PROJECT 4

R(UE)²

RATIONAL AND SUSTAINABLE USE OF ENERGY IN URBAN ENVIRONMENTS

project 4

Analysis of different energetic scenarios in urban areas based on cogeneration and trigeneration technologies

PRINCIPAL ACADEMIC TUTOR

Aldo Canova
Electrical Engineering, Politecnico di Torino

ACADEMIC TUTORS

Giuseppe Genon
Geo-resources and Land, Politecnico di Torino

Giambattista Gruosso
Electronics and Information, Politecnico di Milano

EXTERNAL INSTITUTIONS

Cogenpower
Borgaro Torinese

Arpa Lombardia
Milano

EXTERNAL TUTORS

Silvana Angius
Arpa Lombardia

Francesco Vallone
Cogenpower

TEAM A

Arturo Petrozza [Team controller]
Management, Economics and Industrial Engineering

Ivan Collino
Environmental and Land Planning Engineering

Davide Colzani
Energy Engineering

Mariachiara Guerra
Architecture for Restoration and Preservation of Architectural and Environmental Heritage

Rocco Mastrandrea
Aerospace Engineering

Giulio Sovran
Architecture

TEAM B

Alfino Di Stasi [Team controller]
Management, Economics and Industrial Engineering

Giuseppe Gazzilli
Aerospace Engineering

Guiguie Josiane Koueguem Kouam
Computer Engineering

Paolo Magri
Architecture

Ilaria Tomat
[Project Communication Coordinator]
Communication

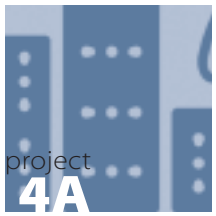
PROJECT DESCRIPTION

The R(UE)² project's aim is to outline the dynamics related to the gradual introduction of a more rational use of energy in urban settings. Complex contexts must be considered as a whole, because several implications, from environmental to social ones, play a fundamental role. In particular, the teams analyzed the current state-of-the-art of the cogeneration and trigeneration technologies application as one of the possible tools suitable to reduce the waste of primary energies. The teams dealt with all the technical, social and economical issues involved in this kind of dynamics, and tried to give answers regarding the effectiveness of this innovative processes, their weaknesses and strengths. The teams put forward also new solutions which could be valuable options for the private as well as the public institutions taking part in the project.
The project was developed following two different approaches. The first consisted in the analysis of an urban site, the Arquata District in Torino, which was selected as a benchmark of energetic requalification with the innovative system of an existing housing estate. The second was chosen to provide a general framework of the developing scenarios of the ESCO companies within the Italian context.

Team A was mainly involved in the analysis of the following aspects: the plant – consisting in the cogenerator and the network for the district heating –, the environmental impacts of the plant, the energetic performances of the buildings envelopes and the project communication to residents and institutions. The technical aspects regarding the plant components and their energetic and environmental performances involved the engineers of the team while the building energy efficiency and communication plan were analyzed by the architects.

Team B worked mainly on the following aspects: energy savings, people's awareness of the sustainable energy issue and of the role of the ESCO as innovator in proposing energy solutions. After having carried out a thoroughful analysis of the context, new scenarios for ESCO development and growth were examined. Particular attention was given to the exploration of the potential of new energy services based not only on high efficiency generation but also on passive solutions for energy saving (e.g. improvement of building energy efficiency). Finally, the environmental aspects related to the ESCO generation model based on distributed generation were studied. The previously mentioned topics required a team including engineering, management, environmental and communication experts.

The most important results of the R(UE)² project come from the proposed integral approach to the complex reduction of energy consumption problem without dramatic changes of life habits. The solution was to be found in collaboration with new energy actors like ESCO and the organizations involved in the environmental protection (ARPA) that are interested in energy efficiency. The project teams analysed real situations and their work may contribute to the implementation of such procedures in other territorial applications.



project
4A

The R(UE)² challenge in Polycity

ABSTRACT

The team was involved in an already existing project, called Polycity, sponsored by Politecnico di Torino, Centro Ricerche Fiat and Agenzia Territoriale per la Casa (the Italian Institution for Social Housing). This project aimed to improve the residents' life quality, through the energetic requalification of the housing estate located in the Arquata district in Torino. This scenario made the complex approach indispensable because very different needs – not only technical – were linked to the new plant and the net of the district heating. The social context played also a significant role as the Polycity project was to be reported to European Initiative Concerto which, through the EU Sixth Research Framework Programme, finances innovative interventions in the energetic field. The goal is to encourage a more rational use of the energetic sources and to promote the adoption of renewable ones. At first the team evaluated the improvement of the approach used in Polycity, from technical, economical, communicative and social point of view. One of the Arquata Project purposes is to study and demonstrate the cogeneration and trigeneration effectiveness within an urban environment. The feature that distinguishes Arquata from other Polycity projects is the readiness to adopt new technologies in the development of residential districts. This work, however, had limited freedom to act: as a consequence, it was more difficult to achieve high energetic, environmental and economic efficiencies. A supply improvement aims to increase energy production efficiency: in our case, it means increasing heat generation efficiency. This result can be obtained adding to boilers a co-generator, able to produce 1MW of electricity: according to the state-of-the-art, this power supply can be better obtained using, as generator, an alternative engine fed by natural gas (not to exceed strict pollution limits). Therefore, the results aim to analyze the critical factors related to each aspects of the Arquata district requalification and to provide an alternative proposal.

TASKS & SKILLS

Ivan Collino evaluated the environmental impacts and measured the emissions of the heating plant with simulation software.

Davide Colzani, **Rocco Mastrandrea** and **Arturo Petrozza** focused their attention on the technical, energetic and economical aspects of the plant analysis.

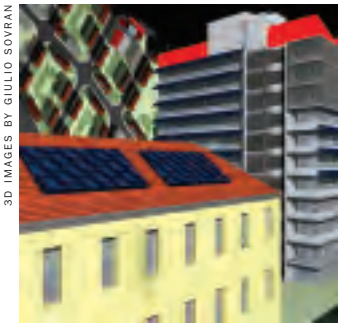
Mariachiara Guerra analyzed the energetic performances of the building components; she studied some typical cases of thermo-electrical plants social impact.

Giulio Sovran worked on the analysis of the heating network and designed the communication project to institutions and residents.

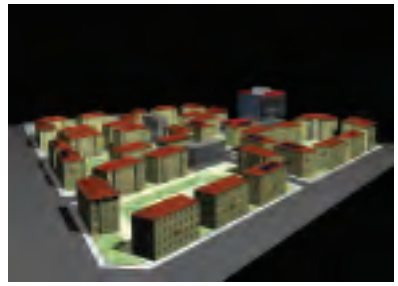
PHOTOS BY MARIACHIARA GUERRA

1 *Via Arquata, Torino. Top view of the district and of the residential buildings*

3D IMAGES BY GIULIO SOVRAN



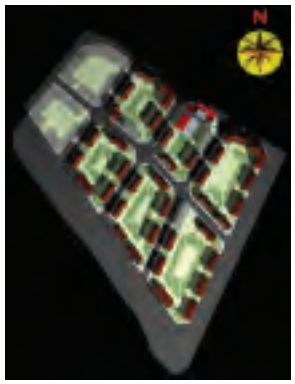
2 *3D model of the ATC building (built up in 1970's) and one of the residential estate (built in 1920's), after the insertion of the PV panels. On the background, the general planimetry of the district*



3 *General view of the Arquata district, from south-west: the PV panels were inserted over the residential building roofs and on the facades of the ATC estate*

UNDERSTANDING THE PROBLEM

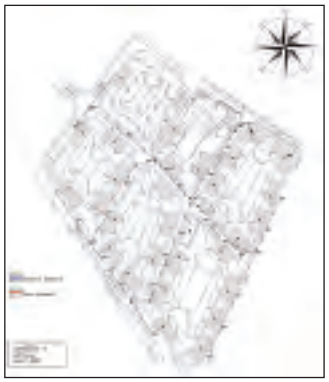
The first stage of our study consisted in a general analysis of cogeneration and district heating urban applications. In general, Collino dealt with the problems related to the environmental emissions while Colzani and Mastrandrea examined the technical aspects of cogeneration and trigeneration; Guerra analysed the procedure to calculate the energetic requirement of buildings and those factors influencing it, whereas Sovran reported the heating network applications within the Italian context. Petrozza examined the structure of ESCO companies and the relevant development in the economical and legislative scenario. In the second stage, the team worked on the application of the acquired knowledge concerning a typical and innovative case: the energetic requalification of Arquata district (Torino), included in the Polycity project. The district is situated in an urban area, close to downtown, but isolated from the city by heavy infrastructures: actually, the building complex, orbiting around via Arquata, is stuck between the railway tracks and a bridge, making it a secluded core. Moreover, the buildings are property of the ATC, which is located right inside the estate, as they were built up in the 70's on the north-eastern perimeter border. This particular position, during the residents' integration process in the society, reflected the physical isolation of the district, merely residential and totally lacking public facilities. The Arquata district had been subject to a district contract since 1996 and then it was chosen as the Italian site to be involved in Polycity. This project refers to Concerto, that is based on a new approach to the energetic policies; it places them in a wide scenario, considering them not only a crucial factor of individuals' quality of life but also an essential element of the local development. As a result, only those projects which, in addition to their innovative technological aspects, include among the promoters the local governments and the public and private institutions operating on the territory, are eligible. Actually Polycity followed this guideline, involving the city of Ostfildern (Germany), Cerdanyola (Spain) and Torino (chief city); the main difference between the Arquata district and the other two places (where new buildings were or are going to be built) lies in the introduction of new technologies in an already existing urban context.



4 *Via Arquata, Torino. General planimetry of the residential building*

5 *Via Arquata, Torino. General planimetry of the residential building, with the district heating network*

6 *Via Arquata, Torino. Master plan of the intervention and the involved buildings*

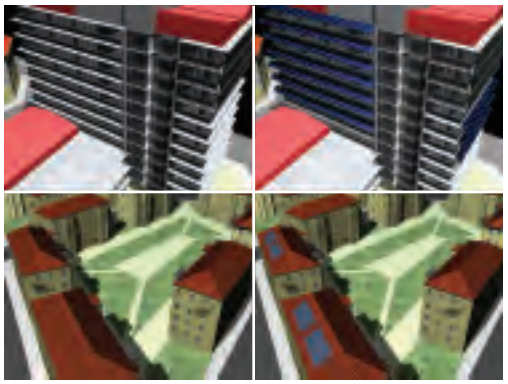


7 *Via Arquata, Torino. General planimetry of the residential building, with the district heating network*

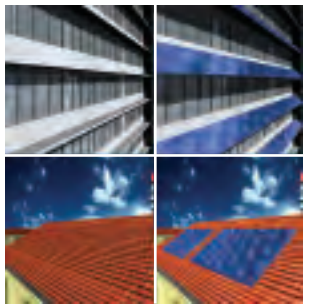
EXPLORING THE OPPORTUNITIES

After having analyzed the context of the project, each member of the team worked on one particular aspect, according to his/her own specific competences, trying to put forward an alternative solution to the adopted one, that minimizes the weaknesses and improves the strengths. First of all, the team proposed a different method of choice for the plant of cogeneration, as, from the supply point of view, there are many obstacles in achieving significant energetic results compatible with the economic costs and the environmental impacts. In order to improve the supplies, it is necessary to increase the efficiency of heat generation, adding a co-generator of 1MW of electricity power. The most important decision is the choice of the number and the size of engines (several engines mean higher flexibility and less operational costs, but imply also higher investment costs) and that is what we did in a preliminary study. This work is a part of this study and it focuses on the use of two alternative engines. Starting from an hypothesis of load diagrams, we determined energy fluxes and associated costs. Economic indicators, such as NPV, PB and IRR, were calculated for different possible scenarios and compared with a certain engine solution: particularly, from an economical point of view, the study simulated a cost/benefit analysis, calculating proceedings, savings and feedback times, obtained through the installation of the machine. The team then carried out the analysis of the energetic performance improvement of buildings, replacing some building components: in Arquata district, five hundreds windows were superseded by new low transmitting ones and the attic isolation was enhanced with a new sheet of a polymeric material. The windows were changed only in some of the buildings while the attic isolation was completed in all: for each block of flats, the Polycity team elaborated an energetic card, including the parameters and the responding values for each building component. The analysis of these cards allowed a comparison before/after the interventions and it identified the improvements achieved with this kind of substitutions in the energetic requirement. These values can be also compared with those collected for the new buildings erected in Ostfildern (Germany) that are really efficient.

The communicative aspect of the project addressed both to institutions and residents was the third stage of the analysis that our team performed. We examined the impact of thermo-electrical plants in socially critical contexts and the procedures, implemented by the institutions involved, to communicate the Polycity project to the residents. All the drawings prepared by ATC surveyors to study the



8 *Via Arquata, Torino. ATC buildings and residential estate, before (on the left) and after (on the right) the insertion of the PV panels*



9 *Via Arquata, Torino. ATC buildings and residential estate, before (on the left) and after (on the right) the insertion of the PV panels. Particular of the roof and the facades*

10 *Ostfildern, Stuttgart. The new high energy efficient buildings, heated by district heating*

11 *Ostfildern, Stuttgart. The biomass plant: detailed view of the external facades with the PV panels*

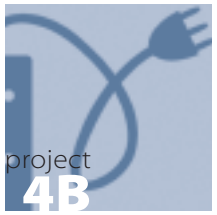
12 *Ostfildern, Stuttgart. The biomass plant: detailed internal view of the machines*

13 *Ostfildern, Stuttgart. The new high energy efficient district, heated by the biomass plant*

district were organized by scale and theme analyzing the distribution of the spaces in the blocks of flats. We tried to emphasize the introduction of the district heating network and how the photovoltaic panels would be placed over the roofs and the facades of the buildings the ATC estate consists of. Further, thanks to a video that we realized it was possible to go through a 3D model of the Arquata district, simulating the application of Photovoltaic panels: this work could be an effective and easy instrument to communicate to the residents the new asset of the buildings after the interventions.

GENERATING A SOLUTION

The main purpose of this work was to outline a new scenario in the existing context of an innovative project: critical factors and/or procedures were detected for each aspect and the team proposed the results achieved as a possible way to improve the complex scene of the energetic problem in the particular case of the Arquata district. On one hand, the need of a more integrated analysis of technical and economical elements, related to the introduction of the plant and its expected benefits, emerged. On the other hand, the necessity of introducing the energetic efficiency concept of the building components in the main actors significantly influencing the energetic requirements, became apparent. Finally, the need of communicating both the innovation and the benefits of the interventions to the residents emerged sharply: in fact, due to the Arquata socially critical context, one of the main challenge consisted in making the residents aware of their life conditions improvement, generated by the Polycity project.



Future Energetic Scenarios

Citizens energetic declaration, a solution to rationalize consumptions and reduce emissions

ABSTRACT

In a context where the Government document of economic and financial planning defines the need of adopting a strategy for energy demand control and reduction, it's essential to understand the energy market state-of-the-art, in particular through the analysis of the most significant case studies.

Firstly we analyzed the business structure, the dedicated services and the problems faced by Energy Service Companies (ESCO), a member of which, Cogenpower, took part in our project as a business partner.

Based on the acquired knowledge, a wide ranging and organic approach to the problem of energy production and use was proposed, with special attention to specific issues like the evaluation of the architectonics variables with relation to the energetic parameters, the emissions of pollutants from energy generation platforms, the software that could be useful to the ESCO for plants monitoring or pollutants assessment. While working on this problems, the importance of a more widespread awareness of energy culture became apparent as a fundamental requirement for the successfully affirmation of alternative energies.

Finally, the proposal concerned a new and innovative service, aimed to spread a greater energy awareness focusing the people's attention on the individual consumptions: everyone should observe the Kyoto protocol and declare his/her energy consumptions.

The energetic declaration was conceived according to a system of incentives and sanctions, to help the consumers to get into more responsible habits.

Moreover, a communication on the polluted emissions would contribute to make people consider the energy efficiency as a problem influencing the society as a whole and not merely the individuals' finances.

TASKS & SKILLS

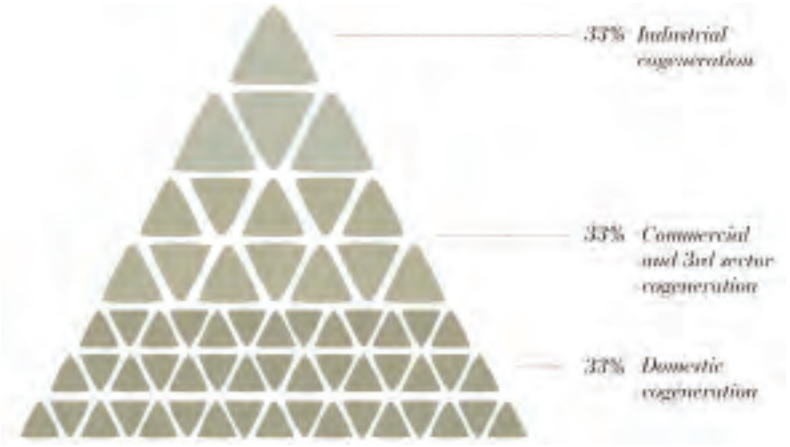
Alfino Di Stasi worked on market analysis and explored new business scenarios for ESCO, searching for new business opportunities and analyzing the economical impacts of project decisions.

Giuseppe Gazzilli performed a technical role in defining the issues related to the emissions of pollutants from energy generation platforms, particularly cogeneration.

Josiane Koueguem Kouam carried out the analysis of the software related to the project as a whole, taking inputs and outputs into consideration, especially those related to the emissions and the monitoring of energy consumption.

Paolo Magri evaluated the architectonics variables relevant to the energetic parameters and compared the European architectural innovation projects relative to the develop of energy culture.

Ilaria Tomat examined the ESCO role and the studies of the services dedicated to the public awareness of the sustainable energy theme. She developed methodologies useful for an effective and simple communication to the consumers.



1 *Energy market for cogeneration.*
• Industrial cogeneration: this market segment is already covered by 75-80%;
• Cogeneration for commercial and 3rd sector: the greatest number of potential clients for ESCOs will fall into this market segment, at least in short-medium term;
• Cogeneration for domestic use: it is the market segment formed by those consumers who live in buildings without centralized heating system but equipped with boiler

THE BRIEF

Following the informations obtained by Cogenpower, one of the project partners, the ESCO role, activities and services in the energy market were thoroughfully analyzed.
The first step was understanding how ESCO and cogeneration offer the opportunity to rationally use the energy in light of the current national energy market scenario; in other words, the positive effects of ESCO solutions were compared with the traditional ones, both for the users and environmental sustainability.
The first part of the work presented here consists in an analysis of the state-of-the-art technologies, processes, scientific knowledge and economic aspects related to ESCO and cogeneration, focusing on the following points:

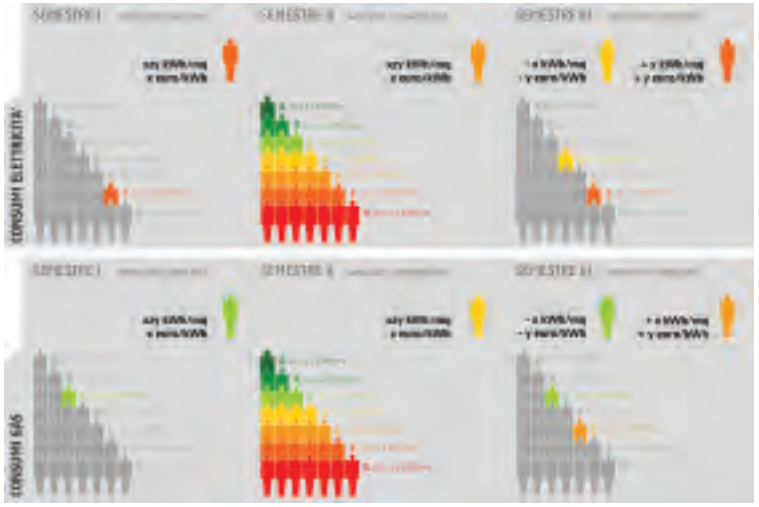
1 Energy service companies
2 Cogeneration and trigeneration
3 Teleheating
4 Buildings mean heat output capacity
5 Models of polluted emissions diffusion in the atmosphere
6 Software

PROBLEM DEFINITION

Based on the acquired knowledge, a wide ranging and organic approach to the problem of energy production and use was proposed. As a result, we had the opportunity to discover all the actors and variables involved in the problem which were not immediately identifiable.
Particular attention was given to the following aspects: the spread of a new energy culture, the ESCO market and the economical implications of the project decisions, the relation between buildings energetic efficiency and energy saving, the environmental impact of the polluted emissions and the application of software used to monitor the energy production and perform the emissions analysis.

ANALYSIS OF THE CONTEXT

For what concerns the achievement of certain objectives concerning energy management – in terms of a new energetic culture – it is fundamental to lay the foundations for a widespread awareness and knowledge of the energy problem among the population.
To this purpose, an analysis on the main actual macro-trends was carried out considering also the possible future scenarios.
In order to better understand what the potential development of an ESCO in the Italian energy market could be, we hold several interviews with managers working for some of the oldest and most important ESCO in the cogeneration industry.
Thanks to this approach it was possible to understand the relation between ESCO and their customers, what are the main difficulties

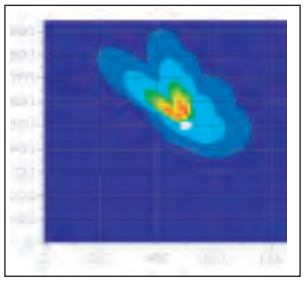


2 *Example of semestral consumption communication to customers.*
a *the customers are notified about their consumptions during the present and the past semester and offered simple solutions to improve energy savings for the next one. The consumption categories are similar to those employed for building certification except for the form because it is very important to emphasize that the problem lies in the individual consumptions.*
b *data on the polluted emissions related to the consumptions, compared to the Kyoto Protocol and the national and international averages*

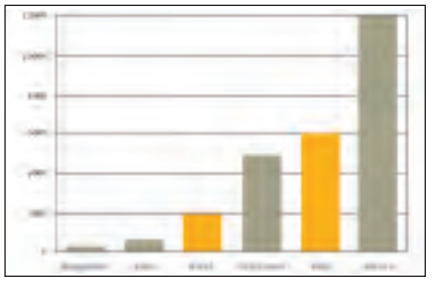
ESCO face when formulating their business proposals and how is possible to divide the target market into segments.
We tried also to understand which customers are preferable to optimize ESCO profits, and the hypothesis of creating two – or more – clients' complementarity with different energy needs to best exploit the installed plant was examined. An analysis regarding the relation between buildings energetic efficiency and energy saving was performed: we examined how the thermic load evaluation reveals important aspects relative to building technologies, such as performing materials and efficient building systems, which could bring benefits in terms of comfort and energy saving.
Another important aspect of the analysis concerns the actual environmental impact of the cogeneration plants, in terms of polluted emission.
The greatest attention was given not only to the different methods of modelling – describing the main characteristics and the applications fields – but also to the procedures needed to choose among different models and to the variables involved in this kind of application.
Finally, a brief investigation of the softwares potentially useful for an ESCO both to monitor the plants and to assess the emissions was carried out.

GENERATING A SOLUTION

Our proposal consists in an "energetic declaration" in which consumers' building and domestic electricity and heating consumtptions are monitored and subsequently analyzed by a State department that could be a provincial bureau or an already existing institution. The board of this institution should easily collect the data and cross-examine them with the data provided by the electric energy suppliers.
Once the data are acquired and validated it is possible – providing this body corporate with a software allowing the unit uniformation, gas and electricity consumption and corresponding CO^2 emissions



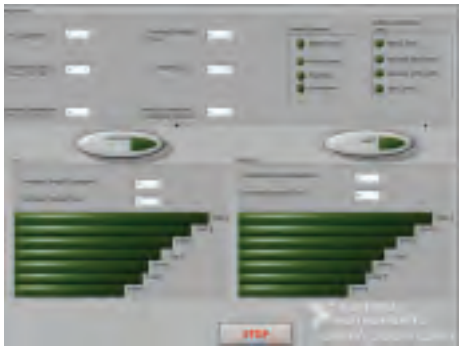
3 *Maximum concentration of CO from MT working at Full Load in stable atmospheric conditions*



4 *A comparison between the consumption per person among different countries. On world scale, today a person averagely requires 2000 watts but, as it can be seen, there are huge discrepancies between the industrialized and developing countries*

5 *System layout*

6 *The Aspsoft interface. This software gives an output value corresponding to one of the categories into which the consumption is organized*



7 *First communication to the customers: it is delivered by mail and notifies them that their energy consumptions will be monitored for one year. An explanation of the energetic declaration framework is given too. This communication includes also useful advice to help the customers to rationalize his consumption modifying their daily habits. This advice would be of a sort of a house signal system*

calculation – to deliver these data to the consumers at the end of the year with the purpose to make them aware of the environmental impact determined by their own energetic behaviour. The software, developed by the team project, is called "Aspsoft" and is also able to balance the consumption input values through four normalization parameter depending on building typology, date of the building construction, climatic area and lodging dimensions.
Thus it can be possible to classify any citizen's consumptions and enter them into an appropriate class.
Once the customers' energetic behaviour is identified and classified, the following year the State department inspector sends to the customers a chart meant to invite them to reduce their energy consumptions. The chart depends on the category it belongs to and incentives are proportional to customers' consumptions.

The incentives consist in the reduction of the gas taxes ("accise"), and "I.V.A." concerning the electric energy consumption; these taxes depend on the central administration. The fines for no consumption reductions are higher than incentives to compensate with "not virtuous behaviour" fine payment the lacking income from the "virtuous" ones; in this way the State avoids a heavy tax loss.
Communication to the consumers occurs through an informative document attached to the bills and sent out every 6 months; it is simply structured so that the consumers can easily and immediately understand it. A system able to suggest – thanks to the pictograms – the daily actions the consumers can put in use to gradually improve their energetic saving was implemented. This kind of communication system responds to the need of giving an easier approach to a subject that is often unfamiliar to most people.