POLYCITY - TORINO / ITALY: POLYGENERATION AND ENERGY MANAGEMENT FOR A CITY DISTRICT

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OVERVIEW OF THE POLYCITY PROJECT IN TORINO

POLYCITY[1] in Torino is a project aimed at requalifying and improving the energy efficiency of a whole district, named Arquata and located near the centre of the city.

The project is coordinated by Centro Ricerche Fiat (hereinafter CRF), in partnership with the relevant local stakeholders, such as the Municipality of Torino, the Housing Authority of the Province of Torino (Agenzia Territoriale per la Casa, hereinafter ATC), the Municipal Utility for Energy Distribution and Sale (AEM) and the Politecnico of Torino.

Arquata is a densely populated district, owned and managed by ATC, that covers an area of nearly 87500 m2.

It is constituted by 30 large council buildings (total 758 dwellings), built at the beginning of the 20th century, and by a 10 storey commercial building, built in the 1970's, where the main premise of ATC is located.

[1] The project in Torino is part of the Integrated Project POLYCITY, co-funded by the European Commission within the CONCERTO Call of the VI Framework Program.
POLYCITY is aimed at the realization and demonstration of three high efficiency communities in Germany, Spain and Italy, based on the rational use of energy and on renewable energy.

The population involved is between 2500 and 2600 persons, of which 2200÷2300 are inhabitants of the council buildings and nearly 300 are employees of ATC.

The project POLYCITY aims at improving the energetic efficiency, the environmental sustainability and the quality of life of the district.

The energy related measures foreseen regard the supply side, the demand side and the integration of supply and demand.

They include, in particular, a district heating network supplied by a cogeneration system operated on natural gas, an extensive integration of photovoltaic in the buildings (one of the largest photovoltaic capacity installed in Italy in urban areas) and several measures to reduce the buildings energy consumption such as improved insulation and utilisation of low emitting glazing.

The most innovative measure is the realisation of the Integrated Energy Manager that has been named I-CEMS (Italian Communal Energy Mgmt System).

It is an automated control system that will enable the energy management of the entire Arquata district, through the local integration of supply and demand.

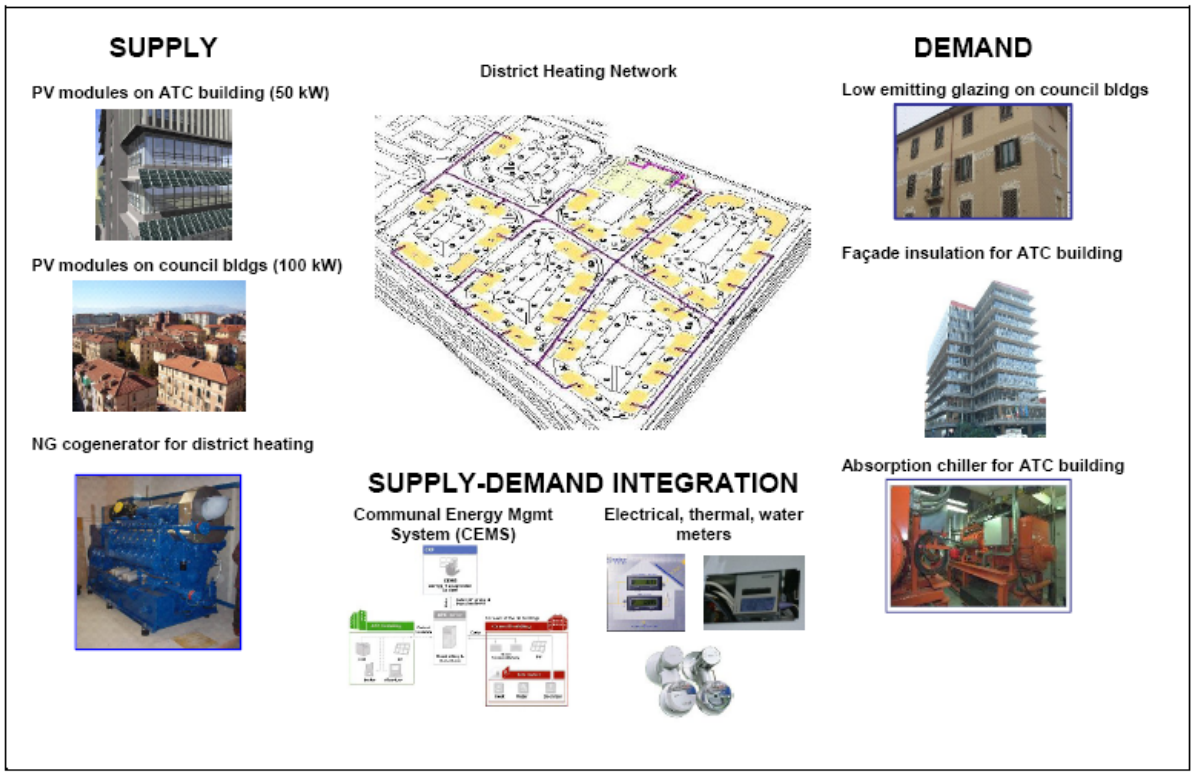

Figure 1. POLYCITY measures

Another relevant innovation of the project regards the socio-economic accompanying activities. A user centred approach has been applied in the different implementation phases of the project (design, realisation, training, monitoring) in order to involve at every stage all the stakeholders that are relevant in the value chain.

In particular a representative sample of inhabitants was involved (nearly 100 families)in order to provide a communication support aimed at ensuring the most effective use of the innovative systems, to save energy and reduce costs.

The social indications collected from interviewing the district inhabitants will be elaborated to become subjective performance indicators. They will be used during the project POLYCITY, together with more objective performance indicators, as part of a monitoring process, aimed at assessing the impact and added value achieved.

DEMAND SIDE MEASURES

The requalification project introduced new services in the district (space heating[2], sanitary hot water, increased lighting in the roads and in courtyards), some of which imply an additional energy demand in the council buildings.

Appropriate countermeasures on energy demand and supply were studied in order to improve energy efficiency.

In the council buildings the following measures were introduced:

- extra thermal insulation (mainly under the roof);
- low emitting glazing;
- high efficiency lighting in the courtyards.

The selection of the measures was strongly influenced by the constraints that apply on the Arquata buildings, especially on the facades, due to their historical and architectural value.

In addition, due to the characteristics of council housing, a very careful cost/benefit evaluation of the measures was necessary, because return of additional investment costs could not simply be achieved by increasing the rent.

Based on building simulation a final space heating demand of 90 kWh/m^2/yr, (-8%) and a final electrical energy demand of 17 kWh/m^2/yr have been estimated.

The reduction in electrical energy demand is substantial, but difficult to estimate due to the presence in the previous situation of many different individual electrical boilers in the apartments.

In the ATC building the following measures were introduced:

- low emitting glazing;

[2]Before the requalification space heating or sanitary hot water were lacking or produced by inefficient small electrical and fossil fuelled boilers.

- solar shading system (integrated with the photovoltaic);
- insulation of thermal bridges;
- high efficiency lighting.

Based on building simulation a final space heating demand of 56,6 kWh/m2/yr (-25%), a space cooling demand of 20 kWh/m2/yr (-25%) and a final electrical energy demand of 58,4 kWh/m2/yr (-10%) have been estimated.

SUPPLY SIDE MEASURES

As part of the requalification process, a district heating network operated by natural gas boilers was installed in Arquata since 2005, designed to supply space heating and sanitary hot water to the council buildings and to the ATC building.

In such a context, the POLYCITY project studied the installation of local poly-generation capacity, aiming at introducing a significant share of renewable energy and at increasing the efficiency of the above mentioned district heating network.

The following measures were then introduced:

- installation of photovoltaic mono-christalline modules on the roofs of 16 council buildings for a total capacity of 100 kWp;
- installation of photovoltaic mono-christalline modules on the NE and NW facades of the ATC building for a total capacity of 50 kWp;
- installation of gas fired cogeneration to supply the bulk of the district heating service, for an installed capacity of 970 kWe and 1166 kWt;
- modification of a pre-existing gas fired absorption chiller and integration with the low temperature waste heat from the cogenerator, for an installed cooling capacity of 234 kWf (estimated COP=0,5).

Based on simulations the following productions have been estimated:

- cogeneration electrical energy: 4123 MWh/yr (4250 service hours)
- cogeneration thermal energy: 4956 MWh/yr (4250 service hours)

- photovoltaic: 158 MWh/yr

MEASURES FOR THE DEMAND-SUPPLY INTEGRATION

The integration of demand and supply is expected to play a relevant role for the overall sustainability of the POLYCITY measures.

In fact the POLYCITY measures were studied aiming at the following objectives:

- to increase energy efficiency by managing demand response on a local base;
- to increase profitability of energy services by managing demand response on a local base;
- to provide the monitoring service suitable to support information actions aimed at favouring more rational consumption behaviours by the inhabitants.

In particular the backbone of demand-supply integration is the Integrated Energy Manager, that has been named I-CEMS (Italian Communal Energy Mgmt System), the most innovative measure to be realised in POLYCITY.

It is constituted by:

- an infrastructure with wireless communication suitable to control all the nodes within Arquata where energy quantities are produced and consumed;
- an automated control system suitable to perform the energy management of the entire Arquata district.

The features of the I-CEMS include:

- monitoring all energy flows inside Arquata and at the interfaces with the distribution grid (installation of more than 1800 digital meters);
- planning the production of the local plants based on predictive models (demand profiles, market prices, service full costs);

- optimising management in real time (profitability, efficiency, service quality and security…) using model based strategies;
- providing advanced diagnostics and maintenance.

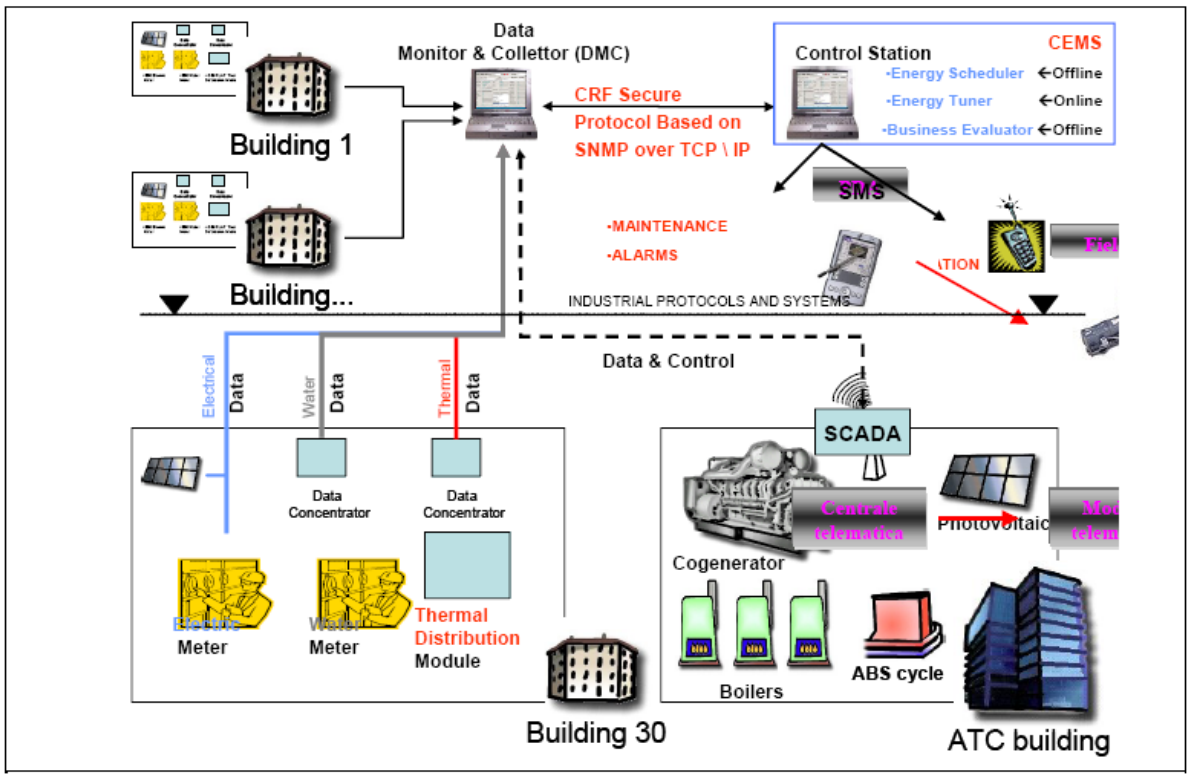

Figure 2. I-CEMS Functional Architecture

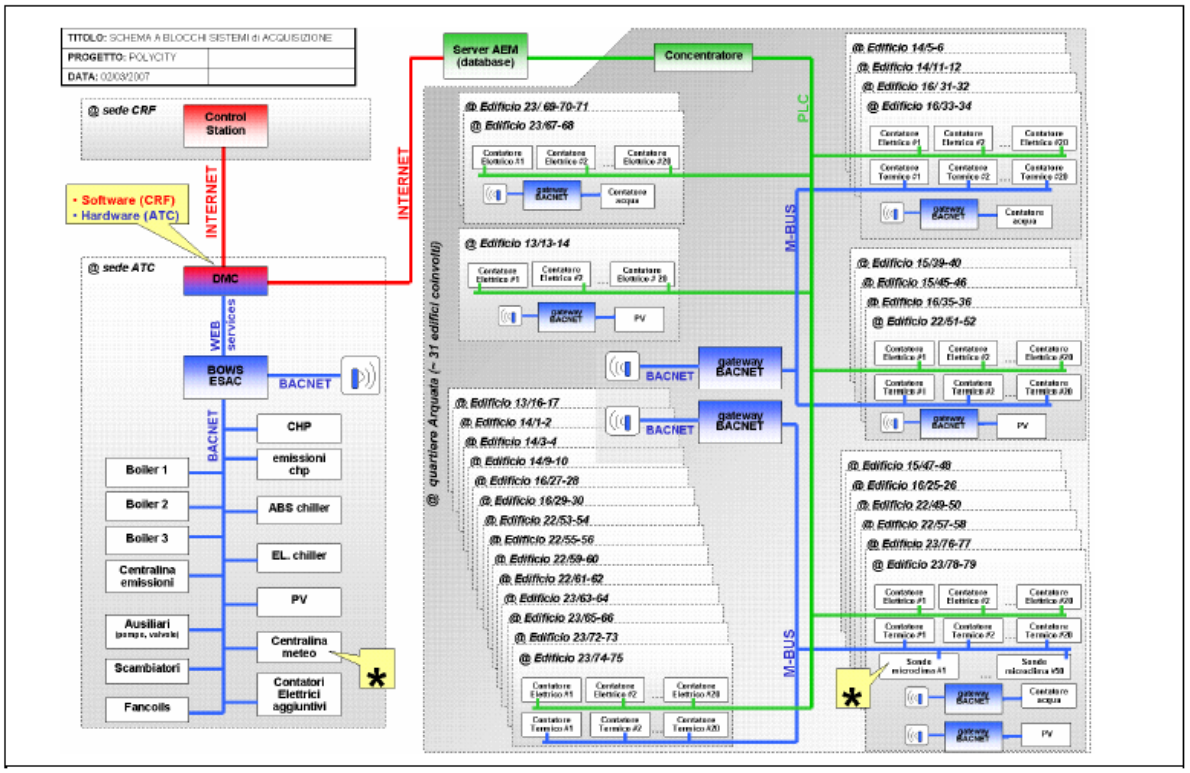

Figure 3. I-CEMS Physical Architecture

In order to increase profitability of the energy service, the excess electricity produced by the co-generation plant will be provided to the distribution grid.

A feasibility study will be carried out regarding the possible implementation of a micro-grid inside Arquata, a physically independent and integrated energy system for the entire district, basically self-sufficient in terms of energy production and optimised in terms of energy management.

Such demonstration project constitutes a unique experience of this kind in Italy and, probably, in Europe due to its characteristics and size (territorial extension, people involved, energy quantities monitored).

Two of the POLYCITY partners, namely ATC (the real estate owner of Arquata) and AEM (the municipal utility) are more directly interested in the practical outcome of the research, in particular in assessing the following:

- benefits for the real estate owner and for the municipal energy system (environmental impact, peak management, distribution costs,...) deriving from managing the demand response on a local base;
- profitability of outsourcing the integrated energy services to an energy service company
- feasibility and profitability of implementing a micro-grid in the Arquata district.

The I-CEMS will be developed by CRF with the support from Politecnico di Torino, by customising technologies developed for automotive applications.

STATE OF IMPLEMENTATION

The POLYCITY project in Arquata started in May 2005 and will last for five years.

At the time being (September 2007) all the measures are in the realisation phase.

The cogeneration plant has already been installed and tested. It is expected to be fully operational for the space heating service in 2007.

High efficiency lighting in the district courtyards are already in place.

SYSTEM ANALYSIS AND EXPECTED BENEFITS

The impact of the measures foreseen in POLYCITY has been estimated, based on:

- historical data for the energy consumptions;
- building simulations to estimate efficiency after the measures;
- estimates of the poly-generation plant productions.

The impact has been evaluated in two steps in order to determine the incremental contribution to the final energy efficiency:

1. introduction of supply side measures (cogeneration + PV);
2. As 1 + introduction of demand side measures.

The final energy balance for the district (step 2) is illustrated in Fig.4.

The expected saving in primary energy is 7633 MWh/yr (-42%). Step1 accounts for 6435 MWh/yr (-36%).

The expected reduction in CO2 emissions is 1964 tCO2/yr (-52%). Step1 accounts for 1713 MWh/yr (-45%).

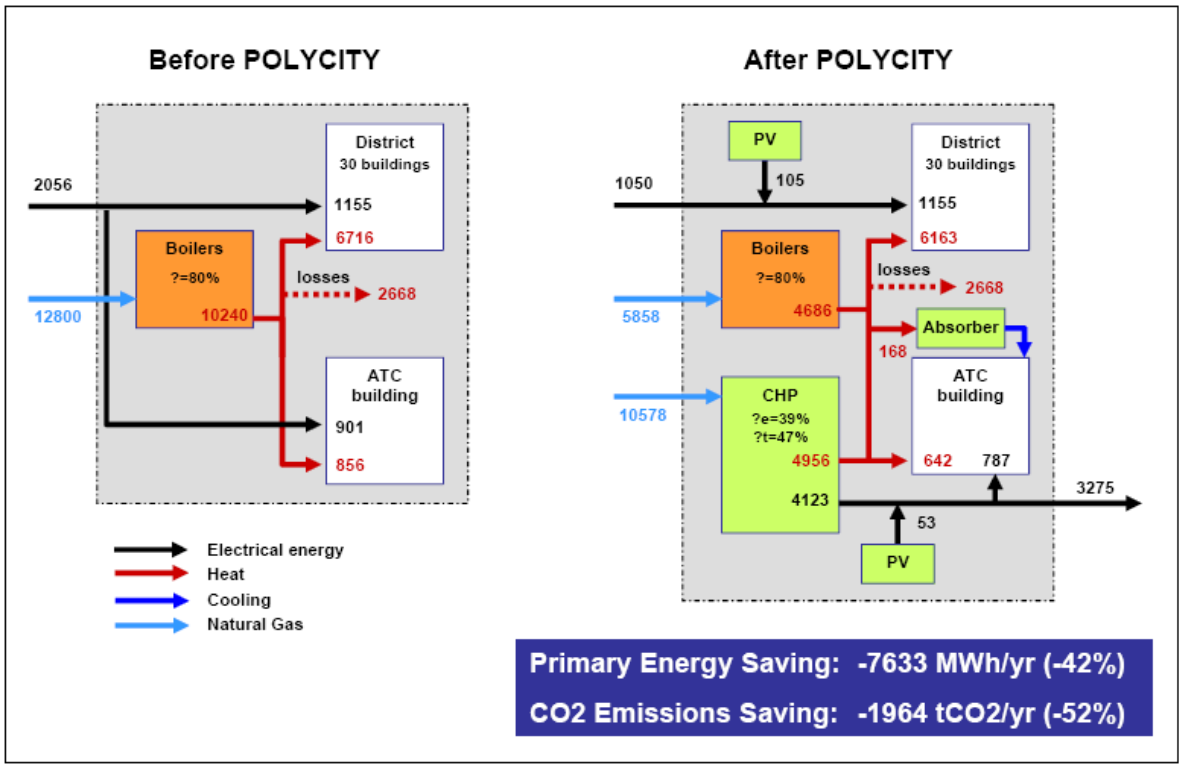

Figure 4. Energy Balance of the Arquata District

COST/BENEFIT CONSIDERATIONS

The implementation of the measures foreseen in the POLYCITY project implies a total expense of 8’164 M€, 16% of which is funded by the European Commission.

Such investment is expected to produce economic and social benefits at different levels such as the following:

- saving in the annual energy costs (electrical and thermal) between 30% and 40% with respect to the initial situation;
- value increase of the real estate due to the efficiency measures implemented
- saving of primary energy and CO2 emissions;
- improved quality of life for the inhabitants by the increase in the services (space heating, sanitary hot water, better illumination,…);
- diffusion of a more energy saving oriented culture.

LESSONS LEARNED

After more than two years since the beginning of the project and after completion of the design and call for tender phases different barriers have been experienced by the partners.

Some possible lessons on how to deal with are indicated in the following table.

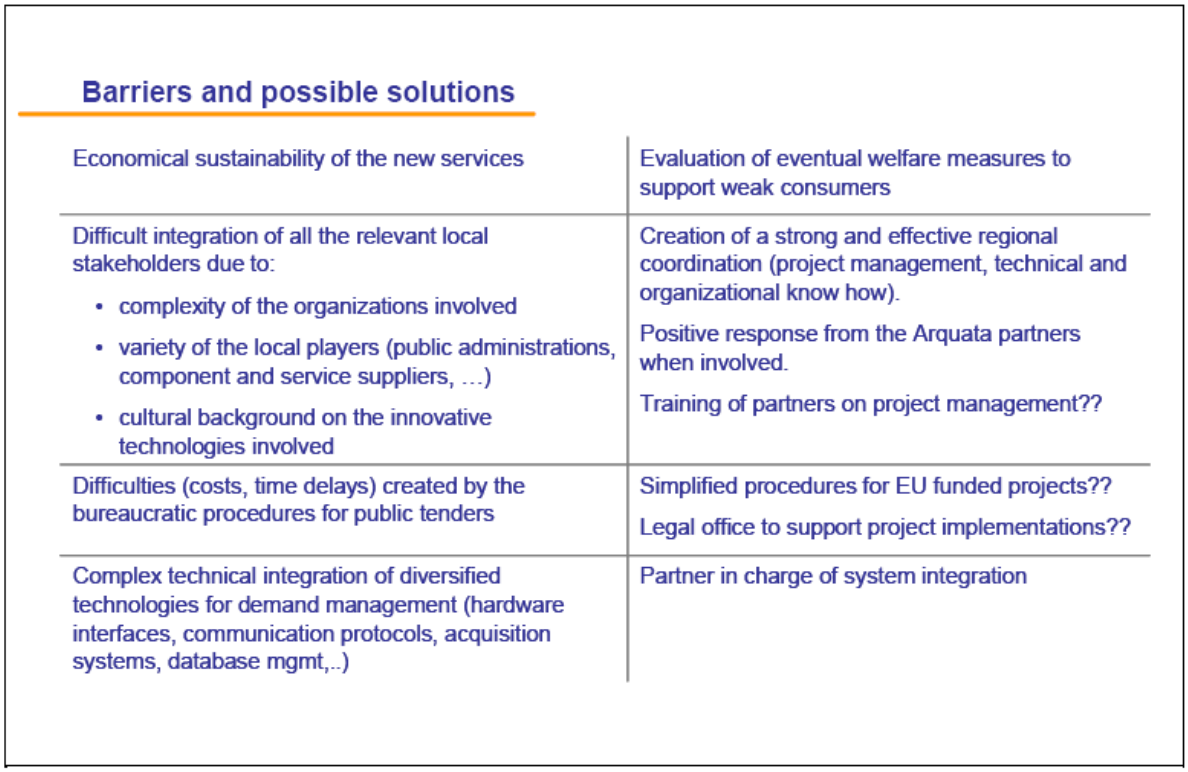

Figure 5. Barriers and possible solutions

REFERENCES

[1] POLYCITY, Technical Annex

[2] Deliverable DR 2.1b “Report on benefits of energy supplies and consumption in the CONCERTO communities”, May 2007

[3] Deliverable DR 2.1a “Report on methodology for energy performance assessment in the CONCERTO communities”, May 2007

[4] Deliverable DR 2.2 “Intermediate report on energy planning models for site performance analysis”, December 2006

[5] Deliverable D 3.2 “Report on communal energy management system specifications”, May 2006

[6] Deliverable D 3.3 “Specifications of energy planning models”, December 2006