing research aimed at overcoming non-technical barriers, which are impeding the market penetration of this type of renewable energy.	**BIOLIQUIDS-CHP** – Engine and turbine combustion of bioliquids for combined heat and power production. http://cordis.europa.eu/projects/rcn/90302_en.html **BEE** – Biomass Energy Europe http://cordis.europa.eu/projects/rcn/86785_en.html **BIOMASS USE IN BRIAN** – Thermal utilization of virgin and residual biomass in Brianza (Italy) for district heating and electric co-generation http://www.uclouvain.be/ecav More info: http://ec.europa.eu/research/energy/eu/index_en.cfm?pg=projects

Area	Technology	Applications (buildings-cities)	Status	EU Support	Research Project Examples
OTHER RES	GEOTHERMAL ENERGY	- Electricity generation - District heating - heating and cooling of individual buildings	According to the Commission's forecast, the capacity of the geothermal power sector is expected to reach 1 GW in 2020 and 1.3 GW in 2030. The estimated maximum potential for geothermal power in the EU-27 is up to 6 GW by 2020 and 8 GW by 2030. This represents about 1% and 1.3% of projected EU gross electricity consumption by 2020 and 2030 respectively. In the heating sector, the estimated maximum potential for geothermal is up to 40 GW by 2020 and 70 GW by 2030 (direct and indirect use combined). Successful development of EGS is currently one of the major challenges facing the geothermal community. Exploration, well-drilling and plant construction make up a large share of the overall costs of geothermal electricity.	Since 2002 (FP6), the EU funded around 10 projects with a total budget of more than EUR 20 million. In particular, the flagship project EGS Pilot Plant, which culminated in the construction of a scientific pilot plant based on an Enhanced Geothermal System, was awarded EUR 5 million. Under the current 7th Framework Programme (2007-2013) research is funded for advancing knowledge in understanding and mitigating of induced seismicity associated with geothermal field development.	**GROUND-MED** – Advanced ground source heat pump systems for heating and cooling in Mediterranean climate. http://cordis.europa.eu/projects/rcn/90316_en.html **TERRA THERMA** - Terrestrial EneRgy Recovery using Advanced sTirling Heat-pumps for Residential temperature Management http://cordis.europa.eu/projects/rcn/86575_en.html More info: http://ec.europa.eu/research/energy/eu/index_en.cfm?pg=projects

Area	Technology	Applications (buildings-cities)	Status	EU Support	Research Project Examples
FUEL CELLS AND HYDROGEN		- End-use sectors: from electric vehicles, to power plants.	The use of hydrogen as an energy carrier requires **developing the entire supply chain**, from carbon-lean hydrogen production to efficient conversion of the hydrogen with fuel cells to power end-use applications. However, its use in energy applications is still at its early stages. The hydrogen economy is not yet developed. A number of technological and non-technical barriers need to be addressed. Solving the technological challenges of hydrogen production, distribution, storage and provision of the necessary infrastructure, at a competitive cost, requires a major concerted European and even global effort.	Since 1986 the EU has funded some 200 projects on hydrogen and fuel cell energy technologies with a total contribution of over EUR 550 Mio. These projects advanced knowledge in: - Hydrogen production, including from renewable sources; - Hydrogen distribution; - Hydrogen storage; - More durable and cost-effective fuel cells; - Integration of fuel cell technology in stationary power applications; - Hydrogen-fuelled vehicles; - Best policies to promote a transition to a cleaner energy system benefiting from hydrogen technologies. Fuel Cells and Hydrogen Joint Technology Initiative: http://ec.europa.eu/research/fch/index_en.cfm?pg=redirect	**HyFLEET: CUTE** -Hydrogen for Clean Urban Transport in Europe http://www.global-hydrogen-bus-platform.com/ **HYCHAIN MINI-TRANS** - Deployment of innovative low power fuel cell vehicle fleets to initiate an early market for hydrogen as an alternative fuel in Europe http://www.hychain.org **FlameSOFC** - Fuel Flexible, Air-regulated, Modular, Electrically Integrated SOFC System http://www.flamesofc.org More info: http://ec.europa.eu/research/energy/eu/index_en.cfm?pg=projects

Area	Technology	Applications (buildings-cities)	Status	EU Support	Research Project Examples
ENERGY NETWORKS	SMART GRIDS	- Energy distribution, metering and security improvement - RES integration	The upgrade and development of energy networks across the European Union is one of the key challenges to securing a sustainable and competitive energy future in the EU. An in depth re-engineering of transmission and distribution networks is required to tackle environmental challenges, European internal market developments, competitiveness and security considerations. The networks need to become "smarter". Electricity grids of the future will be smart in several ways: - Demand management - Efficiency and efficient exchange of energy. - better integration of renewable energy sources Two key concepts underpin future electricity grids: - Better interconnection of existing networks to create a truly pan-European grid. - A two-way flow of electricity	To facilitate the transition to more sustainable energy systems, "Smart Energy Networks" are one of the priority topics in the current EU Framework Programme (FP7, 2007-2013). The focus is on the efficiency, safety, reliability and quality of the European electricity and gas networks, notably within the context of a European energy market. The activity is structured along the following research areas: - Development of inter-active distribution energy networks - Pan-European energy networks - Cross cutting issues and new emerging technologies of a technical and non-technical nature	**ADDRESS** – Active distribution networks with full integration of demand and distributed energy resources http://www.addressfp7.org/ **PEGASE** – Pan European grid advanced simulation and state estimation http://fp7-pegase.com/ **OPEN METER** – Open public extended network metering http://www.openmeter.com/ More info: http://ec.europa.eu/research/energy/eu/index_en.cfm?pg=projects

Area	RESEARCH PROJECT EXAMPLES APPLYING FOR HEATING AND COOLING AT BUILDINGS OR DISTRICT SCALE
ENERGY EFFICIENCY AND ENERGY SAVINGS	**SOLERA** – Integrated Small Scale Solar Heating and Cooling Systems for a Sustainable Air-conditioning of Buildings http://cordis.europa.eu/projects/rcn/85693_en.html **DOMOHEAT** – Tertiary heating systems using agro, forest and wood residues http://cordis.europa.eu/projects/rcn/85668_en.html **PROECOPOLYNET** – Network for promotion of RT results in the field of Eco-building technologies, small Polygeneration and renewable heating and cooling technologies for buildings http://cordis.europa.eu/projects/rcn/85645_en.html **REHES** – Renewable Energy for Heat Supply in Dwellings with Individual and Local Heating Systems http://cordis.europa.eu/projects/rcn/85638_en.html **NEGST** – New generation of solar thermal systems http://www.swt-technologie.de/html/negst.html

6. Innovative technologies in NMP, EEBPP, ENERGY and ICT Projects

This section present the main projects participated by ACCIONA in the last years in the field of energy efficiency for buildings and district, which can be useful if more detail on innovative technologies is demanded by city stakeholders. In ACCIONA projects, originally the buildings scale was the principal objective and a great effort was done in the study of new technologies, materials and components and its integration in buildings with the objective of reducing energy loses, costs and increase the quality indoor living conditions. Control systems for building were also important.

After that phase, big demonstration projects have come into the agenda. And progressively the district scale has been acquiring a big interest for the European Community. That scale has brought new challenges of managing, integration and control and also the need of new business models.

The future of the zero energy buildings/district and smart cities approach is applying in those innovative research proposals for intelligent energy systems, combined by multiple devices and controls and the combination of different energy sources with the renewable energy sources leading the achievement of ambitious energy and contaminant emissions reduction.

The following table organize ACCIONA project by type (technology, method/tool, integration, business model/management, policy) and each project is later described in detail.

ACRONYM- Name	TYPE (main objectives)	INFO
MESSIB- Multisource Energy Storage System Integrated In Buildings	TECHNOLOGIES	http://www.messib.eu/
CLEAR-UP – Clean buildings along with resource efficiency enhancement	TECHNOLOGIES METHOD-TOOL	http://www.clear-up.eu
H2 SUBUILD.- Hydrogen and sustainable buildings	TECHNOLOGIES INTEGRATION	http://www.h2susbuild.ntua.gr
COST EFFECTIVE - Resource and cost effective integration of renewables in existing high-rise buildings	TECHNOLOGIES TOOL INTEGRATION BUSINESS MODEL	http://www.cost-effective-renewables.eu/
CILECCTA – Construction	TOOL	https://www.cileccta.eu/

Industry Life Cycle Cost Analysis software		
NanoPcm – New Advanced Insulation Phase Change Materials	TECHNOLOGIES	http://www.nanopcm-eu.net
Nano Insulate – Development of nanotechnology-based high performance opaque&transparent insulation systems and biocide formulations for Energy Efficient buildings	TECHNOLOGIES	http://www.nanoinsulate.eu/
FC-Districts – New m-CHP network technologies for energy efficient and sustainable districts	TECHNOLOGIES INTEGRATION	http://fc-district.eu/
E-HUB – Energy-hub for residential and commercial districts and transport	INTEGRATION BUSINESS MODEL MANAGEMENT	http://www.e-hub.org/
Aerocoins – AEROgel-based Composite/hybrid nanomaterials for cost-effective building super-INSulation systems.	TECHNOLOGIES	http://aerocoins.eu/
Biobuilt – High Performance Economical and Sustainable Biocomposite Building Materials	TECHNOLOGIES INTEGRATION	http://www.biobuildproject.eu/
SUS-CON – Sustainable Innovative and Energy-Efficient Concrete based on the integration of All-Waste materials	TECHNOLOGIES	http://www.sus-con.eu/
EINSTEIN – Effective integration of seasonal thermal energy storage systems in existing buildings	TECHNOLOGIES INTEGRATION	https://www.einstein-project.eu/
MEEFS – Multifunctional Energy Efficient Facade system for building retrofitting	TECHNOLOGIES	http://www.meefs-retrofitting.eu/
GE2O- Geoclustering to deploy the potential of Energy Efficient	TOOL POLICY-CONCEPT	http://www.geoclusters.eu/ http://www.geoclusters.eu/ge

Buildings across Europe.		20/
RESILIENT- Renewable, Storage and ICT, for Low carbon Intelligent Energy management at district level	TECHNOLOGIES INTEGRATION MANAGMENT	http://www.resilient-project.eu/
iNSPiRE – Development of Systemic Packages for Deep Energy Renovation of Residential and Tertiary Buildings including Envelope and Systems	INTEGRATION BUSINESS MODELS – MANAGEMENT	http://inspirefp7.eu/
NEW-BEE- Novel Business model generator for Energy Efficiency in construction and retrofitting	BUSINESS MODELS	http://www.newbee.eu/
NANO-HVAC – Novel Nano-enabled Energy Efficient and Safe HVAC ducts and systems contributing to a healthier indoor environment	TECHNOLOGIES	http://www.nanohvac.eu/
BRICKER- Integration in public building renovation.	INTEGRATION	
SESBE -Smart elements for sustainable building envelopes	TECHNOLOGIES INTEGRATION	http://www.sesbe.eu
ADAPTIWALL – Multifunctional light-weight WALL panel based on ADAPTive Insulation and nanomaterials for energy efficient buildings.	TECHNOLOGIES	http://www.phoenix-eu-project.eu/detalle_oferta_demanda.php?of_id=16
OSIRYS-FOrest baseD compoSites for facades and interior partitions to improve Indoor aiR qualitY in new buildingS and retrofitting actions	TECHNOLOGIES	http://www.osirysproject.eu/
ECO-SEE - Eco- innovative, Safe and Energy Efficient wall panels and materials for a healthier indoor environment	TECHNOLOGIES	http://www.eco-see.eu/

AP2BEER – Affordable and Adaptable Public Buildings through Energy Efficient Retrofitting Holistic and Optimized Life-cycle Integrated SupporT for Energy-Efficient building design and Construction.	INTEGRATION MANGEMENT – BUSINESS MODEL	
HOLISTEEC- Holistic and Optimized Life-cycle Integrated Support for Energy-Efficient building design and Construction	METHOD – TOOL	http://www.holisteecproject.eu/es
COMMON ENERGY – RepliCable and InnovaTive Future Efficient Districts and cities	METHOD-TOOLS INTEGRATION MANAGEMENT	http://www.commonenergyproject.eu/
ECOLABEL – Development of a novel ECO-LABELing EU-harmonized methodology for cost-effective, safer and greener road products and infrastructures	POLICY – STANDARIZATION	http://www.observatorioplastico.com/detalle_oferta_demanda.php?of_id=4221&seccion=automocion&id_categoria=90
OPEN-HOUSE – Benchmarking and mainstreaming building sustainability in the EU. Transparency and openness (open source and availability) from model to implementation	METHOD – TOOL POLICY – STANDARIZATION	http://www.openhouse-fp7.eu/
EFFESUS- Energy eFFiciency for Eu historic districts SUStainability	METHOD – TOOL MANAGEMENT	http://www.effesus.eu/
FASUDIR – Friendly and affordable sustainable urban districts retrofitting	METHOD – TOOL	http://fasudir.eu
PIME's- CONCERTO communities towards optimal thermal and electrical efficiency of buildings	INTEGRATION MANAGEMENT – BUSINESS MODEL	http://www.pimes.eu

and districts based on microgrids		
BFIRST – Building-integrated FIbre-Reinforced Solar Technology	TECHNOLOGIES INTEGRATION	http://www.bfirst-fp7.eu/home/
BEEM-UP – Building Energy Efficiency for massive market uptake	METHOD MANAGEMENT	http://www.beem-up.eu/
Need 4B – New Energy Efficient Demonstration for Buildings	METHOD MANAGEMENT – BUSINESS MODELS	http://www.need4b.eu/
REEB – The European strategic research roadmap to ICT enabled Energy-Efficiency in buildings and construction	POLICY – CONCEPT	http://www.artist-embedded.org/docs/Events/2010/GREEMBED/0_GREEMBED_Papers/REEB_greembed2010_final.pdf
FIEMSER – Friendly Intelligent Management System for Existing Residential Buildings	INTEGRATION MANAGEMENT	www.fiemser.eu
ENERGY WARDEN – Design and Real Time energy sourcing decisions in buildings	TOOL INTEGRATION MANAGEMENT	http://buildingwarden.com/energywrdn
MAKE SENSE – Easy Programming of Integrated Wireless Sensor Networks	INTEGRATION MANAGEMENT	http://www.project-makesense.eu/
IREEN- ICT roadmap for Energy Efficient Neighborhoods	TECHNOLOGIES TOOL MANAGEMENT	http://www.ireenproject.eu/about
E+ – New systems, technologies and operation models based on ICTs for the management of energy positive and proactive neighborhoods	TOOLS MANAGEMENT – BUSINESS MODEL	http://www.eplusproject.eu/index.aspx
EPIC-HUB – Energy Positive Neighborhoods Infrastructure Middleware based on Energy-	METHOD – TOOL INTEGRATION MANAGEMENT –	

Hub Concept	BUSINESS MODEL	
GENIC- Globally optimized ENergy efficient data Centres	METHOD MANAGEMENT	http://projectgenic.eu/
e-DIANA.-Embedded systems for energy efficient buildings	METHOD - TOOLS INTEGRATION MANAGEMENT	http://s15723044.onlinehome-server.info/artemise/
ARROWHEAD- Innovation Pilots	METHOD - TOOLS INTEGRATION MANAGEMENT	http://www.arrowhead.eu/
ACCUS- Adaptive Cooperative Control in Urban (sub) Systems	METHOD - TOOLS INTEGRATION MANAGEMENT	http://projectaccus.eu/
LIVING-LAB-Design study for a living Lab Reseach Infrastructure for Energy Efficiency in buildings	METHOD - TOOLS INTEGRATION MANAGEMENT	http://www.livinglabproject.org
H2HOME - Development of a novel compact multi fuel steam reforming device integrated into a cost effective fuel cell micro combined heat and power generation system for residential building application	TECHNOLOGIES INTEGRATION	http://www.ist-world.org/ProjectDetails.aspx?ProjectId=ceb5d647687d4267b2602f610db1e56b
ICT4SMARTDG - Thematic Network on ICT solutions to enable smart distributed generation	INTEGRATION MANAGEMENT	http://www.ict4smartdg.eutc.org/
HOSPILOT- Intelligent Energy Efficiency in Hospitals	METHOD- TOOL MANAGEMENT	http://www.hospilot.eu/
E3SoHo - ICT services for Energy Efficiency in European Social Housing	TECHNOLOGIES METHOD - TOOL MANAGEMENT	http://www.e3soho.eu/
Showe-It - Real life trial in social housing of water and energy efficient ICT services	TECHNOLOGIES METHOD - TOOL MANAGEMENT	http://showe-it.eu/
EDEA-RENOV - Development of Energy Efficiency in Architecture:	METHOD - TOOLS INTEGRATION	http://www.renov.proyectoedea.com/en/content/edea-

Energy Renovation, Innovation and ICT's	MANAGEMENT	renov-project

TECHNOLOGIES

6.1 MESSIB – Multisource Energy Storage System Integrated In Buildings

Info: http://www.messib.eu/

The overall objective of MESSIB project is the development, evaluation and demonstration of an affordable multi-source energy storage system (MESS) integrated in building, based on new materials, technologies and control systems, for significant reduction of its energy consumption and active management of the building energy demand.

The MESSIB basic principles are based on the combination of:

Rational use of thermal energy for primary energy savings and for increasing the building indoor comfort. Improvement of thermal energy storage developing active building components based on phase change technologies. The isothermal process improves the use of heating and cooling units by decreasing energy requirements. The adequate integration and use of RES decreases further peak loads, thereby reducing grid power needs.

Improvement of electrical energy storage, equally integrated with RES in order to shift the demand with the production and to optimize the use of low cost “off peak” power from the grid. This will lead to a reduction of the overload time increasing the security and efficiency of the network.

Integration of the technologies in the building. Each of the technologies developed in the project and the whole system will be integrated with conventional installations (heating ventilation and air conditioning systems (HVAC) and electrical grid) optimizing their functionality.

An active control/actuation system will smartly manage the profile of use of each storage system and their interactions. This will contribute to the intelligent management of building energy demand and to ensure its security, quality and reliability by selecting how to operate, by cutting in to the conventional network in times of high grid demand or through a parallel supply topped up by low cost power or external sources.

MESS is composed by two thermal and two electrical storage systems, integrated with the building installations and a control system to manage the building energy demand. This new concept will reduce and manage smartly the electrical energy required from the grid favoring the wider use of renewable energy sources (RES) in any type of building and district level. It will reduce raw material use for thermal performance and improve the indoor environment, the quality and security of energy supply at building, including Cultural Heritage (CH), and district level. Furthermore, a significant reduction of the energy unit cost for end-users will be achieved.

To install additional conventional energy generation and distribution network assets with the capacity to accommodate to the maximum (short-term) demand is economically inefficient. Furthermore, productivity decreases when power plants cannot operate at full capacity in periods of reduced demand. The basic idea behind energy storage in buildings is to provide a buffer to balance fluctuations in supply and demand. The demand fluctuates in cycles of 24 hour periods (day and night), intermediate periods (e.g. seven days) and according to seasons (spring, summer, autumn, winter). MESSIB systems for storing energy (thermal/electrical) will cover these cycles, with short-term, medium-term or long-term (seasonal) storage capacity.

TECHNOLOGIES // METHOD- TOOLS

6.2 CLEAR-UP.- Clean buildings along with resource efficiency enhancement

Info: http://www.clear-up.eu

Clear-up aims to reduce energy use in existing buildings using environmentally-sound components, creating sustainable solutions. Clear-up strives to deliver comfortable homes and workplaces to an affordable price.

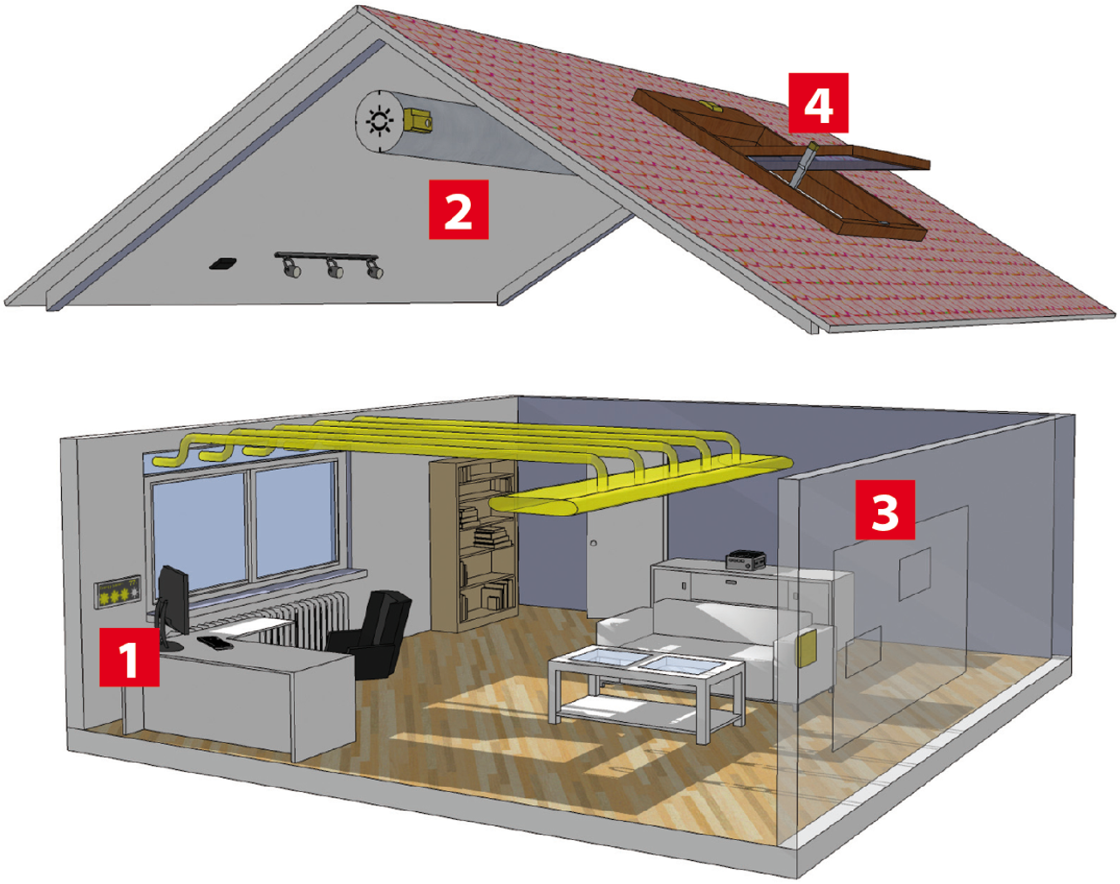
Our primary needs in a building are for daylight, fresh air and the right temperature. Clear-up is responding to these demands using both natural and technological solutions. Clear-up is important because it will work to improve existing buildings as well as new builds. The project will drive change in construction with new tools and methods and will improve buildings for their occupants.

Clear-up develops new technological solutions, integrates new components and building control strategies in a holistic system, uses large scale tests at real buildings, and simulates the energy savings but also the uptake of resources and costs.

Energy optimized and resource efficient solutions will have top priority but their success will also depend on factors such as affordability, user acceptability, and the achieved indoor environment. Clear-up considers such market aspects and puts the

user at the center of the design. It recognizes that the building must work for its occupants; otherwise they will take action to change it.

Clear-up works on four key components of buildings:



[1]Sensors and control provide an underpinning technology for clear-up's approach. New sensors will be developed for smart windows, demand controlled ventilation, and air purification.

[2] Air conditioning. Clear-up will improve demand controlled ventilation and the intelligent combination of natural and artificial ventilation.

[3] Walls. Clear-up uses photocatalytic materials for air purification and nano-porous vacuum insulation combined with phase change materials to passively control temperature.

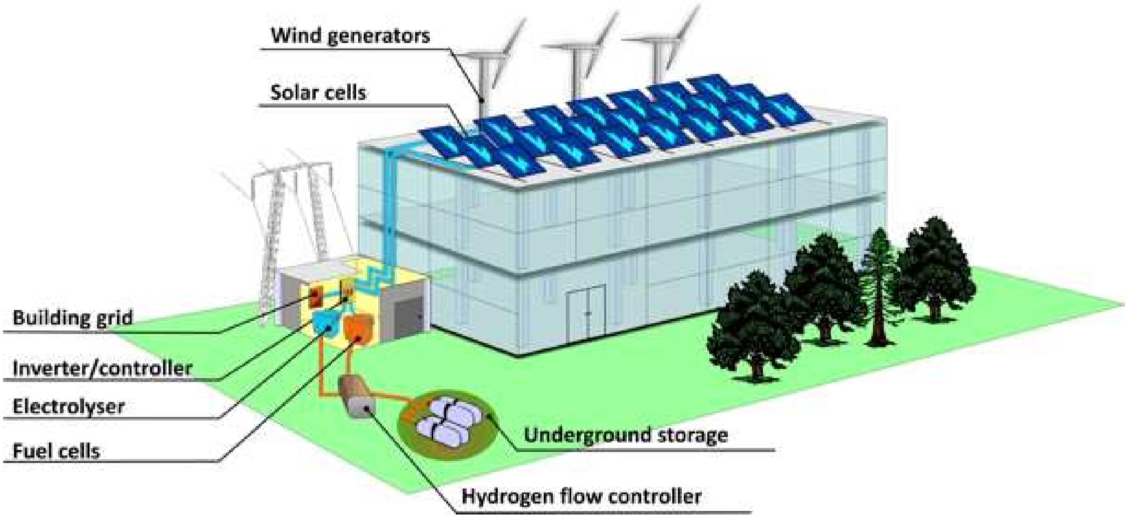
[4] Windows. Clear-up uses shutters and electro-chromic window foils which reduce the building cooling load and along with light-guide technology, reduce the need for artificial lighting. It incorporates controlled natural ventilation with integrated heat recovery potential reducing the need for heating in winter and cooling in summer.

TECHNOLOGIES // INTEGRATION

6.3 H2 SUBUILD – Hydrogen and sustainable buildings

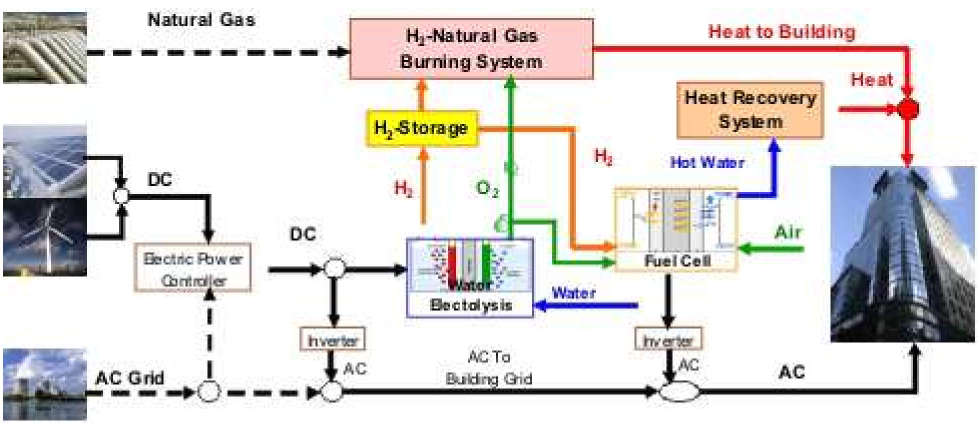
Info: http://www.h2susbuild.ntua.gr

The objective is to develop a clean and energy self-sustained building in the vision of integrating H_2 economy with renewable energy sources-



Our concept is the development of an intelligent, self-sustained and zero CO_2 emission hybrid energy system to cover electric power, heating and cooling loads (tri-generation) of either residential/commercial buildings or districts of buildings. In the proposed system, the primary energy will be harvested from RES and directly used to cover contingent loads, while the excess energy will be converted to hydrogen to be used as energy storage material and to be further applied as a green fuel to cover the building heating needs through direct combustion or to produce combined heating and electricity by means of fuel cells.

CONCEPTUAL DIAGRAM OF A RES – H2 BUILDING ENERGY SYSTEM



The energy needed to cover the building needs originates exclusively from RES (solar, wind and hydro power where available) and is used either directly as electricity to cover the building electrical loads or stored as chemical energy in the form of hydrogen. Hydrogen is produced in the building from water by electrolysis. The stored hydrogen is used as a green fuel to: a) cover the building heating needs through its CO_2-free combustion ($2H_2+O_2=2H_2O$) in suitably designed burners and b) level and balance the intermittent nature of RES, by storing the excess energy produced by the RES (e.g. in commercial buildings during weekends, when energy consumption is minimum) or by providing the electricity needed to cover the building electrical loads in periods (e.g. during night, cloudy or windless days) when either RES are not effective enough to produce it. The latter is achieved with the direct conversion of hydrogen energy into electrical energy in appropriately designed fuel cells (CHP), integrated in the building electrical grid. The heat produced by hydrogen burning in the fuel cells is recovered and used to cover part of the building heating needs.

The energy generation and distribution in the building and the safe operation, control and monitoring of the various system modules is managed by an intelligent energy and device management system developed for the specific application. In order to secure a stable and continuous operation, the proposed system is connected to the main electrical and natural gas utility grid and uses them only in cases of energy shortage (e.g. in-house energy production is not enough, malfunctions, repair or service). The main parts of the proposed system include photovoltaic array(s), wind generator(s), electrolyser, fuel cells, hydrogen storage tanks and intelligent management and control system. The system will be applicable both in residential and commercial buildings.

Successful achievement of this target will significantly contribute to the realization of the targets set by the EC and will address one of the major challenges of the 21st century for the Building Sector.

TECHNOLOGIES // TOOL // INTEGRATION // BUSINESS MODEL

6.4 COST EFFECTIVE – Resource and cost effective integration of renewables in existing high-rise buildings

Info: http://www.cost-effective-renewables.eu/

The project Cost-Effective – Resource and Cost-effective integration of renewables in existing high-rise buildings – has been successfully completed on 30th September 2012.

The project wants to contribute to the development of a competitive industry in the fields of energy efficient construction processes, products and services, with the main purpose of reaching the goals of the EC set forth for 2020 and 2050 to address climate change issues and to contribute to improve EU energy independence.

The use of renewable energy in the building sector is today dominated by the application of solar domestic hot water and PV systems in single-family houses. In order to significantly increase the use of renewable energy in the building sector, concepts have to be developed for large buildings. In these buildings high fractions of the energy demand can only be met with renewable energy sources, when the façade is used for energy conversion in addition to the roof. This is especially true for buildings with a small roof area compared to the floor area ("high-rise buildings") and for existing buildings which generally have a higher energy demand than new buildings. Therefore the main focus of the project is to convert facades of existing "high-rise buildings" into multifunctional, energy gaining components. This goal will be achieved by:

development of integrated building concepts, suitable for a major share of the high-rise building stock, which can be characterized as the most cost-effective combinations of existing and/or newly developed components;

development of new multi-functional façade components which combine standard features and the use of renewable energy resources;

development of new business and cost models which consider the entire life cycle of a building and which incorporate the benefits of reduced operating costs and greenhouse-gas emissions;

a decision support tool will help the planners to find the best integrated building concept.

The new components will in particular profit from the application of nano-structured coatings and films which will enhance their performance and durability due to antireflective, anti-soiling and seasonal shading functionality.

In order to achieve a successful development and implementation of these new technologies and concepts European key actors from construction industry and energy research have agreed to collaborate within this project.

The project results will be an important support for the European technology platforms ECTP, ESTTP and PV-platform in which the project partners have a leading role.

TOOL

6.5 CILECCTA - Construction Industry Life Cycle Cost Analysis software

Info: https://www.cileccta.eu/

CILECCTA has brought top class academical and industrial researchers, associations and enterprises together in a consortium to develop a suite of software that will enable the assessment of sustainable options providing decision support.

The software will be capable of full Life Cycle Cost Analysis (LCCA) and compatible with codified Price Banks (PBs) as well as Life Cycle Inventory Results (LCIRs) across Europe. It will also be customizable/configurable for whole assets and their components.

A user-oriented, knowledge-based suite of Construction Industry LifE Cycle CosT Analysis software for pan-European determination and costing of sustainable project options.

TECHNOLOGIES

6.6 NanoPcm.- New Advanced Insulation Phase Change Materials

Info: http://www.nanopcm-eu.net/

NanoPcm is a FP7 funding project that pursues the development and production of low cost and improved Phase Change Materials (PCM) for new high performance insulation components in existing buildings.

Objetives:

- To design and develop organic form-stable phase change materials (PCM) with improved conductivity incorporating nanoparticles
- To design and develop a nonporous material in which selected organic/inorganic PCMs will be embedded. The using of thermal conductive nanomaterial will improve the thermal transfer behavior of the PCM avoiding super cooling and consequently the efficiency of the final material
- Characterization and simulation performance or the developed materials
- To Validate developed materials tough prototypes constructions by incorporating the NanoPCM materials in a real sale to measure insulation improvements

The main technical innovations in which NanoPCM focuses are:

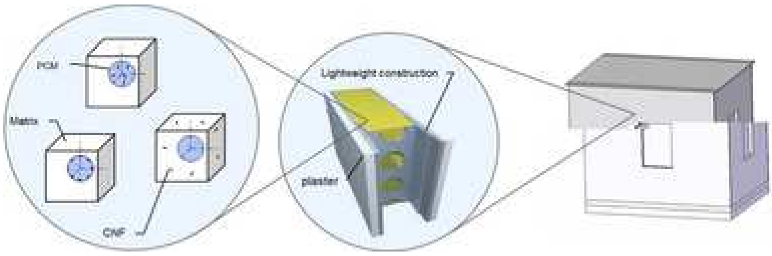
New low cost form stable thermal storage component (anchorage at nano scale of organic PCMs between polymeric chains). The PCMs will be based on by-products of different industries (i.e. the glycerin produced in biodiesel industry).

New thermal insulation inorganic nano-foam with thermal storage capacity through impregnation with inorganic or organic phase change materials.

• Thermal behavior improvement of the materials developed and PCM microcapsules with the introduction of high thermal conductive nano-materials, CCNT or CNF inside their structures.

The combination of PCMs with nano-scale components will sole most of the inconvenient derived to the use of PCM.

The introduction of PCM in different nano-porous will avoid leakage, sweated and losses, and will improve the holding, miscibility and their future application, avoiding microencapsulation and reducing the cost.



Micro scale models – Macro scale model I – Macro scale model II

The new developed materials in NanoPCM project are low cost and improved Phase Change Materials (PCMs). The overall production costs have been reduced making wide scale commercial application feasible by pilot plant production implementation at real scale. The new products are available as a panel and as sprayable foam.

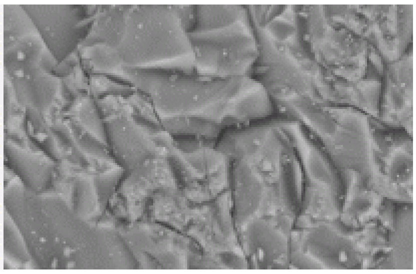
TECHNOLOGIES

6.7 Nano Insulate – Development of nanotechnology-based high performance opaque&transparent insulation systems and biocide formulations for Energy Efficient buildings

Info: http://www.nanoinsulate.eu/

Nano Insulate will develop durable, robust, cost-effective opaque and transparent vacuum insulation panels (VIPs) incorporating new nanotechnology-based core materials (such as nanofoams, aerogels and aerogel composites) and high-barrier films, that are up to six times more energy efficient than current solutions.

These new systems will provide product lifetimes in excess of 50 years suitable for a variety of new-build and retrofit building applications. Robustness (resistance to physical and climatic damage) is key in these applications.

Initial building simulations based on the anticipated final properties of the VIPs indicate reductions in heating demand of up to 74% and CO_2 emissions of up to 46% for Madrid, Spain and up to 61% and 55% respectively for Stuttgart, Germany for a building renovation which reduces the U-value of the walls and roof from 2.0 W/m.^{2}K to 0.2 W/m.^{2}K.

This reduction could be achieved with NanoInsulate products down to 25 mm thick, giving a cost-effective renovation without the need of changing all the reveals and ledges. Novel design and mounting techniques will be used to promote physical robustness similarly, significant reductions in U-values of transparent VIPs (3 W/m.^{2}K to 0.5 W/m.^{2}K) are shown by substituting double glazed units in existing building stock.

Target final manufacturing costs for insulation board (production rates above 5 million m^2/year) <50% current costs (based on design R-value over 50 years, not initial value).

TECHNOLOGIES // INTEGRATION

6.8 FC-Districts - New m-CHP network technologies for energy efficient and sustainable districts

Info: http://fc-district.eu/

New µ-CHP network technologies for energy efficient and sustainable districts.

The overall objective of the FC-DISTRICT project is to optimize and implement an innovative energy production and distribution concept for sustainable and energy efficient refurbished or new "energy autonomous" districts, exploiting decentralized co-generation coupled with optimized building and district heat storage and distribution network.

The concept is based on dynamic heat exchange between the buildings (fitted with Solid Oxide Fuel Cells) for energy production collaborating with improved thermal storage and insulation building systems, the distribution system (optimized piping and district heating with or without a heat buffer) and the consumer (new business and service models), aiming to achieve energy balance at district level.

A technology in scope of the project is a high temperature solid oxide fuel cell (SOFC) with versatile fuel processor for gas reforming and optimized peripheries making possible successful integration with district networks. FC-DISTRICT integrates a proven innovative SOFC technology with heat management at building and district level (building thermal storage coupled with intelligent distribution networks) to serve the consumer needs for economy-ecology-sustainability. It introduces a new paradigm in energy efficiency by developing materials, technologies, methodologies and systems specifically intended for integration at district level.

Advanced insulation materials will be developed and implemented for the improvement of building and pipe thermal response. The energy reduction will originate from improved efficiency and cost effective high temperature (SOFC), to act as μ-CHP systems providing demand-flexible electricity and heat to the building and district, coupled with optimized energy and power distribution networks that will optimally control heat storage at building and district level.

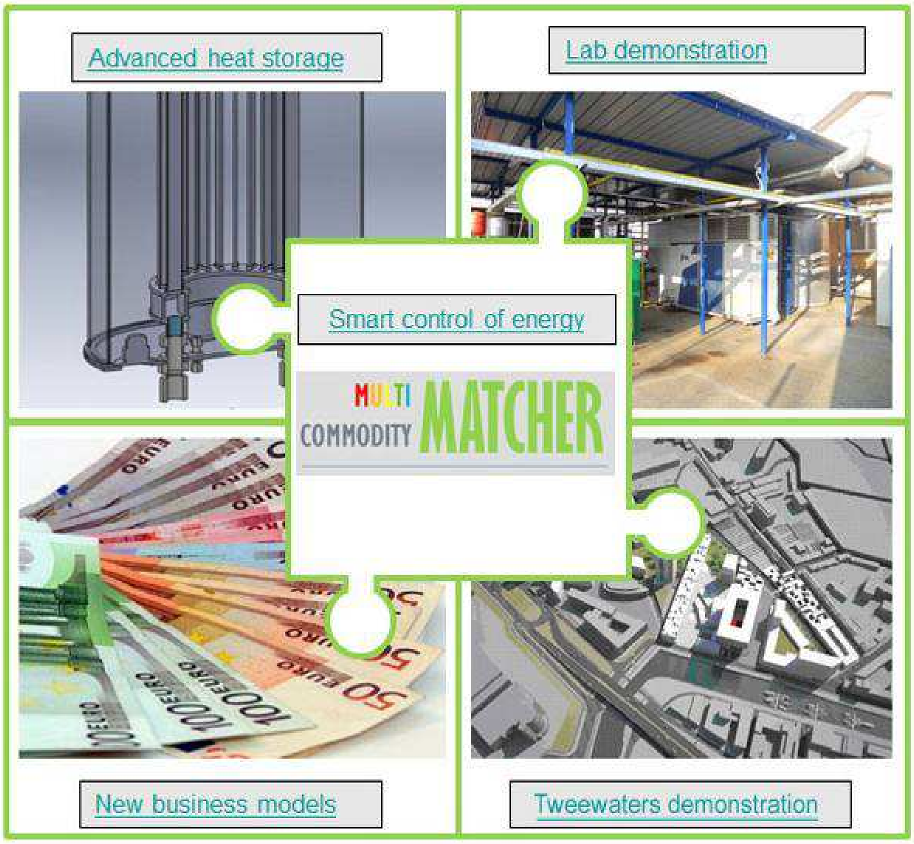
INTEGRATION // BUSINESS MODELS – MANAGEMENT

6.9 E-HUB – Energy-hub for residential and commercial districts and transport

Info: http://www.e-hub.org/

District Heating, Cooling & Power with on-site renewable energy

The Energy Hub is a collaborative European project, part funded by the EU under the Seventh Framework Programme, which aims to demonstrate the full potential of renewable energy by providing 100% on-site renewable energy within an "Energy Hub District".



An Energy Hub is a physical cross point, similar to an energy station, in which energy and information streams are coordinated, and where different forms of energy (heat, electricity, chemical, biological) are converted between each other or stored for later use.

The Energy Hub is a mechanism for exchanging energy via the grids between its members (households, renewable energy plants, offices, businesses), who may be both consumers and suppliers. The members exchange information on their energy production and energy needs with the Energy Hub. The Hub then distributes the available energy in the most efficient way.

To match supply and demand, the Energy Hub converts and stores energy and performs load shifting by controlling the E-Hub components for managing energy flows within the district. The members are connected to the Energy Hub by means of bi-directional energy grids (low and high temperature heat grids, electrical grids (AC and DC) and gas grids (hydrogen, biogas, syngas).

Renewable energy may be generated by individual members (e.g. from solar thermal panels or PV on residences) or by central means (a ground source energy or a large combined heat and power plant) located within the district that may be fuelled by solar energy, biofuel or hydrogen.

Central to the E-Hub project is the Multi Commodity Power matcher: this smart controller allocates energy dynamically to its most demanding members from the most efficient sources of supply.

The aim is to design systems and mechanisms to achieve low energy districts or, ultimately, zero energy districts.

E-Hub Components for thermal storage and district heating:

An E-Hub is a control system for integrating and optimizing on-site renewable energy resources within a local community: Capture of energy/ Conversion of energy/Transfer of energy/ Storage of thermal energy/ Delivery of energy/Management of energy

An E-Hub is a control system for integrating and optimizing on-site renewable energy resources within a local community:

Capture of energy

solar thermal collectors (sunlight → heat)

road solar collectors (sunlight → heat)

photovoltaic collectors (sunlight → electricity)

wind turbines (movement → electricity)

wave turbines (movement → electricity)

Conversion of energy

- a heat pump (using electricity to concentrate and transfer heat)
- a boiler (fuel → heat)
- a sorption cooler (heat → cold)
- Transfer of energy
- a ground source heat pump transfers heat (ground → building) to provide space heating in winter
- a ground source heat pump transfers heat (building → ground) to provide space cooling in summer and to store thermal energy
- an air source heat pump transfers heat (air → building) to provide space heating in winter
- an air source heat pump transfers heat (building → air) to provide space cooling in summer

Storage of thermal energy

heat can be stored in insulated vessels

thermal piles can be used to transfer heat to a thermal bank

boreholes can be used to transfer heat to a thermal bank in the ground for Underground Thermal Energy Storage

energy can be stored in thermochemical materials

Delivery of energy

a heat pump (using electricity to concentrate and transfer heat)

electric grid

gas grid

heat network

Management of energy

information grid

control of energy capture

control of energy conversion

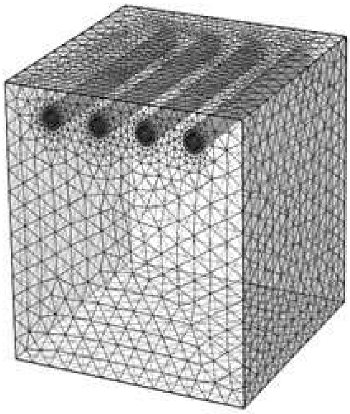
control of energy storage

control of energy delivery

time shifting of energy load demand to suit energy supply availability

matching supply and demand

energy management system

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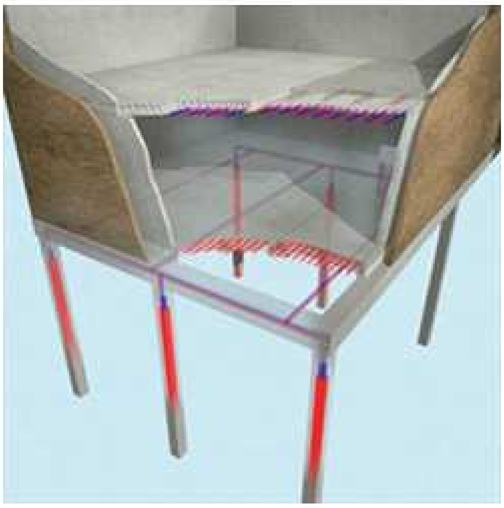
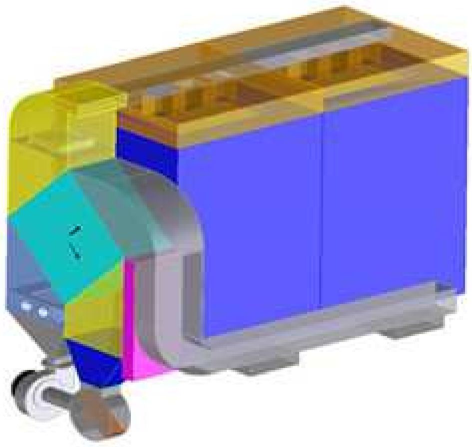




TECHNOLOGIES

6.10 Aerocoins - AEROgel-based Composite/hybrid nanomaterials for cost-effective building super-INSulation systems.

Info: http://aerocoins.eu/

Buildings in Europe account for approximately 40% of the total global energy consumption and a 36% of the total CO_2 emissions. To help address climate change the European Commission has launched the EUROPE 2020 STRATEGY, which aims at reducing energy consumption by 20% and reducing CO_2 emissions by 20%.

Improving the ENERGY EFFICIENCY of BUILDINGS therefore is a promising way to save energy. AEROCOINs proposes to significantly enhance the thermal resistance of the

insulation layer in the building envelope for a given layer thickness. A clever combination of SOL-GEL SCIENCE and NANOTECHNOLOGY can greatly advance in the design and development of novel SUPERINSULATION SILICA AEROGEL MATERIALS.

AEROCOIN proposes to create a new super insulating material by overcoming the two major obstacles which have so far prevented a wide-spread use of silica-based aerogel super-insulation components in buildings and construction. These obstacles are the POOR MECHANICAL PROPERTIES of silica aerogels and the HIGH COST associated with its production.

Aerogels are the perfect meso-porous, nanostructured solids for thermal insulation and the lowest thermal conductivity solids known to man ($\lambda < 0.012$ W m-1 K-1 at ambient conditions). Silica aerogels are the most widely studied and used class of aerogel materials for thermal superinsulation applications.

Currently the main inhibitors that avoid spreading the use of superinsulating aerogel materials are: (i) the high cost involved in their production and (ii) the poor mechanical properties of the associated current silica aerogel insulation products.

Therefore, the production of silica aerogels on a large scale at a reasonable cost and with good mechanical properties still remains a great challenge.

AEROCOIN proposes to create a new class of mechanically strong super-insulating aerogel composite/hybrid materials by overcoming the two major obstacles which have endured for so long and have prevented a more wide-spread use of silica-based aerogel insulation components in the building industry:

- Strengthening of silica aero-gels by cross-linking with cellulosic polymers or the incorporation of cellulose-based nanofibres.
- Lowering the production cost of monolithic plates or boards of composite/hybrid aero-gel materials via ambient drying and continuous production technology.

Acting on these two material & process incentives, new superinsulating aerogel-like materials with improved thermo-mechanical properties will be synthesized at the lab scale, developed at pilot scale and a fabrication concept for cost effective mass production laid out for further pre-industrial development.

PROJECT OBJECTIVES:

- Synthesize and elaborate novel, mechanically strong and superinsulating aerogel-based materials via a subcritical ambient drying process.

- Design and fabricate a highly efficient and robust building component for its implementation in the external part of the envelope of existing buildings.
- Demonstrate the significant cost reduction of the commercial production of superinsulating aerogel-like materials and hence also of the component.

EXPECTED RESULTS

Related to the elaboration and development of a composite/ hybrid aerogel material:

Obtain a reinforced aerogel-based thermally superinsulating material: improving mechanical properties (by a factor of 100 compared to conventional silica aerogel) while maintaining a low thermal conductivity (λ< 0.018Wm-1K-1) by polymeric cross-linking and/or nanodispersion concepts based on use of cellulosic species

Develop an ambient drying process: minimizing evaporation-induced shrinkage by optimized fine-coupling between materials and process parameters

Related to the design and development of the insulation façade construction component:

- Design and fabricate a novel building component prototype based on the developed aerogel-like material. The component should be compatible with conventional construction installations where the envelope is part of the buildings
- Design a cost-effective continuous industrial-level process for the production of the aerogel-like material boards

Related to the validation of the efficiency of the insulation façade component and building integration:

Demonstrate the thermal, structural and mechanical performance of the highly insulating component under real conditions

TECHNOLOGIES // INTEGRATION

6.11 Biobuilt – High Performance Economical and Sustainable Biocomposite Building Materials

Info: http://www.biobuildproject.eu/

Biocomposites for high-performance, low environmental impact, economical building products. The aim of BioBuild is to use biocomposite materials to bring about a step-change in the reduction of embodied energy in building-façade and internal-partition

systems, whilst being commercially competitive and, of course, delivering state-of-the-art-performance.

BioBuild is a collaborative project part-funded by the European Commission. It has 13 partners from seven European countries and a total budget of nearly €7.7m. The project has a duration of three-and-a-half years, and will end on 31 May 2015.

The aim of the BioBuild project is to use biocomposite materials to reduce the embodied energy in building-façade, supporting-structure and internal-partition systems by at least 50% over current materials, with no increase in cost. This will lead to a step-change in the use of sustainable, low-carbon construction materials, by replacing aluminium, steel, fibre-reinforced polymers (FRPs), brick and concrete in new-build and refurbished structures.

Biocomposite materials

Biocomposite is a term for a FRP comprising natural fibres, such as flax, jute or hemp, in a polymer matrix derived from natural materials, such as agricultural wastes, vegetable oils or corn starches. The low embodied energy of biocomposite materials offers significant potential for reducing the environmental impact of building products.

The specific mechanical properties of natural fibres are competitive with those of glass fibres. Flax and other natural fibres also have excellent resistance to fatigue, and good vibration- and acoustic-damping characteristics, compared with glass and carbon fibres.

Although biocomposites offer many characteristics equal to or better than conventional composite materials, in the service conditions of many building components their durability is currently too low. The BioBuild project will address this through the development of fibre treatments and bio-resin formulations, to provide resistance to moisture absorption and other degrading agents. These treatments will also enhance other characteristics, such as fire performance.

TECHNOLOGIES

6.12 SUS-CON - Sustainable Innovative and Energy-Efficient Concrete based on the integration of All-Waste materials

Info: http://www.sus-con.eu/

The project aims at developing new technology routes to integrate waste materials in the production cycle of concrete, for both ready-mixed and pre-cast applications, resulting in an innovative light-weight, eco-compatible and cost-effective construction material, made by all-waste raw materials and characterized by low embodied energy and CO_2 and by improved ductility and thermal insulation performances. The target of low embodied energy and CO_2 will be mainly achieved through working on the binders' side, while the target of energy efficiency (heat insulation) will be mainly achieved through working on the aggregates side.

The use of lightweight recycled aggregates will allow making the target material lightweight and heat-insulating. The focus will be on waste materials that, for quantity, distribution and characteristics are also a social problem but, on the other hand, are available in quantities enough for feeding the concrete industry. On the binder side the aim is the complete replacement of cement by waste materials of high silicon dioxide content, e.g., municipal incinerator ash, ash disposed from coal-fired thermal power plants, and/or in combination with by-products such as ferronickel slag and natural or man-made pozzolans like -silica and metakaolin. Properties regulators will be studied, consisting of highly active products that will regulate the performance of the binder, taking into account the waste raw materials variability, in order to achieve and stabilize the required properties of final products. The innovative solutions set-up at material level will then be employed to develop innovative concepts of modular building components.

The project results, while setting-up a novel low-cost material for producing energy-efficient buildings components, will also contribute to solving the issue of "waste

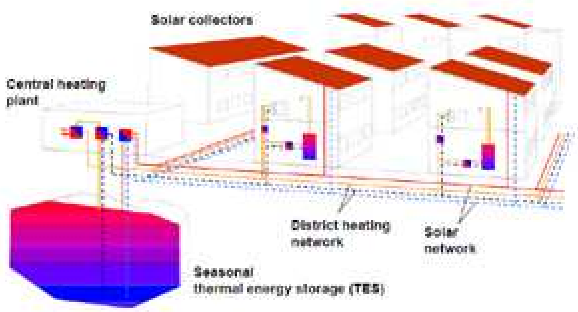
pressure" on towns and to reducing the consumption of not-renewable natural raw materials.

TECHNOLOGIES // INTEGRATION

6.13 EINSTEIN - Effective integration of seasonal thermal energy storage systems in existing buildings

Info: https://www.einstein-project.eu/

Taking into consideration that heat demand can represent up to 60-70% of total amount of energy consumption in a residential building, **heating system based on Seasonal Thermal Energy Storage (STES) concept** is currently the most promising technology able to fulfil the objectives established in Europe about energy efficiency in a short term. The fact that the concepts developed within this project are based on innovative adaptation of existing technology is a remarkable aspect, as it makes possible the development of nearly zero energy buildings (one of the objectives of EPBD directive) at short time.



The overall objective of the project is the **development, evaluation and demonstration of a low energy heating system based on Seasonal Thermal Energy Storage (STES) systems in combination with Heat Pumps for space heating and domestic hot water (DHW) requirements for existing buildings** to drastically reduce energy consumption in buildings.

The **integration between STES system and heat pumps** is one of the main breakthroughs of the EINSTEIN project. STES systems are known in northern Europe and heat pump technology is known and used all over the world, but the integration between these two systems is not optimized. An appropriate heat pump does not exist, neither an evaluation tool for this integration design. Within the EINSTEIN project, both barriers will be overcome.

Main objectives of the EINSTEIN project:

To make STES systems cost-effective and to adapt this technology to be applied in existing buildings.

To develop a novel, high efficiency, cost-effective and compact heat pump optimized for STES systems.

To develop a Decision Support Tool (DST) for selection, design and evaluation of STES integrated system suitable for existing buildings. It will be a user-friendly analysis tool that will allow engineers to select the most suitable technologies to install according to particular specifications of the retrofitting project, to design the heating system based on the STES concept and to evaluate the expected impact of the innovative solar heating plant.

TECHNOLOGIES

6.14 MEEFS - Multifunctional Energy Efficient Facade system for building retrofitting

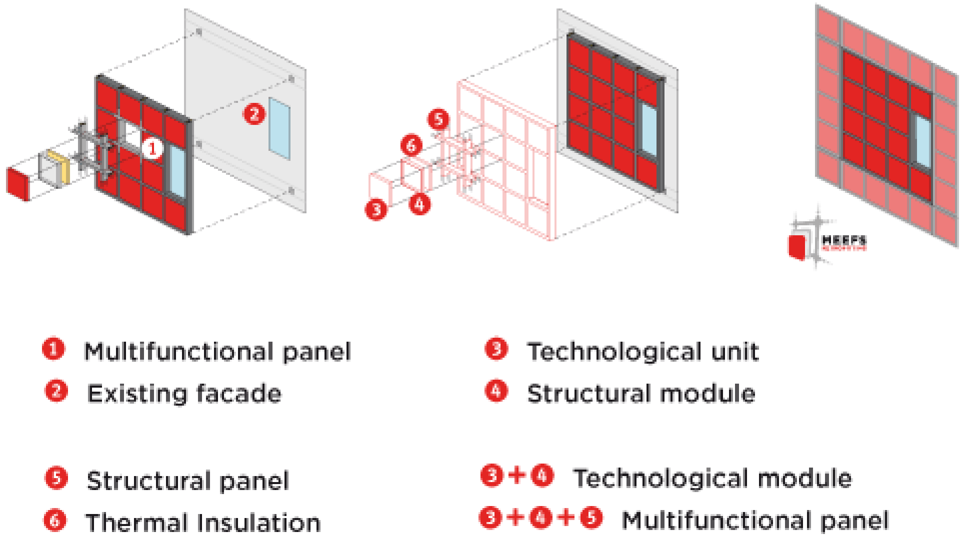
Info: http://www.meefs-retrofitting.eu/

The MeeFS project aims to develop, evaluate and demonstrate an innovative multifunctional façade system for drastically improving the energy efficiency of retrofitting geared towards the residential building sector across Europe.

The team will work collaboratively on the façade development (architectural, energetic, breakthrough technologies according to passive and active technologies, energy management system, installation, and structural material), façade evaluation (of energy efficiency, new composite material life cycle and fire resistance) and façade demonstration (in real life building in Spain).

The present project, MeeFS (Multifunctional energy efficient façade system for building retrofitting), aims to develop, evaluate and demonstrate an innovative energy efficient multifunctional façade system geared towards the residential building sector. The result should bring a flexible and modular solution. Flexible as it could be adapted to different architectonic configurations and typologies. And Modular as a system that combines different technological solutions.

Concept Idea: A Multifunctional Energy Efficient Façade System for Building Retrofitting



The concept idea of MeeFS is based on efficiency and on a multifunctional integrated system. It is an innovative façade concept for retrofitting which applies multifunctional energy efficient panels and technological modules, as well as innovative composite façade structure materials, all easily integrated in the façade for building envelope retrofitting. This new and innovative façade system will be easily adapted to fit a variety of climatic conditions and any type of residential building façade, making it highly flexible in terms of use and deployment. This has the potential to drastically improve the energy efficiency of residential buildings in Europe.

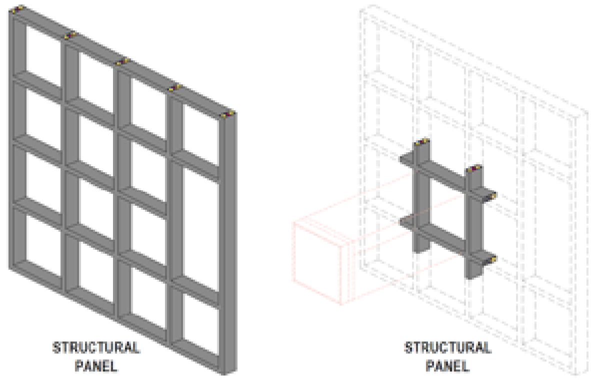
Energy Efficient panels and modules integrated in the façade will include a particular technology for reducing energy demand of the building or for supplying energy by means of RES; two new energy efficient modules will be developed: Advanced Passive Solar Protector and Energy Absorption auto mobile unit, and Advanced Passive Solar Collector and Ventilation Module.

The façade system will be manufactured on composite materials (FRP – Fibre Reinforced Polymer) for improved lightness. Previous Life Cycle Analysis studies for the proposed materials have been done, as such recyclability considerations have also been taken into account.

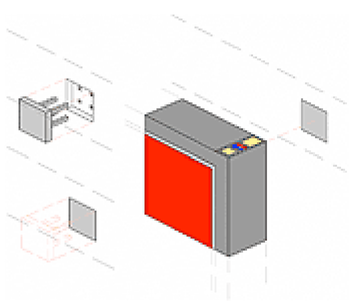
It will also be based on new industrialized constructive system with a non-intrusive installation. This will allow personalized configurations for each façade typology, orientation and local climatic conditions, always using standardized panels and technological modules. It will be cost effective in service life, with low maintenance, easy assembly and disassembly.

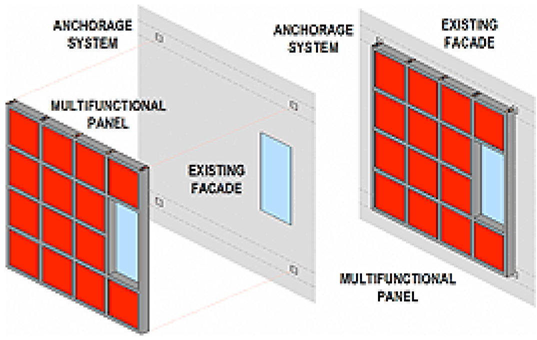
Products under development

Structural panels

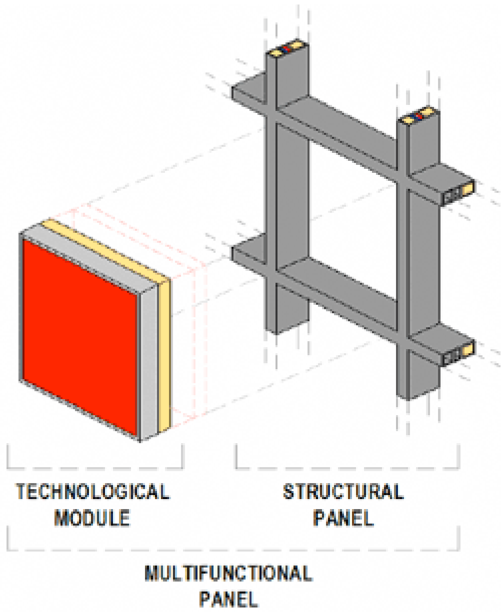


The anchorage system of the structural panels will be made out of the same FRP material and fixed to the slabs of the existing building in specific points.



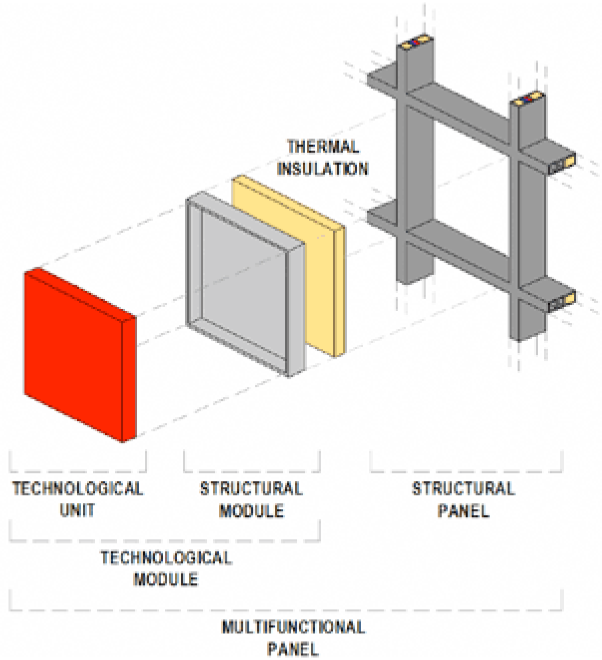


Technological Modules



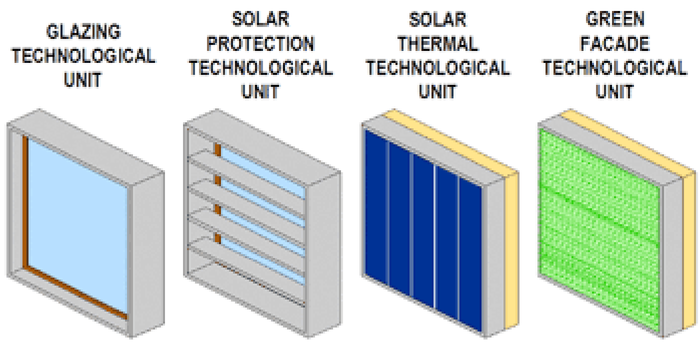
Technological Units

Technological units will be of different types and will be fitted into the technological modules and then onto the facade of the building.



There are 4 different types of technologies that will be explored in the development process of the Technological Units. They are to be based on an efficient combination of technological units which utilize active and passive technologies.

Some examples of technological units are:



Advanced passive solar protector & energy absorption unit

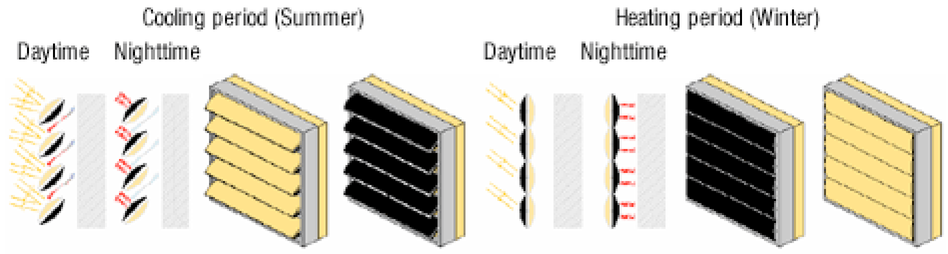
The novel system will:

Utilize a variety of passive strategies within the same unit and its functioning will be defined by meteorological conditions

Be adaptive to the envelope, thus integrating in the MeeFS retrofitting system

The technological unit will be formed by a row of horizontal rotating multifunctional slats (manufactured with two different materials and selective coatings). The position

of the slats will change to adapt to the meteorological conditions with a simple system of sensors modifying the slats' position.



Advanced passive solar collector and ventilation unit

This proposed concept is based on passive dual-layer bioclimatic configurations which are integrated into a unique module.
The system will consist of:

A semitransparent external layer

A lightweight high inertia internal wall

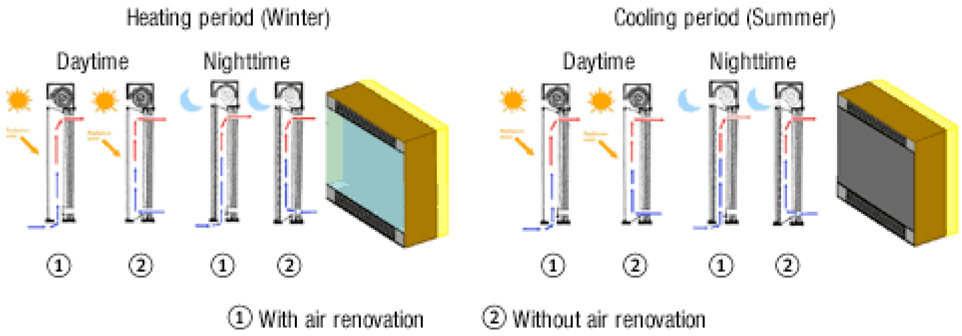
An air circulation space between them

A controllable cladding system

A patent application filed in December 2009, allows the advanced ventilation management to be applied in passive solar collectors. It can manage the ventilation patterns of most widespread bioclimatic passive systems (Trombe wall, Parietodynamic wall, ventilated façade, solar chimney and passive cooling), all of which are integrated in the same technological unit.

This level of integration of passive bioclimatic systems into a modular concept has never been achieved. This system doesn't require additional HVAC equipment, and thus is passive in terms of its energy consumption. Even as a passive system, it is actively controlled, which extends its functionalities beyond traditional dual layer façades. The main innovation of this system is an air flow controlling louver system that selects the most appropriate airflow pattern in the collector. The system also includes a cladding element, which prevents heat dissipation in the absence of sun in winter and prevents day heating in summer.

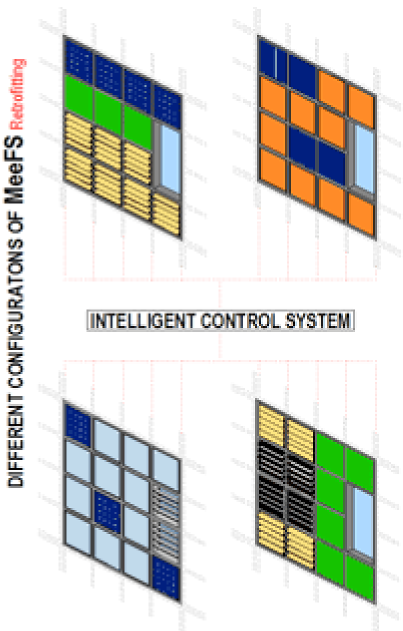
The louver system and cladding element are intended to function as part of an intelligent building-level integrated system. This way, the most appropriate functioning mode -heating, ventilation or cooling – will be provided depending on the external conditions and user needs.

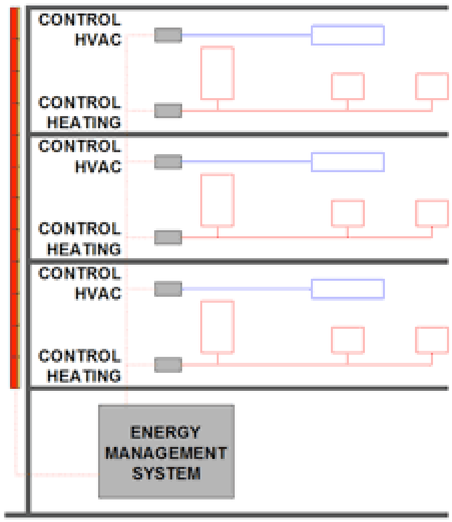


Intelligent control system and Building energy management system

The Intelligent Control System for operating the Façade System will be an autonomous system to manage all the mobile elements (solar slats, ventilation grilles, etc., of the façade and the management of the energy coming from the façade (BIPVs). It will be integrated in the building energy system.

The Building Energy Management System will manage the different energy installations such as HVAC, illumination, and the energy supply installation such as BIPV, solar thermal collectors in order to achieve optimal building energy balance.





Façade software and guide of design

A guide of design, for retrofitting and commissioning buildings to be retrofitted will also be developed as a support instrument for the implementation of the façade system. The guide will cover the architectural, structural design and construction process. It will also cover the use and maintenance steps of the façade system.

In addition, a decision-support software tool for the design of the optimum modules combination of the façade system, depending on the energy efficiency requirements while achieving and/or maintaining the aesthetical values will also be developed.

TOOL // POLICY-CONCEPT

6.15 GE2O- Geoclustering to deploy the potential of Energy Efficient Buildings across Europe.

Info: http://www.geoclusters.eu/
http://www.geoclusters.eu/ge2O/

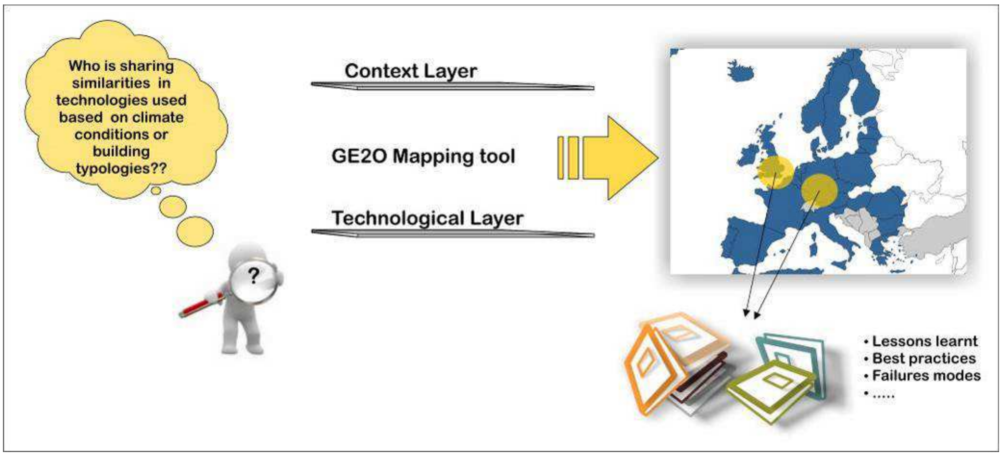
The concept of "Geo-clusters" is highly relevant, being virtual trans-national areas where strong similarities are found (i.e. climate, culture and behaviour, construction typologies, economy, energy price and policies and gross domestic product, to name a few). In this framework, it is clear that the geo-cluster map will not be based on fixed geographic regions, but is to be considered as a multi-dimensional and dynamic tool.

Our goal is to locate similarities across enlarged EU by combining single or multiple parameters and indicators organized in homogeneous layers and sub-layers. As a pure example, we may consider a Technological layer (i.e. building typologies, technologies…), a Context layer (i.e. climatic conditions...), a Socio-economic layer (i.e. macroeconomic indicators, behavioural aspects…), a Political-strategic layer (i.e. standards and regulations, energy policies...).

There are however a number of barriers that are due to scattered knowledge, specific needs, failure modes and bottlenecks, as well as the weakness and threats experienced by running clusters dealing with energy efficiency in the built environment across EU, requiring a EU coordination action centred on a two-fold approach:

1. Structuring and correlating the existing knowledge and information available at broader public level on EU, National and local basis. Once descriptors have been identified, a correlation methodology will then be developed to associate the different data layers and create multi-dimensional maps.

2. Validation through two pilot clusters, performing an in-depth analysis and validation of the overall approach and methodology focusing on the two pilot clusters Mediterranean arc and Western Central and Northern West EU.

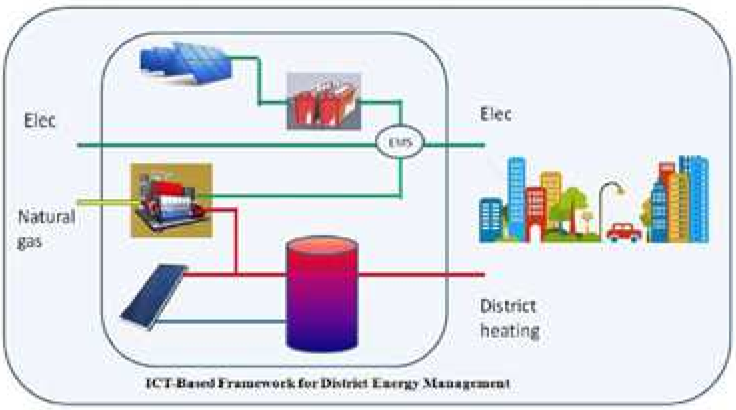


TECHNOLOGIES // INTEGRATION // MANAGMENT

6.16 RESILIENT- Renewable, Storage and ICT, for Low carbon Intelligent Energy management at district level

Info: http://www.resilient-project.eu/

The RESILIENT project aims to design, develop, install and assess the energy and environmental benefits of a new integrated concept of interconnectivity between buildings, DER, grids and other networks at a district level. The RESILIENT approach will combine different innovative technologies including smart ICT components, optimized energy generation and storage technologies, also for RES, integrated to provide real time accounts of energy demand and supply at a district level and assist in decision-making process.



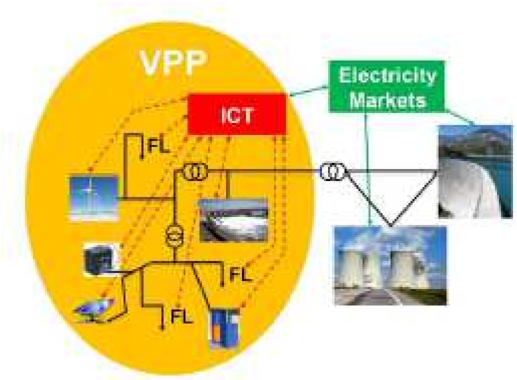
The project strategy relies on a comprehensive R&D and demonstration approach. The proposed integrated concept will be first modeled and simulated for different typologies of buildings and different climates and then installed, monitored and evaluated in three pilot projects (including residential and non residential buildings) in

the UK, Belgium and Italy. These demonstrators will be used to assess the energy and environmental benefits of the new integrated concept and also to validate models and technologies in order for the concept to be easily replicable throughout different climatic areas.

The major impact from RESILIENT will be the development of a complete value chain where the annual primary energy demand of buildings collated at a district level is decreased by at least 20% compared to their expected energy performance summed on an individual building basis, this energy gain being associated with a decrease of more than 20% of the CO2 emission reference level.

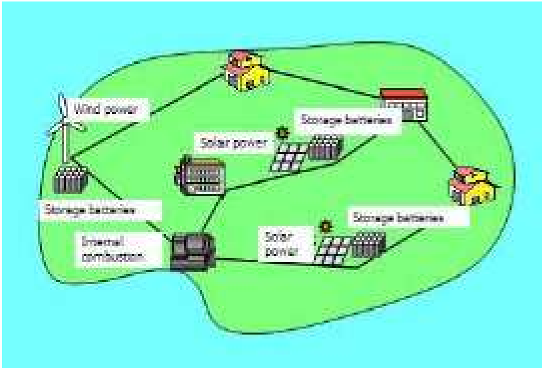
To improve the integration of Renewable Energy Sources (RES) in the grid, several concepts have been developed:

- **Virtual Power Plant (VPP).** VPP is a cluster of distributed energy generation installations (such as CHP, wind-turbines, small hydro, etc.) which are collectively run by a central control system over an information network (managed by ICT). To balance the weather-dependent power production, flexible loads (FL) and storage capabilities are added. Therefore, the group of DER is comparable to a power plant connected to the transmission grid. Participation in the energy market is then facilitated. Interaction of different energy carriers is only rarely considered.

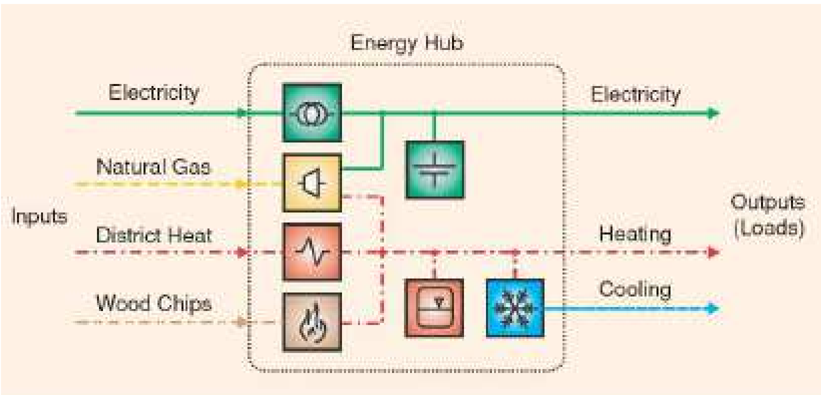


- **Microgrid.** A microgrid is a cluster of DER and loads operating as a single, autonomous grid either in parallel to or "islanded" from the existing utility power grid. In the most common configuration, DER is tied together on their own feeder, which is then linked to the grid at a single point of common coupling. More than 160 microgrid projects are currently active around the

world, with power generation capacity totaling more than 1.2 GW. For reasons of reliability microgrids should be implemented in a small local area.



- **Energy Hub**. An energy hub is a unit where multiple energy carriers can be converted, conditioned, and stored. It represents an interface between different energy infrastructures and/or loads. Energy hubs consume power at their input ports connected to, e.g., electricity and natural gas infrastructures, and provide certain required energy services such as electricity, heating, cooling, and compressed air at the output ports. Within the hub, energy is converted and conditioned using, e.g., CHP technology, transformers, power-electronic devices, compressors, heat exchangers, and other equipment. This concept is quite new and there are very few ongoing projects.



INTEGRATION // BUSINESS MODELS – MANAGEMENT

6.17 iNSPiRE – Development of Systemic Packages for Deep Energy Renovation of Residential and Tertiary Buildings including Envelope and Systems

Info: http://inspirefp7.eu/

The European Union has announced ambitious targets for the reduction of energy consumption of buildings in Europe.

In recognition of the potential for energy savings in existing building stock, the Energy Performance of Buildings Directive recast (EBPD recast, 2010) states that, alongside its target to construct zero-energy new buildings by 2020, renovation targets should aim to transform existing buildings into nearly zero-energy buildings, too.

The European Union has announced ambitious targets for the reduction of energy consumption of buildings in Europe. In recognition of the potential for energy savings in existing building stock, the Energy Performance of Buildings Directive recast (EBPD recast, 2010) states that, alongside its target to construct zero-energy new buildings by 2020, renovation targets should aim to transform existing buildings into nearly zero-energy buildings, too. A bold target requires an equally aspirant project and iNSPiRe has set its sights on finding solutions to help meet the EU's energy-consumption reduction goals in existing building stock across Europe.We are going to define a process for renovation, but we are also going to develop technologies and products that will be placed on the market.

iNSPiRe is a four-year long, EC-funded project that will see the collaboration of 24 partners across nine work packages from the combined fields of research and development, industry, small business and not-for-profit organizations. The objective of iNSPiRe is to tackle the problem of high-energy consumption by producing systemic renovation packages that can be applied to residential and tertiary buildings. The renovation packages developed by iNSPiRe aim to reduce the primary energy consumption of a building to lower than 50 kWh/m2/year. The packages need to be suitable to a variety of climates while ensuring optimum comfort for the building users.

The first stage of iNSPiRe is the analysis of building stock across Europe to produce seven target examples that represent the majority. By looking at these buildings holistically, taking in all aspects of the structure and energy distribution, iNSPiRE will use these templates to consider renovation procedures with a large replication potential.

The second major stage of iNSPiRe will be the development of multifunctional renovation kits that make use of innovative envelope technologies, energy generation systems (including RES integration) and energy distribution systems. Here there are

exciting plans for the development and design of façade and roof kits with innovative energy storage solutions and heating/ventilation devices. In order to realize the implementation of systemic renovation packages in future renovation projects, iNSPiRe aims to develop effective, reliable and cost-efficient technologies that are ready for use by the construction industry.

We can help make that step forward. We are going to try to make it easier for public authorities and decision makers who aren't skilled in the sector of energy renovation but have to make decisions.

BUSINESS MODELS

6.18 NEW-BEE- Novel Business model generator for Energy Efficiency in construction and retrofitting

Info: http://www.newbee.eu/

The increasing cost of traditional energy sources and the availability of new emerging building technologies in lighting, heating, ventilation, air conditioning, isolation, energy monitoring and management of the buildings as well as integrated renewable energy technologies, are expected to increase the global market for low carbon solutions. However, some financial, organizational and social innovation enablers are required to leverage the transformation towards more sustainable buildings and cities. New green performance based business models clearly have to be introduced for stepping up the adoption of new energy efficient solutions through the creation of cooperative and collaborative business networks, which will allow an early involvement of all relevant value chain stakeholders in the energy efficient construction optimization process. This includes e.g. construction SMEs, ESCOs, building owners (private and local authorities), local administrations or financial institutions.

TECHNOLOGIES

6.19 NANO-HVAC - Novel Nano-enabled Energy Efficient and Safe HVAC ducts and systems contributing to a healthier indoor environment

Info: http://www.nanohvac.eu/

The NANO-HVAC project concept aims at developing an innovative approach for ducts insulation while introducing new cleaning and maintenance technologies, all enabled by cost-effective application of nanotechnology.

The main concepts are:

Safe, high insulating HVAC-ducts enabling minimization of heat/cool losses: cost-effective, safe and extremely thin insulating duct layers that can be applied both to circular ducts (wet-spray solutions) and to square ducts (pre-cast panel). Insulation will be obtained using sprayable aeroclay-based insulating foams that can be automatically applied during manufacturing of ducts, avoiding manual operation needed for conventional materials. Such technologies, coupled with advanced maintenance systems (objective 2) will guarantee a 50% saving in energy losses compared with conventional ducts.

Cost-effective pathogen and allergenic removal during operation and maintenance to reduce microbial growth: (a) development of anti-microbial, sprayable and self-adhesive photocatalytic coating, based on titanium oxide nanoparticles, for HVAC filters. (b) Development of an injectable liquid polymer matrix containing antimicrobial nanoparticles for air ducts in situ maintenance activities. The liquid polymer will polymerize in situ creating a thin coating which will cover the surface trapping dirt, debris and microorganisms, thus "regenerating" the duct inner layer. The procedure may be repeated over time without affecting HVAC energy performance.

Scientific and technological objectives within NANO-HVAC project can be organized in four areas: (1) high efficient and cost-effective insulation solutions for HVAC ducts (2) inhibition and removal of pathogens and allergenics (3) integration and lab scale characterization, (4) demonstration and validation. The project duration is estimated to be 36 months, with tasks organized in 9 Work Packages.

Therefore, designers and contractors ask for novel insulation materials meeting the highest insulation requirements and complying with the strictest fire resistance regulations, while at the same time they are looking for low density, cheap, and safe-to process materials that can be combined with metal piping and panels in a fully automated production facility.

Moreover, according to American Society of Refrigeration and Air Conditioning Engineers (ASHRAE), “Building occupants can become colonized or infected by mold, fungus and bacteria that may grow within the building and HVAC system. The associated diseases include invasive aspergillosis, legionelloisis and histoplasmoisis. Important non-infectious biological agents indoors include viable and non-viable fungus and bacteria, animal dander, and allergens from dust mites, cockroaches and plants”. In this framework, continuous commissioning processes with special focus on air quality and safety control and improvement should be implemented. Nanotechnology may effectively contribute in addressing the need for high energy and safe HVAC ducts without increasing costs for building maintainers and HVAC installers

Within this framework, the NANO-HVAC project aims at developing an innovative approach for ducts insulation while introducing new cleaning and maintenance technologies, all enabled by cost-effective application of nanotechnology. The whole system aims to be developed with a requirement of service life of the building of 25 years. Following the market needs the consortium will design and develop safe and high insulating HVAC-ducts enabling minimization of heat/cool losses and a Cost-effective pathogen and allergenic removal procedure which will be continuously effective during HVAC operation and maintenance.

INTEGRATION

6.20 BRICKER- Integration in public building renovation.

The four-year Bricker project will examine how to integrate passive and active energy sources in the refurbishment of non-residential, publicly-owned buildings to cut in half their overall energy demand.

The consortium will examine three demo sites in Spain with the goal of developing and implementing passive technologies (such as PCM-enhanced insulation, ventilated façades, and aerated windows), as well as renewable heating, cooling and electrical co-generation technologies (such as solar and biomass). Buildings will be considered as single energy-consumption units and at the same time, connected to other buildings forming high energy efficient districts.

A scalable, replicable, high energy efficient, zero emissions and cost effective SYSTEM to refurbish existing public-owned non-residential buildings to achieve at least 50% energy consumption reduction through: a) A systemic methodology for optimal building retrofitting towards zero emissions, developed to ensure cost effectiveness, scalability and replicability of the interventions taking into account external (geographical, climatic, resources, social) and internal (envelope, facilities and use) building boundary conditions. b) Development of demand reduction strategies: Based on envelope U-value improvement through innovative technologies, material applications and design techniques. c) Development of Energy reduction strategies: An effective interaction and integration of an innovative, scalable, high efficient renewable HVAC hybrid cogeneration system fed with locally available RES, including thermal energy storage strategies as the core of the methodology A/s implementation. d) Effective interactions of energy flows: building to building, building to electrical grid and building to heating and cooling networks and improved methodologies for

interconnectivity of smart grids and heating and cooling networks under the control of a building level energy operation system. Buildings will be considered as single energy-consumption units and at the same time, connected to other buildings forming high energy efficient districts prepared to be connected with other districts around. These energy units will be able to provide advanced energy services (electrical and thermal) to other buildings in their district, which will make the building strategies replicable al district level in order to attract investments.

TECHNOLOGIES // INTEGRATION

6.21 SESBE -Smart elements for sustainable building envelopes

Info: http://www.sesbe.eu

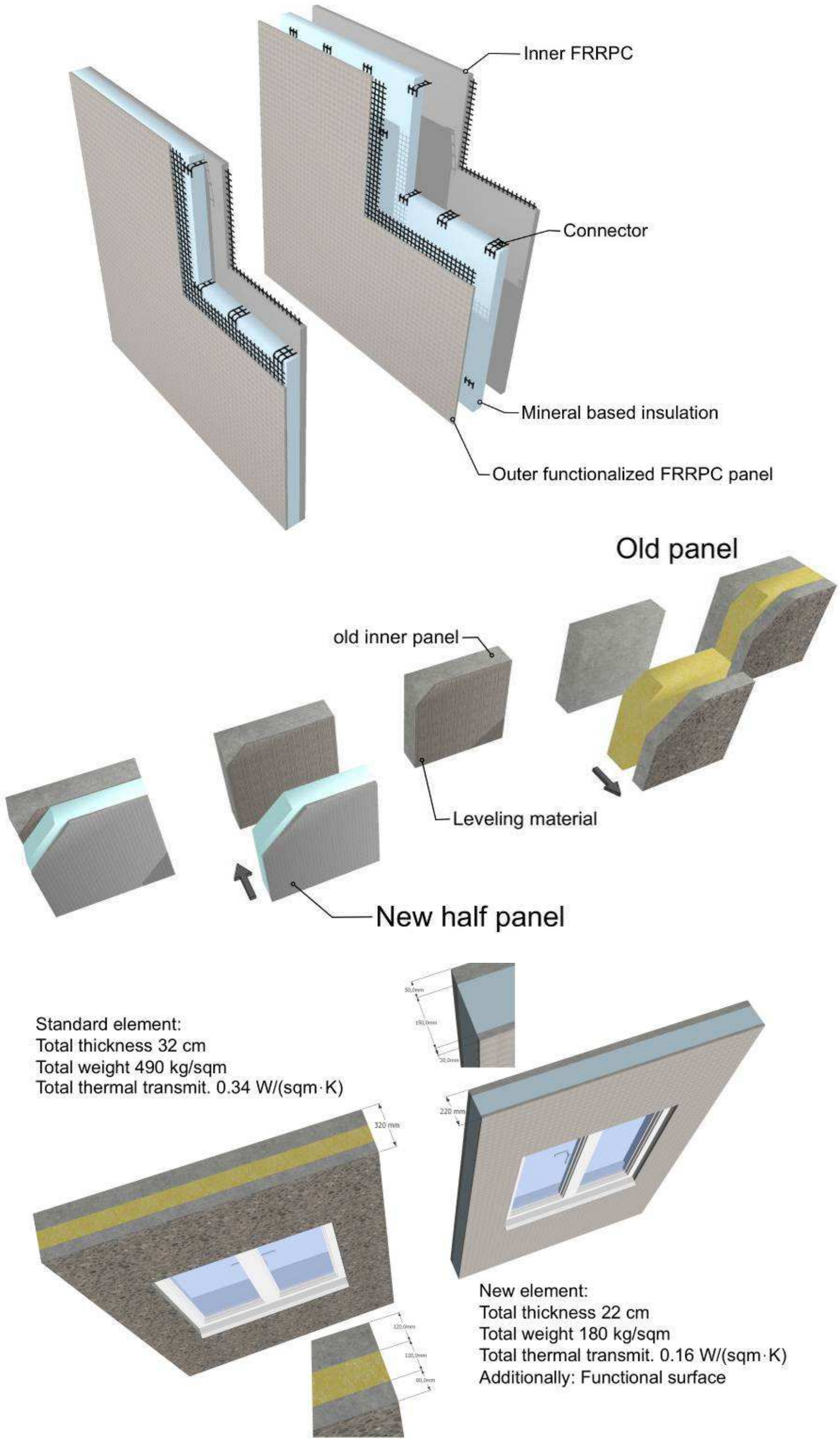
The SESBE consortium, consisting of three SMEs, four industrial and five research partners, addresses this and will provide new solutions for lightweight, energy efficient and safe façade elements. Nanomaterials and nanotechnology will be used as a tool to custom design functional and performance properties of façade sandwich elements for new constructions and half elements for refurbishment of existing buildings as well as a new type of sealing tape and intumescent coating for fire protection.
It is highly expected, the new solutions will have a significant impact on the building sector, not only commercially and societal but also giving impulses to SMEs to invest more in innovation and to partner-up with competent research partners whenever possible. This approach could be a role model for the partnership of research, industry and SMEs in achieving the mutual goal of making housing sustainable, energy efficient, affordable, safe and healthy.

Façade elements made of concrete have a long tradition in the built environment. The huge demand of housing after WW II forced the construction industry to find new approaches to build large amounts of houses at an affordable price. This was solved by the production of pre-fabricated elements in concrete and their assemblage to multi-apartment buildings on-site. Precast concrete façade elements are made either load bearing or non-load bearing. Due to the intrinsic properties of concrete and the requirements for thermal and structural performance existing standard concrete panels are fairly thick and heavy.

Façade design based on precast concrete elements does not yet include many major breakthroughs in material development towards reduced weight and increased thermal efficiency. The SESBE project undertakes the development of new precast façade elements, which are based essentially from inorganic materials.

The SESBE project proposes:

a new type of sandwich element based on cementitious materials, which will have a strongly reduced thickness and will at the same time be lightweight and non-flammable providing a high fire resistance. The insulation layer of the sandwich will consist of aerogel modified foam concrete. The inner and outer layer of carbon fiber reinforced reactive powder concrete. To round it up, a new type of more efficient sealing tape for panel joints and façade openings based on nanotechnology will be developed;



a new and innovative, cost and energy efficient method for the renovation of existing buildings with precast façade sandwich panels, which does not add additional insulation to the thickness of the panel and which will not make it necessary to dismantle the entire façade;

to include functions into the newly developed materials and components, which utilize nanotechnology in order to enlarge the property spectrum of the materials and façade elements:

Easy-to-clean by a super hydrophobic surface of the elements and alternatively

Self-cleaning by a super hydrophilic layer

Increased heat reflectivity by a heat reflective layer – the heat reflective layer will increase fire resistance and thermal efficiency

Control of moisture build-up in the insulation by nano clays

TECHNOLOGIES

6.22 ADAPTIWALL – Multifunctional light-weight WALL panel based on ADAPTive Insulation and nanomaterials for energy efficient buildings.

Info: http://www.phoenix-eu-project.eu/detalle_oferta_demanda.php?of_id=16

Achieving EU's energy-efficiency targets (2050 goals) depends on the right measures to retrofit existing building stock, which is dominated by residential buildings. Approximately 85% of the existing dwellings were built before 1990 with poor facade and roof insulation. Due to this weakness much energy is wasted when operating auxiliary heating, ventilation and air conditioning installations. Current retrofitting attempts by increasing envelope thickness bring negative consequences like too high airtightness, over-heating, poor ventilation and loss of space due to voluminous retrofit units.

ADAPTIWALL solves this problem by using nanotechnology to develop a multifunctional and climate-adaptive panel for energy-efficient buildings. This novel panel consists of 3 elements: 1) lightweight concrete with nanoadditives for efficient thermal storage and load bearing capacity; 2) adaptable polymer materials for switchable thermal resistance; and 3) total heat exchanger with nanostructured membrane for temperature, moisture and anti-bacterial control.

ADAPTIWALL panel is innovative due to its lightweight design and quick low-cost installation; switchable thermal resistance for heat exchange and storage; highly improved energy efficiency; and suitability to be used for facade or roof in cost-efficient retrofitting and new buildings in different European climate regions. When used for facades, ADAPTIWALL panels reduce the building's energy consumption by more than 50% in comparison with conventional retrofitting. Their ventilation and heat exchange properties significantly contribute to create a healthy and comfortable indoor climate, while eliminating the need for auxiliary installations.

The ADAPTIWALL research project focuses on developing adaptive (nano) materials; applying the materials in a lightweight panel; enhancing the panel's structural, fire safety and sound insulation properties; and demonstrating the novel prefabricating systems to European construction industry.

TECHNOLOGIES

6.23 OSIRYS-FOrest baseD compoSites for facades and interior partitions to improve Indoor aiR qualitY in new buildingS and retrofitting actions

Fuente: http://www.osirysproject.eu/

Indoor Air Quality and emissions from building materials have been over the last decades a major challenge for scientists, industry and consumers. Traditional construction materials contribute to contaminants such as VOCs, formaldehyde, particulates and fibres. However, new eco-innovative building materials are able to provide a healthier indoor environment both by substituting source of contamination and by elimination of contaminants arisen from other indoor sources.

Within OSIRYS proposal a holistic solution for facades and interior partitions will be developed ready to be applied in building retrofitting and new construction by means of the development of forest based biocomposites with different functionalities able to meet the strictest requisites of the Building Code and improve indoor air quality by VOC and microorganisms elimination, increase thermal and acoustic insulation and control breathability of the construction systems.

Thermoset epoxy resin based in forest wastes and thermoplastic lignin-base polymer will be reinforced with natural fibres such as wood, flax, hemp, etc. Besides, cork granules will be used for insulation performance. Special attention will be put on additives, especially fire retardants, to meet cost/processability/performance ratio. However, it is expected that biomass feedstock in each building element will be >75%, what allows to reduce embodied energy on building materials by more than 25%.

TECHNOLOGIES

6.24 ECO-SEE - Eco- innovative, Safe and Energy Efficient wall panels and materials for a healthier indoor environment

Info: http://www.eco-see.eu/

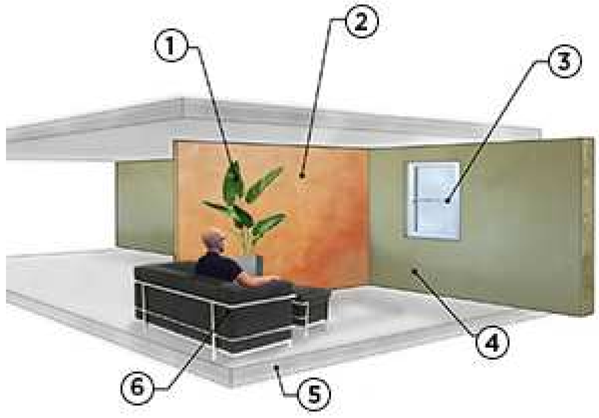
The ECO-SEE project aims to develop new eco-materials and components for the purpose of creating both healthier and more efficient buildings. It will create and symbiotically use natural eco-materials for healthier indoor environments through hygrothermal (heat and moisture) regulation and the removal of airborne contaminants through both chemical capture and photocatalysis.

The ECO-SEE project aims to address an emerging health problem associated with modern low carbon buildings. Modern buildings have been developed to be very airtight, improving their energy efficiency and reducing their carbon footprint. However, these sealed environments have created unexpected side effects, with research showing that a build-up of potentially harmful chemicals in the air is potentially causing negative impacts on occupants.

The ECO-SEE project studies the use of innovative eco-building materials that will address poor air quality, while also radically improving the energy efficiency of buildings.

Through the project the researchers will develop highly insulated wall panels treated using novel chemical processes to enhance the capacity of building materials to capture VOCs. The team will also develop highly novel photocatalytic coatings using nanoparticle technology, which will decompose harmful chemicals when exposed to sunlight, preventing them from being released into the air.

The objective of the project is to deliver products with at least 15 per cent lower embodied energy than traditional construction materials, with at least 20 per cent longer expected lifespan, and for at least 20 per cent lower build costs. By making better products at a lower price the research group can create a cost effective solution with the potential for real market impact.



1. Sources of Humidity
   - People and pets
   - Kitchens and bathrooms
   - Laundry
   - Plants

2. Eco-See interior Wall Panel
   - Hygrothermal and moisture buffering materials prevent moulds
   - Photocatalytic coatings on both faces treat harmful pollutants

3. Windows and Doors
   - Low U-value
   - Air tight details and seals
   - Low emissivity glass

- Low emission materials
- Accoustic comfort

4. Eco-See Exterior Wall Panel
   - Highly insulated, air tight construction
   - Vapour permeable materials
   - Hygrothermal and moisture buffering materials
   - Photocatalytic coatings on internal face treat harmful pollutants
   - Bio-insulation materials remove VOCs
   - Low emission materials

5. Building construction
   - Air tight construction
   - Sealed (with membrane) to prevent radon gas entry

6. Sources of VOCs
   Furnishings, carpets and paints
   Manufactured goods
   Cleaning products
   Air fresheners

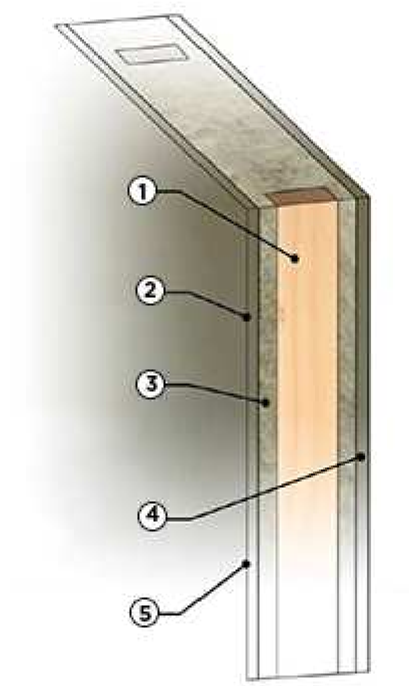
Eco-see exterior wall panel

Air tightness levels meeting PassivHaus requirements

U-Values below 0.15 W/m^2K

Robust detailing provide acoustic comfort

No thermal bridges



1. Low carbon structural elements
2. Novel moisture buffering plasters
3. Novel bio-based insulation (VOC capture & hygrothermal regulation)
4. Durable materials, details and finishes
5. Novel vapour permeable photocatalytic coatings

INTEGRATION // MANGEMENT – BUSINESS MODEL

6.25 AP2BEER – Affordable and Adaptable Public Buildings through Energy Efficient Retrofitting Holistic and Optimized Life-cycle Integrated SupporT for Energy-Efficient building design and Construction.

METHOD – TOOL

6.26 HOLISTEEC- Holistic and Optimized Life-cycle Integrated Support for Energy-Efficient building design and Construction

Info: http://www.holisteecproject.eu/es

The HOLISTEEC project aims at providing the European AEC/FM industry with a comprehensive design approach taking into account the whole building life-cycle and the influence of the neighborhoods, with the objective to make a decisive contribution to build environment energy efficiency improvement.

By means of HOLISTEEC, all the actors involved in the building value chain including architects, designers, contractors, owners, component suppliers, users and related public authorities will be able to effectively interact in the different design, construction, operation, and maintenance phases of the building, ensuring that the best construction techniques are applied, possible problems and drawbacks early detected and correction strategies promptly applied, contributing to boost high quality new energy efficient buildings design and construction.

The HOLISTEEC platform and tool will be applied to real cases, namely four pilot projects especially selected to demonstrate the new holistic approach in different contexts and typologies of building projects, proving its potential for market replication.

HOLISTEEC software platform will account for all physical phenomena at the building level, while also taking into account external, neighborhood level influences. The HOLISTEEC concept relies on a combination of:

- Field knowledge, brought by the big players of the European AEC sector: building life cycle workflows and practices, business models, value chain knowledge from major actors of the building / engineering domain. This knowledge will be used as a base both for HOLISTEEC platform specification and for validation of the HOLISTEEC platform services.

- A full-fledged BIM framework, encompassing all building level physical and nonphysical aspects in an integrated way, while also addressing neighborhood level description. This data model will heavily rely on and extend existing standards (IFC, CityGML) and will feature easy plug-in interfaces for third party tools. It will rely on existing technological results from the project partners.

A holistic multi-physical simulation engine, able to capture and assess in an integrated way building performances in various dimensions at building and neighborhood level: energy, environment, acoustics, lighting. This result will also rely on results from the research partners and the software editors involved in the project.

A web-based, BIM-enabled, on-the-cloud, collaborative design software platform. This platform will rely on the HOLISTEEC BIM framework, to provide collaborative design support services, encompassing building models exchange /

access management and smart visualization. Here, the consortium brings its intensive background in BIM design tools interoperability and its field knowledge of design workflows.

- A building design decision support tool, relying on advanced artificial intelligence techniques and on the multi-physical simulation engines, able to provide semi-automated, focused, assistance for fast and optimized design decisions.

METHOD-TOOLS // INTEGRATION // MANAGEMENT

6.27 COMMON ENERGY – RepliCable and InnovaTive Future Efficient Districts and cities

Info: http://www.commonenergyproject.eu/

The main idea of CommON*Energy* is to shift from single-action refurbishments to deep – energy performing – retrofitting.

The basis for doing this is a systemic approach involving technology solution sets and innovative methods and tools:

Integrated design process guidelines,

An integrative modelling environment,

Energy-economic evaluation tools,

Lean construction and management procedures,

A continuous commissioning approach and

An environmental and sociocultural impact assessment.

The Systemic Retrofitting Approach (SRA) allows for achieving ambitious targets:

Up to factor 4 reduction of energy demand,

Power peaks shaving and

50% increasing share of renewable energy source favored by intelligent energy management and effective storage.

10 to 20 systemic solution-sets will be developed to allow for a wide replication of the demonstration cases. The energy performances will be achieved with short pay-back

times (below 7 years) and high indoor environmental quality, thanks to industrial conceptualization of the solutions and implementation tools. Technical workshops will contribute to training skilled practitioners and to produce a domino effect maximizing the project benefits.

In addition, we intend to share the project benefits with a broad audience, and thereby hope to create awareness for the importance of a more sustainable consumer behavior.

POLICY – STANDARIZATION

6.28 ECOLABEL – Development of a novel ECO-LABELing EU-harmonized methodology for cost-effective, safer and greener road products and infrastructures.

Info:http://www.observatorioplastico.com/detalle_oferta_demanda.php?of_id=4221&seccion=automocion&id_categoria=90

The EU Ecolabel identifies products and services that contribute to sustainability because they have demonstrated a reduced environmental impact throughout their life cycle. There are already more than 17,000 EU Ecolabelled products on the market, but there are no references for road products and infrastructures The concept of the ECOLABEL project arises from the necessity of a new, green, holistic and EU-harmonized Eco labeling methodology integrating by a Life Cycle Engineering approach: environmental indicators along with the economic, technical and social aspects, for the assessment of future and existing road infrastructures, as well as their construction materials such as asphalt mixtures and cement-based materials. This methodology, together with a guide for road eco-labelling and a multi-criteria software tool to be developed, will define eco-labels and provide recommendations to improve the label achieved, supporting and motivating relevant stakeholders and industry in order to include greener, more cost-effective and safer technologies in their road construction, maintenance and renewal projects.

In order to achieve the expected results a complete work plan has been performed. This plan that will move from the definition of the new ecolabelling methodology considering existing relevant labelling approaches, plus the analysis of road products, to the development of guidelines and of a software tool that thanks to the direct involvement of CEN in the project, will motivate future EU-harmonized labelling approaches for roads that would grant the implementation of the ECOLABEL results. The ECOLABEL project will contribute to the implementation of European policies and strategies, boosting the integration of transport in sustainable development promoting technologies and materials that reduce pollutant emissions and the use of natural and financial resources.

METHOD – TOOL // POLICY – STANDARIZATION

6.29 OPEN-HOUSE – Benchmarking and mainstreaming building sustainability in the EU. Transparency and openness (open source and availability) from model to implementation

Info: http://www.openhouse-fp7.eu/

The overall objective of OPEN HOUSE is to develop and to implement a common European transparent building assessment methodology, complementing the existing ones, for planning and constructing sustainable buildings by means of an open approach and technical platform.

OPEN HOUSE will develop a transparent approach able to emerge collectively in an open way across the EU. This approach will be communicated to all stakeholders and their interaction and influence on the methodology will be assured in a democratic way.

The baseline will be existing standards (both CEN/TC 350 and ISO TC59/SC17), the EPBD Directive and its national transpositions and methodologies for assessing building sustainability at international, European and national level.

The core assumption of our approach is that there is little chance for any assessment methodology to become the mainstream and to reach the "label" level, unless it is something that has been developed in a transparent, collective way.

Only EU wide discussion towards a common approach will produce an EU wide assessment methodology for sustainable buildings contributing to current activities on standardisation of assessment methodologies at European level and also to a European potential related standard. Transparency is the key word; just as the ISO recommendations wisely highlight.

The scientific and technical objectives are:

To define the OPEN HOUSE baseline: an open and transparent European platform for building sustainability

To widely communicate the baseline concept and outline the mechanism for interaction among the project and stakeholders

To build up the OPEN HOUSE Platform: facilitating a pan EU effort towards a common view on building sustainability

To pave the way for implementing and evaluating the methodology: selection of case studies and mechanisms for decision making

To evaluate and refine the methodology by the feedback resulting from case studies and real sustainable public procurement cases and other stakeholders inputs

Towards dissemination and exploitation of the OPEN HOUSE methodology

Development of a methodology compatible with EPBD and its national adaptations.

OPEN HOUSE can contribute to a future European Sustainable Building Directive

Involvement of public participation by means of a transparent and open approach that will permit to stakeholders and public in general the access to an open source of information materialized in an open and accessible platform.

Regularly public consultations through the OPEN HOUSE Platform.

Training activities for stakeholders, assuring in that way methodology's proper implementation and its continuity.

To be designed and developed by a transparent and consensus process. Therefore, it is automatically suitable for all European countries.

To be a non proprietary method, thus fostering the exploitation.

To be a comprehensive and user-friendly methodology, support by an interactive web tool (OPEN HOUSE Platform) that will facilitate the communication and interaction between the building stakeholders.

To be based on international/European standards.

To be based on objective, scientifically rigorous and stringent performance criteria.

To address the unresolved issues concerning building sustainability (E.g. performance requirements such as accessibility, weighting, variables such a building type, target user and climate).

To develop new indicators, especially those related with economic and social factors, like for example safety and security, spaces for privacy or conviviality (e.g. co-housing, cafeteria in an office building), externalities (e.g. use of local services or products, unemployment rate of the area), European concept of cost and value (the cost for improving the labeling classification of the building, value of the labeled

building after a time period, value for policy makers and end users), radioactive wastes, etc.

METHOD – TOOL // MANAGEMENT

6.30 EFFESUS- Energy eFFiciency for Eu historic districts SUStainability

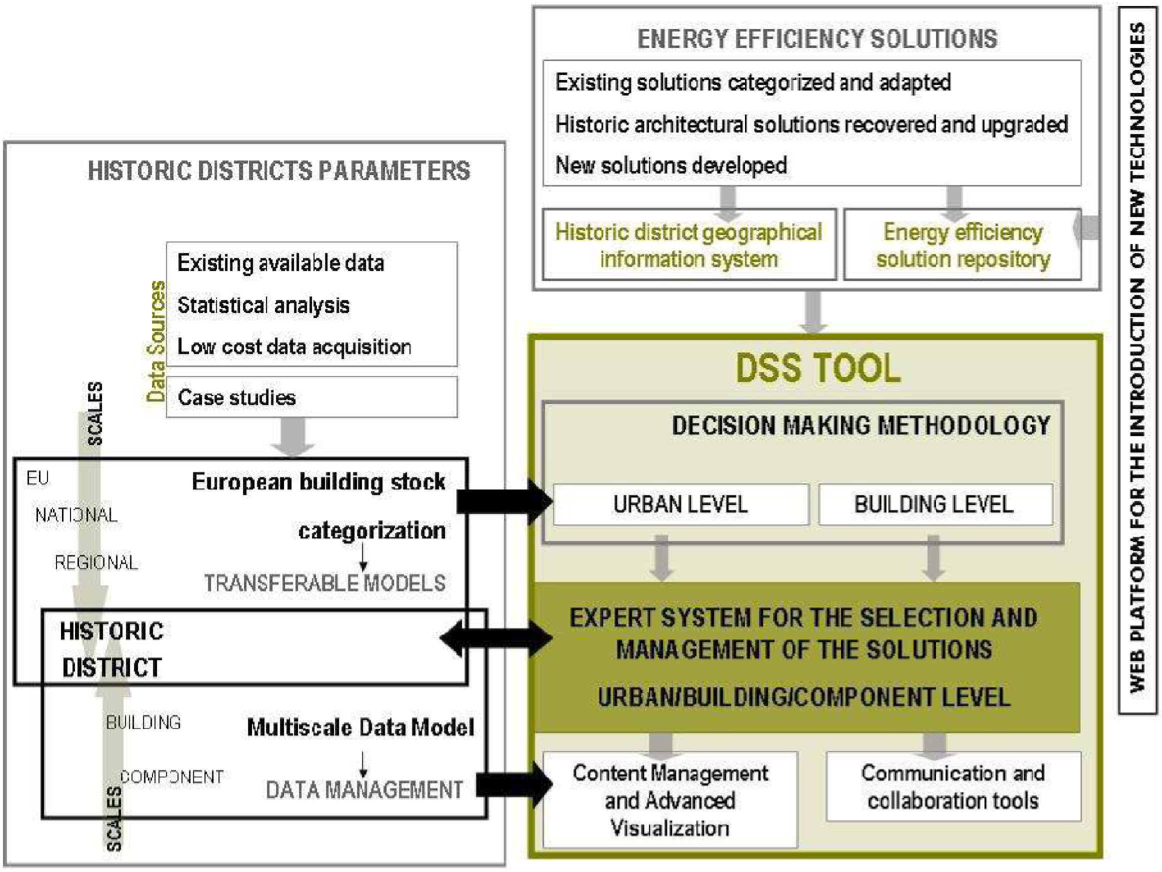
Info: http://www.effesus.eu/

The main goal of EFFESUS is to develop and demonstrate through case studies a methodology for assessing and selecting energy efficiency interventions, based on existing and new technologies that are compatible with heritage values. A Decision Support System will be a primary deliverable. The environment in historic buildings and urban districts is controlled differently from modern cities and accordingly the project will also develop a multiscale data model for the management of energy. In addition, new noninvasive, reversible yet cost-effective technologies for significantly improving thermal properties will also be developed. Finally, existing regulations and building policies may not fit cultural heritage specificities so the EFFESUS project will also address these nontechnical barriers.

The four main scientific objectives are:

1. Categorization of European historic districts and development of a multiscale data model
2. Evaluation, development and implementation of cost-effective technologies and systems for significantly improving energy efficiency in historic districts
3. Development of a methodology and a software tool to assess energy retrofitting interventions in historic districts
4. Overcoming technical and nontechnical barriers for the implementation of project results

The main output of the project will be a Decision Support System (DSS), a software tool, which includes all the parameters needed to select suitable energy efficiency interventions for historic districts.



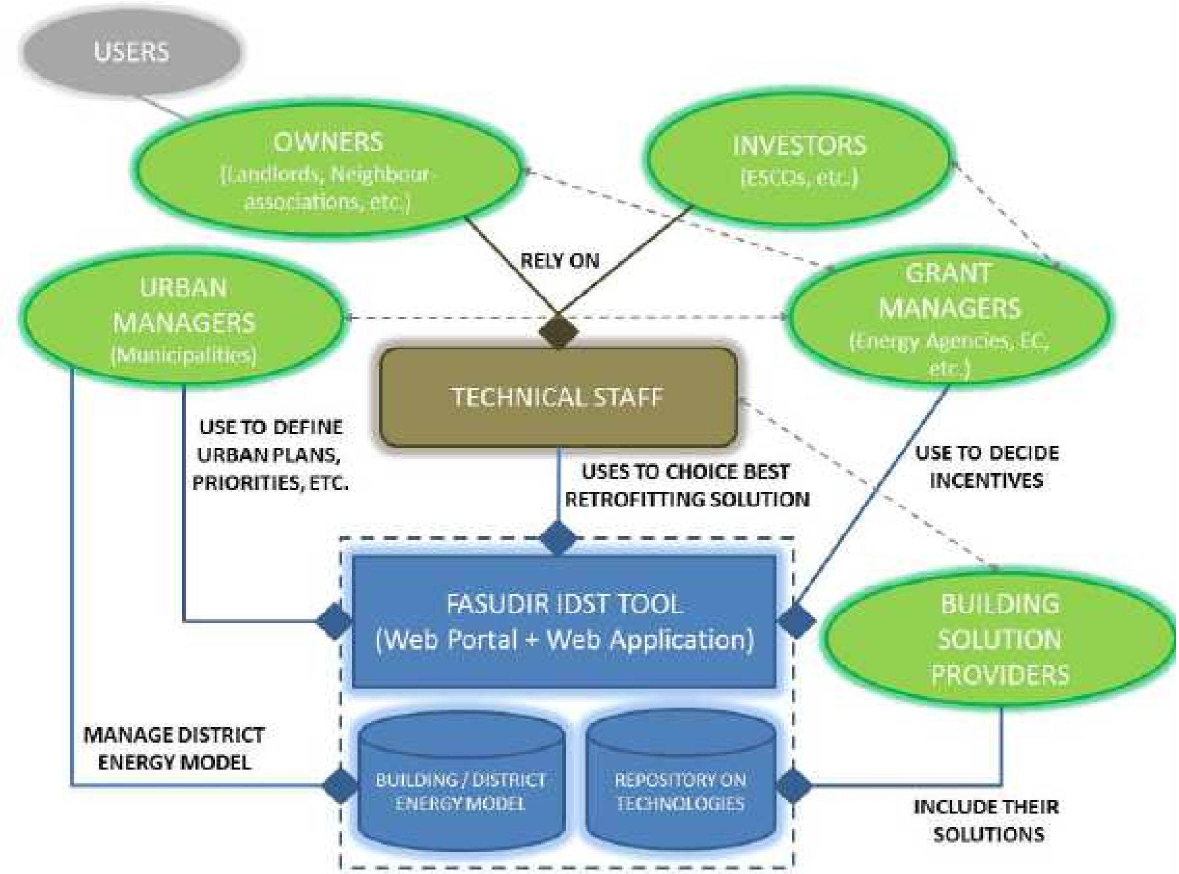
METHOD – TOOL

6.31 FASUDIR – Friendly and affordable sustainable urban districts retrofitting

Info: http://fasudir.eu

The IDST will be based on a decision making methodology, designed to select and priorities energy efficiency retrofitting interventions. It will implement existing and new cost-effective solutions, for significant sustainable improvements in the rehabilitation of urban districts.

Taking into account the different European urban typologies and the priorities of the decision makers, the methodology will support retrofitting actions that are deployed as a unique intervention, but also scheduling sequential interventions in the most cost-effective way.

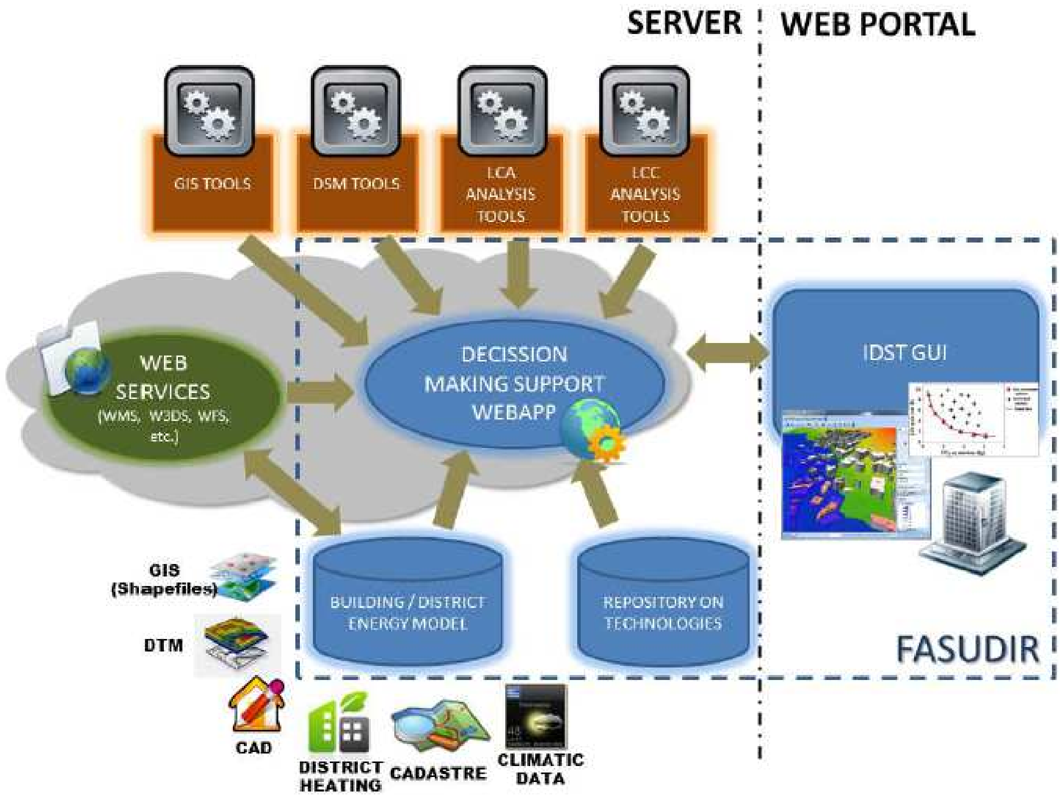


This methodology will focus on the initial stage of the retrofitting process at district level, in which the retrofitting framework is established, with the definition of strategies and technological solutions.

Ultimately, the IDST will allow selecting the optimal, off-the-shelf technologies and strategies for each specific energy retrofitting project in terms of sustainability as a whole (environmental, economic and social).

To ensure usability and effectiveness, the IDST will contain a collection of sustainable retrofitting strategies and technical solutions at building and district level. Each strategy will be characterized according to different aspects, such as adequacy, costs, technical properties, environmental parameters, and so on.

The software will enable modelling the district and building with an adequate level of definition, in such a way that evaluation results will be precise enough, but the input data to define the retrofitting project will be easily supplied. The IDST will feature a 3D graphical user interface, in order to facilitate the interaction between the multiple stakeholders involved in the decision making process.



The users will be able to select the most promising sustainable retrofitting strategies and technical solutions at building and district level, by choosing from a ranked list of possible scenarios proposed by the IDST.

INTEGRATION // MANAGEMENT – BUSINESS MODEL

6.32 PIME's- CONCERTO communities towards optimal thermal and electrical efficiency of buildings and districts based on microgrids

Info: http://www.pimes.eu

PIME'S is a project within the Concerto program, an initiative from the European Commission.

The PIME'S project started up in December 2009, but we held our first official meeting in Sandnes in March 2010. The partners in the project will take part in building and restoration of existing buildings in three different towns. Vitoria-Gasteiz in Basque country of Spain, Szentendre in Hungary and Sandnes in Norway.

The consortium consists of 14 partners from Germany, Spain, Hungary and Norway. The lead partner is Rogaland County Council.

Improved housing areas for better living

Sustainable living is not only about technical quality of houses, reduced use of energy and renewable resources. Creating a better future should take into account the need of those living in the houses and make sure that we also help the daily life. The climate challenges in our three towns are very different, still we have common challenges. The summers in Hungary might be warm and dry, still Szentendre will have winter temperatures coming down below -10 Celsius. Vitoria-Gasteiz has a dry climate and very warm summers but even in Spain you might have snow some years. Sandnes is situated at the part of Norway which normally don't get to cold winters, neither are the summers not to warm.

To make houses that take into account the local climate and at the same time reduces the need of heating or cooling will be the challenge for all partners. By exchanging experiences, sharing knowledge, developing new technology and using this in smart and economically reasonable ways we will create better living areas for the future.

The CONCERTO initiative is a European Union Initiative focusing on demonstration of innovative practice within energy efficiency.

The CONCERTO initiative is a Europe wide initiative proactively addressing the challenges of creating a more sustainable future for Europe’s energy needs. Today, there are a total of 45 communities in 18 projects, each working to deliver the highest possible level of self-supply of energy. CONCERTO is part of the framework research programme supervised by the DG Energy and Transport of the European Commission.

TECHNOLOGIES // INTEGRATION

6.33 BFIRST - Building-integrated FIbre-Reinforced Solar Technology

Info; http://www.bfirst-fp7.eu/home/

The aim of BFIRST project is the development and demonstration of a set of standardized, multifunctional photovoltaic building components based on a recently developed technology for solar cells encapsulation within glass fibre-reinforced composite materials.

The overall objective for B-FIRST project is the development and demonstration of a set of standardized multifunctional photovoltaic products for building integration based on a recently developed technology for solar cells encapsulation within glass fibre-reinforced composite materials. Currently available photovoltaic solutions will be extended with a portfolio of new products with advanced performances developed to a pre-industrial stage.

Scientific and technical objectives:

- Design and development of a set BIPV products based on alternative encapsulation materials (composite materials) with same efficiency levels of traditional modules.
- Enhanced properties of PV modules due to: monolithic structures, light weight, modularity, flexibility in shapes, finishes and colours.
- Light transmission properties tailoring depending on the application.
- Multifunctional performance complying with building and photovoltaic standards.
- Up-scaling of production processes for real-scale prototype fabrication.
- Definition of successful integration strategies for the developed products.
- Demonstration of BIPV products in three different sites (with different climates and general frameworks for BIPV).
- Technical assessment of BIPV products (including architectonical and electrical integration, energy yields and performance).
- Development of product catalogues and datasheets of new standardized components, with complete information on characteristics, performance and building integration methods for each product.

Economical objectives:

Development of BIPV elements with costs comprised between 1,5 and 2,5 €/Wp.

Reduction of 20% on transport, manipulation and installation costs based on lighter weight, materials substitution, enhanced modularity and fixing strategies integrated in the BIPV products manufacturing process.

Specific BIPV systems for retrofitting market.

Economic assessment of BIPV products.

Exploitation plan.

Standardisation objectives:

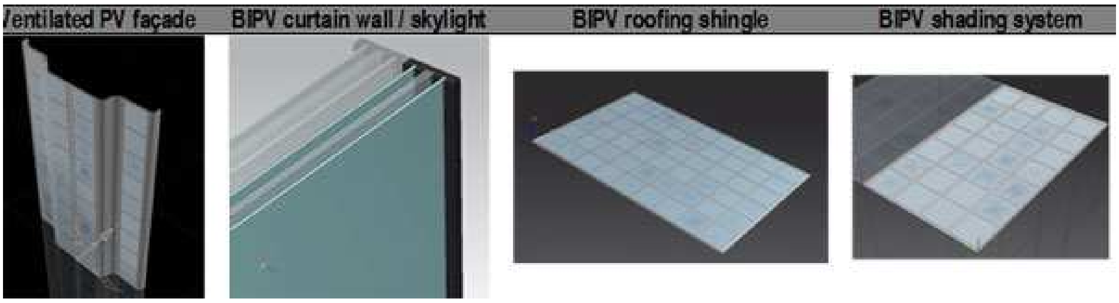
- Detection of current and future harmonisation needs for standardisation of BIPV components.
- Recommendations to extend the existing building codes regarding the integration of standardised PV components.

Educational objectives:

- Easy-to-use guidelines for architects and decision makers for enhancing the use of PV building components.
- Educational and training material for professionals and students. Training activities.
- Dissemination plan and its deployment.

BIPV PRODUCTS

Five standardized BIPV components have been proposed to be demonstrated within the project. These products are a ventilated, hybrid PV/T façade module, a solar shading system, a prefabricated PV fibre-reinforced pane either for curtain walls or skylights and solar PV tiles. Every product is a monolithic structure, manufactured by means of liquid composite moulding.



METHOD // MANAGEMENT

6.34 BEEM-UP - Building Energy Efficiency for massive market uptake

Info: http://www.beem-up.eu/

BEEM-UP is a Public Private Partnership collaborative project that aims to demonstrate the economic, social and technical feasibility of retrofitting initiatives for drastically reducing the energy demand in existing residential buildings, and lay the ground for massive market uptake of such initiatives.

BEEM-UP Stands for Building Energy Efficiency for Massive market Uptake

BEEM-UP involves key expertise to implement and demonstrate innovative building and energy management approaches with the overall aim to improve energy efficiency and obtain better indoor comfort conditions.

The BEEM-UP project takes an integral approach to overcome technical, social and economic barriers through three ambitious retrofitting projects in Sweden, the Netherlands and France.

METHOD // MANAGEMENT - BUSINESS MODELS

6.35 Need 4B - New Energy Efficient Demonstration for Buildings

Info: http://www.need4b.eu/

The overall objective of the project is to develop an open and easily replicable methodology for designing, constructing, and operating new low energy buildings, aiming to a large market uptake. NEED4B methodology will be validated and refined by a strong demonstration programme, envisaging the construction of 27.000 m2, spread among five demo sites covering different climatic zones, buildings types and uses, what ensures replicability of the project results and guarantees their impact in the construction sector.

NEED4B will develop a new replicable methodological approach for designing, constructing and operating very low energy new buildings. This methodology will be

validated and enriched by the experience gathered in a series of demonstration buildings to be constructed in 5 European countries. These buildings will proof the feasibility of constructing buildings with an energy consumption target lower that 60 kWh/m2 year.

It is expected that the measures to be undertaken in the buildings will reduce CO2 emissions by 94% compared to a standard building and will have an impact on the energy bill which could be reduced in 9,6 €/m2·year.

NEED4B expects to contribute also to the standards, regulations and policies related to energy efficiency in buildings at different levels, on the basis on the experience gained by means of the demonstration activities.

The project will also deliver recommendations and guidelines adapted to different types of stakeholders: investors, promoters, owner, users, architects, contractors, public authorities, standardization bodies, policy makers, SMEs, etc. By means of these project outputs, these actors will be able to adopt the developed and demonstrated innovative, cost effective and high performance techniques, concepts and solutions, contributing to boost construction of high quality new energy efficient buildings

An ambitious dissemination plan has been foreseen, as the demonstrators have been carefully selected to ensure the project's visibility and impact within the European construction sector. In this sense, the Belgian demonstrator is integrated in the initiative: Mons, European Capital of Culture 2015: where culture and technology come together. Swedish national television will emit a reality show displaying the life of a family in an energy efficient house. The famous Japanese architect, Arata Isozaki, will be in charge of designing the Italian demonstrator. The Turkish demonstrator, which consists in a hall of residence for university students will be a banner for the Zero Istanbul 2050 initiative. Lastly, Zaragoza will host the fifth project demonstrator, aimed for experimenting and applying energy efficiency construction technology in the tertiary sector.

In addition, exploitation plans will be developed so as to obtain new business models that overcome current market barriers and failures. Specific exploitation plans will be deployed for individual technologies (such as ICT tools) to boost their market uptake, and guidelines and recommendations will be developed targeting the different actors of the value network. This strategy will be in constant improvement and adaptation to the new regulations, standards and policies, always considering a holistic and integrated project delivery perspective.

POLICY – CONCEPT

6.36 REEB – The European strategic research roadmap to ICT enabled Energy-Efficiency in buildings and construction

Info: http://www.artist-embedded.org/docs/Events/2010/GREEMBED/0_GREEMBED_Papers/REEB_greembed2010_final.pdf

The REEB project is a Co-ordination action addressing the Strategic Objective: ICT for Environmental Management & Energy Efficiency for the construction sector.

The project aims at providing a vision and a roadmap for coordinating and rationalizing current and future RTD in the fields of ICT support to energy-efficiency in the built environment of tomorrow. The main outcome is a strategic research agenda that has been elaborated with the support from a European-led community dedicated to the innovative use of ICT supporting EE in Construction, bringing together the ICT community and key actors of the (Construction) Environment and Energy business sectors.

Growing concerns priorities today, especially in Europe, are environment protection and energy conservation, moreover in a context where "systems" (should they be transportation systems, industrial systems, systems empowering the built environment, etc.) are more and more complex and demanding in terms of information management: it is nowadays acknowledged that ICT (Information and Communication Technologies) is the key for a 2-way flow of both energy and information in the Energy sector as a whole (production, distribution, consumption and management). Due to its impact and the opportunities it offers, ICT is considered too as the key for a liberalised market, leading to changes in business practices in the Energy sector (in a similar way this has been the case with ICT strongly impacting the Telecom sector and market). ICT is the key for empowering people in the (built) universe in which they live, with smart e-metering and new smart e-devices, A high potential is also foreseen for ICT becoming fully pervasive in the future optimization of energy in the built environment – where "Energy-efficient smart buildings" are buildings which contain systems that manage information for an optimal operation of building energy flows over the whole building lifecycle.

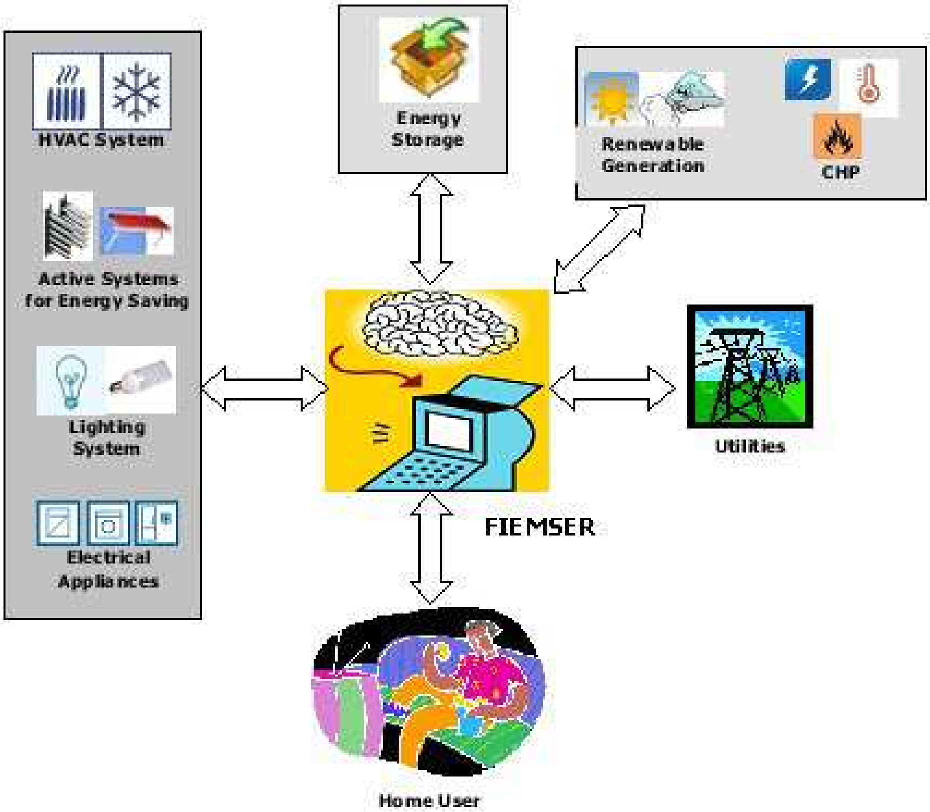
REEB has been launched as a response to the need for coordinating and rationalizing current and future RTD in Europe in the area of ICT support to EE in constructions: it has been set to develop a European-wide agreed vision and roadmap providing pathways to accelerate the adoption, take- up, development, and research of emerging and new technologies that may radically transform building constructions and their associated services in terms of enhanced energy consumption.

INTEGRATION // MANAGEMENT

6.37 FIEMSER – Friendly Intelligent Management System for Existing Residential Buildings

Info: www.fiemser.eu

The FIEMSER architectural design has been complemented with the data modeling of the information exchanged between the main parts of the system. Data models are defined for information coming from outside (weather conditions, electricity prices, gas prices…), data to be exchanged between the main components of the architecture, and data to be exchanged with loads, generators and storage devices. This modeling activity takes into account previous work and other approaches like: IFC and gbXML data models for the building sector, as well as work done in other related R&D projects.



Based on this analysis and the functional specification of the FIEMSER system, a complete UML FIEMSER data model, with more than one hundred classes have been defined. This data model covers data categories/packages that are described in the next table:

Special attention was paid to the interoperability with architectural CAD tools and building energy simulation tools. The two main standard data models in EEB (Energy

Efficiency in Buildings), IFC and gbXML, were analyzed. Finally, the gbXML data model was selected as reference data model for the FIEMSER System development. gbXML, which results from a bottom-up approach, focuses on building thermal load properties. It is then simpler and easier to use and more efficient than IFC to integrate with thermal analysis software, thus allowing quicker implementations. The XML basis (data model in XML Schema and data format in XML) provides flexibility and extensibility, and data can be easily processed by XML parsers. Besides, gbXML is integrated with CAD, design and simulation tools (REVIT, SketchUp…). The limited features in terms of geometry (compared to IFC) are not an obstacle for FIEMSER since we are addressing buildings with standard geometrical features. Nevertheless, this does not mean that we will ignore the BuildingSMART community in our further work. Indeed, it is planned that our modelling work will be disseminated (as a proposal for possible standard extension), not only towards the gbXML community, but also towards all relevant standardisation bodies, including BuildingSMART.

As result of FIEMSER project, several potential products are expected, which could be exploited as an integrated energy management system for residential buildings, the FIEMSER platform, or each component as an independent product:

IPv6 Wireless control network. There is a huge potential to this type of communication networks, because in the near future, homes will be more intelligent and will require flexible and non-intrusive communication platforms which will have to be fully compatible with Internet.

Holistic home energy manager. Latest EU initiatives are evolving towards energy positive buildings in order to reduce C02 emissions and energy costs; building related legislation and building users are becoming more aware about its need. Consequently, a new generation of control systems will be required to coordinate the main energy demand systems in the building (HVAC and lighting) with the local generation (RES and CHPs (Combined Heat and Power)).

- **Multimodal user interface.** Increasingly, all services are becoming more supported by ICTs. The FIEMSER multimodal user interface will open these services to the typical ICT user (used to manage computers), to the mobile users (familiarized with PDAs, smartphones …) and also to the ICT "excluded users", as elderly people or technologically unskilled users, which are much more comfortable with the TV.

TOOL // INTEGRATION // MANAGEMENT

6.38 ENERGY WARDEN - Design and Real Time energy sourcing decisions in buildings

Info: http://buildingwarden.com/energywrdn

ENERGY WARDEN (EW) addresses the optimization of renewable energy technology (RET) deployment in the building domain. EW will develop and market the following products: SIMULATOR (EW-S): A simulator and modeling tool, including dynamic models for energy producing, storing and using units that may provide decision aid when designing or retrofitting energy infrastructures at the building domain. Important to highlight is that the simulator will be run in a short and a long term time frame; that of 1-4 days and that of a year.

The first time-frame will be driven by meteorological forecast data, which have a large level of confidence for this time-frame. The first time frame delivers set points to the EW Controller, whereas the more long term one is more suitable for assessing RET investment scenario. CONTROLLER (EW-C): The controller will be based on an expert system/ neural network approach and will provide real time control of the RET infrastructure. The real time controller will manage how energy is allocated between uses, stores, and possibilities to be fed back to the energy network. The EW-C may also unveil energy use trends, particularly useful for the simulator. In this way, the EW-S and the EW-C form a closed loop. The EW-C will include a data collection module, low cost hardware including sensors and data loggers/ transmitters, which will be deployed at the building over a period of time and facilitate the collection of data.

It is emphasized that emerging wireless protocols will be a key aspect of this data collection, as such systems are particularly important in the case of energy retrofit action, where wired sensors may be impossible or costly to install. POLICY (EW-P): A higher level functionality will support policy conformance and emission trading, allowing monitoring the building performance, old and new, against existing policies or standards, including the EU directive on building energy as well as supporting the capability for use in emission trading calculations. EW will be an open, standard compliant, system, able to support many new, upcoming, supply/ store/ use options that are constantly entering the market.

The EW-Simulator software has the following purposes:

To suggest optimal configurations of Renewable Energy Technology (RET) deployment at a given building

To provide yearly, daily and hourly estimations of the renewable energy that will be captured along any of these configurations

To communicate with the second part of the ENERGYWARDEN tool-set, the EW-Controller (EW-C) and to exchange with it information.

The EW Controller will be able to:

- Get building environment information through different sensors.
- Use the provided information (operational set-points) from the EW Simulator.
- Control and optimize the supply, storing and demand side of all energy infrastructures.

The EW-P serves the following objectives:

- Read energy module and building operational data from the EW-Controller.
- Develop a real time evaluation module of the energy performance.
- Run a number or applications related to policy conformance (building energy footprint, support for emission trading, etc.).
- Develop a real-time emission trading calculation module connected to the network.

INTEGRATION // MANAGEMENT

6.39 MAKE SENSE – Easy Programming of Integrated Wireless Sensor Networks

Info: http://www.project-makesense.eu/

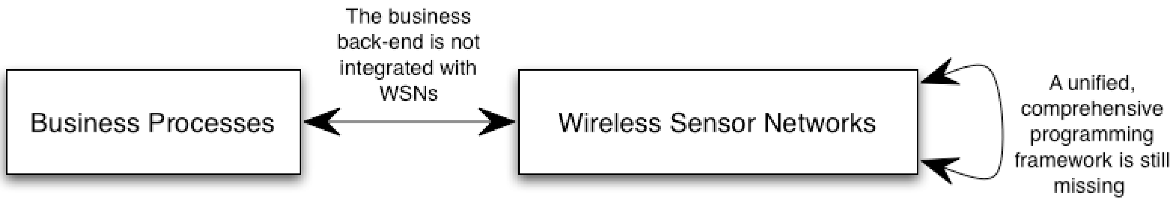
This project aims at simplifying both the programming of wireless sensor networks and their integration with business processes.

Wireless Sensor Networks (WSN) are a key component of the upcoming Internet of Things revolution that will revolve around sm art objects cooperating in an autonomous fashion to achieve a higher level goal(s). However, sensor networks currently are exceedingly difficult to program. Programming is focused on individual sensor nodes, and programmers focus on low-level details rather than high-level objectives.

Make Sense intends to drastically improve the ease of wireless sensor network programming by allowing programmers to express high-level objectives, and leave the low-level details to the compiler and run-time system. The goal is also to enable easy integration with other systems, such as business systems, mainly via the usage of business process modeling.

Make Sense aims at lowering the barrier for adoption of WSNs in real-world applications, notably business processes. In making this vision a reality, the make Sense approach must be sufficiently expressive to specify a range of different business applications, and be easy to use with no need for specialized training for domain-experts.

Today it is notoriously difficult to realize WSN applications. Current programming platforms are low level, typically at the operating system level. The programmer therefore must concentrate on details quite far from the application logic, such as communication protocols, or power management. The programming task is particularly hard in WSNs because of the inherent antagonism between the desired application requirements and the constraints of WSNs: requirements such as high reliability or long lifetime are difficult to realize in the highly dynamic, unreliable, and resource-constrained setting characterizing WSNs. This situation generates a lack of visibility: it is hard to investigate the performance or correctness of WSN processes, since they are typically hard-coded from scratch every time. The research community has tackled these problems, but has not yet solved two fundamental issues: the problems of unification and integration, schematically shown in the figure below



The core contribution of make Sense is a comprehensive macro programming system that enables the integration of WSNs into business processes. The programming platform is supported by a complete tool-chain starting from business processes down to the code running on the individual nodes, including tools to assist the developer in the programming activity and the compiler technology required to bridge the gap between the application and the WSN hardware. At system level, make Sense will leverage an efficient run-time system. Key to its efficiency will be the effectiveness of the distributed protocols implementing the required semantics. The run-time layer will be able to optimize its own behavior towards goals specified by the higher layers and information provided by a novel holistic self-monitoring approach. The results will be evaluated in a real-world, building automation scenario, aiming at reducing energy consumption. We will introduce wireless sensors performing real-time metering of relevant environmental parameter and the current energy consumption of buildings. Make Sense will enable the design and implementation of the required functionality by application domain experts, from the business process level down to the code running on the individual devices.

TECHNOLOGY // TOOL // MANAGEMENT

6.40 IREEN- ICT roadmap for Energy Efficient Neighbourhoods

Info: http://www.ireenproject.eu/about

IREEN is a strategy project which examines the ways that ICT for energy efficient and performance can be extended beyond individual homes and buildings to the wider context of neighborhoods and communities.

The key aim is to extend the notion of energy positive buildings and by extension, districts and neighborhoods. "Energy positive" are buildings / areas being those that have the capacity to generate more energy than they use. This can be achieved in three ways:

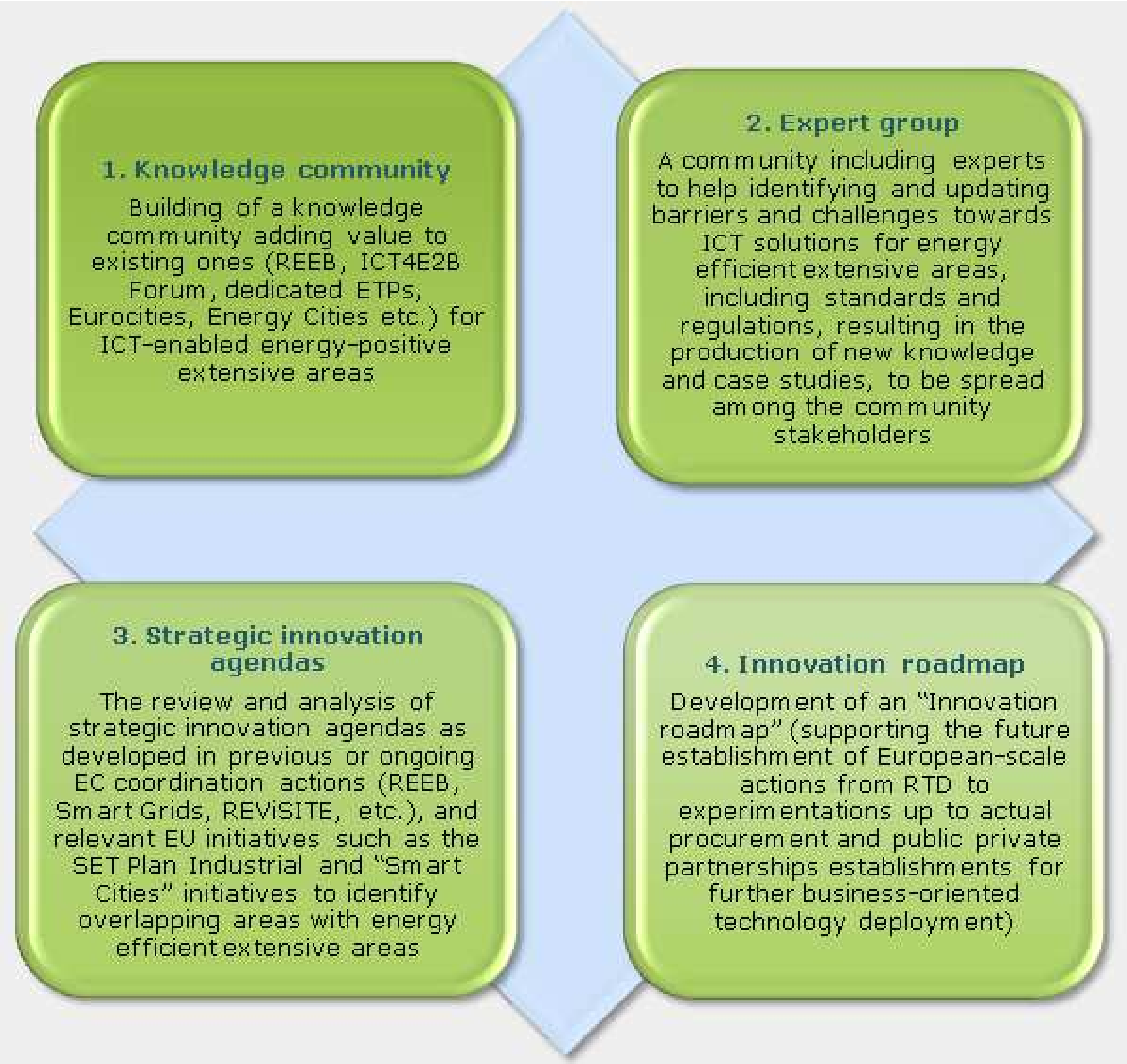
Low energy consumption – less than the energy than they have produced over a given time

Facilitating eco-responsible behaviours

Consuming low energy over their "life cycle" requiring less energy for their construction and less for the use by users/occupants.

Taking the context of current industry social and economic trends and challenges currently facing Europe, the project will engage with a wide range of stakeholders including those from technology, energy, construction, local authorities, building managers and owners.

IREEN aims to engage European and other international experts and stakeholders in discussions and workshops to gather their input in to a strategy and the final output from the project a roadmap. The expertise will be drawn from the energy sector (both providers and distributors); the technology industry including appliance manufacturers, infrastructure and software technologists; the construction sector; stakeholders from the demand side including local and regional authorities. IREEN will also connect to smart cities partnerships across Europe.



TOOLS // MANAGEMENT – BUSINESS MODEL

6.41 E+ – New systems, technologies and operation models based on ICTs for the management of energy positive and proactive neighbourhoods

Info: http://www.eplusproject.eu/index.aspx

The main objective of E+ is to develop a (A) control system for energy management at neighborhood level and its associated new business and operation models. The expected role of ICT tools is to enable (1) large share of distributed RES, (2) massive deployment of EVs and storage systems, (3) customers participation and (4) loads control. This expected role will be demonstrated with the final goal (B) of reducing the energy consumption and the CO_2 emissions at neighborhood level.

A secondary objective is to (C) produce a set of public recommendations for neighborhoods urban planning, addressing the refurbishment of existing neighborhoods as well as new ones. E+ solution is paving the way for (D) achieving

zero-energy balance districts, improve the energy efficiency, minimize the CO2 emissions and reduce the energy tariffs to the end users, enabling the citizens to participate as active energy prosumers.

E+ will develop, implement and validate a new ICT based energy control system at neighborhood level. This energy management system will consider three operation strategies looking for (1) real time instantaneous zero energy balance at neighborhood level for a long term scenario, (2) yearly zero energy balance at neighborhood level for a mid-term scenario and (3) energy infrastructure optimization for a short term scenario. The E+ goals will be based mainly on the energy efficiency side and the CO2 emissions reduction. Depending on the operation strategy considered for the district, different goals values will be achieved.

- The CO2 emissions reduction will be fulfilled mainly by the supply of energy with local renewable resources and the consideration of electric mobility as main driver for future districts.
- The energy efficiency targets will be achieved by the use of energy storage in districts, reduction of energy losses in the power flows due to the proximity of the energy generation to the consumption and the flexibility in the energy flows given the bi-directionality proposed in E+.

Expected results:

- New business models for energy management at district level
- New operation strategies for energy management at district level
- Guidelines and recommendations for energy urban planning, both for districts refurbishment and new districts
- E+ module – hardware and software – for the energy management at district level
- E2+ module – software – for the energy management among districts
- Prototypes to be installed at Malaga and Mons pilot, to assess the energy operation according to the E+ concept
- Comparative analysis between current and new energy operation models
-

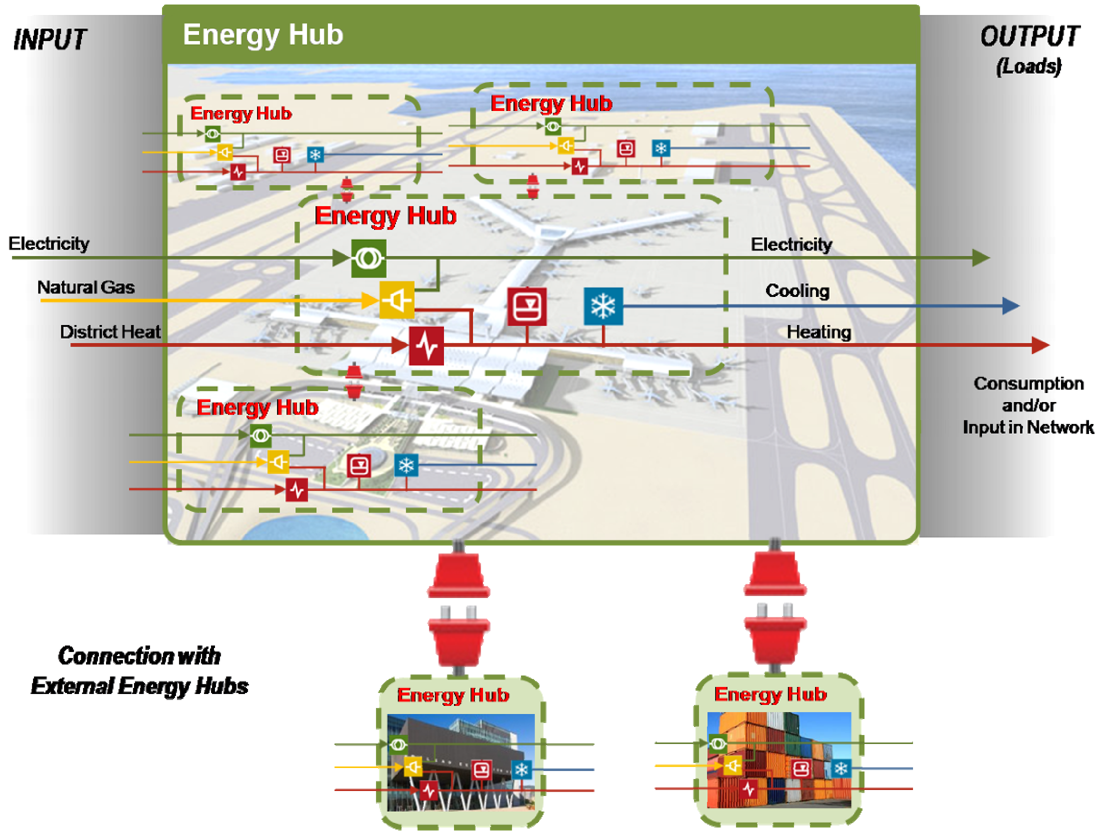
METHOD – TOOL // INTEGRATION // MANAGEMENT – BUSINESS MODEL

6.42 EPIC-HUB – Energy Positive Neighbourhoods Infrastructure Middleware based on Energy-Hub Concept

Info: http://www.epichub.eu/

The goal of EPIC-HUB is to develop a new methodology, an extended architecture and services able to provide improved Energy Performances to Neighborhoods (NBH). By combining powerful Energy-Hub-based Energy Optimization capabilities with seamless integration of pre-existing and new ICT systems, EPIC-HUB will contribute to achieve the global objective of the Energy-positive Neighborhood.

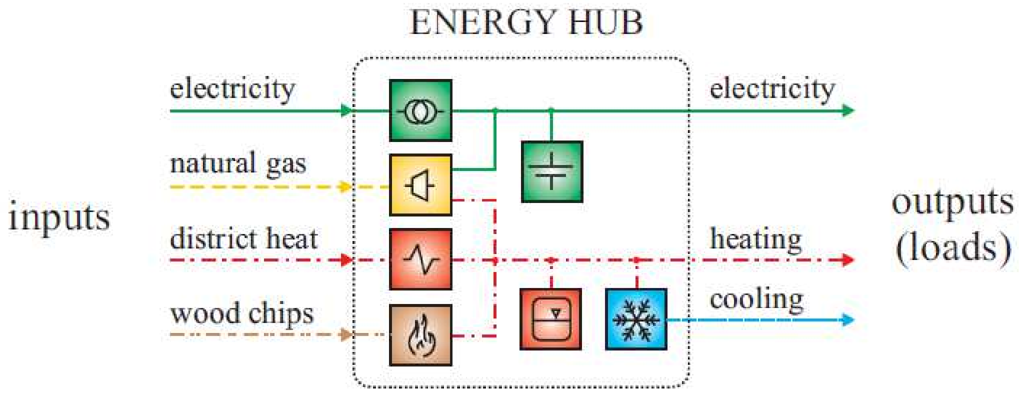
EPIC-HUB covers all the aspects directly or indirectly connected to efficient Energy-based Management, Control and Decision-Support at neighborhood-level, and defines a Fully-Interoperable Middleware solution able to provide integration and a structured vision of the overall infrastructure, friendly usable by all the involved stakeholders (e.g. the energy managers and utilities).



By exploiting the concept of Energy Hub, EPIC-HUB Middleware will focus on energy usage optimization at neighborhood level: EPIC-HUB will define a "neighborhood-aware" energy trading platform that will improve Energy Efficiency and reduce the

energy cost, taking into account Renewable Energy Sources as well as the Electricity Distribution Grid.

From an energy point of view, the EPIC-HUB methodology models the neighborhood as an Energy Hub or an aggregation of different Energy Hubs with their energy sources, storage devices and controllable loads.



Source [1]

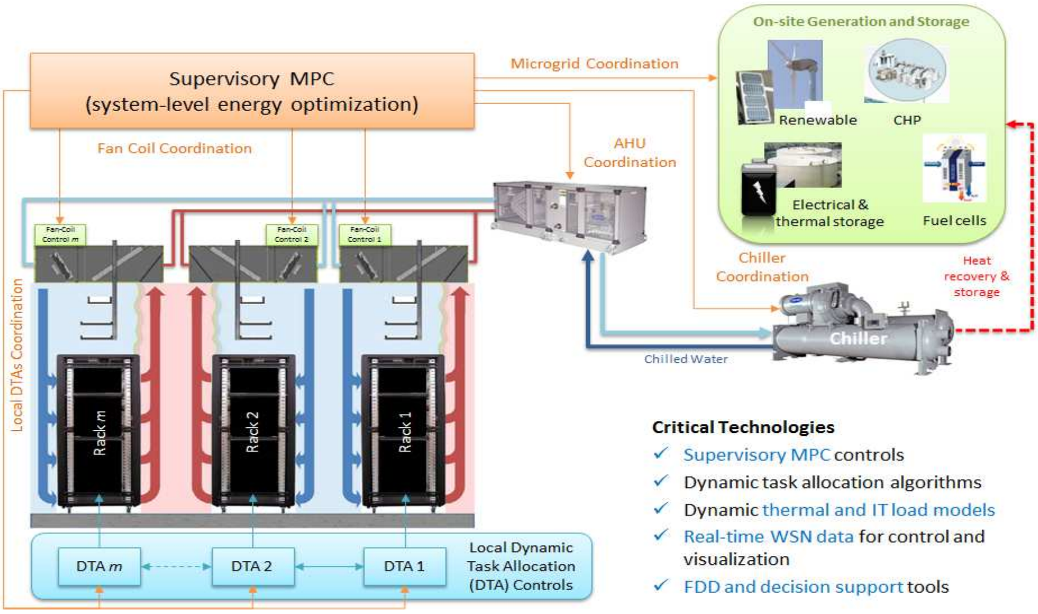
In EPIC-HUB methodological approach, the neighborhood becomes a modular system able to grow up or scale down by adding or removing components and, at the same time, it can easily interact with other neighborhoods and infrastructures extending the concept to interacting Energy Hubs. Furthermore the Interoperable approach of EPIC-HUB Middleware will allow taking into account all ICT systems deployed, able to provide meaningful information and operational constraints to the Energy-Hub Running Model.

METHOD // MANAGEMENT

6.43 GENIC- Globally optimized ENergy efficient data Centres

Info: http://projectgenic.eu/

The fundamental premise of GENiC is that the energy consuming equipment in data centers must be supplemented with sustainable energy generation and storage equipment and operated as a complete system to achieve an optimal energy and emissions outcome. This vision is centered on the application of hierarchical adaptive supervisory control to operate all of the primary data center components in an optimal and coordinated manner, minimizing energy use through: manipulation of local equipment controller set-points to achieve the maximum system efficiency regardless of individual component efficiencies; and provision of optimized control of computing load and cooling distribution to enable operation of servers closer to Service Level Agreement (SLA) and CPU reliability constraints.



Based on the requirements definitions and energy management architecture specification in WP1 GENiC will develop a data center energy management platform that will have open interfaces and a common data format thus facilitating the integration of energy control, workload optimization and monitoring, fault detection and decision support components developed in WP2, WP3, and WP4, respectively into a single platform in WP5. In WP5, the project will also validate the platform to demonstrate substantial energy savings and power usage efficiency (PUE) improvements that can be achieved by integrating cooling and workload management. In WP6, the project will demonstrate the energy savings ability and how this can be enhanced through heat recovery and renewable energy provision to achieve significant carbon usage efficiency (CUE) improvements and demonstrate that it is possible to power data centers with at least 80% renewable energy in a cost-effective manner. The validation and demonstration will be based on a clear evaluation methodology and base line which will be established at the start of the project.

METHOD - TOOLS // INTEGRATION // MANAGEMENT

6.44 e-DIANA.-Embedded systems for energy efficient buildings

Intro: http://s15723044.onlinehome-server.info/artemise/

The eDIANA Platform is a reference model-based architecture, implemented through an open middleware including specifications, design methods, tools, standards, and procedures for platform validation and verification. eDIANA Platform will enable the interoperability of heterogeneous devices at the Cell and MacroCell levels, and it will provide the hook to connect the building as a node in the producer/consumer electrical grid.

Thus, eDIANA will provide a Reference Architecture for a network of composable, interoperable and layered embedded systems that will be instantiated to several physical architectures. The eDIANA Platform realisations will then cope with a variable set of location and building specific constraints, related with parameters such as climate, Cell/MacroCell configuration (one to many, one to one etc), energy regulations etc.

The technology to be developed in eDIANA will improve energy efficiency and optimize buildings energy consumption by 25%, providing real-time measurement, integration and control. Moreover, comfort will be improved, making the user aware and enabling user-controlled policies for household devices (lighting, domestic electronics, etc.).

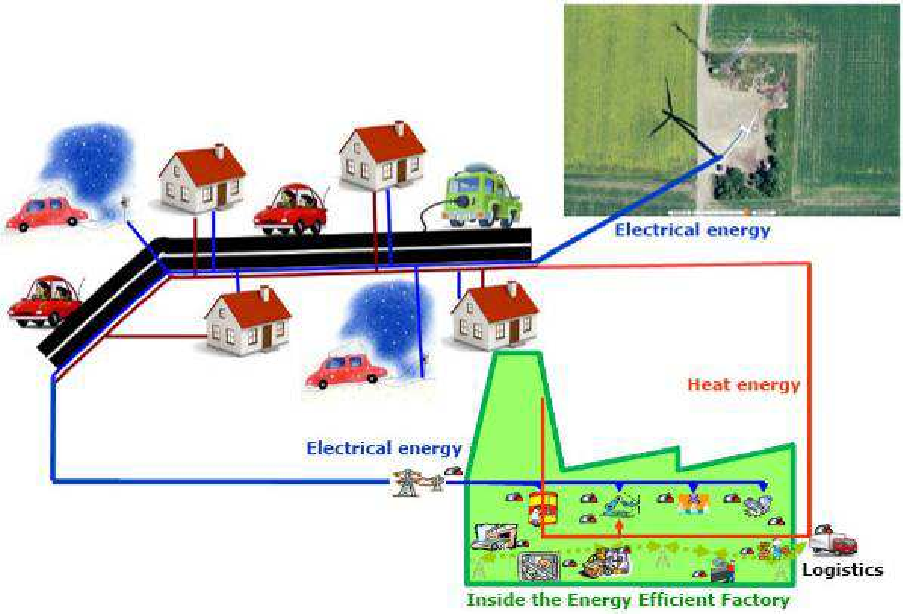
Such progress beyond the state of the art will enable the building to become an "active macroCell" in the energy network, connected to similar macroCells in a district or urban area.

METHOD - TOOLS // INTEGRATION // MANAGEMENT

6.45 ARROWHEAD- Innovation Pilots

Info: http://www.arrowhead.eu/

Arrowhead is addressing efficiency and flexibility at the global scale by means of collaborative automation for five application verticals. That means production (manufacturing, process, energy) smart buildings and infrastructures, electro-mobility and virtual market of energy.



The vision is to enable collaborative automation by networked embedded devices. The grand challenges are enabling the interoperability and integrability of services provided by almost any device.

We assume that a service-based approach will be the feasible technology that enables collaborative automation in an open-network environment connecting many embedded devices.

The success of Arrowhead technology depends not only on the technology but also on the capability to create and pursue innovations supported by the core of our technology. If successful the approach is expected to strongly contribute to very significant reduction, 75 % or more, in the design and engineering efforts for the predicted multi-billion networked devices.

The objective of the Arrowhead project is to address the technical and applicative challenges associated to cooperative automation:

- Provide a technical framework adapted in terms of functions and performances
- Propose solutions for integration with legacy systems
- Implement and evaluate the cooperative automation through real experimentations in applicative domains: electro-mobility, smart buildings, infrastructures and smart cities, industrial production, energy production and energy virtual market
- Point out the accessible innovations thanks to new services
- Lead the way to further standardization work

The strategy adopted in the project has four major dimensions:

- An innovation strategy based on business and technology gap analysis paired with a market implementation strategy based on end users priorities and long term technology strategies
- Application pilots where technology demonstrations in real working environments will be made
- A technology framework enabling collaborative automation and closing innovation critical technology gaps
- An innovation coordination methodology for complex innovation “orchestration”

METHOD – TOOLS // INTEGRATION // MANAGEMENT

6.46 ACCUS- Adaptive Cooperative Control in Urban (sub) Systems

Info; http://projectaccus.eu/

The ACCUS (Adaptive Cooperative Control in Urban (sub) Sytems) is an ambitious Project meant to achieve a better sustainable management and to engage synergies in order to improve citizens' quality of life.

It is motivated by the societal challenge "Smart buildings and communities in the future" and the supporting scenarios "Mobility for everyone", "Energy control in the urban and rural environment" and "Security" as defined in the ARTEMISIA Strategic Research Agenda (SRA).

The ACCUS project is focused on the integration of urban subsystems such an intelligent transport systems, city light systems and energy management systems. Rather than developing solutions for specific applications and scenarios, the ACCUS project will develop theoretical framework (e.g. semantic interoperability concepts) and practical framework (e.g. methodology, reference architecture) to design new applications within converged scenarios.

Urban systems like traffic, energy, and outdoor lighting are managed by self-contained embedded systems - though the managed processes are deeply interconnected. New applications and collective optimization require integration of these systems which represents a truly "systems of systems" integration problem: these urban systems evolve independently, have their own purpose and internal policies which must not be affected by such integration and have their own management. As a result, the integration has to manage emergent behavior and take non-availability of components as the norm rather than the exception. This is particularly challenging when control loop span across several systems.

ACCUS aims at three innovations:

1. Provide an integration and coordination platform for urban systems to build applications across urban systems
2. Provide adaptive and cooperative control architecture and corresponding algorithms for urban subsystems in order to optimize their combined performance
3. Provide general methodologies and tools for creating real-time collaborative applications for systems of systems

METHOD – TOOLS // INTEGRATION // MANAGEMENT

6.47 LIVING-LAB-Design study for a living Lab Reseach Infrastructure for Energy Efficiency in buildings

Info: http://www.livinglabproject.org

LIVING LAB is a research and development infrastructure to research human interaction with, and stimulate the adoption of, sustainable, smart and healthy innovations around the home. Occupant interaction with the home can be studied in an adaptable and controllable home environment.

This way the technical development, the implementation and the social uptake of sustainable innovations can be accelerated.

LIVING LAB brings together Europe's top research institutes and companies and aims to stimulate cooperative projects in the fields of user centered research and product development.

LIVING LAB's general goal is to address environmentally critical forms of consumption and to contribute to the realization of sustainable households in Europe. In particular, we want to stimulate the mass-deployment of:

- Energy-efficient techniques and products for the home;
- Domestic products and techniques that use renewable energy sources;
- Water-saving techniques and products for the home.

TECHNOLOGIES // INTEGRATION

6.48 H2HOME – Development of a novel compact multi fuel steam reforming device integrated into a cost effective fuel cell micro combined heat and power generation system for residential building application

Info: http://www.ist-world.org/ProjectDetails.aspx?ProjectId=ceb5d647687d4267b2602f610db1e56b

The construction sector represents a strategically important sector for the European Union employing in 2005 13.8 million people, SMEs are indeed the major force of the construction sector representing 99% of such industry. The EU Building Sector is a major energy consumer (more than 40% of the total energy consumed in the EU is used to cover the needs for heating, cooling and electricity). According to Directive 2006/32/EC in the community there is a need for improved energy end-use efficiency

and according to Directive 2002/91/EC on energy performance of buildings need to be certified. In this scenario, our idea is to develop a 30kW micro CHP system able to provide heat and power for a more efficient energy end-use in buildings. The main objective of H2OME is to introduce the novel concept of a Polymeric Electrolyte Membrane (PEM) Fuel Cell based CHP system able to satisfy both the thermal (heating and sanitary water), cooling and electrical power need of the whole building replacing the small methane boiler installed in the single flats as well as old-fashioned centralized oil thermal plant used in the 60s. In order to achieve the above overall objective the following innovations need to be developed: *compact and high efficiency steam reformer able to operate with methane, methanol and bio-gas* composite catalyst compound promoting water gas shift reaction with a temperature of about 300°C and able to operate with an hydrogen rich mixture without any CH_4 formation * a novel thermal spraying-based manufacturing process for the production of the helicoidally shaped structure made by a metallic mesh coated with a ceramic porous coating catalytic layer. As a consequence of the new directives, it is estimated that 10 million boilers in European homes more than 20 years old need to be replaced and considering an initial market penetration of 2% in 5 years of the project the potential market is about 600 M.

INTEGRATION // MANAGEMENT

6.49 ICT4SMARTDG - Thematic Network on ICT solutions to enable smart distributed generation

Info: http://www.ict4smartdg.eutc.org/

The general objective of this Thematic Network (TN) is to foster and promote large-scale integration of domestic and distributed micro generation and promote improvements in energy efficiency through the implementation of innovative ICT solutions into local smart power grids.

The TN will bring together key relevant players in the telecommunications and energy sector. They will overview and provide insight of existing and new innovative ICT technologies available for smart distributed generation at domestic level, forecast steps forward that can promote large-scale implementation, identify best technical solutions available, non-technical barriers, as well as to promote all TN results and conclusions as key elements to boost deployment.

Specific Objectives:

- Build and expand an European forum for stakeholders for experience and information exchange and consensus building
- Overview and provide insight of ICT technologies available for smart distributed generation at domestic level
- Bridge knowledge gaps by interacting with key ICT, Power Generation, Distribution System Operators and the Telecoms Operators and Solutions Providers
- Identify and promote benefits of ICT-based solutions available in the short to medium term (2009 - 2015)
- Forecast steps forward to promote large-scale implementation of ICT based solutions
- Identify inhibitors to large scale implementation and make targeted recommendations to overcome them.
- Disseminating results to specific targeted audiences i.e., policy makers, ICT community and energy industry and increase awareness of general public.

METHOD- TOOL // MANAGEMENT

6.50 HOSPILOT- Intelligent Energy Efficiency in Hospitals

Info: http://www.hospilot.eu/

A decision support software tool for hospital managers: getting the best advice for newly built and refurbishing hospitals.

With advanced capabilities embedded, while at the same time easy to use, the HosPilot Tool is designed for the technical advisor or facility manager of a hospital. The essence of HosPilot is to capture the expertise of Lighting and HVAC consultants to provide decision support for energy efficiency refurbishing strategies.

Improve your hospital building

Learn how to save energy

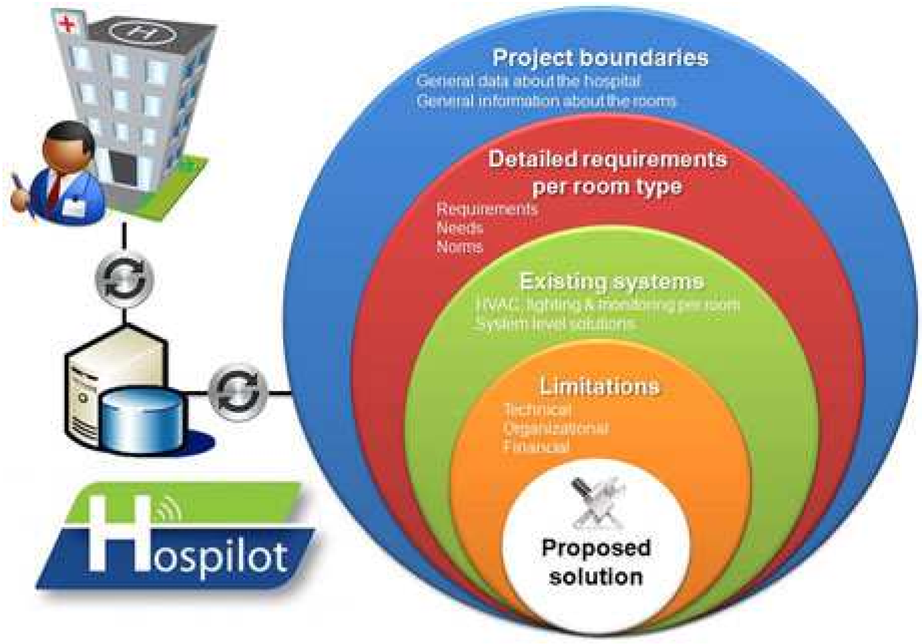
Save money & make smart investment

Adaptable for all European countries

Cross-Browser compatibility

Reliable algorithms

HosPilot implements reliable and well-proven algorithms inspired by building simulation softwares.



TECHNOLOGIES // METHOD - TOOL // MANAGEMENT

6.51 E3SoHo - ICT services for Energy Efficiency in European Social Housing

Info: http://www.e3soho.eu/

The overall objective of E3SoHo project is to implement and demonstrate in 3 Social Housing pilots an integrated and replicable ICT-based solution which aims to bring about a significant reduction of 25% of energy consumption in European social housing by providing tenants with feedback on consumption and offering personalized advice for improving their energy efficiency, reducing the energy consumption and increasing the share of RES (Renewable Energy Sources) by informing and supporting the user to decide for the most appropriate behavior in terms of energy efficiency, cost, comfort and environmental impact, monitoring and transmitting consumption data to Energy Services.

Companies which could enable real time energy audits in order to perform more accurate refurbishment activities as well as maintenance operations. The proposed service offers a holistic solution that provides advice on how to reduce energy consumption, the installation of the system accordingly, and the monitoring and tuning of energy the consumption. The proposed service will tailor, install and tune an ICT based system that will significantly reduce the energy consumption and will enable an improved management of energy production systems already installed in the building.

Therefore, the E3SoHo service is built up of the following sub-services that can be provided separately:

- Perform an audit in the building to identify the energy saving potential.
- Provide the owner with an ICT based blue-print to reduce the energy consumption.
- Implement the system according to the blue-print
- Tuning of energy consumption by monitoring
- Maintenance of the installed system.

This service will be disseminated to the open market, so the total service can be exploited as one package by the consortium and/ or other organizations, e.g. SMEs, consultancy agencies specialized in energy efficiency.

TECHNOLOGIES // METHOD - TOOL // MANAGEMENT

6.52 Showe-It - Real life trial in social housing of water and energy efficient ICT services

Info: http://showe-it.eu/

The SHOWE-IT project is an international initiative that is co-funded by the EC which aims to reduce energy and water consumption in social housing. This project should prove the impact that ICT solutions can make in saving energy and water. Hence to create a solution that can be replicated easily and that will be attractive and accepted on a large scale across Europe. To make the results of the project financially viable we expect to need savings of around 20% in consumption.

The objective of the SHOWE-IT project is to demonstrate, under real conditions, how advanced ICT components and systems can enable services that help reduce energy and water consumption in social housing across Europe. To achieve this, the project takes a demand-driven approach, prioritising as starting point an affordable investment per dwelling for Social Housing associations, and putting in place a „menu" of cost-effective, integrated and easy replicable ICT-based services that significantly reduce energy and water consumption in social housing while improving quality of life. The project expects to achieve an overall energy and water consumption reduction of between15% and 25% (note strong variations between pilot sites, between seasons and between actual calendar year); more concretely we have the following objectives (which will be delivered within the project):

- Diagnose in very detailed levels the actual consumption patterns of energy and water, going beyond the consumption as a single household figure, entering into the level of typical behaviours or behavioural patterns that result in avoidable energy or water consumption.
- Through qualitative and quantitative interviews, deepen our insights into the social and psychological aspects of changing water and energy consumption patterns and the interaction that ICT enabled services can have.
- Demonstrate with statistical relevance the socio-economic viability of the ICT-services proposed by providing social housing landlords with smart funding models and engaging the end-users (tenants and managers) in the different stages of the project.

- Install and manage affordable ICT-based energy and water saving systems and services adapted to the energy and water consumption profiles of the tenants in 211 dwellings distributed across the three pilots.
- Monitor for duration of at least 12 months the 211 service-provisioned dwellings and a control group of 120 dwellings across the three pilots and provide both groups with equivalent guidance on how to attain energy and water savings.
- Assess how ICT enabled services can change the behaviour of tenants and building managers leading to a reduction in energy and water consumption by comparing the service provisioned dwellings / households with those in the control groups.
- Create business case calculation templates, showcase documentation, technological and methodological descriptions (blueprints and best practices) made available online and offline to facilitate replication on several levels: inside the consortium's social housing associations partners stock, inside a mirror group stock, and ultimately towards any social housing entity in Europe.

METHOD – TOOLS // INTEGRATION // MANAGEMENT

6.53 EDEA-RENOV – Development of Energy Efficiency in Architecture: Energy Renovation, Innovation and ICT's

Info: http://www.renov.proyectoedea.com/en/content/edea-renov-project

EDEA-RENOV is a project of Regional Ministry of Infrastructure, Housing, Urban Planning and Tourism of Government of Extremadura, financed by LIFE+09 programme. The main objectives of EDEA-RENOV are pointed over a new need focused on existing buildings that should be renovated and on which it is not viable to apply the same technology than new ones. So EDEA-RENOV to achieve their new goals will use three ways: Renovation, Innovation and Communication Technologies and Information (ICT).

ANNEX . PRESENTATIONS FOR THE DESCRIBED TECHNOLOGIES

An Annex to this report includes all the PowerPoint presentations that have been prepared by TECNALIA, ATAF, and CSE for the selected technologies described. Those presentations are intended to be used for discussion and knowledge exchange activities with the different stakeholders involved in smart city planning.