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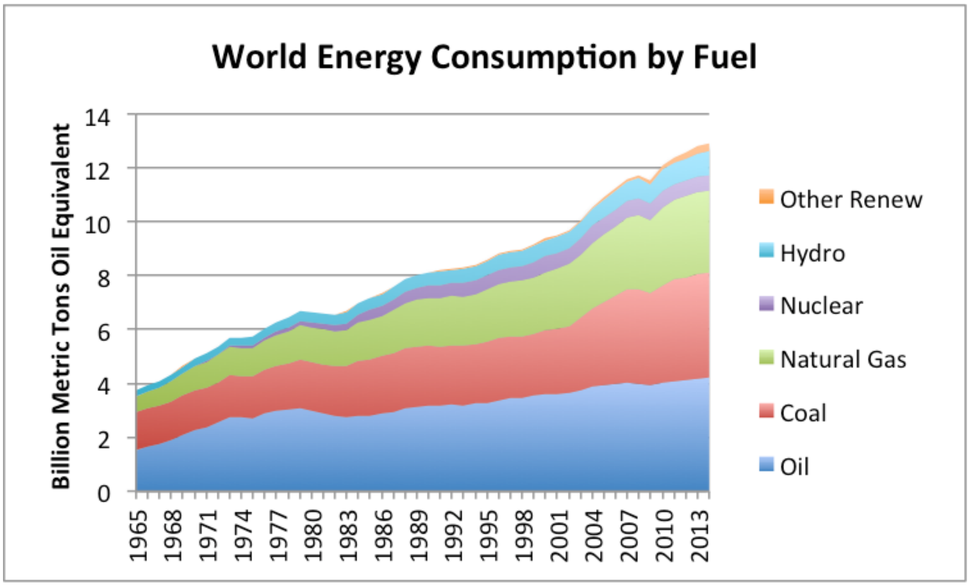
“Energy issues”



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GeoProgress Journal

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Editorial Note

The articles published in this number, like the ones of the previous one, have been proposed during the International Conference of Brussels, held on 7 September 20176, within the context of the (2nd) Geoprogress Global Forum (GGF) on “Sustainability and Energy Issues” (see www.geoprogress.eu/events). Even these, like almost all the previous ones, deal with techniques to produce, distribute and consume energy in more sustainable ways. None of them deals with an essential issue highlighted in the call for papers: whether and how is it possible satisfy, in a sustainable way, the future energy needs of humanity, including those of the current billion of people that have still no access to electric light. This should have been, in our intentions, the core issue of the Conference promoted by the Geoprogress Journal ln Bruxelles.

Consequently, we consider it necessary to relaunch the call for papers and to develop new initiatives, referring to this fundamental question, but also to the need to deepen many other specific issues related to energy production and consumption, to individual countries. and their energy and ecological policies.

For this purpose we also report the call at the bottom of this issue of the GeoProgress Journal.

Emer. Prof. Francesco Adamo, Editor in Chief

PAPERS

ROAD TRANSPORT ELECTRIFICATION, A NEW HIGHWAY TO ENERGY SAVING

Maria Lelli, Gabriella Messina, Giovanni Pede[1]

Abstract

Mobility of people and goods is achieved through different means of transport; among them “on the road” transport, with vehicles powered by internal combustion engine, is undoubtedly the most practiced. This is true despite the drawback, due to thermal traction, that road transport is less efficient and more polluting than most other modes of transport, comparing specific fuel consumption and harmful emissions.

As a matter of fact, electric traction is 3-4 times more efficient than thermal one. The advantage is such as to largely compensate the losses occurring during the electricity production and distribution, losses greater than the correspondent ones in refining and distributing liquid and gaseous fuels.

By comparing, for example, a trolley bus and a 18 m articulated bus, the electric vehicle consumes 53% less, in terms of primary energy. Achilles’s heel of the electrified road transport are the batteries; recent huge progresses in electric storage systems can overwhelm the handicap of battery’s weight. The current high cost of storage system, instead, is expected to decline in the coming years. The paper deals with a benchmark between electric traction vehicles and thermal ones, based on a big data set available in ENEA.

1. Introduction

The transport sector, consuming about 39.69 Mtoe (Source: National Energy Balance 2016), accounts for about one-third of the total final energy consumption and is responsible for the Italian dependence on oil; indeed, while other sectors such as the industrial and energy sectors have been converted to alternative fuels, transport has so far not differentiated energy sources, remaining anchored to fossil fuels which continue to be responsible for the prevalent (about 92%) of final consumption of the sector.

It is well known that the conversion efficiency of fuels energy in mechanical energy is much higher in a thermoelectric power plant than in an internal combustion engine (ICE), considering the average efficiency - in real use - of such power plant in a vehicle; the efficiency of a thermoelectric power plant is so higher, even the double with respect to the average of an ICE, to largely offset the losses occurring during the distribution of electricity and the on-board, final conversion of electric energy in mechanical energy (tank-to-wheel, TTW).

This is true in general, but even more true in our country. Indeed, thanks to the efficiency improvement of the national electricity system (see Figure 1), the so called well to tank (WTT) efficiency of a "pure" electric vehicle (BEV) have been substantially improved in recent years, though is still much lower than that one occurring to refine and distribute liquid and gaseous fuels. The increase in average efficiency is mainly due to the diffusion of combined cycle systems and cogeneration plants, for the combined

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production of electricity and heat. The thermoelectric CO_2 emission factor also declined, from 708 g CO_2 / kWh in 1990 to 488.9g CO_2 / kWh in 2015 [1].

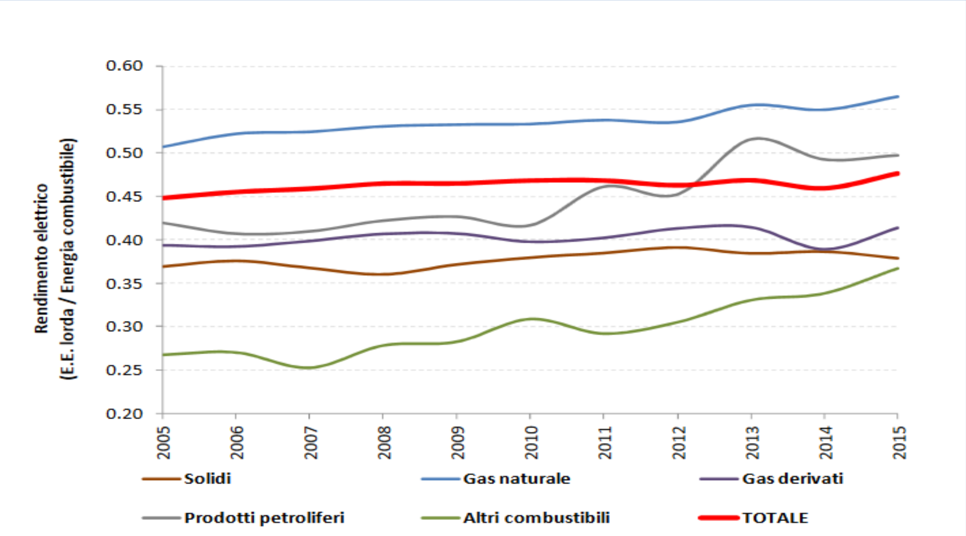


Figure 1: Generation efficiency for electric energy by fossil fuel (ISPRA)

These factors favor the electric vehicle in comparison with the conventional vehicle; for example, in Italy a B-segment car, the VW Golf, may have a primary energy saving reduced of about 50% compared to its petrol version.

Considering that i) in a large urban area (Rome) 40% of the vehicles does not exceed 100 kilometers per week (corresponding to the range of an average electric car rechargeable in 30', at ultra-fast charging station of 50 kW or more), ii) in this way it is possible, in urban use, to replace these cars with equivalent electric vehicles, iii) annual primary energy consumption for cars and taxis in cities in 2014 is around 8.9 Mtoe and, finally, estimating an average energy consumption reduction of about 30% (petrol-diesel-weighted value), there would be a 10% reduction in imported fuels consumption. Even greater is the reduction of greenhouse gas emissions, thanks also to the progressive penetration of renewable sources that have a zero emission. As a matter of fact, electricity from renewable sources, considering hydroelectric production too, rises in 2014 up to 37% , more than doubling with respect to 2005 (17%). Finally, the (local) emission of harmful and acoustic emissions would be total.

In the following, the energetic issues will be deepened with regard to individual transport only, passenger cars, using a big data set about the real urban use of cars developed by ENEA, but similar considerations can also be made for road freight transport, with reference to urban and periurban tracts.

2. The Italian situation

From the AEA [2] database, in 2015, in Italy more than 1.57 million passenger cars have been sold, more than 55% diesel-fueled, and an appreciable fleet of hybrid cars

(HEVs), in particular petrol-fueled vehicles (**Errore. L'origine riferimento non è stata trovata.**).

Fuel	Car registrations (total 1.573.729)	CO_2 (g/km)	Fuel Consumption (g/km)	Energy Consumption (Wh/km)
Diesel	55,4%	115,50	37	439
Petrol	31,2%	117,99	38	461
LPG	7,7%	118,99	40	509
Natural gas	4,0%	98,44	49	480
Diesel-Electric	0,04%	113,46	36	431
Petrol-Electric	1,57%	86,23	28	337
Petrol-Electric Plug-In	0,04%	50,37	16	335
Electric	0,09%	0,00	0,00	147

Table 1: Car registrations, emissions and consumptions – Year 2015

Specific fuel consumption FC (g/km) and energy consumption EC (Wh/km) were estimated for the new vehicles sold in 2015, disaggregated for different fuels, using the National CO2 Emission Factors (Mg CO_2Mg fuel and Mg CO_2/MJ fuel) published by ISPRA in the GHG Inventory Report [3]. In the case of CNG, only the EC was available, so that the FC was estimated by converting this data on the basis of the Inferior Calorific Power declared by the National Energy Balance and the CNG density established by UN/ECE Regulation N. 101 [4].

1.1 Comparison between different power-train

Since the energy performance of vehicles depends to a large extent on the weight and power of the vehicle itself, in the following the normalized characteristics (per unit of weight) of the best-selling diesel fuelled cars. The analysis allows to compare vehicles with similar characteristics and different power train (Table 1).

Type	Weight (kg)	Power (kW)	CO2 (g/km)	FC (g/km)	EC (Wh/km)	EC/weight (Wh/kg-km)
FIAT 500L	1.399	68	111,97	36	425	0,304
FIAT 500X	1.429	88	115,42	37	438	0,307
VW GOLF	1.360	78	103,73	33	394	0,290
RENAULT CLIO	1.165	58	91,54	29	348	0,298
NISSAN QASHQAI	1.406	84	104,61	33	397	0,282
average	**1.627**	**87**	**115,26**	**37**	**439**	**0,304**

Table 1: Clockbusting models characteristics (Year 2015)

The same was made for different powertrains, results are reported in Figure 2 and Figure 3.

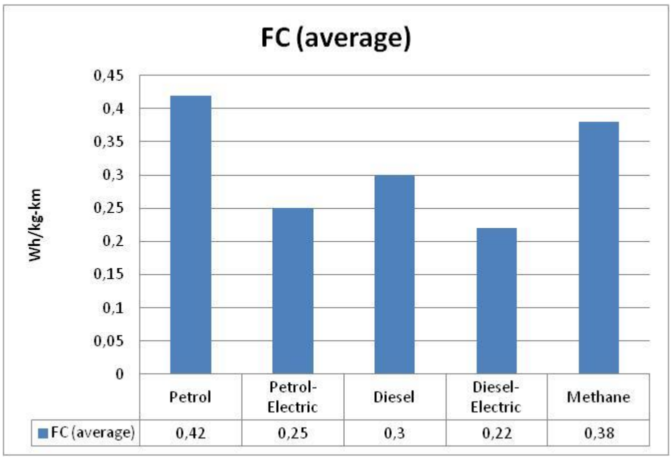


Figure 2: Specific (per weight and distance unit) consumption (Year 2015)

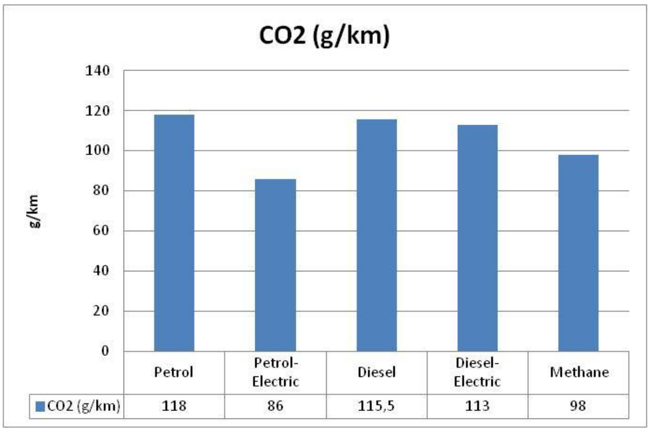


Figure 3: Specific CO_2 emissions

It is worth of note that the majority of petrol models are city-cars, their displacement is below 1400 cc, except for a 7% of models, notwithstanding they show a consumption 30% higher than that of diesel. The hybridization opportunity is therefore much greater for petrol cars, because it allows to compensate for their lower performance compared to a diesel engine, more energy efficient thanks to its much higher compression ratios. Moreover, for a hybrid diesel car the cost of engine, that has to be added to the cost of the hybridization, is higher than the cost of spark-ignited engine (i.e. petrol fuelled). As a matter of fact, a diesel engine is more "loaded", because of the higher pressures it is subjected to, and needs to be heavier. And a hybridized petrol car doesn’t suffer the issues related to the emission of nitrogen oxides, which were the origin of the "diesel gate".

The electric cars sold in Italy (2015) according to the AEA were 1458, but only 6 models, out of 19, exceeded 100 registrations (Table 2).

Type	Sold (n)	Weight (kg)	Power (kW)	EC (Wh/km)	EC/weight (Wh/kg-km)
NISSAN LEAF	386	1.542	80	150	0,097
RENAULT ZOE	328	1.502	43	146	0,097
CITROEN C-ZERO	164	1.140	35	126	0,111
SMART FORTWO	152	977	35	145	0,148
TESLA MODEL S	134	2.205	123	181	0,082
BMW I3	111	1.270	-	129	0,102
average	**210**	**1.479**	**58**	**147**	**0,099**

Table 2: Average characteristics of "pure electric cars" sold in Italy (2015)

In Table 2 their characteristics and average values are reported, and it can be noticed that the offer significantly increased with respect to a recent past, ranging throughout all market segments, from classic citycar such as SMART to Model S of Tesla.

1.2 Pure" electric vehicles and "plug in" hybrids (BEV & PHEV) vs. conventional ones

To overcome the differences, in weight and power, in the characteristics of the different commercialized vehicles, it is proposed to compare the energy consumption of different versions for the same car model, the VW Golf. For this model there are on the market three different kind of power train: gasoline, hybrid gasoline (HEV), plug-in hybrid (PHEV). To consider pure electric (BEV) too, a car of the same manufacturer (Jetta) that has similar characteristics, was considered. Below there are the specific consumption data declared by the manufacturer (Table 3) for different technologies, with the distinction between electric energy consumption and gasoline consumption for plug-in hybrids. Consumptions are measured according to the homologation cycles, in which urban cycle mileage is significantly lower than extra-urban mileage (3,9 km vs. 6,9 km).

FC (FUEL CONSUMPTION) IN L/100 km	**Petrol**	**HEV**	**PHEV**	**BEV**
Urban	**6,20**	**4,4**		
Extraurban	**4,40**	**3,90**		
mixed	**5,10**	**4,1**	**1,70**	
EEC (ELECTRIC ENERGY CONSUMPTION) (Wh/km)				
mixed			**124**	**139**
TOTAL ENERGY CONSUMPTION (Wh/km)				
FC			**124**	**139**
EEC	**467**	**375**	**156**	
Total (mixed use)	***467***	***375***	***280***	***139***

Table 3: Well-to-Tank energy consumption for a Golf (different models).

As the plug-in hybrid are chosen by people used to drive in the city (otherwise, their high investment cost is not justified with respect to a diesel car), we recalculated FC and

EC according to real-use percentages as resulting in a study by ENEA, to better estimate the balance between electric engine and ICE use (Figure).

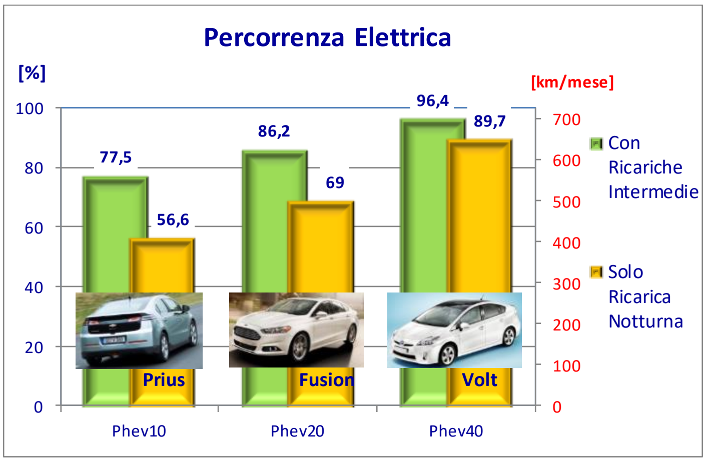


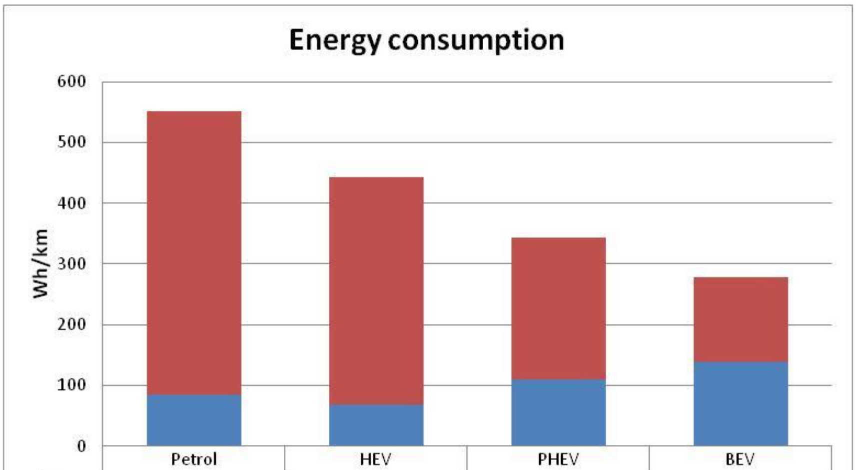
Figure 4: Monthly mileage in electric mode for three PHEV Font ENEA [5]

The study is based on a big-data set obtained from the actual daily travels recorded for a sample of 15,000 vehicles equipped with onboard units in the city of Rome [5].

It was also assumed that the plug-in hybrid consumes like the hybrid petrol car when it works with the thermal engine, and like the electric car when it moves into electrical.

2. Results

On the basis of these hypotheses, WTT(well to tank) and TTW(tank to wheel) specific energy consumptions were estimated for the different fueled versions of the same model (**Errore. L'origine riferimento non è stata trovata.**).



	Petrol	HEV	PHEV	BEV
TTW	467	375	233	139
WTT	84	68	110	139

From these data, the annual WTW consumptions were calculated for the different versions of the Golf together with the consumption reduction for the hybrid and electric models respect to the petrol car (Table 4).

Cars	Annual Mileage (km/year)	WTW EC (MWh/anno)	WTW EC reduction (%)
Petrol	15.000	8,27	-
Petrol-Electric	15.000	6,64	- 19,6%
Petrol-Electric Plug-In	15.000	5,94	- 28,2%
Electric	15.000	4,18	- 49,4%

Table 4: WTW consumption and % reduction respect to petrol Golf. Font: ENEA estimations from VW official data

The electrification of the collective transport is even more advantageous because electric vehicles, such as metro, trams and trolleybuses, are not penalized by the weight of the batteries and their losses in the charging and discharge phases. In fact, by comparing, for example, a trolleybus and an 18-car (18-inch) ATV (ATAC data) we have a consumption of 0.83 L/km of diesel per kilo of diesel and 2.2 kWh / km of trolley buses. Considering the same transformation / distribution yields of the previous case, the electric vehicle consumes 53% less, always in terms of primary energy.

Even greater reductions would be made with innovative electric buses (without catenary) with quick charging at the terminus stations, so that their battery package can be minimized, from the at one for travelling 100-150 km with only night recharging to the one required for a few tens of km [5].

3. Conclusions

The approaches to vehicle electrification followed by car manufacturers are of two kinds: the progressive hybridization of their range, preferred by most manufacturers, or the one adopted by Nissan and Renault, considering the electric vehicle sector a strategic development axis, and offering a full range of fully electric vehicles, from the micro car to the van.

Which of the two strategies is the winning one, we cannot know, but surely the path of a progressive electrification of road transport is marked and goes through the development of electrical storage systems of two types: "power storage" that have allowed the birth of the hybrid, and "energy storage", which push the spread of the "pure electric" vehicle.

From the results illustrated above, it is clear that electrification of road transport leads to significant energy savings, even in global terms, from the well to the wheel. In addition to this benefit, the electrification gains another important advantage at local level, in terms of air quality in urban areas, lowering the emissions of toxic and harmful gases. Of course, CO_2 emissions are also reduced, even in comparison to bifuel gasoline-methane vehicles.

Given that the transport sector has become over the years the most critical one in achieving the goals of reducing energy consumption and global emissions in our country, the certain advantages represented by a transition to road vehicles hybridization and electrification would well justify incentive measures similar to those taken in the past with the introduction of Green Certificates and Energy Efficiency Titles.

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HYBRID MODELS FOR THE EVALUATION OF ENERGY SUSTAINABILITY IN URBAN AREAS

Guglielmina Mutani, Mariapia Martino, Michele Pastorelli[2]

Abstract

Urban population in the world accounts for 54%, with 69% in Italy, and it continues to grow (The United Nations Population Division's World Urbanization Prospects, 2015). In this work, energy sustainability has been analysed in urban contexts with high energy consumptions and low availability of renewable energy sources. The sustainable management of energy is a great opportunity in the complex environments of urban areas where the buildings are always an important contributor. Main results of recent research activities, carried out by the authors, are presented with energy-use models for buildings considering statistical bottom-up and top-down models. These models have been tested on about 50 municipalities in the Metropolitan City of Turin comparing the results of bottom-up models (at building scale) with the top-down model at municipal scale using a GIS tool. Finally, new hybrid models have been integrated to consider urban morphology, solar exposition and microclimatic variables of different urban environments. The use of a GIS tool consents to manage and represent buildings data at urban scale.

1. Introduction

The energy sustainability in urban areas is a critical issue because of complex environments, high population densities, many anthropic activities, high environmental impact, together with high-energy demand, low availability of spaces and of renewable energy sources. A sustainable management of energy could be a great opportunity to be exploited and buildings are always a key-contributor to optimize the use of energy and to reduce greenhouse gases emissions [1].

The aim of this work is to provide a replicable method for future energy self-sufficient districts or cities and to help policy makers to solve the main three energy issues: energy security, energy sustainability and energy equity (Energy Trilemma [2]). In Italy, until now prior actions are energy efficiency and renewable energy sources issues, encouraged also by national and regional subsides [3].

In this work, the models of energy consumption are presented from building to blocks of buildings, district and urban scale, with the aim of identifying a methodology, to optimize the overall energy system - from the demand to the supply - taking into account all the constraints present in real urban environments: territorial, economic and social constrains (i.e. mutual shadowing between buildings, the morphology of built environment, the presence of vegetation, water and historical heritage) as well as the microclimatic variations in the urban settlement [4, 5]. With these models, also the integration of energy harvesting systems, renewable energy technologies and different retrofit solutions of the buildings stock can be investigated at the district or urban scale [6, 7]. Energy models at territorial scale could also help in evaluating the impact of climate change in the energy demand/supply of buildings, as well as the impact of future energy policies.

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The approach of this work is explained in detail in the methodology section (Section 2), while data collection is described in Section 3. The discussion on the results is reported in Section 4 and in the conclusions.

2. Proposed methodology

In an urban environment, the buildings alone could not satisfy all energy needs, then a bigger scale should be used as block of buildings, district, urban, municipal or territorial one. A sustainable city cannot be only a set of sustainable buildings, but it should be considered also the relations between the buildings and the surrounding spaces and the interrelationships between all elements within a city considering also environmental, economic and social aspects.

Precisely, in the building sector, energy consumptions are affected by several factors that can be grouped in three main categories:

- specific characteristic of the building related to the construction;
- specific use of the building and variables related to the people living in the buildings;
- specific characteristic of the analysed territory and spatial organization of the buildings at blocks of buildings, district or territorial level.

The space heating energy consumption of buildings can be divided by two main components [8, 9, 10]: the first related mainly to the building’s use, envelope, systems’ efficiencies, and climate characteristics; the second related to the surrounding environment, open spaces and urban context features, and the locally variations of microclimate. The consumption of buildings can be therefore represented with the following two components:

$$TEC = ECB + ECU \quad (1)$$

where:

TEC	is the specific yearly Total Energy Consumption [kWh/m^2]
ECB	is the specific yearly Energy Consumption depending from Building, users and climate [kWh/m^2]
ECU	is the specific yearly Energy Consumption depending on Urban context [kWh/m^2].

The first component is widely known and it represents the average energy consumption as function of the main characteristics of the building and its users; the second component can differentiate building energy consumptions depending by the characteristics of the surrounding context in which the building is located, taking into account microclimate variations in the built territory; the same building in different parts of the city, can have a different energy-consumption.

Only recently the research is focused on the second component which will have an important role especially for nearly zero energy buildings (nZEBs) with a minimum contribute in energy consumption of the building itself (first component of Eq. 1); then, the role of urban planning will be fundamental for the design of sustainable districts and cities with different urban characteristics. To take into account this new component, the scale of the analysis changes to consider a larger area, at least the one around a group of buildings and then move from the building scale to a larger scale: blocks of buildings, district or urban scale.

Several approaches have been proposed for the energy analysis that can be grouped in three categories: top down models, bottom up models and hybrid models [9, 10, 11].

The first analyses on bottom-up and top-down models were performed by the authors in 2006 within the research project financed by Fondazione C.R.T. [12] and they continued with Cities On Power (www.citiesonpower.eu) and EEB Zero Energy Buildings in Smart Urban District (www.s3lab.polito.it/progetti/progetti_in_corso/eeb).

In this work, the combined use of bottom-up, top-down and hybrid models is presented using a GIS Tool (in Figure 1). This methodology is GIS-based and it applies the simplified bottom-up models to all types of building for the whole city of Torino. Then the overall buildings consumption is compared with the top-down municipal scale data with an iterative procedure as long as the results of bottom-up and top-down models do not match. This methodology was tested on more than 50 municipalities in the Metropolitan City of Turin with different databases and accuracy in the research project Cities On Power [6].

2.1 Bottom-up models

These models operate at building scale, and are usually used to evaluate the energy balance of a single building with high detail. Models at building scale need good knowledge of the building characteristics together with measurement of the energy consumptions for their validation. Usually, from bottom-up models, simplified models can be elaborated using the more energy-correlated variables and defining functions of specific energy consumptions for every group of buildings when the analysis is at urban or territorial scale. Then from data related to specific groups building, the evaluation of energy consumption for block of buildings, district and cities can be carried out with, for example, a GIS tool. To achieve valid and reliable results at district and urban scale, large amount of data must be processed, as more than 2,000 buildings over 2 to 3 heating seasons for the city of Turin [13]. Bottom-up models can also be used for the evaluation of energy savings after buildings retrofits.

2.2 Top-down models

Energy-use data at urban or territorial scale are compared with climate variables, census data and statistical surveys to determine average energy consumption for the existing buildings. These models can compare energy consumptions with different variables (i.e. socio-economic and climate data), evaluate energy consumption trends but cannot distinguish spatial variations in energy consumption on a territory due to different types of buildings or urban contexts. Typical top-down models are used for the Covenant of Mayors action plans (i.e. https://www.covenantofmayors.eu/).

2.3 Hybrid models

These models integrate the earlier models with engineering methods based on the building physics, for example, to simulate variations in energy consumption due to conditions other than real ones. In this work, CitySim Pro tool (https://citysim.epfl.ch/) was used to represent energy consumptions and GHG emissions at block of buildings and district scale. In Section 4 an example of different districts for the city of Turin is reported in Figures 12.

The same methodology can be applied also to evaluate the energy savings targets that can be reached on a real building heritage (Figure 2). With this purpose the Energy Certificates database of Piedmont Region, with buildings data and socio-economic variables, was used to evaluate the citizens' participation at the local energy policies, or the feasibility of buildings' retrofits, for the reduction of buildings consumption [6, 14].

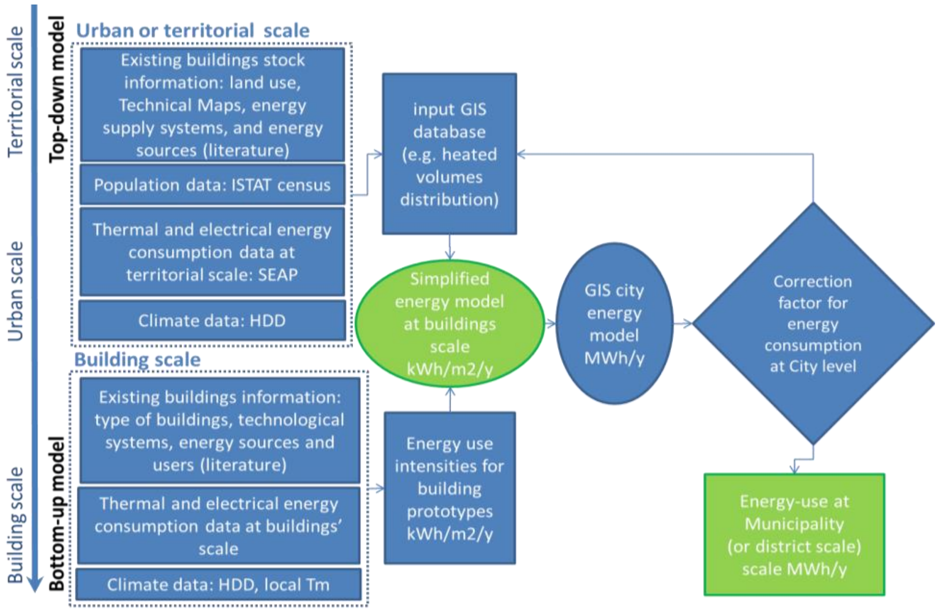


Figure 1: Block representation and comparison between top-down and bottom-up models.

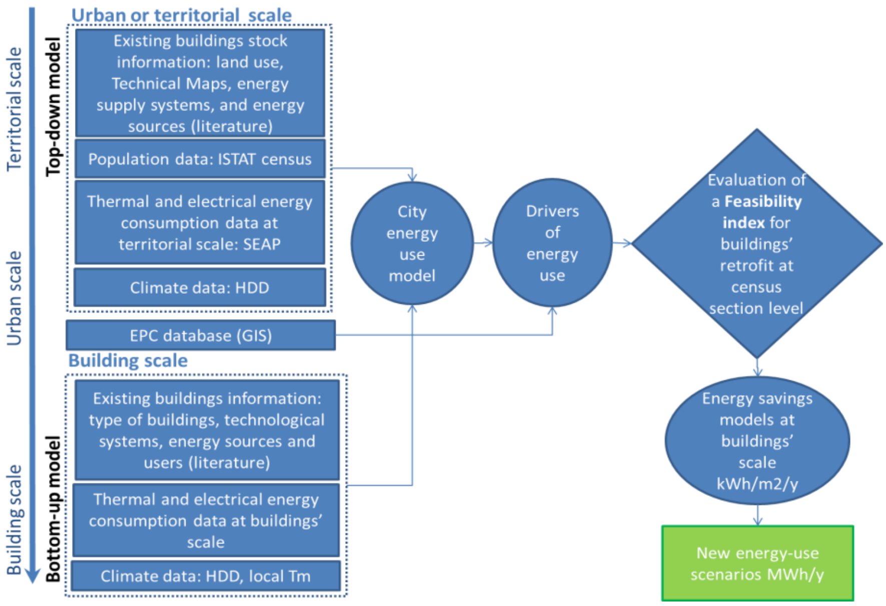


Figure 2: Block scheme for the evaluation of energy savings in a real building heritage.

This procedure is based on average or median values of energy intensities for every type of building and then cannot evaluate how changes in the urban context can influence energy consumptions.

Then, seven typical districts of Torino were identified, four districts built before 1940: Arquata, Crocetta, Raffaello and Sacchi; and three districts built after 1990: Mediterraneo, Spina 3 and Villaggio Olimpico. The use of the software CitySim Pro [15] was integrated in the procedure as engineering tool to evaluate how changes in the urban context can modify the consumption of buildings.

The aim of this work was to define a methodology through a case study. Particularly, the development of a simplified model for the thermal energy-use of different types of building was performed for the city of Turin and the municipalities of the metropolitan area. Beside, an hybrid model was used to consider how the various urban contexts can influence buildings energy consumptions for space heating.

3. Data collection

The availability of reliable data concerning the energy models, mapping and planning of the energy demand and related supply systems is fundamental for the analysis and the development of energy and environmental policies. In Europe there is a lack in harmonisation especially for buildings data and buildings performance certificates. The European community, with the INSPIRE Directive 2007/2/EC, is establishing an infrastructure for spatial information and to data models to support Community policy makers but also to solve the energy trilemma: energy demand/supply optimization, economic competiveness and environmental sustainability considering the specific characteristics of every country, population and building heritage [16].

The necessity of reliable data is also focused in several EU funded projects and in the general objective of the EU Program H2020. The mapping tools must be able to describe the existing area of interest and supply information that help innovative actions. The key factors that make useful and reliable a mapping tool have been identified in the ability to process large and complex data sets to provide a detailed and comprehensive description of the existing energy system and the dynamic development of all relevant supply and demand elements within a given geography.

Specifically, the heating and cooling mapping tool should be capable of modelling flexibility needed for integrating variable renewable energy, and demand response and enable analysing the impact of the increasing number of low energy buildings [17]. Models for the energy demand and supply have the objective to reach more efficient scenarios considering hourly, monthly, seasonal and yearly time periods [18] and the economic impact of new solutions at local, regional and national level.

Data	Database	Scale
Building geometrical and typological characteristics	Technical maps of the City of Torino (CTC, 2015)	building
State of building maintenance	ISTAT 2011 census	block of buildings
Digital surface model	LIDAR ICE data of 2009-2011	grid of 5 m x 5 m
Energy supply system for space heating and hot water production and fuel	ISTAT 2011 census	block of buildings
	District heating company (2010-2016)	building
Energy distribution network	District heating company (2010-2016)	building
Climate data	Regional Agency for the Protection of the Environment (ARPA Piemonte)	weather stations
Energy consumption	District heating company (2/3 heating seasons: 2012-2015)	building
	Sustainable Energy Action Plan, SEAP - Covenant of Mayor (2005)	municipal
Energy Performance Certification of Buildings	Piedmont Region	building
Land use	Technical maps of the City of Torino (CTC, 2015)	building
Population characteristics and distribution	ISTAT 2011 census	block of buildings
Socio-economic variables	ISTAT 2011 census	block of buildings

Table 1: List of database useful to define energy models at territorial scale.

Final users of the data are all the stakeholders involved in the existing power plants and energy infrastructures aimed to make more efficient the energy demand and supply balance at lower costs [19]. Specific final users of the mapping tools are the boards and the Institutions responsible for the promotion and the adoption of actions focused on better energy usage, energy savings plans and integration of heating and cooling plants into spatial policy and urban planning [20, 14]. Modelling tools should be user friendly and open source yet able to model the full energy system, i.e. heating and cooling, electricity and transport.

To create energy model at territorial scale, the databases and their accuracy are essential. In this work, data collection includes the databases reported in Table 1. As it is possible to observe, the different variables are given at different scale, then some reasonings must be done for accurate results (using average, median or prevalent data at building or blocks of buildings scale depending on the variable).

4. Results and discussion

The proposed methodology is a hybrid approach where the simplified building models, derived by the bottom-up approach, match with the energy consumption of a district or a city (top-down approach) but these models can have variations in energy performance due to local changes in urban context and this can be evaluated with an engineering tool.

Comparing the results of the bottom-up approach at buildings scale and top-down approach at municipal scale, a correction factor was determined as the bottom-up model is an average model and it does not take into account important factors such as the spatial variability in: solar gains, indoor/outdoor air temperatures variations, the utilization of renewable energy sources and, mainly, the level of buildings' retrofit that may have changed the energy consumptions of buildings over the years. To consider these variables and to adapt the model to real energy consumption data, the model of the specific energy-use of buildings was multiplied by a correction factor of 1.02 as function of the typical built environment analysed (research project: "Cities On Power" http://www.citiesonpower.eu/en/). This value, very closed to the perfect match value (unity value) between building and city energy models, indicated that the databases used are very accurate.

For all the buildings in Torino, the information of heated volumes in the SEAP and in the Technical Maps CTC of the Municipality of Torino were compared; therefore, knowing the overall consumption for the different buildings in the city of Torino, the specific energy-use value was deducted for each type of building. In Figures 3 and 4 the data used for the buildings of Torino are reported with the relative average specific energy-uses for the average heating season 2011-12 (2221 HDD at 20°C).

For residential buildings, the more detailed information about energy-use data, also subdivided by the buildings' period of construction and compactness (with the surface to volume ratio S/V), allows a more accurate model of energy-use with linear regression models of space heating and hot water production (Figure 3 and [13]).

The models reported in Figures 3 and 4 have been calibrated considering the different types of heating system for each census section, knowing the percentage of centralised and individual heating systems using different type of fuels and the presence of the District Heating network (considering the different heating systems efficiencies).

In Figure 5 the energy performance of residential buildings is reported as functions of the compactness, the period of construction, the percentage of occupied building and the closest weather station.

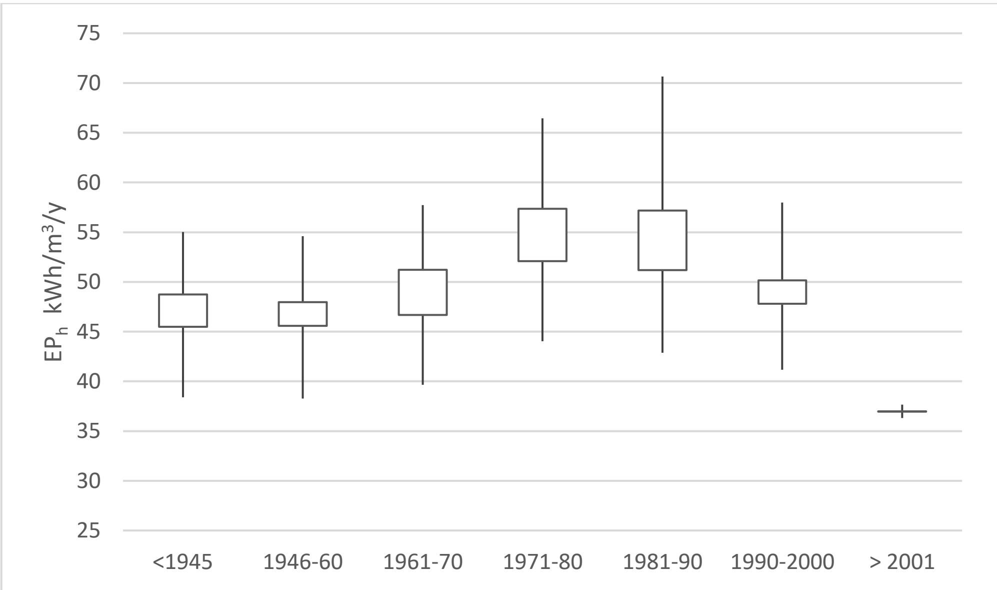


Figure 3: Specific space heating energy consumptions EPh [kWh/m3/y] computed from the heated gross volume, putting in evidence the first quartile, median, average and third quartile values for the heating season 2011-12 (2221 HDD at 20 °C).

In Figure 6 an example of the territorial, technical and economical constrains for the DH network expansion is represented, with respectively: the territorial limits given by the Po river and the hill (in green), the presence of individual heating systems (28.4%), and the high density historical old town in the centre of Torino (in red) and, finally, the economical constrains due to little buildings which will not be connected to the DH network.

With these model, the energy-uses for space heating and hot water production can be represented, as in Figure 7, with the possibility also to correlate these data with the spatial distribution of the CO_2 emission, as described in the QUADRANTE research project for the Italian city of Ivrea (TO) (http://quadrante-livinglab.netsurf.it/index.php, in Italian).

The energy consumption model described in this paragraph was also used to evaluate the potential of solar technologies integrated in the rooftop of existing buildings, as solar renewable energy sources are the most realistic and easy solutions in a high density urban context [6, 13]. A web-interface with an interactive cost-benefit analysis was also developed in the research project “Cities on Power” for all the Metropolitan City of Torino with about fifty municipalities, to evaluate for each building and each Municipality the potential of energy production with roof-integrated solar technologies [21, 22].

Finally, considering the socio-economic variables of the population and buildings (form ISTAT census 2011) with this model was also possible to evaluate the expected energy savings due to future renovation scenarios of buildings. Considering the most influencing socio-economic variables, a feasibility index of future buildings’ renovation was calculated for residential buildings, with a resulting energy saving rate for Torino of 19-27% in the medium and long-term scenarios [8, 14, 22].

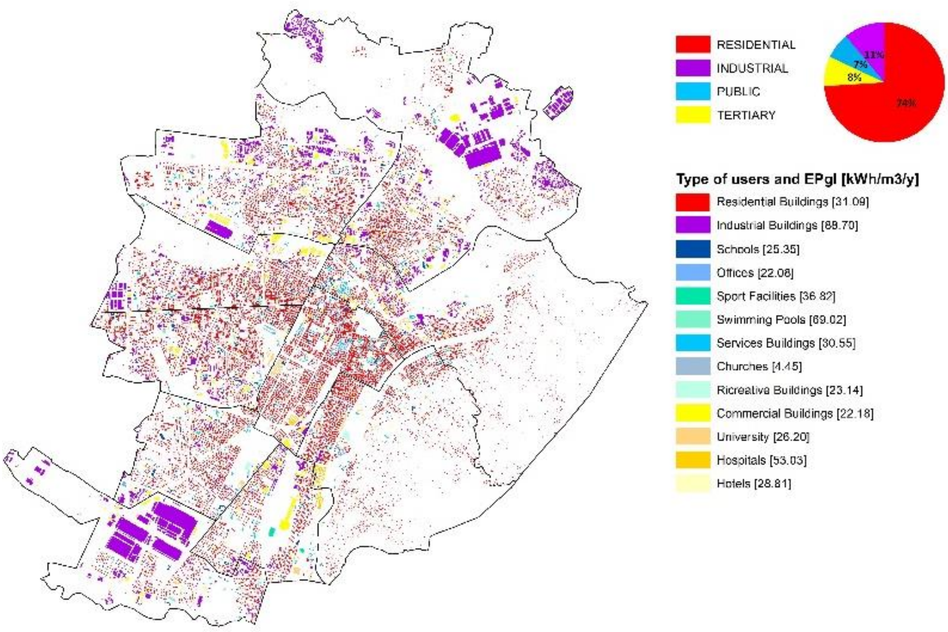


Figure 4: Different type of buildings analysed in Torino with energy consumption EP_{gl} [$kWh/m^2/y$] for the heating season 2011-12 (2221 HDD at 20 °C).

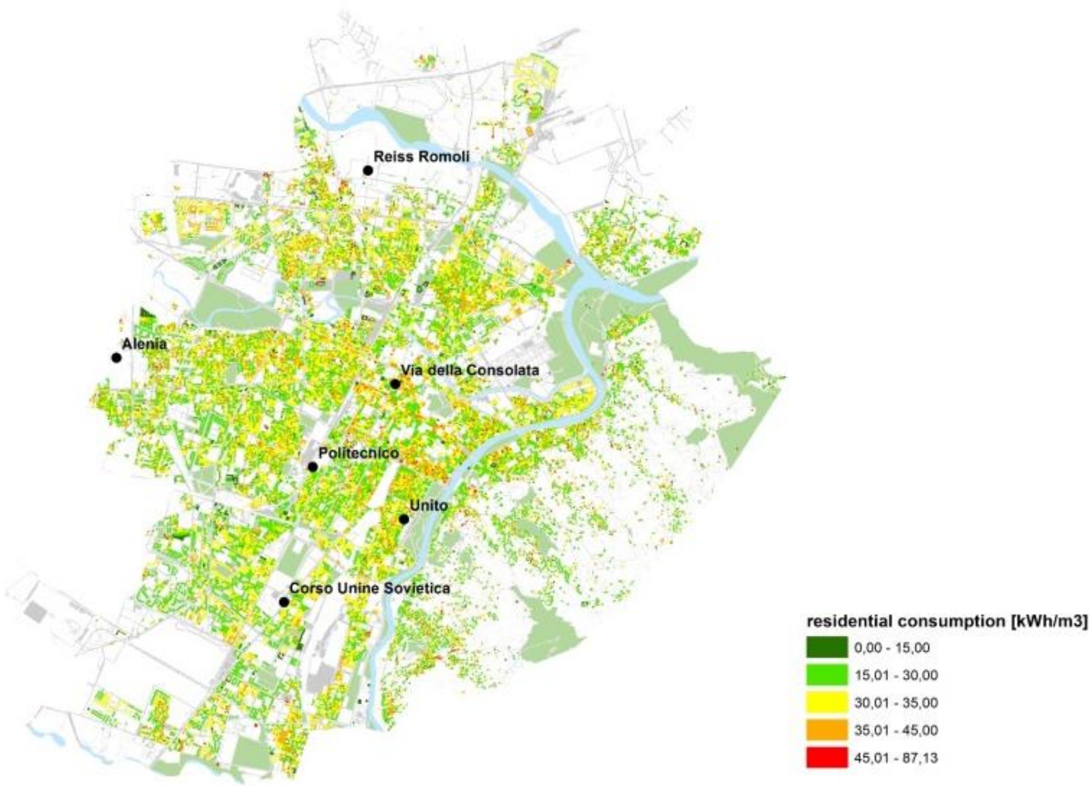


Figure 5: Residential buildings energy performance EP_{gl} [kWh/m^2/y] for the heating season 2011-12 with the location of six weather stations.

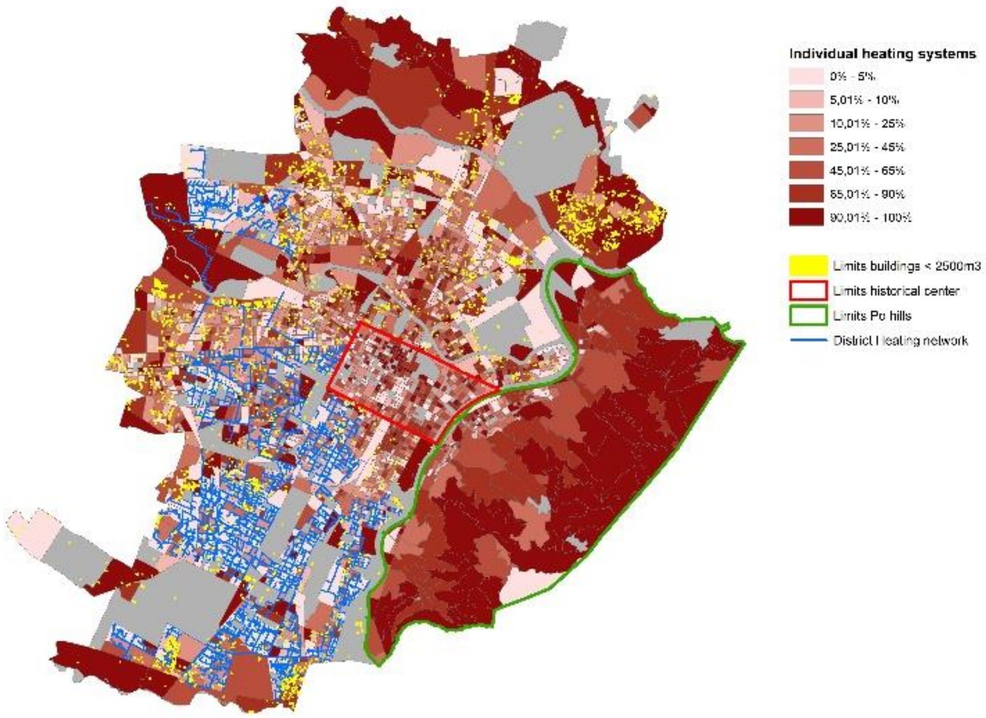


Figure 6: Data about individual heating systems and the territorials and economical constrains for the DH network expansion

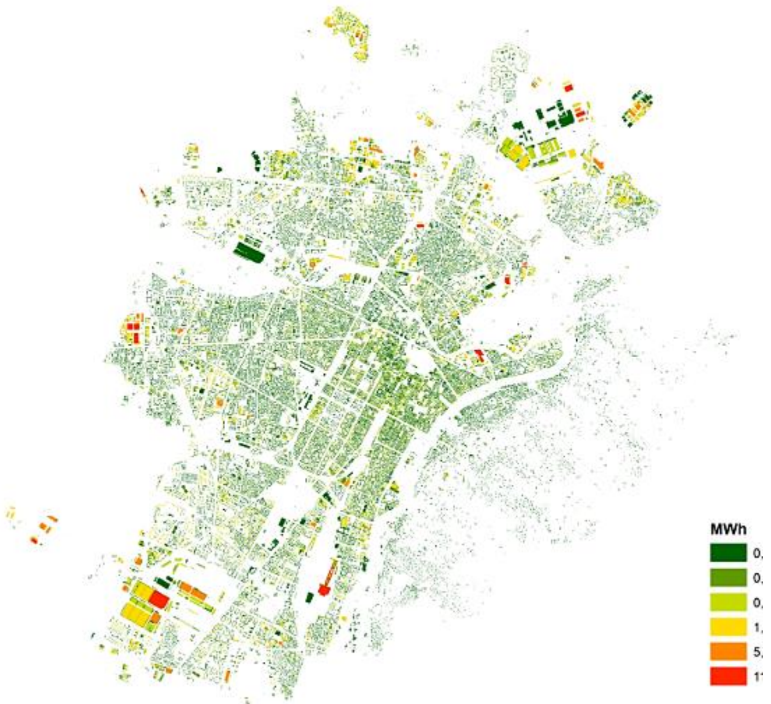


Figure 7: The yearly energy-use for space heating and hot water production (GWh/y) for the heating season 2011-12 (2221 HDD at 20 °C).

The second component of the energy-use for residential buildings in Eq. 1, is related to the surrounding environment, the urban context and the locally variations of microclimate. The same building with different surrounding environments, has different energy consumptions for space heating and cooling. Also the microclimate changes influence energy consumptions of buildings and in Torino the average monthly air temperatures, registered in the different weather stations inside the city, can record differences on the monthly air temperatures of about 3-4 °C, principally during the colder months [23, 24]. Considering the average yearly air temperature in the last 10 years, the coldest areas in Torino are the parks in the periphery, while the warmer ones are in central zones with high building density.

To take into account urban variables in residential energy consumption models, a territorial unit corresponding to the census section was considered with a globally average area of 3.38 ha for the city of Torino and with and average area in the central districts of 1.15-2.12 ha, corresponding to the blocks of buildings area [25]. For each census section, three urban factors have been calculated: the "Urban morphology" factor (U), the "solar exPosure" factor (P) and the albedo coefficient (A).

The "Urban morphology" factor (Eq.2) describes the urban morphology, at block of buildings scale:

$$U = BCR \cdot H/W = BD/W \quad (2)$$

where: BCR [m^2/m^2] describes the relationship between the territorial unit area (census section area) and the buildings' footprint; the "aspect" or "height to distance" ratio H/W [m/m] represents the canyon effect causing higher air temperatures and lower air velocities in the urban outdoor spaces surrounded by buildings; BD [m^3/m^2] is the building density.The "solar exPosure" (P) is the product of the ratio between the heights of the buildings (H) and the height of the surroundings (H_m) and of the main orientation of the streets (MOS):

$$P = H/H_m \cdot MOS. \quad (3)$$

The main orientation of the streets (MOS) influences the orientation of the buildings, the shadowing on the outdoor spaces and the canyon effect A more detailed descriptions of the urban variables can be found in [9].

Finally, the "albedo" coefficient (A) should normally be considered because it influences the outdoor air temperatures and the canyon effect; it depends on the outdoor surfaces materials as asphalt or concrete streets, green areas, buildings' facades and roofs. Usually at urban scale, only the albedo characteristics of horizontal surfaces are considered as they can be recorded by satellite sensors; the ASTER images (at 22nd July 2004) were used [23, 24]. In this work, the energy-use for space heating of residential buildings was compared with the average value of each urban variable with global value "G" among each territorial unit. Considering the census section or block of building area as a territorial unit, a correlation between the urban context characteristics (G-UPA) and the average energy consumption data for buildings' space heating was analysed. In Figures 8, 9, 10 and 11 the urban variables BD, BH, H/W and A are represented for the 3840 census sections of the city of Torino.

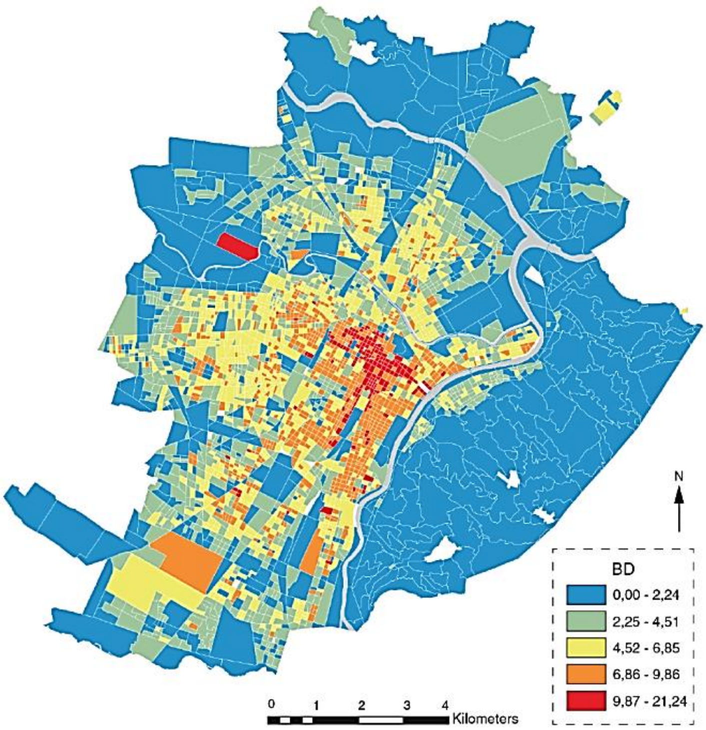


Figure 8: The building density BD [m^3/m^2].

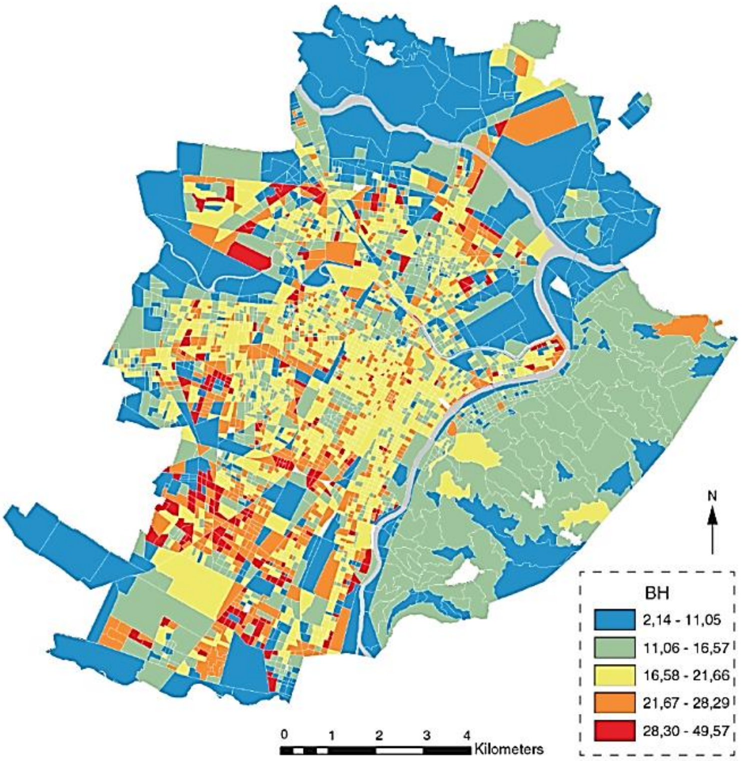


Figure 9: The building height BH [m].

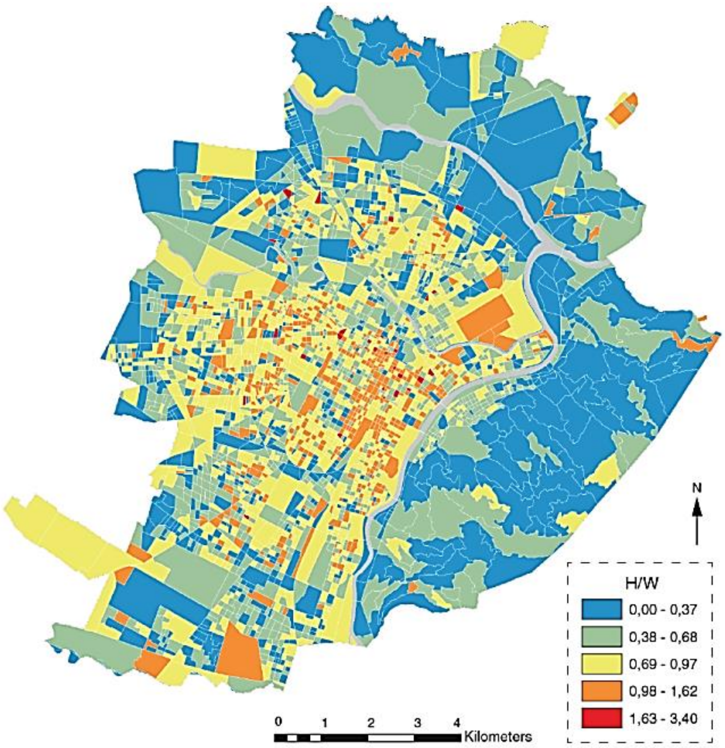


Figure 10: The aspect ratio H/W [m/m].

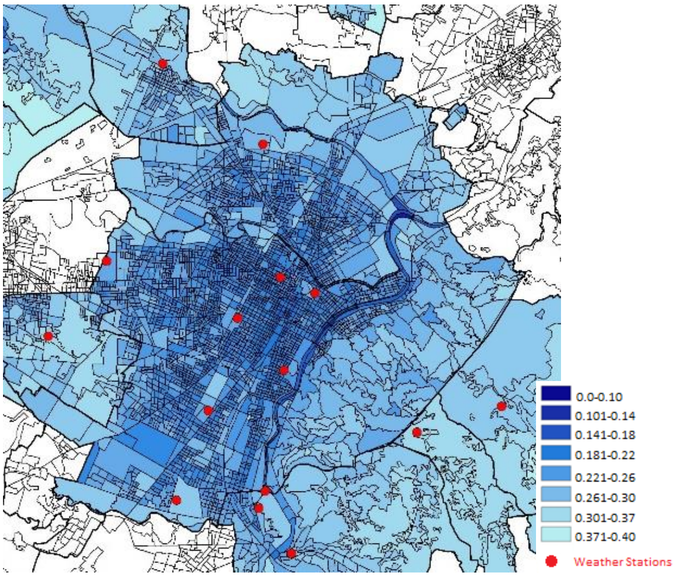


Figure 11: The albedo coefficient A.

To evaluate how urban morphology can influence building energy consumption, the same procedure has been applied to different districts in Torino; the first four districts mainly built before 1945 and the last three ones with newer buildings:

1. Sacchi: 75% of buildings was built before 1945; the 15%, between 1946 and 1980. Its main urban characteristics are: BCR=0.50; BD=8.6 m^3/m^2; BH=19.5 m; H/W=1.2; H/Hm=1.0; MBO=1.1; MOS=0.9; A=0.16.
2. Arquata: 80% of buildings was built before 1945; the 15%, between 1946 and 1980 and 5% after 1992. Its main urban characteristics are: BCR=0.23; BD=4.0 m^3/m^2; BH=19.1 m; H/W=0.4; H/Hm=1.0; MBO=1.0; MOS=0.9; A=0.18.
3. Crocetta: 30% of buildings was built between 1919 and 1945; only 12% after 1981. Its main urban characteristics are: BCR=0.41; BD=6.7 m^3/m^2; BH=20.3 m; H/W=0.9; H/Hm=1.0; MBO=1.1; MOS=1.1; A=0.2.
4. Raffaello: 90% of buildings was built before 1970 with the 67% built before 1960. Its main urban characteristics are: BCR=0.48; BD=8.2 m^3/m^2; BH=20.0 m; H/W=0.9; H/Hm=1.0; MBO=1.0; MOS=1.0; A=0.16.
5. Mediterraneo: 65% of buildings was built between 1946 and 1980; only 5% after 2000. Its main urban characteristics are: BCR=0.27; BD=6.7 m^3/m^2; BH=27.5 m; H/W=0.9; H/Hm=1.0; MBO=1.1; MOS=0.9; A=0.17.
6. Spina 3: all buildings were built after 1990. Its main urban characteristics are: BCR=0.22; BD=3.1 m^3/m^2; BH=21.3 m; H/W=0.7; H/Hm=1.0; MBO=1.1; MOS=1.3; A=0.23.
7. Villaggio Olimpico: 70% of buildings was built after 2000; the 20%, between 1980 and 1990. Its main urban characteristics are: BCR=0.20; BD=4.1 m^3/m^2; BH=21.4 m; H/W=0.4; H/Hm=0.9; MBO=0.9; MOS=1.3; A=0.19.

In Figure 12 are represented the districts: Arquata (a), Crocetta (b), Villaggio Olimpico (c) and Spina 3 (d). As it is possible to observe, Crocetta has higher buildings density and aspect ratio H/W typical of cities centres. Conversely, the newer districts Spina 3 and Villaggio Olimpico have lower building densities, buildings coverage ratio and aspect ratios.

For this study, the typologies of buildings were grouped with similar characteristics, so the variation in energy consumptions was caused only to the urban context differences (second component in Eq.1). Then, to have more differences on the urban context, the tool CitySim Pro was also used to change the urban layout creating new configurations; the validation of the models was made with the real urban configurations comparing the space heating measurements and the results of the CitySim Pro simulation on at least two heating seasons.

Combining the energy-use data with the results of the different urban layouts and associating two different class of solar exPosure factor ($P < 1.15$ non-optimal and $P \geq 1.15$ optimal), different trends of heating energy consumptions can be observed (in Figure 13): two parabolas with the lowest energy consumption in correspondence of the "optimal" classes of U and P factors.

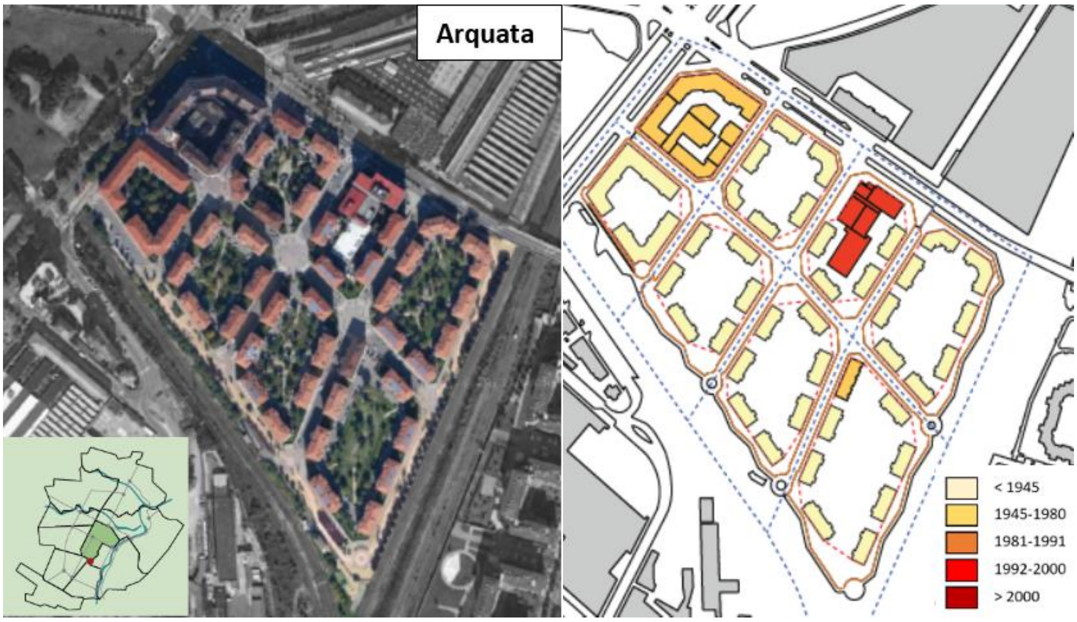


Figure 12(a): Urban configurations of Arquata district with buildings' period of construction.

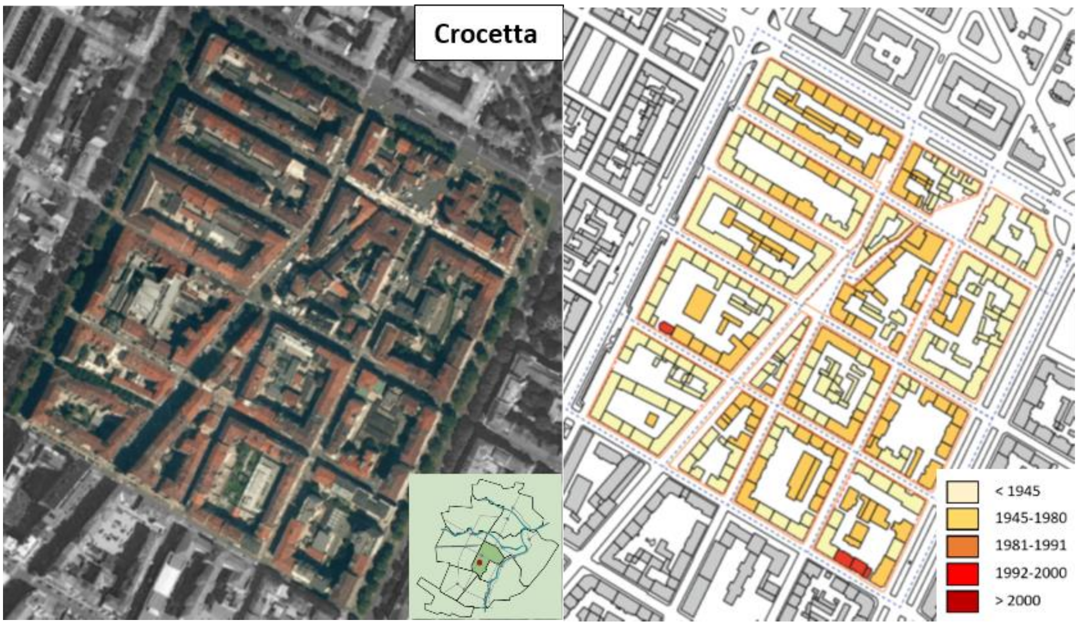


Figure 12(b): Urban configurations of Crocetta district with buildings' period of construction.

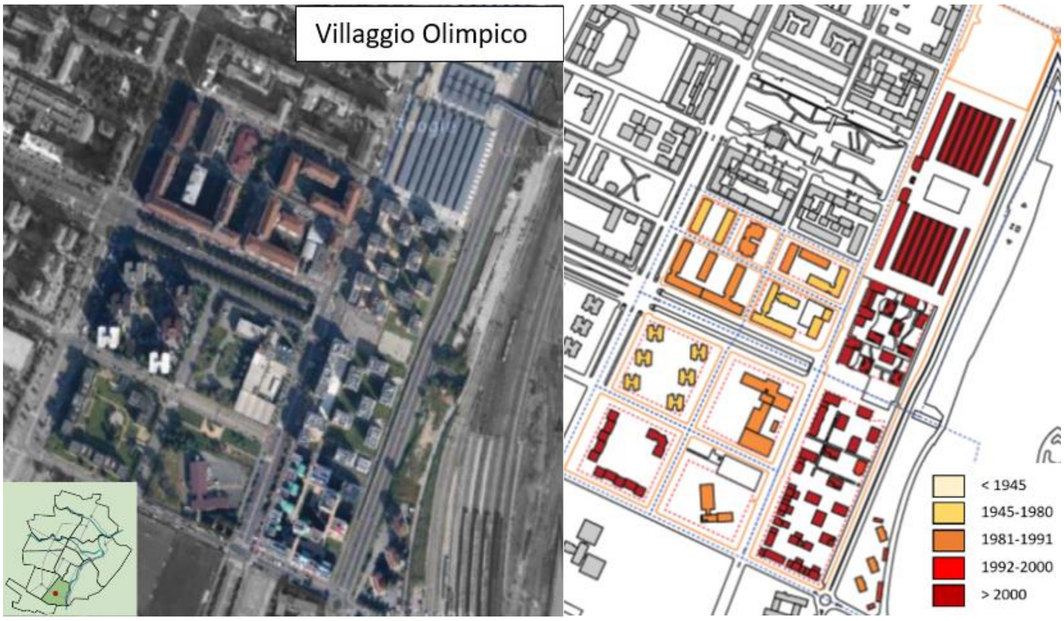


Figure 12(c): Urban configurations of Villaggio Olimpico district with buildings' period of construction.

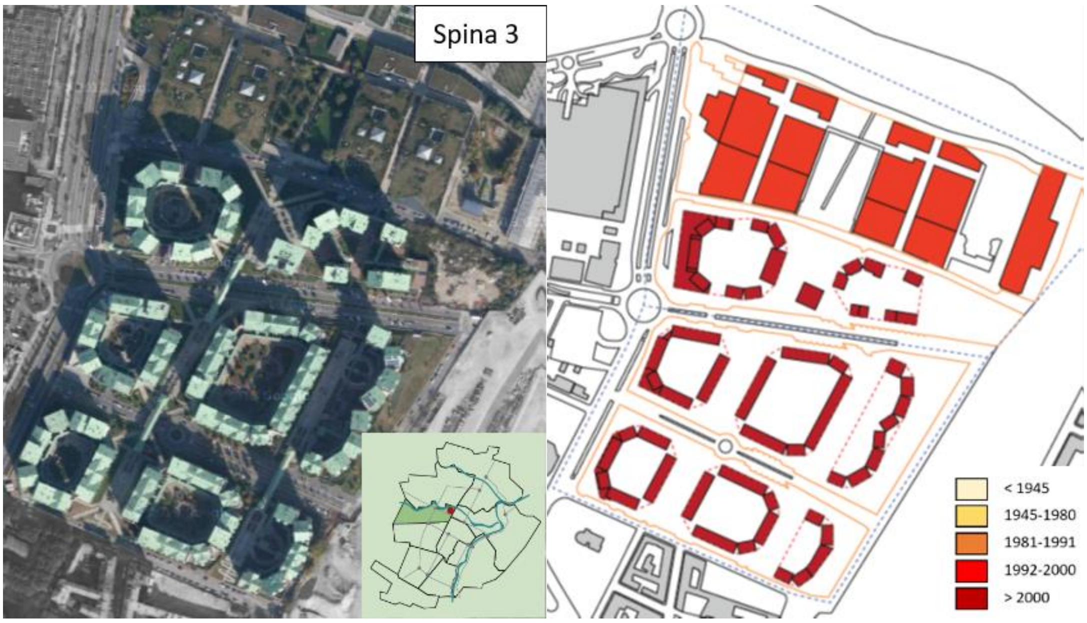


Figure 12(d): Urban configurations of Spina 3 district with buildings' period of construction.

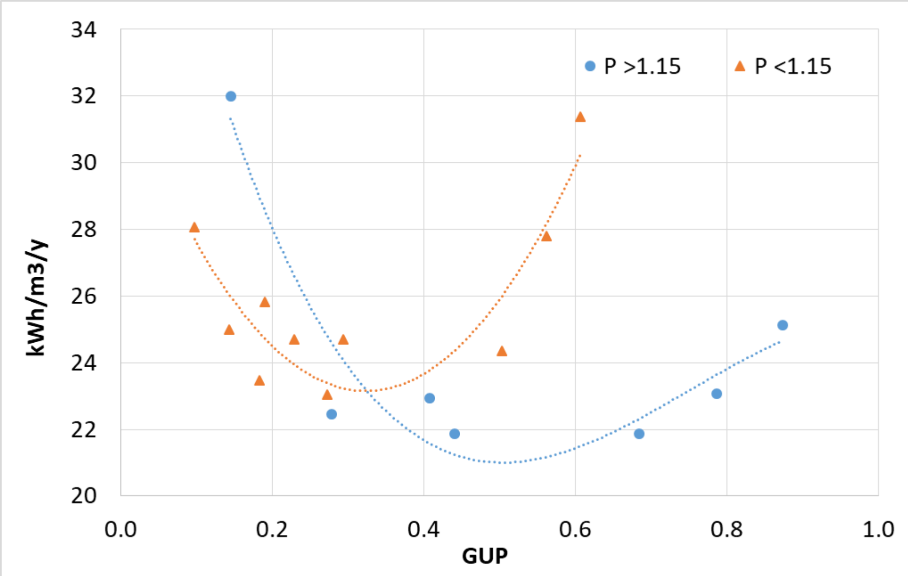


Figure 13: Heating energy consumptions and GUP values as a function of the solar exposure factor P classes (P<1.15 non-optimal and P≥1.15 optimal) for a central district in Torino.

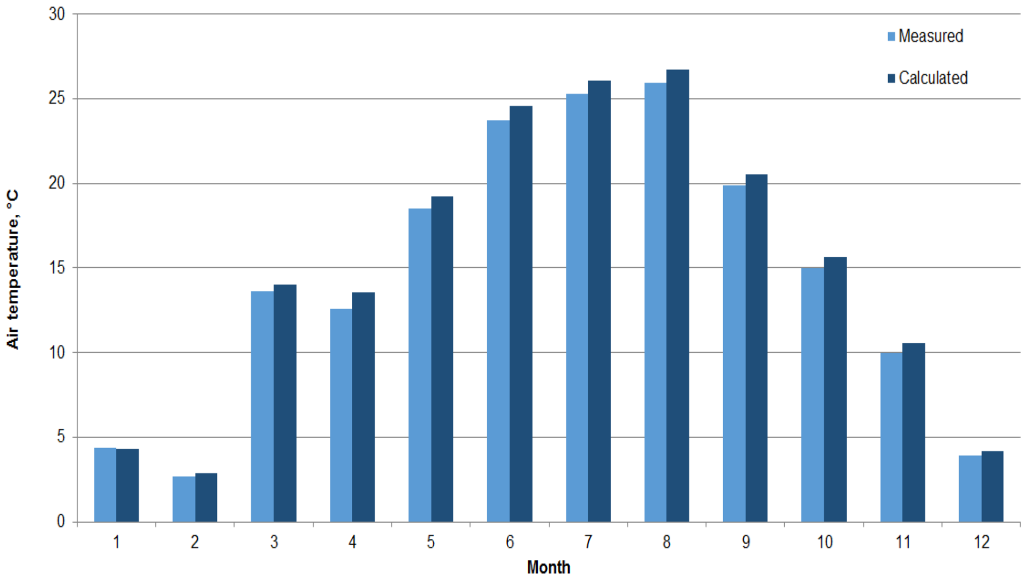
In Figure 13 it is possible to note that for low buildings densities (lower GUP values), energy consumption increases independently by the solar exPosure factor P; as for low-density urban layouts with low aspect ratio H/W no canyon effect can be exploit with a resulting higher heating energy-uses [9]. Otherwise, with higher buildings densities and aspect ratios, consequently higher GUP values, there is a different trend of increasing consumptions depending by the solar exPosure factor P. With a low solar exposition, the energy consumption increases rapidly, while with a better solar exposition this effect is smoothly with a larger range of the optimal GUP values with low energy consumptions.

Finally, from a comparison of the outside air temperatures recorded by eight weather stations in the city of Torino some correlations have been founded as function of the urban characteristics [23, 24]. In particular, considering the 2012 as an average reference year, the following correlation for the average monthly air temperature has been obtained for every census section (and represented in Figure 14):

$$T_{air,m} = (23.84\ G_{T,m}) + (1.4\ BCR) + (0.34\ H/W) + (0.39\ MOS) + (0.26\ H/H/) + \\ + (1.06\ MBO) + (-1.06\ A) + (-1.43\ H_2O) + (-0.32\ V) \qquad (4)$$

where:

$G_{T,m}$ is the gradient of monthly air temperature varying on the annual period from 0 to 1, and H_2O and V represent respectively the presence of water and green surfaces (presence=1, absence=0).



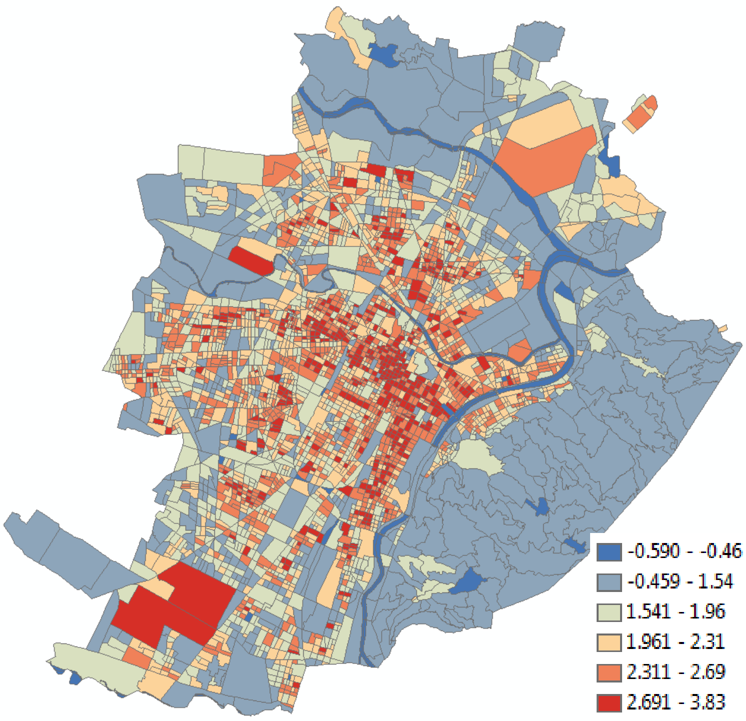


Figure 14: Monthly outside air temperatures measured and calculated (Eq. 4) for "via della Consolata" weather station and outside air temperature calculated with Eq. 4 for the coldest month of February 2012 for the city of Torino.

(1) Conclusions

The sustainability of urban environments should be analysed on multiple dimensions considering also socio-economic elements, varying from city to city and then no "one-solution" strategy can be proposed. The optimization of energy demand and supply of buildings and the exploitation of renewable energy sources at urban level could be a good compromise to the need of a sustainable environment and the high energy consumption for the anthropic activity, especially in urban contexts.

Main studies demonstrated also the influence of urban morphology on energy consumptions and moreover a correlation between energy consumptions and the microclimate variation in an urban environment. Therefore, simplified hybrid models based on Geographical Information System (GIS) tools could be an interesting solution to manage big data coming from different sources to design more sustainable and liveable cities. The research group is working on the demonstration of the validity of the proposed models to a wider geographical area, with different climatic conditions and building heritage. The study will cover not only the Italian territory, but also other countries such as the developing countries.

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PRELIMINARY ANALYSIS OF THE POTENTIAL BENEFIT OF THERMOREGULATION SYSTEMS AND INDIVIDUAL METERING OF HEAT CONSUMPTIONS IN THE ITALIAN RESIDENTIAL BUILDING STOCK

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Abstract

Individual metering in residential buildings has been identified by the European Union (EU) as one of the main drivers to reduce energy consumption in the residential sector.
The European Directive 2012/27/EU on energy efficiency requires the introduction of consumption-based cost allocation of heating, cooling and hot water in multi-apartment buildings supplied by a central heating source. The purpose is to ensure that users of each apartment have enough information to adopt energy-efficient practices.
To this aim, the Italian Decree nr. 102/2012 and subsequent modifications set the obligation for apartment and multi-apartment buildings supplied by a common central heating source or by a district heating/cooling network, to install, by June, the 30th, 2017, sub-metering systems to allow a fair cost allocation through the tenants.
In buildings where the use of heat meters is not technically feasible or not cost-efficient, individual heat cost allocators shall be used for measuring heat consumptions at each radiator, unless it would be demonstrated that the installation is not cost-efficient according to UNI EN 15459.
In several studies conducted in different EU Member States a very wide range (8-40%) of the expected benefit of individual metering of heat consumptions has been found. Unfortunately, specific studies regarding the Italian territory and the Mediterranean climatic conditions are still lacking.
In the present study, after a brief analysis of energetic benefit of such systems installed in some real multi-apartment buildings, the authors evaluate the potential benefit of thermoregulation and individual heat metering in the Italian residential building stock.
To this end, the Italian residential building stock has been analysed through both the ISTAT census 2011 and a recent statistical analysis performed by ENEA based on ISTAT data.

1. Introduction

In 2012, the European Union placed particular emphasis on greater knowledge of the energy consumption of end users by issuing the Energy Efficiency Directive 2012/27/EU [1]. In particular, Article 9 provides that consumers should be encouraged to better manage their consumption through individual accounting and informative billing.

In particular, article 9 set the obligation for multi-apartment buildings supplied by a common central heating source or by a district heating/cooling network, to install, by December the 31st 2016, sub-metering systems to allow a fair cost allocation through the tenants. The obligation applies as long as the installation of such systems is considered to be efficient in terms of cost/benefit ratio.

Italy applied article 9 without any substantial changes with Legislative Decree n. 102/2014 and Legislative Decree n. 141/2016 , making the obligation effective from 31st

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December 2016 (actually the obligation has recently been extended to June 30th 2017 with "Milleproroghe" Decree).

As regards multi-purpose buildings supplied from a district heating or a common source, owners are obliged to install individual heat meter for heating/cooling and DHW for each apartment or unit.

In multi-purpose buildings where the use of heat meters is not technically feasible or not cost-efficient, individual heat cost allocators (HCA) and thermoregulation systems shall be used for measuring heat consumptions at each radiator, unless it would be demonstrated that the installation is not cost-efficient according to UNI EN 15459.

To date, the potential impact of the application of this policy strategy on the Italian Country system is not completely clear, as the scientific literature lacks of studies regarding the effects of the installation of individual metering and thermoregulation systems in non-continental climates.

With respect to the mentioned regulatory obligation, Member States (MS) adopted different policy approaches [2]: in Germany and Austria, for example, the installation of heat accounting systems is compulsory for almost the majority of the buildings supplied by a common central heating source, whereas Sweden and Finland exempt nearly all the buildings virtually subject to the obligation, as it has not yet been clarified the existence of a real advantageous cost/benefit ratio at the actual operating conditions.

With regard to the expected benefits resulting from the installation of individual accounting systems in terms of energy savings, the interpretative note of Directive 2012/27/EU estimates that these can reach up to 30% [3].

In scientific literature there are not many studies on the evaluation of expected benefits for European countries. These studies describe energy savings ranging from a minimum of 8% to a maximum of 40% [4].

In particular, a recent bibliographic summary of the last 85 years [5] examines the results of 32 studies on individual accounting and billing of actual consumption in continental climates (Poland, Germany, Austria, Austria, Switzerland, Russia, etc...), based on the measurement of consumption before and after installation of measurement systems.

Among the studies concerning this matter, only few are based on the actual measurement of the energy saving carried out after the experimental observation of the buildings before and after the installation of the heat accounting and thermoregulation systems and, as previously mentioned, the vast majority is conducted in MS with continental climate (Poland, Germany, Austria, Switzerland, Russia etc.). The study estimates average savings in Europe of around 20%.

Among these, Cholewa et al. (2015) [6] analysed the energy consumption of 40 apartments in a multifamily building located in Poland for over 17 heating seasons. For the study, half of the investigated apartments have been equipped with heat cost allocators (HCA) on each radiator, half did continue to pay the heating costs basing on the square meter of the floor surface area. All the investigated apartments were equipped with thermostatic radiator valves (TRV) after 2 heating seasons from the beginning of the observation. The results have shown a clear difference between the energy consumption of the apartments equipped with both TRV and HCA and the ones of the flats without

HCA (-26.6% on average at the second year from TRV installation). The difference became greater when a more extensive retrofit intervention on the building envelope was carried out, allowing a better regulation of the internal temperature by the tenants.

It is underlined that, to the authors' best knowledge, no long-term experimental campaign for an empirical assessment of the benefit expected from the installation of heat accounting and thermoregulation systems was performed in Mediterranean climates. Indeed, it is difficult to extend the abovementioned results to buildings located in warm climates, such as the Italian one, also due to the different constructive characteristics of the national building stock.

2. Analysis of potentially benefits and influencing factors

The benefit obtainable by individual metering and thermoregulation, as well as energy consumption, is variable depending on several factors such as, family income, type of feedback and level of user information (a more frequent and detailed information on consumption can increase the total savings up to about 4% [7]), time between the installation of individual heat meters and the observation (in general, the expected benefit is fully realized from the second year since the installation of thermal meters) [8].

In order to assess the potential expected benefits, a preliminary study was conducted on 15 multi-apartment buildings supplied by a central heating source. The investigated buildings are located in two regions (Piemonte and Lazio).

The building consumption for space heating has been investigated during two heating seasons: one year before the installation of individual metering systems and one year after the installation of such systems.

Table 5 shows the results normalized respect to actual degree day (DD) of the zone. Although some of the buildings have increased their consumption, an average saving of around 8% was observed during the frist year after the installation of thermoregulation and individual heat metering systems.

The first results show a high variability of benefit for different buildings probably due to the diversity of climatic conditions and the numerous mentioned variables.

To allow for a better estimate of the benefit under the different conditions, it is necessary to extend the study to a higher number of multi- apartment building as envisaged by the current ENEA-UNICAS project.

City	Gas consumption before installation [m^3/DD]	Gas consumption frist year after installation [m^3/DD]	energy saving at 1st year [%]
TO	28.95	30.21	4.40%
TO	14.94	15.12	1.20%
TO	10.36	7.88	-24.00%
TO	6.48	5.37	-17.20%
TO	6.43	5.31	-17.40%
TO	8.48	7.30	-13.90%
TO	11.31	13.17	16.50%
TO	11.95	13.21	10.50%
TO	8.91	8.13	-8.80%
TO	5.76	6.67	15.80%
TO	22.83	20.19	-11.60%
RM	26.40	22.47	-14.90%
RM	10.75	8.63	-19.70%
RM	14.57	12.04	-17.40%
RM	25.57	20.91	-18.20%
Total	**213.69**	**196.58**	**-8.00%**

Table 5: Benefit from normalised thermoregulation with respect to climatic data

3. Characterization of the regional building stock

The aim of the study is to estimate the potential effect of the obligation introduced by Italian Legislative Decree 141/2016 on the Italian country, in terms of tons of oil equivalent potentially savable per year.

To this end, the Italian residential building stock has been analyzed through both the ISTAT census 2011 and a recent statistical analysis performed by ENEA based on ISTAT data.

In particular, the ISTAT 2011 census surveyed 31,138,278 dwellings. About 22% of the Italian dwellings is inhabited, while only 0.001% of the Italian dwellings is occupied exclusively by non-resident people, the latter is considered negligible for the purposes of the present analysis. ISTAT divides the surveyed dwellings in 6 dimensional categories and 9 constructive ages (between 1918 and 2006).

Referring only to dwellings occupied by residents, about 64% of Italian dwellings is part of a multifamily building (i.e. a building with 3 or more housing units), while the remaining share is equally distributed between the single/two-family building categories. For the scope of the present analysis, it is useful to observe that about 70% of the Italian dwellings was built before 1980, i.e. before any legislative requirement for energy efficiency of buildings (Law 373 of 1976) was issued. Of these, approximately 45% are multifamily buildings (see table 2).

Building category	housing units	buildings [n]	before 1980	1981 - 2000	Post 2001	All ages
single family house	1	4688972	14.27%	3.82%	1.39%	19.48%
two-family building	2	3995081	12.32%	3.32%	0.96%	16.60%
multy family house	3 - 4	3518114	44.85%	13.28%	5.79%	63.92%
	5 - 8	3443130				
	9 -15	3044095				
	16 and more	5375902				
Total		24065294	71.44%	20.43%	8.13%	100.00%

Table 6: Italian dwellings for different categories and construction ages (data processing by ISTAT census)

In order to take into account the variability of building typological and constructive features, the ISTAT database was analyzed on a regional basis, thus identifying: i) useful floor area, ii) number of floors and apartments per building, iii) heating systems features (i.e. central or independent heating system).

Figure 4 shows regional distribution of the 6 dimensional categories of building basing on the latest (2011) ISTAT census.

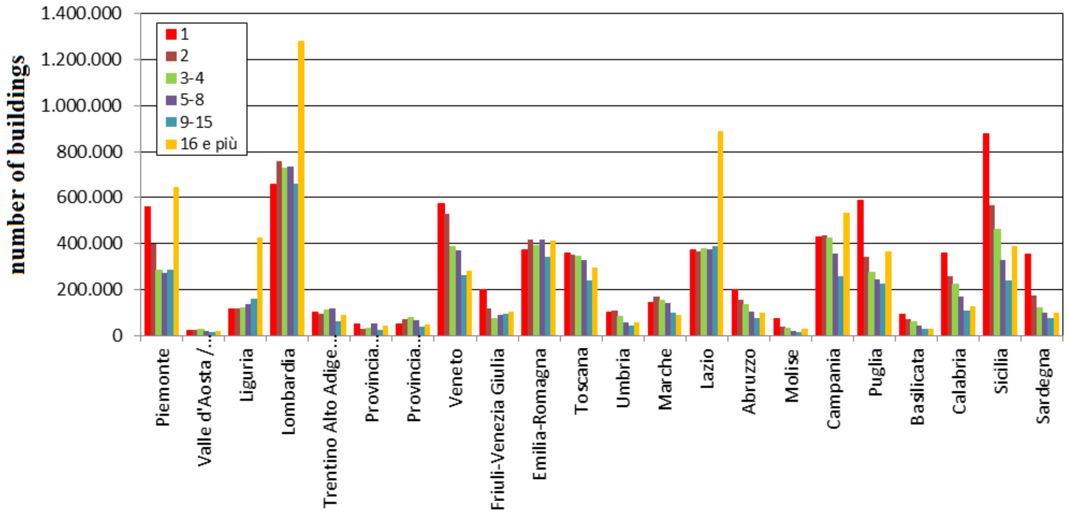

Figure 4: regional distribution of the 6 dimensional building categories (ISTAT census, data processed by UNICAS)

Finally, according ISTAT census, centralized heating plant is about 18.75% of the total heating systems in building/ dwelling occupied by residents in Italy as shown in Table 3.

Type of thermal plant	mumber of plants	percentage of plants
centralized heat plant	4,871,072	18.75%
Autonomous system for single dwellings	15,717,341	60.51%
Single fixed devices for the whole house	2,137,636	8.23%
Fixed individual appliances for some parts of the house	3,246,891	12.50%
TOT.	25,972,940	100%

Table 7: Dwellings occupied by residents: number and type of heating installation

According to the regional distribution, it can be noticed that) about 55% of total central heating plants is located in three regions (Piemonte, Lombardia e Lazio).

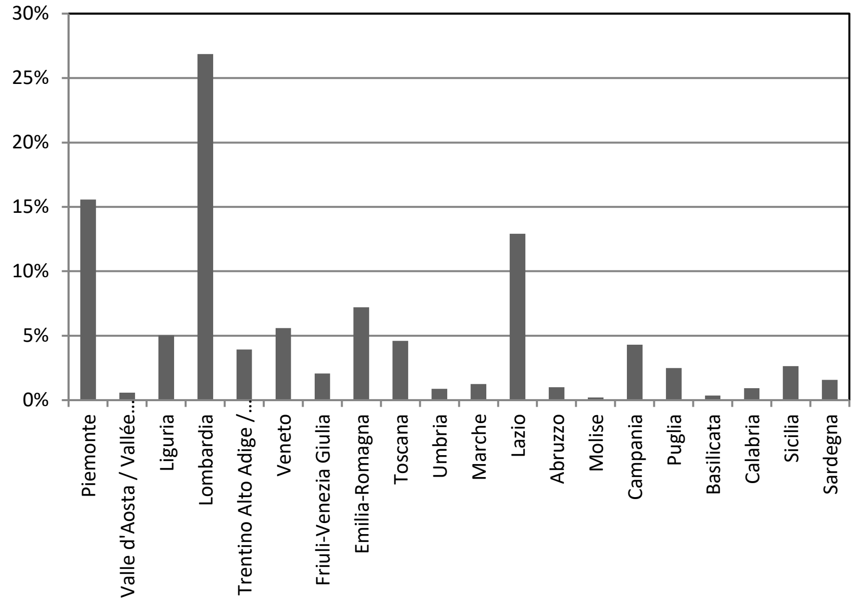

Figure 5: Regional distribution of dwellings with centralized heat plant

3.1 Evaluation of regional energy demand for space heating

In order to allow the assessment of the overall energy benefit of individual metering and thermoregulation systems, the energy consumption for space heating of the Italian residential building stock has been estimated.

According to statistical analysis, the classification of buildings was carried out in 54 classes (6 categories of occupation and 9 constructive periods between 1918 and 2006) associated to each region with the following simplified assumptions:

i) Average number of floors per occupational category, determined by weighted average: number of floors / number of building;

ii) floor height, obtained from the characterization of the national office building stock published by ENEA [9].

iii) Average useful floor area of dwellings: determined by total dwellings and total useful surface provided by ISTAT census

iv) External surface assuming: (i) cubic form of heated volume ; ii) ratio of window surfaces / useful floor area equal to the current legal limit (1/8) for all typologies and constructive times;

v) 10% thermal bridge increase for all building categories;

vi) thermal transmittance of envelope components varying as a function of the construction age (Figure 3), based on data from TABULA project [10] which identifies the national construction types and the relevant period of greater diffusion for the climatic zone E. For the purpose of this study, such constructive typologies have been considered representative throughout the national territory.

In order to take into account both building envelope retrofit throughout the national territory and the variability of the constructive features of regional building stock, the average thermal transmittance of buildings prior to 1990 have been reduced in percentage according to degree day of climatic zone.

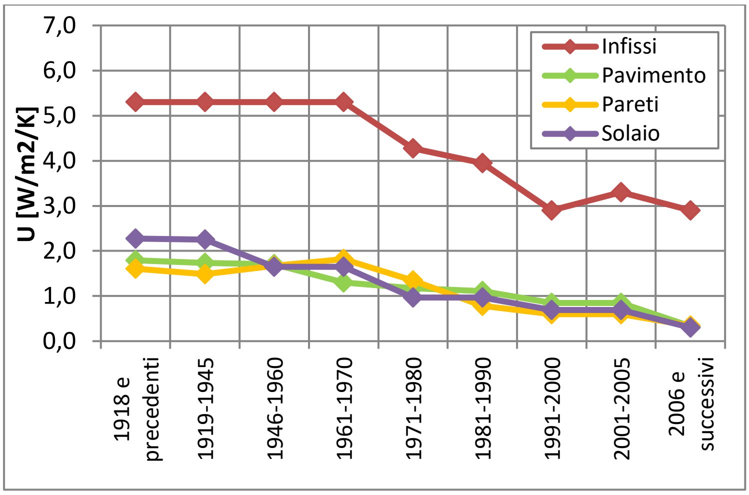

Figure 6: Estimated thermal transmittance of national building stock (UNICAS processing of TABULA data)

The primary energy need for space heating has been estimated according to asset rating method as described by Ministerial Decree 26/06/2009 with the following simplified assumptions: i) solar heat gain evaluated for a real reference building, located in different latitudes ii) boiler efficiency evaluated according to data available by TABULA project for different ages iii) no unheated spaces in the building iv) efficiency of distribution and regulation system equal to 0.95 v) free gain utilization factor equal to 0.95. Primary energy demand for space heating has been evaluated in operational rating condition using the intermittent coefficients previously estimated by ENEA following a sampling analysis involving 20,000 buildings of the Italian territory. The intermittent coefficients are available for six representative provinces of the respective climatic zones and for different dwelling typologies (single family house, multi-family house, apartment close-up, top floor apartment, intermediate floor apartment)

4. Benefit of thermoregulation systems and individual metering

The primary energy need for space heating of residential Italian building stock amount to about 20.4 Mtep, as calculated by the authors. In order to validate the calculation model, the result has been compared with the data provided by Regional Energy and Environmental Plans (PEARs) [11], and National Energy Balances (BEN) provided by the Ministry of Economic Development [12]. However, these data are provided in aggregate form under “Residential macro area” including energy consumption from heating and cooling, lighting and household electrical appliances, cooking and domestic hot water. To overcome this problem, the share for space heating has been evaluated comparing Italian residential sector consumption evaluated by EUROSTAT from 1990 to 2015 with national energy demand for space heating evaluated by ENEA from 2000 to 2013 as shown in table 4.

Year	Italian residential sector consumption (EUROSTAT) [Mtep]	Space heating (ENEA) [Mtep]	Share for space heating [%]
1990	26.06		
1995	26.32		
2000	27.59	16.7	60.42%
2001		17.1	
2002		17.2	
2003		19.7	
2004		19.2	
2005	33.92	21.7	63.88%
2006		21.1	
2007		20	
2008		22.8	
2009		23.3	
2010	35.39	23.9	67.50%
2011	32.38	20	61.77%
2012	34.35	22.2	64.69%
2013	34.23	22.2	64.91%
2014	29.55		
2015	32.49		
Media			**64.02%**
Incremento % annuo (2000-2013)			**2.56%**
Incremento % annuo (2003-2013)			**1.15%**

Table 8: Residential consumption (BEN) and share for air conditioning

Furthermore, the Regional Energy and Environmental Plans (PEARs) have been issued in different years, starting from 1998 (Liguria region) to 2013 (Molise region). In order to allow a comparison, all data have been discounted compared to the reference year 2017, considering a percentage increase in space heating energy consumption by 1% per year, as shown in table 5.

	space heating (evaluated by authors) [Mtep]	space heating (PEAR data and average share factor 0.64) [Mtep]	Percentage error [%]
Sardegna	0.283	0.335	-15.52%
Sicilia	0.599	0.552	8.54%
Calabria	0.267	0.241	10.81%
Basilicata	0.14	0.133	5.35%
Puglia	0.815	0.83	-1.88%
Campania	0.777	0.791	-1.79%
Molise	0.119	0.121	-2.03%
Abruzzo	0.259	0.245	5.49%
Lazio	1.593	1.851	-13.97%
Marche	0.525	0.491	6.85%
Umbria	0.225	0.224	0.63%
Toscana	1.324	1.335	-0.82%
Emilia	1.672	1.485	12.57%
Friuli-Ven.	0.424	0.392	8.28%
Veneto	3.799	3.995	-4.90%
Trentino	0.552	0.529	4.41%
Lombardia	3.805	3.651	4.20%
Liguria	0.685	0.729	-6.05%
Valle d'Ao.	0.101	0.087	16.17%
Piemonte	2.407	2.254	6.77%
Italy	20.37	21.212	-3.97%

Table 9: Comparison between calculated heating consumption and actualized PEAR data. (UNICAS processing of EUROSTAT data [20] and ENEA data [25])

The average error of estimated energy demand for space heating (Table 5) is within 4% compared with to national data and within 20% compared with regional data of PEARs; This one is consistent but acceptable; indeed, regional data comparison is altered by lack of current data as well as data about actual energy demand for space heating.

The potential benefit of thermoregulation systems and individual metering of heat consumptions has been calculated by "filtering" regional consumption shown in table 5 compared to: (i) the percentage of regional centralized heat plan, ii) categories of occupation (excluding single-family house), iii) cost / benefit ratio of the installation according to UNI EN 15459.

The cost / benefit ratio is strictly dependent on energy consumption for space heating before systems installation.

According to Celenza et al. [2], the economic efficiency of thermoregulation systems and individual metering is not demonstrated below a threshold of primary energy consumption for space heating (asset rating).

According to results of technical-economic analysis shown in the document of the Authority for Electricity, Gas and Water Systems, AEEGSI, (DCO 252/2016), installation of individual heat meters is not cost efficient in case of primary energy need for space heating (EP) is less than 80 kWh / (m2* year); indeed individual heat meters in multi-family building is cost efficient in case of EP is greater than 155 kWh / (m2 *year) evaluated by Energy Performance Certificates (EPC).

In the same document, AEEGSI identifies a minimum level (10%) and maximum level (20%) of expected benefit of individual metering in the multi-family building.

In this study two scenarios have been analyzed combining the minimum benefit (10%) to buildings with a primary energy consumption more than 155kWh/(m2*year) and maximum benefit to buildings with primary energy consumption more than 80 kWh(/m2*year).

As shown in Table 6, if all the potentially obliged buildings (EP>80 kWh/m^2, EP>155 kWh/m^2) would install thermoregulation systems and individual heat metering ,the expected energy saving would be between 0.247 and 0.839 Mtoe / year.

	Apartments with centralized thermal plant [%]	Centralized heat plant - Energy Cunsumption [Mtoe]	Centralized heat plant - Energy Cunsumption (Ep>155 kWh/m^2) [Mtoe]	centralized heat plant - Energy Cunsumption (Ep>80 kWh/m^2) [Mtoe]	Total Energy saving (benefit 10%) [Mtoe]	Total Energy Saving (benefit 20%) [Mtoe]
Sardegna	11.61%	0.0329	0.0098	0.0226	0.001	0.0045
Sicilia	6.63%	0.0397	0	0.0231	0	0.0046
Calabria	5.91%	0.0158	0	0.0097	0	0.0019
Basilicata	7.43%	0.0104	0.0045	0.0083	0.0004	0.0017
Puglia	8.04%	0.0655	0.0184	0.0446	0.0018	0.0089
Campania	10.34%	0.0804	0.004	0.0484	0.0004	0.0097
Molise	8.39%	0.01	0.0058	0.0087	0.0006	0.0017
Abruzzo	9.53%	0.0246	0	0.0161	0	0.0032
Lazio	27.61%	0.4398	0.1923	0.3998	0.0192	0.08
Marche	9.97%	0.0523	0.0347	0.0476	0.0035	0.0095
Umbria	11.96%	0.0269	0.0082	0.0215	0.0008	0.0043
Toscana	14.68%	0.1944	0.1179	0.1798	0.0118	0.036
Emilia	18.82%	0.3147	0.2065	0.2935	0.0206	0.0587
Friuli-Ven.	18.72%	0.0794	0.0047	0.0548	0.0005	0.011
Veneto	13.99%	0.5317	0.4366	0.5129	0.0437	0.1026
Trentino	45.61%	0.2518	0.1797	0.2457	0.018	0.0491
Lombardia	31.97%	1.2164	0.5244	1.082	0.0524	0.2164
Liguria	33.02%	0.2261	0.1396	0.2223	0.014	0.0445
Valle d'Ao.	47.36%	0.048	0.0448	0.0477	0.0045	0.0095
Piemonte	39.49%	0.9505	0.5425	0.9078	0.0543	0.1816
Italy				**[Mtoe]**	**0.247**	**0.839**
				[%]	**1.21%**	**4.12%**

Table 10: Summary of estimated consumption and potential savings (data discounted to 2017)

5. Conclusion

In this work, the first results of an ongoing UNICAS-ENEA experimental study were presented, showing a high variability in the benefits of installing individual heat metering and thermoregulation systems in residential buildings supplied by centralized heating systems. Although some of the buildings under study have even increased their consumption, an average saving of around 8% was observed during the first heating season and 10% at the end of the second heating season after the installation of the systems.

In order to assess the potential impact of the installation of individual heat metering and thermoregulation systems in buildings required by Legislative Decree 102/2014 and subsequent amendments, an analysis of energy consumption for space heating in the Italian residential sector was carried out through the characterization of the building stock in each region.

The analysis shows that the total savings achievable on a national basis updated to 2017 is between 0.247 and 0.839 Mtoe, values respectively associated with a benefit for thermoregulation and individual heat metering of 10% and 20%.

However, a more accurate calibration of the calculation model should be obtained through: i) a better characterization of thermal transmittances for each climatic zone and/or Italian region (also drawing on the regional databases under construction), ii) the determination of the number of buildings that have already installed metering and temperature control systems, iii) the retrieval of official consumption data for space heating in the Italian and regional residential area.

The authors believe that it is necessary to extend the experimental study to a substantial number of multi apartment buildings in order to identify the average benefit applicable to the Italian territory and the possible factors of influence.

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OVERVIEW OF THE ENTREPRENEURSHIP OF BIODIESEL COMPANIES IN MEXICO, PERSPECTIVE BASED ON THE INSTITUTIONS

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Abstract

The objective of the present research is to analyze the role of the institutions in the biodiesel industry, in order to know if there is a relationship with the quality and maturity of the same with the ventures. Starting from a literary review, the framework of the current situation is identified, covering aspects related to formal institutions, laws, rules, regulatory bodies and the theory that supports the relationship between institutions and entrepreneurship. Concluding that the institutions in Mexico have increased their maturity and incentive to increase the number of producers and distributors of biodiesel thus taking advantage of the growing market.

Keywords: Institutions, entrepreneurship, biodiesel
JEL: M20, M13, Q13, Q35, Q42

1. Introduction

The current situation of a shortage of natural resources requires the innovations and ventures in production sectors that help to reverse the situation, so the research seeks the stability of markets that achieve competitiveness and preservation of the environment.

The biodiesel market is in constant growth. By 2023 consumption is expected to reach more than 40 million liters around the world. According to OECD (2017) information, the United States, as well as European countries and some countries of South America such as Argentina, Brazil, Colombia and Chile stand out to have quickly added in this new project of an economy with a better vision of the preservation of the environment. This new change in the consumption trends of the people, generates new markets that can be exploited by developed country economies as emerging countries that have the necessary resources for the production and supply of biodiesel.

Entrepreneurship is given by several factors, some of which may be the best scenarios, such as unique opportunities, innovations that meet specific needs that were not counted in the past. These types of entrepreneurship are what the countries need because they get the most number of benefits, job creation, sustainable economic growth. The boom in the demand for biodiesel at the global level could be one of those opportunities that must be taken advantage of. However, the opportunity to recognize a growing market alone does

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not ensure success because the planning and knowledge of the terrain in which entrepreneurs seek to enter, are flaws that could be had. Being a relatively new market few are those who have all the necessary information to say know or be experts in the competitive bioenergy market.

For this reason, formal institutions such as laws or bodies that govern the conduct of industry can be a tool that helps entrepreneurs to have a delimited vision of the actions that are possible to carry out, which can be observed as a knowledge which is transferred from the institutions to the entrepreneurs that helps them to generate success.

In addition to the existence of formal institutions with sufficient quality and maturity as can be easy to apply legal frameworks and regulatory bodies with good planning and implementation of actions, such as aid in reducing taxes. This may provide financial support and development on the part of the researchers in a specific line of research, which serves to give rise to a greater degree of entrepreneurship in a specific sector that has all the incentives.

The background check showed that there was a clear concern about the lack of rules in the game in this sector that made the market in Mexico unable to consolidate. However, there were already bodies that were looking to develop enough regulations to clarify the path of those interested in entering this new market that was emerging at a fast pace.

Therefore, in this study, a theoretical analysis will be carried out, comparing the evolution of the biodiesel production companies in Mexico, in order to determine if there is a relationship with the formal institutions and they will solve the inefficiency that was seen in this sector in 2008.

2. Background of the problem

In 2009 Biotop, which was a project for the evaluation of technical opportunities and research needs for Latin America, mentioned how the Mexican regulatory framework for the promotion of biofuels was at an early stage and was still under development. Limiting for biodiesel companies in Mexico could be due to formal institutions that did not work in the best way.

The knowledge of this failure in the Mexican market seeks to be solved as Rembio in 2009 mentions that there were no specific promotion policies for the second generation of biofuels, but these are likely to be included in a new biofuels research program, which will be developed by The National Council and Technology (CONACYT).

It has been noted in the empirical review that a problem in Mexico for entrepreneurs interested in the renewable energy markets in specific biodiesel is that the institutions are not clear enough in their actions that helps to understand the market.

3. Delimitation of the problem

Given the growing market for biodiesel consumption and the fact that there are no companies that monopolize production, a solid production base can be created in Mexico to help the country's economic growth. However, no solid evidence has been found to be advanced at the pace that should be.

Considering that natural factors are conducive to the production of the raw material and there is no monopolizing company of production in Mexico, adding that the demand for biodiesel is increasing, it would be expected that by complying with the theory of resources and capabilities and that the industry is not strong, the biodiesel production sector is increasing. This leads to conclude that there is some other factor inhibiting this growth, and the antecedents of the lack of institutions that help the initiatives of productive companies in biodiesel generates the following question:

How have formal institutions impacted the creation of biodiesel producing companies in Mexico?

4. Justification

As the biodiesel sector is a growing market that demands more liters' year after year, it is an opportunity for Mexico, to consolidate its productive industry and to be competitive worldwide.

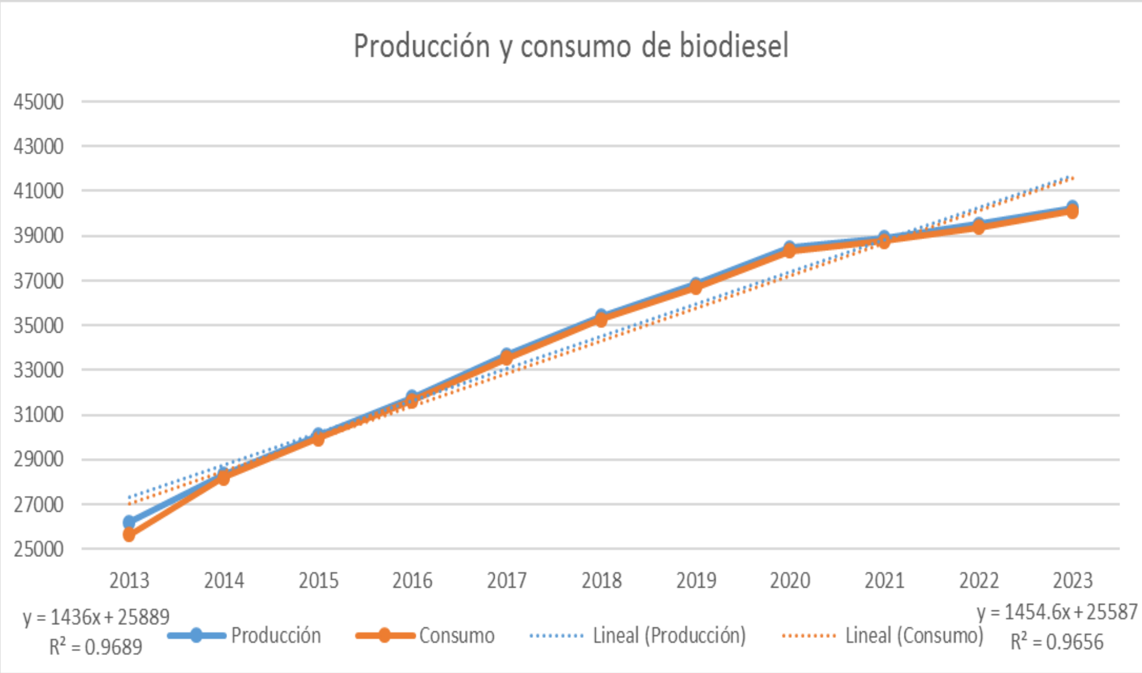

Figure 1: Projection of biodiesel production and consumption from 2013 to 2023
Source: Prepared by the Organization for Economic Co-operation and Development (OECD Stats, 2017).

As can be seen from 2014 consumption has approached the production with its increase of 1454.6 per year in average consumption compared to the 1436 that increases per year on average the production. It is concluded that, if this trend continues, the demand to consume will be higher than the production, which is why it is a moment for there to be ventures in this sector. The estimators of the variations in the independent variable are good estimators because the coefficient of determination (r^2) is greater than .6 which is a parameter that is used to accept.

However, there is concern that institutions have been able to improve the picture, so that enterprises in this sector have a better direction. The Energy Regulatory Commission in (2014) mentions the regulatory area in which it is in charge of energy, in addition to mentioning the institutions that also help regulate it, such as the National Hydrocarbons Commission (CNH), the Secretary of Energy SENER), the Ministry of Finance and Public Credit (SHCP), the Federal Economic Competition Commission (COFECE) and the Security, Energy and Environment Agency (ASEA).

The objective of the institutions is to create conditions for the efficiency of the energy markets (Energy Regulatory Commission 2015). There is a growth in the regulatory framework of bioenergetics, for which it is necessary to know if the stability in the regulatory framework that has been established has helped in the stability of the market and above all to know if the institutions have favored that there are ventures in biodiesel.

There is a relationship with institutions and entrepreneurs around the world as research in 2015 mentions that:

"To the extent that the entrepreneur carries out his activity in an environment where the rules of the game are well-defined (i.e. that there is good protection of property rights, that the judicial system functions properly, that governments are stable or that there is no corruption, among other factors), the entrepreneur will enjoy greater security that will positively contribute to the success of his company "(Fuentelzas and Gonzalez, 2015).

5. Theoretical conceptual framework

5.1 Emergence of biodiesel

With the emergence of the industrial revolution by force, the great population growth around the world arises some problems, as Agarwal (2007) mentions humanity faces problems, in which arises the main interest on the environmental deterioration and the crisis of the industry energy. One of the main causes of air pollution is the burning of oil, since the combustion of air produces large amounts of greenhouse gases (carbon dioxide, oxides of nitrogen), sulfur oxides, unburned hydrocarbons and ash thin (Agarwal, 2007). In addition, it needs to be considered that hydrocarbon-based fuel is a non-renewable good, it is finite on the planet and therefore it has been necessary to resort to energies that can be renewable and more friendly to the environment.

"Recent studies indicate that there are other sources of energy, which have extremely low emissions and appear to have the potential to become energy sources for automotive propulsion, including alcohols, natural gas, hydrogen and biodiesel" (Medina, Chávez and Jáuregui, 2012, 63).

This leads to the conclusion that an alternative for this destruction that causes economic growth inconsiderate by the environment, may be the use of these substitutes for conventional fuels.

The definition of biodiesel used for this work is as follows:

"It is a mixture of methyl esters of fatty acids (FAMEs) that is obtained by a process of transesterification, mainly from vegetable oils and animal fats and, more recently from algae. It can be used as a substitute for conventional diesel, as it has similar properties, reducing pollution and extending the life of the vehicle's engine. In its production, glycerin is obtained as a by-product, with multiple industrial applications. "(Molina, 2012, 7)

6.2 Theories of entrepreneurship

First, it is necessary to state that it is what is understood as an entrepreneurship. The entrepreneurship is the search for constant change, generation of ideas, speculation of projects that generate beneficial effects for the economy and society (Contreras and González, 2010). In a broader explanation, Sánchez and Pérez (2015) define it as those initiatives of an entrepreneurial nature that relate the way of being an individual where are included the way of thinking, reasoning and acting, with the search for a business opportunity, which give as a result initiative that generate value not only in an economic sense. In addition, concerned with social aspects, where all the actors are involved in the initiative, which go from owners, employees, customers, suppliers and society in general that enjoy this benefit.

However, Baumol (1990) makes a distinction between undertakings that are productive, unproductive and destructive. The productive enterprise is one in which there really is innovation, economic growth and can be associated with the discovery of good business opportunities. There are more distinctions between what are entrepreneurships like the one that is done between entrepreneurship by opportunity and entrepreneurship by necessity. When there is an opportunity venture, there is greater growth in the economy because that innovation has found a new niche market, which is exploitable. What does not happen when individuals are forced to undertake by necessity, that the development of jobs and growth of the economy is not with the same acceleration (Reynolds, Bygrave, Autio, Cox and Hay, 2003)

The World Economic Forum also continues to classify high-impact entrepreneurship as one that generates greater benefits for consumers through the use of innovations, which in turn also generate more job opportunities and greater wealth for owners (Economic Forum World, 2014).

For all in their classifications they approach the same point in which they describe the entrepreneur as the one who manages to find opportunities that generate greater benefits and the use of innovations that sustain and exploit the opportunity more time. These entrepreneurs who focus on their clients are the ones who generate the greatest wealth for their owners (Hitt, Ireland, Sirmon and Trahms, 2011). These entrepreneurs tend to plan their actions better and to enter the market early and the most usual is that they undertake in markets with which they have already had interaction, which makes their rate of failure less than in situations in which there is no such planning and market knowledge (Liñán, Fernández, Romero, 2013).

Entrepreneurship is an indispensable mechanism for the development of economies (Schumpeter, 1934), it is necessary for every economy to develop enterprises that foster the generation of valuable jobs and innovations. However, the view was that political rulers should focus on favoring the growth of developed firms with the greatest potential for growth, leaving behind small firms and ventures (Friar and Meyer 2003). The political rulers who are responsible for the development of public policies, which Bazua and Valenti (1993) explains that a public policy is a reference to any social decision, which can be taken by an individual, an organization or the state.

Governments at all levels from federal, state, and local to the importance of firms on the economy, social and political issues have focused on creating the policies needed to support entrepreneurship. But they are faced with the decision whether policies will focus on supporting the nation's leading firms, helping existing firms achieve survival, or focusing on the formation of new enterprises (Stam, Studdle, Hessels and Stel, 2009).

6.3 Theories of formal and informal institutions

North (1990) defines institutions as the humanly constructed constraints that structure human interaction, which is understood as the "rules of the game". Companies must take into account the terrain in which they will enter to know how they can act and if it is possible to take advantage. In addition to mentioning that institutions are created to reduce uncertainty. These institutions that are created to reduce uncertainty can encourage investment to increase productivity, but in countries where institutions are not as robust, the effect is the opposite (North 1990).

Peng (2012) states that the institutional framework is constituted by both formal and informal organizations, which will mark the actions that can be taken individually and collectively. Formal organizations are institutions that are represented in writing and are usually more rigorous in making them comply with the desired pattern of behavior; These are the laws, the regulations and the rules. However, for the study of this research, the informal institutions that although in many investigations show that it is one of the main factors to consider when entering new markets of which knowledge is lacking, this study only focuses on analyzing how the formal institutions favor or not the ventures.

Undoubtedly, the levels of entrepreneurship in a given country or region are conditioned by the environment in which entrepreneurship is carried out, since such an environment can facilitate or discourage the initiation of new initiatives (Fuentelsaz, González and Macías 2015). Institutions of a formal nature, such as laws or regulations, make it easier to visualize how processes should be carried out, which makes the business easier to manage and if it does not have experience, as is the case of ventures having a well-defined way of acting can achieve success. Proprietary rights, commercial legislation, constitution procedures, ideas, cultural beliefs, gender, attitudes towards the entrepreneur, etc., influence the appearance and development of new companies (Marulanda and Morales, 2016, 18).

Based on the theory of institutions, Urbano and Diaz (2009) affirm that the environment in each country will be decisive in terms of business opportunities that are available in addition to the perception about them and their ability or capability to adaptation to use them in their favor will generate greater incentives for the creation of new companies.

Without the necessary experience, in the new environment in which new start-ups seek to penetrate, they may encounter problems that limit access to financing, make it difficult to hire high-quality personnel and result in higher transaction costs (Aldrich and Auster, 1986). Under the circumstances of uncertainty on the part of those seeking to undertake an initiative, Fuentelzas (2015) mentions how the existence of solid institutions can facilitate the resolution of complications of inexperience, access to resources necessary for its functioning, and stability in the development of its activities. Institutions can facilitate access to resources and provide the necessary stability for the development of the activity, with the consequent effect on levels of business survival.

This demonstrates that the quality of institutions has a strong influence on competitiveness and growth, affects investment decisions, the organization of production and plays a key role in the way societies distribute profits and the costs of developing strategies and policies. However, an unstable institutional environment leads to even more complicated behavior among firms, hinders their cooperation and makes the vision of growth in the short term, which has negative effects on the quality and success of firms. (Fuentelzas and González, 2015).

The uncertainty faced by the initiatives means that the number of successful ventures is reduced, however, as Vargas, Guerra, Bojórquez and Bojorquez (2014) mention that institutions have as their main role to reduce uncertainty and distinguish between uncertainty in a) Policy, which refers to ethnic disturbances that can cause problems for firms, and b) economic, which are all transaction costs that can be given by opportunism, to prevent these negative circumstances in the firm refer that firms can make use of contracts.

6. Contextual framework

The main regulatory framework in Mexico is the political constitution of the United Mexican States that establishes the framework of action of the authorities and the governed, through principles, rights and obligations that govern the rest of the national legal framework. Article 4 of the Constitution speaks of "Everyone has the right to a healthy environment for their development and well-being”. "The damage and environmental deterioration will generate responsibility for who provokes it in terms of the provisions of the law" which has been added as Decree of the Official Gazette of the Federation on February 08, 2012. In article 25, the constitution mentions that "the State is responsible for national development to ensure that it is comprehensive and sustainable." This demostrates its concerns about caring for the environment.

The main law in specific terms in renewable energy is the Law on the promotion and development of bioenergetics that in its first article mentions "to promote the production of inputs for bioenergetics from agricultural activities, forestry, algae, biotechnological processes and sovereignty food "its main obligation under this law is to promote the use of bio energies in Mexico. Article 8 of this same law mentions that "the Bioenergetics Committee is created, which will be composed of the members of SAGARPA, SENER, SEMARNAT, the Secretary of Economy and the Secretary of Finance and Public Credit" with which several organizations are involved in the promotion of bioenergy production and research.

Likewise, the energy agency in Mexico, the Secretary of Energy (2017), reports that 7 permits are granted for the production of bioenergetics, 41 bioenergy marketing permits, 5 transport permits and 21 permit exemption notices for Production of bioenergetics.

The National Commission for Science and Technology in February 2017 reports that the Secretary of Energy launches a call for the creation of development projects in sustainable energy technologies that comes with the support of the Bank of Mexico in which the first prizes will be awarded prizes in cash of up to 2 million dollars for the first place, from 500 thousand dollars for the second place and 100 thousand dollars for the third place. There are these types of competitions that encourages the research and development of initiatives in alternative energy with which firms who want to venture but lack financing. This type of competitions can be the solution, these are not isolated situations, it is a way to encourage development that has its opportunity year after year.

The Ministry of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA) (2016) reports that it has promoted from 2013 to date 960 projects for the production of biofuels in Mexico. In the last four years' incentives have been granted around 275 million pesos, which has generated a total investment of 529 million pesos. And on the installation of 7 biofuel plants, six of which are dedicated for the production of biodiesel with 4 plants more than they existed in 2009.

7. Method

In the present research the qualitative method based on the literary revision is used, based on studies applied in Mexico, Latin America and Spain, as well as data presented by institutional organisms and comparing with the applied theories of entrepreneurship and institutionalism, with the aim to explain and describe the phenomenon under study.

8. Analysis of results

An attractive market such as biodiesel for its constant growth should have a sufficiently strong regulation to encourage the consolidation of existing companies as well as new entrepreneurs seeking to enter into competition for the market, so that it was imminent that the State should intervene to promote economic growth.

The ventures for companies producing biodiesel in Mexico for the years 2008-2009 that were their beginnings in the Mexican market, there was a confusion and instability, generated uncertainty that caused that the enterprises in this sector were not encouraged, so It was necessary an intervention of formal institutions, and the state who can generate new regulatory frameworks in any sector.

After the review of events on how to change the landscape of institutions in Mexico to be a first-time trial and error, it has been possible to consolidate and strengthen entrepreneurship initiatives in biofuel companies, especially biodiesel has been favored with a growth of twice what existed. So it can be noted that if there is a relationship between the formalization or solids of the institutions with the initiatives and start-up of enterprises, which supports the theoretical basis and study that was carried out by Fuentelzas, who show how institutions are an important factor for successful ventures in their areas.

9. Conclusions and recommendations

Because of this one of the concerns that must be had if the economy is to be more competitive compared to countries with a faster growth rate than the Mexican, it is necessary to be clear that formal institutions is a way in which entrepreneurs achieve organizations that exploit available markets and do so in a sustainable manner.

In addition, all those who seek to generate a project in the renewable energy sector as well as any other type of industry need to look for countries with better formal institutions, or in case of entering emerging markets that usually do not have a solid structure in its laws, regulations and regulatory agencies, to anticipate the failures that can be caused and the costs that this would cause to enter the market with proactive strategies and not wait to be in unsustainable situations.

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CROWDFUNDING WIND FARMS IN CHAMPAGNE BERRICHONNE: TOWARDS ACCEPTABILITY OF FACILITIES?

Roman Garcia[7]

Abstract

The challenges posed energy are at the heart of contemporary energy policies. Energy efficiency and reducing greenhouse gases are causing new directives essential in a Europe dominated by oil and, to varying degrees, by nuclear. In this context, rural territories are at the heart of this issue to move towards the energy transition. The changes in rural areas also crystallize societal tensions in terms of acceptability. The installation of wind farms generates tensions and even conflicts of use. It is in this context that new forms of wind energy development are realized, including Champagne Berrichonne. Citizens are associated with development through the establishment of a participatory financing of wind farms, which implies the establishment of new forms of governance and management of wind farms.

Introduction

Energy issues are at the *heart* of contemporary energy policies. Energy efficiency and the reduction of greenhouse gases are at the origin of new indispensable directives in a Europe dominated by hydrocarbons and, to varying degrees, by nuclear power. Wind energy is at the *heart* of these environmental and energy policies. It is now the greenest energy installed in the country (if hydroelectricity is not taken into account), either in terms of power generation and installed capacity. The installed capacity in January 2016 was 10,308 MW (source: France Energie Eolienne). France has set a target of achieving an installed wind power of 19,000 MW by 2020.
In this context, rural territories are at the *heart* of this problem to move towards energy transition. For twenty years now, there has been a functional change in these spaces, with the emergence of new energy functions thanks notably to the development of wind energy. This functional change, starting with wind, also guarantees the countryside a part of their development, thanks to the economic spin-offs for local authorities.

Changes in rural areas also crystallize societal tensions in terms of acceptability. Despite the economic benefits achieved, in spite of the environmental challenges generally accepted by all, the installation of wind farms generates tensions and even conflicts of use at all levels: both with decision-making bodies and citizens whose environmental concerns are reflected in the facts by a rejection of these facilities. It is in this context that new forms of wind development take shape, notably in Champagne Berrichonne (north of the department of Indre, France). Citizens are involved in development through the implementation of participatory financing for wind farms and through information provided throughout development. The objective of the study is to understand how these forms of public participation (information meetings, participatory financing) can contribute to the acceptability of wind energy in Champagne Berrichonne. The study will first focus on the definition of the social acceptability of wind energy, in order to understand what are the ins and outs. The wind turbine in Champagne Berrichonne will then be presented, with an analysis of the opposition to the projects

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carried out, before studying an atypical project that has been accepted by the population (Saint-Georges-sur-Arnon) where the majority of wind developments are usually rejected. This case study will put forward one of the solutions to make acceptable the wind projects with the association of the citizens in the phases of development.

1. Social acceptability of wind turbines : factors and definition

Wind development is one of the main avenues in France for a successful energy transition. The sector benefits from a relatively favorable administrative framework, with a simplification of the projects and the purchase prices of the high electricity produced, in order to enable actors of wind energy to develop it. For example, the State has set a target of 19,000 MW of land-based wind power to be developed by 2020. Nevertheless, despite favorable national and regional political will, wind development faces local tensions and conflicts related to the social acceptability of wind power. These tensions represent a brake on the development objectives set by the State, as projects are longer and more difficult to carry out. In March 2017, France had an installed wind power capacity of 12,141 MW (Source: Renewable Energies Union) and the target of 19,000 MW for 2020 would be difficult to achieve. This is why it is important to look at the acceptability of wind energy, in order to understand what are the obstacles to the development of this energy and which solutions are needed. It is necessary to first define the local acceptability of wind energy before considering wind energy development and its brakes in the area studied (Champagne Berrichonne).

A bibliographic work was carried out in order to define the social acceptability of wind power. In a 2009 paper, Fortin et al. (Wolsink, Devine Wright, Jobert, Loring, Nadaï, Van der Horst). These factors are shown in the table below:

Dimensions	Factors
Wind power	Initial Attitude
	Institutional frame
Project	Impacts
	Spin off
	Origin and local control
Decisional process	Legitimacy of the process
	Equity of the decision
Characteristic of social environment	Building institutional capital

Table 1: Factors making up the acceptability of wind power. Source : Côté G. (al), 2009.

Initially, there is a discrepancy between the initial perception of the habitants on wind power in general and the perception at the local level when a project is developed near the habitants. This discrepancy between the general and the local is regularly repeated in different studies. A survey carried out by ADEME in 2010 tends to confirm this hypothesis. 74% of the panel questioned favored the installation of wind turbines in France, indicating a relatively good acceptability of wind energy in general. On the other hand, this rate is only 54% for the installation of wind turbines (between 5 and 10 wind

turbines) within one kilometer of the respondents' place of residence. Locally, acceptability is less strong. This survey concerns a hypothetical installation of wind turbines locally, and not on "real" projects.
Nevertheless, it is important to indicate that the mentalities seem to evolve with the appearance of a local development of the wind energy and the possibility for the citizens concerned to have wind turbines near their home. This discrepancy between the initial perception of the wind energy by the habitants and the perception at the local level was also highlighted in the works of Nadaï and Labussière (2010). This gap is one of three major issues put forward by the authors which will determine the acceptability of wind energy. Wind energy tends to be "approved in principle, as an environmental policy, wind power can be challenged in its project phase, at the level of a landscape policy". In general, the population will be favorable to the installation of wind turbine but not in its territory. There is also a need to consider the scale of acceptance of wind energy: the relationship to this technology will be different between a very large scale for a wind turbine installed 500 meters from a dwelling (minimum distance defined by the law between a dwelling and a wind turbine in France), on a large and medium scale, in the territory of the population (which may be larger or smaller than administrative territories, such as municipalities), and on a small scale. Wind farm is located in another region. Scale plays are important to take into account. This energy modifies landscapes on a large scale because of the size of wind turbines, which in some cases reach 180 meters in height and impacts on local biodiversity (even if impacts on the local environment remain measured). Conversely, on a small scale, the interest of wind turbines will be perceived in a different way since the negative impacts are not felt, it is the environmental benefits of wind power that will be perceived.

The institutional framework (or rather the absence of an institutional framework) is also a factor that can explain the unacceptability of wind projects (Jobert, 2006). One of the remarks made on wind power is that its development is considered as anarchic, especially by opponents. The French wind energy development is framed by the regional wind patterns (SRE). The SRE is an annex to the Regional Climate Air Energy Plan (SRCAE), introduced in 2010 by the Grenelle II law. It is the only scheme currently in place to set up zones for French regions to be respected by development companies or other actors (citizens, inter-municipalities, etc.) in order to benefit from the purchase price, as well as the potentiality of reception of these spaces in terms of power (MW). Thus, once the project is located in a favorable zone of the SRE, each actor can develop the type of project desired on a territory (number of wind turbines, size, shape, etc.), with little concern for the level of wind development on the neighboring municipalities, which can lead to wind turbines. This is particularly the case in Champagne Berrichonne, where many wind farms are in operation and where development dynamics are strong, which leads to a form of wind anarchism in the territory insofar as each project is developed independently from the others. In addition, SREs are sometimes sued by anti-wind energy associations because of the lack of environmental assessments. For example, the SRCAE (and therefore the SRE) of Auvergne and Pays-de-la-Loire were cancelled by the courts in 2016 (March and May).

Moreover, the purchase prices fixed by the State are also criticized. Currently, EDF is obliged to purchase the electricity produced by the wind farms to the amount of 8.2-euro cents for one KW (for the parks located in the favorable zones of the SREs). This tariff is deemed too high by a number of people (notably the wind power opposition associations), as well as by the Energy Regulatory Commission (CRE) in a 2014 report on profitability and Cost of renewables. The CRE states that the profitability of certain wind farms is too high, and recommends to "adapt the duration of support to the lifetime of wind farms on land". This excessive profitability is pointed out by the opponents in particular, which indicate that wind development is first economic before being ecological in the design of projects by companies, and that the habitants pay the extra costs via the CSPE. It should be noted, however, that all wind farms don't have an excessive profitability, and that a high purchase price has facilitated the development of the sector according to the State.

Potential impacts perceived by the population are also a factor of acceptability. Wolsink stressed that the potential impacts of wind turbines on the physical and social environment can lead to a change in the opinion of the habitants, who become opposed to the projects. These impacts were taken up by Fortin et al. (2009), and are grouped into three main categories: impacts on the landscape (including the type of project, large or small), economic spin-offs (whether for the territory or for the habitants) and origin and local control of the project. For the latter category, Devine Wright pointed out that projects were all the more accepted as the local population was financially involved. The work of Gross (2007) shows that when the project is carried out without informing the public or the participation of the habitants is not realized or carried out inadequately, the acceptability of the projects tends to be low or non-existent. This result is confirmed by Loring (2006), which shows that public participation in decision-making "is seen as a way to address the concerns of residents and reduce conflict". It appears that significant public participation is a means of making projects acceptable. Nevertheless, according to Fortin et al. (2009), "participatory schemes can influence these interactions and the perception of stakeholders, but they do not determine it".

Loring (2006) argued that when wind-neutral players are structured in a network, such as associates, there is less acceptability for a wind energy project, as opposed to a stable network supporting a project, acceptability is not necessarily greater (at least the project is not more likely to succeed).

These elements are taken into account in the accepted definition of social acceptability, which was formulated by Fortin, Fournis and Beaudry in a study of 2013: "social acceptability is defined as a process of political evaluation, a project that interacts with a number of actors involved at different scales and from which are gradually constructed institutional arrangements and rules recognized as legitimate because they are coherent with the vision of the territory and the development model privileged by the actors concerned." The authors have taken up the factors that make up the social acceptability of wind power, to which they added the concept of legitimacy in decision-making. The rest of the study will rely on this definition and the factors that compose it to deal with the acceptability of wind energy in a French rural territory, Champagne Berrichonne.

2. Wind power in Champagne Berrichonne : an important objection on projects by the population

2.1. Champagne Berrichonne, territorial and landscape context

The Champagne Berrichonne is a natural region located in the Centre Val-de-Loire region. This area is mainly rural, the largest town being Issoudun (12,000 habitants). A part of this territory is studied within the framework of research, it is an administrative level, the community of communes of Pays d'Issoudun, which comprises 24 communes distributed between the departments of Indre (21 communes) and Cher (3 communes). The territory is mainly marked at the landscape level by agriculture. Cereal farming is one of the most pronounced agricultural activities in this area, which has shaped the landscape, which is typical of an open field. Only four communes of the EPCI have a different technical and economic orientation from cereal farming, with the practice of polyculture and poly-breeding (Reuilly, Reboursin, Guilly and Chezal-Benoît). Agricultural activity concerns only a few assets (1.8%), although this is structuring within the territory, especially at the landscape and historical level. This functional perception of the landscape is reinforced by a weak presence of other types of activities in the local economic fabric. Only "base" activities (banks, small shops) are present. The population of the community of communes tend to migrate towards the poles like Issoudun, Châteauroux and Bourges, which concentrate economic activities.
The community of communes of Pays d'Issoudun is essentially a rural space that has experienced a demographic crisis, with an aging population. Agriculture also experienced a crisis with declining assets and farms. This space is typical of the fragile (French ?) countryside and is quite affected by the abondonment of agricultural land.
Nevertheless, in recent years, Champagne Berrichonne has undergone a functional transformation of its spaces, with a new economic activity that has shaped the landscape: the development of renewable energies, notably with wind energy and solar photovoltaic. Since 2009, the landscape has evolved with the installation of the first wind turbines in the territory. This wind development has continued quite significantly in northern Champagne Berrichonne: nowadays a true agroenergy landscape is visible. This landscape change is reinforced by the appearance of solar panels, whether on certain roofs or in the field of solar panels installed in Issoudun, and which is close to the wind turbines of Saint-Georges-sur-Arnon.

Figure 1 : Photos n ° 1 and 2: Agroenergy landscape in Champagne-Berrichonne (Saint-Georges-sur-Arnon and Issoudun). (Photo : Romain Garcia, 2016)

The two photos above show the presence of this agro-energetic landscape, marked by the presence of two types of renewable energy: wind energy, here in Saint-Georges-sur-Arnon, which gives a verticality to a relatively flat landscape, and solar photovoltaic, in Issoudun. The two "parks", wind and solar, are close since they are separated only from a departmental road. The landscape integration of wind turbines is an important issue. Indeed, in an openfield landscape like the one in Champagne Berrichonne, wind turbines tend to be visible. This visibility in the landscape is an element that is likely to increase the opposition, since in this type of landscape a large number of villages can be impacted by this visual and thus lead to a multiplication of people who can oppose.
The wind development started in the early 2000s was reflected in 2009 with the appearance of the first wind turbines in Champagne Berrichonne. Since then, this development has intensified, the parks are numerous, as is the opposition.

2.2. A major wind energy densification creating opposition

All the communes of the studied area (north of Champagne Berrichonne) are located in a favorable zone of the Regional Wind Energy Plan (SRE). These favorable zones are determined by the State services, and in which it is allowed to develop wind projects. For this territory, the SRE recommends that project holders verify the state of the wind development in order to avoid excessive densification which can lead to cumulative effects. The target set in the SRE in terms of wind power to be achieved is 180 MW (indicative target).
In the northern part of Champagne Berrichonne, by counting the planned and installed wind turbines of the studied communes and those of the neighboring communes (Indre and communes bordering the Cher), a total of 73 wind turbines are exploited[8].

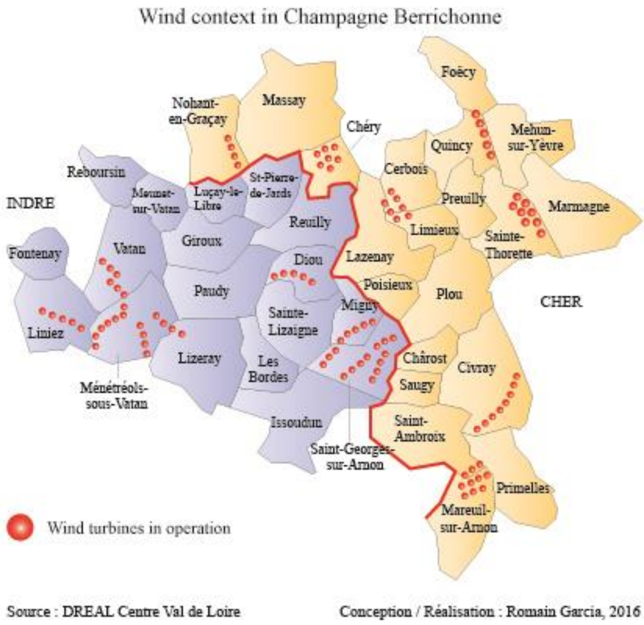

Figure 2 : Map n °1. Context of wind energy in Champagne Berrichonne in 2016.

[8] The wind farms studied are located in a wind densification area. A numerical target for wind development has been defined by the State services for this territory. Champagne Berrichonne must reach a total of 180 MW by 2020 in order to fulfill the objective (at the national level, the set of cumulative objectives must reach 19,000 MW of installed wind power for 2020, compared to around 14,000 MW in 2017).

Three wind projects will be presented in the community of communes of Pays d'Issoudun in order to address qualitatively the factors of opposition and support for wind power, and then the opposition will be quantified in a second time. The first is the one of Saint-Georges-sur-Arnon and Migny. This is an extension of an operating park consisting of 19 wind turbines (5 in Migny, 14 in Saint-Georges-sur-Arnon). The project consists of 11 new wind turbines, nine will be located in Saint-Georges-sur-Arnon and two in Migny.

The wind turbines will have a nominal power of 2.4 MW and a total height at the blade tip of 149.4 meters. The project was officially launched in June 2013 through an information process in both municipalities. Public meetings were organized to present the project (the preliminary studies were carried out upstream) and an exhibition with panels was held in order to answer to the questions of the population. According to the investigating commissioners, "the meeting is well invested by the local population" (report of public inquiry, Pierrots wind project, 2015). These elements are important, especially in terms of acceptability. Indeed, there was very little opposition during the public inquiry phase, which was also the case during the development of the first park. It was developed in four years and eight months, which is a relatively short term compared to wind development in the rest of the region (6 to 10 years and over). The public inquiry for this new project was carried out between June and October 2015. The files are currently being studied by the various departments of the State.

The second wind project studied in Champagne Berrichonne is Saint-Pierre-de-Jards, and is composed of eight wind turbines. There are no windmills in the town, but it is surrounded by parks located in two neighboring communes: Nohant-en-Graçay (4 machines) and Chéry (7 machines). The project, developed by NEOEN, is made up of higher wind turbines than those located in the region, with a height of 175 meters and a unit power of 3,075 MW (compared with an average wind turbine of 150 meters). Studies began in 2010, the company then met with elected officials and residents in 2012. The project plans to install wind turbines to the west of the municipality.
The public inquiry took place between September and October 2014. Contrary to the Saint-Georges-sur-Arnon project, the opposition was important to this project. Indeed, during the public inquiry, of the 50 people who voted, 39 were unfavorable to the project. The main complaints of the habitants during the public inquiry were about the potential impacts of wind turbines on health (23% of the opinions expressed), a project poorly designed by the development company (20% Of the opinions expressed) and a certain fear of the future of the municipality with the presence of wind turbines (16% of the opinions). Two petitions against the project were made by the Vent Contraire association, the first gathered 26 signatures (petition on paper that circulated during the public inquiry), the second circulated on the internet and collected 584 signatures. The Board of Inquiry issued a negative opinion on the application to operate the wind farm. The file is being studied in the State authorities. In addition, the city council voted against the development of this wind project.
An interview was held with the mayor of the commune of Saint-Pierre-de-Jards in order to obtain additional information on the progress of the project. At the beginning of the interview, the mayor declared himself unfavorable to wind power and the installation of wind turbines in his commune, which can "skew" certain answers given by the elected representative (subjectivity of the opinions expressed). Several elements were pointed out by the mayor, in particular in the process of evaluation of the project by the State services, which he said did not correspond to the opinions and perceptions issued locally within

the municipality. During the public inquiry, the opponents spoke more broadly than the persons in favor and, moreover, the Commission of Inquiry had given an unfavorable opinion on the authorization to operate the wind farm. The prefecture has disregarded this unfavorable opinion: "We put unfavorable opinions, we write, we make a gracious appeal to the Prefect, if the Prefect does not answer you, it means that he sits on it and then he ignores you completely. [...] I think that it is a great contempt from the administration, the high administration "(Mayor of Saint-Pierre-de-Jards, interview carried out on May 12, 2015). Here one finds one of the factors of social acceptability analyzed above, the institutional framework deemed failing by the mayor.

The wind power intensification of the territory is also a point of inacceptance for the mayor of the municipality. The wind farms in operation are numerous in this zone of Champagne Berrichonne, as indicated on the map n °1. It is the landscape impact that is put forward by the mayor: "it destroys completely a landscape; well, it is true that it is a landscape that needs verticality, but the verticality that we need this is not particularly wind turbines, okay for a few ones but that's all "(mayor of Saint-Pierre-de-Jards, interview of 12 May 2015). These landscaping impacts and the massive presence of wind turbines within the territory are perceived as a constraint to the development of the municipality by the mayor, with, according to him, a non-renewal of the population, new residents not wishing to settle in the municipality because of the projects developed, which represents a major problem for this commune of 113 habitants of which nearly 25% are more than 75 years. The impacts highlighted by the Mayor of Saint-Pierre-de-Jards, notably the impacts on the living environment, are another cause of non-acceptability.
Other complaints about wind power have also been put forward by the mayor, but will not be dealt with in this part, since they appear secondary (these grievances are important, but for the sake of brevity, will not be analyzed here, they are nevertheless found in the quantitative analysis of the factors of opposition to the wind energy that intervenes later).

The third project presented is the project of Ménétréols-sous-Vatan. It is an extension of an existing wind farm, as in Saint-Georges-sur-Arnon, where it is planned to add seven new machines to the existing twelve (plus an additional wind turbine authorized to be installed). The opposition to this extension is important, which marks a significant difference with the extension of the Saint-Georges-sur-Arnon wind farm. The project, developed by the company WPD, counts 7 turbines of 2MW of unit power, with heights varying from 130 to 150 meters.
The project began in 2013, the development company met with owner-operators on the potential wind turbine location, and then launched the preliminary studies. Presentations to various public actors took place in 2014: sub-prefecture of Issoudun, municipal council, community of communes. WPD also met the Vent Contraire association, which opposes the projects developed in Champagne Berrichonne. Meetings continued in 2015 (DREAL, DDT, community of municipalities), and at the end of the studies applications for building permits and authorizations to operate were submitted between June and September 2015. A public office took place in February 2015 and the public inquiry was held between November and December 2016. The estimated investment for the development of the wind power project (study, construction, operation) is estimated at 22.4 million euros, in which 25% are covered by the development company's own funds (WPD) and 75% via a bank loan.
An interview was also conducted with the Mayor of Ménétréols-sous-Vatan. He declared

himself in favor of wind power, but expressed some criticism towards the development of this energy, notably in Champagne Berrichonne: "Wind turbines must be put in, but there are places like here or like in Beauce where there are enough now [...]. I am in favor of wind turbines but not in favor of doing anything anywhere" (Mayor of Ménétréols-sous-Vatan, interview carried out on December 23, 2015). In economic terms, the mayor spoke about the economic benefits associated with wind farms and acknowledged that despite the low spin-offs for municipalities (most of the taxes being collected by the EPCI, the department and the region), it nevertheless allowed small rural villages to have additional funding : "previously we had big benefits with the professional tax, now that there is the IFR we have fewer benefits but we still have something, it gives a great boost to the commune anyway"(Mayor of Ménétréols-sous-Vatan, interview conducted on December 23, 2015). It is an essential element for the survival of these rural areas, which have no other economic activities that allow them to collect taxes and which had to face for several years the reductions of State's allocations. However, this can be qualified by the fact that the contribution perceived by "fragile" rural municipalities via wind power does not allow them to carry out development projects. With the successive waves of decentralization, it was the communities of communes that took over in terms of territorial development. Although wind power does not allow municipalities to develop themselves economically, communities of municipalities, on the other hand, are largely beneficiaries of the spin-offs.

In spite of the will of the municipal council and the mayor to continue the wind development on the commune, a fairly strong opposition mobilized. The Vent Contraire association (an association that opposed the Saint-Pierre-de-Jards project) took action against this extension of the existing park. The points criticized by the association are on the one hand on the densification deemed too important: "A new promoter wants to build seven new wind turbines in our village, while we are already surrounded by five wind turbine lines, twenty-seven machines, and by more than one hundred and fifty others within a radius of 20 km. Enough is enough !" (Vent Contraire association, November 2016) and on the negative impacts on the population and the living environment: "A consultation of the citizens was requested and refused by the town hall of Ménétréols-sous-Vatan. The territory has been classified as a Strong Vigilance Zone for visual saturation, density, known nuisance. [...] The noise generated by the wind turbines has been observed by recognized measures, especially during the night. "(Vent Contraire association, November 2016). The two arguments put forward here by the Vent Contraire association refers, on the one hand, to wind energy densification, considered to be anarchic and too important, which can be compared to the lack of institutional framework (wind development is not, according to the association, framed by the services of the State, which leads to a fragmentation and a densification deemed too strong). On the other hand, the second factor of acceptability are the potential impacts of wind turbines, notably on the living environment (noise and visual).

To complete the analysis of the opposition to wind energy in Champagne Berrichonne, public inquiry reports were studied and analyzed in order to identify the habitants' grievances against wind power. Wind farms are subject to an operating license of the ICPE type (installations classified for environmental protection) provided when wind turbines have a height of more than 50 m, as well as wind farms with more than 20 MW of power. An administrative procedure is being carried out, which plans a public inquiry to cover all municipalities within a radius of 6 km around the location of the machines. During the public inquiry, the public can consult the files relating to the project, and make oral or written observations. The observations, favorable, neutral or unfavorable, are recorded in a register by the investigating commissioners (grouped together in a commission of inquiry). These registers were analyzed for projects in Champagne Berrichonne in order to quantify the reasons for opposition to wind energy in this zone. Three projects are taken into account, 328 negative opinions on the projects were issued by 259 people, while 49 favorable people issued 49 opinions.

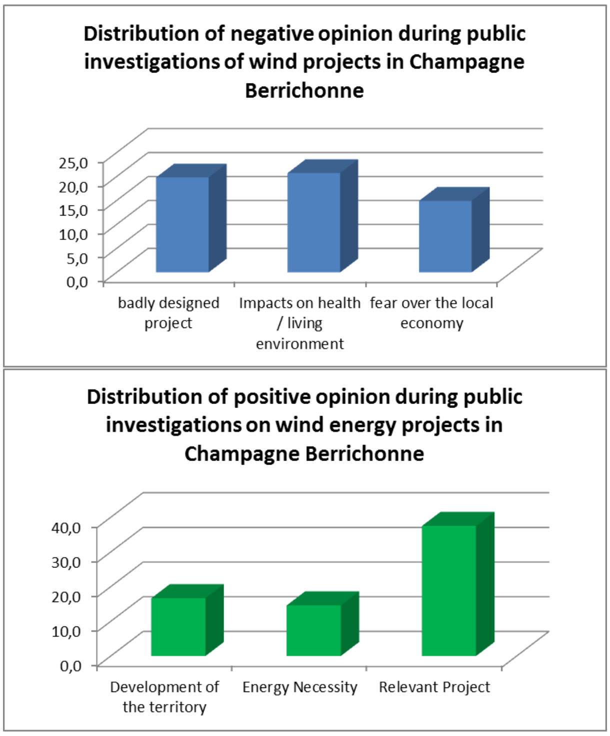

Figure 3 and 4: Distribution of negative and positive opinion during public investigations of wind projects in Champagne Berrichonne.

The landscaping impacts are barely mentioned because of the landscape character of the territory, which is not perceived aesthetically by the habitants, although they are attached to it.

The positive opinions on the projects included in this quantitative analysis focus on the possible economic development of the territory, the need to carry out the energy transition and the relevance of the projects. This last argument (the project deemed relevant) is the one that comes most often from the favorable ones, indicating that the project seems legitimate. It is interesting to note that the legitimacy of projects is a key element for opponents and people in favor of wind power.
Opposition to wind power projects is relatively high in Champagne Berrichonne, with grievances centered on the potential impacts of projects, the lack of an institutional framework and projects that are not recognized as legitimate by the unfavorable. However, Saint-Georges-sur-Arnon seems to escape this trend. To understand the acceptability of the wind projects studied in Champagne Berrichonne, interviews were conducted with the mayors of the three municipalities concerned (Saint-Pierre-de-Jards, Ménétréols-sous-Vatan and Saint-Georges-sur-Arnon), as well as only with inhabitants

of these territories. The interviews were conducted between June 2015 and June 2016. These are sociological interviews that were conducted (twelve interviews with the inhabitants make up the sample, eight were selected for analysis). The interviews were recorded, transcribed in full and analyzed to highlight the reasons for support or opposition to wind projects, as well as their sociological determinants.

3. Saint-Georges-sur-Arnon, an atypical case of a participative project accepted by citizens

3.1. Little opposition to the project, but some grievances from the habitants

The Saint-Georges-sur-Arnon wind farm did not encounter opposition during its development, which is also the case for its expansion of eleven wind turbines, which is ongoing. To understand why this development was carried out without opposition from the habitants unlike the rest of the projects carried out in Champagne Berrichonne, interviews were conducted with the mayor, as well as with residents. These interviews made it possible to obtain an image of their perception of wind energy in their commune. These interviews were carried out between 2015 and 2016, during the development of the second project. The habitants thus had a first experience of the wind energy, and live near the first wind turbines installed in 2009.

An interview was held with the Mayor of Saint-Georges-sur-Arnon on June 9, 2015. He is a key player in local wind energy development by getting involved locally in some projects (by contributing in surveys Public) or by conducting lectures on wind energy in Saint-Georges-sur-Arnon. The municipality was one of the first in Indre to start wind energy development, driven by the mayor who, upstream from the development of projects (the first resulted in the installation of 19 wind turbines in 2009), realized important public information with the municipal team and the wind energy development company (according to the mayor): "we did not let the developer do his project alone; every three months, we had an information meeting here, progress report, on the 14th of July, there was a stand, in the wishes of the mayor there were explanations, there were photos, there were pictures, there were also visits, etc. "(J. Pallas, Mayor of Saint-Georges-sur-Arnon, June 2015). Information and consultation seem to have been carried out effectively within the commune, which is one of the factors that may explain the weak opposition to the development of the wind farm between 2005 and 2009. The concerns of the municipal council, which were legitimate insofar as no wind turbines were located in the department, were dissipated by a visit to a wind farm. According to the mayor, the primary motivation of the municipal council for this wind power development is to contribute to the protection rather than to the economic development induced by the taxes paid by the operating company to local authorities: “ We became aware, well, we answered the question about why a wind farm in Saint-Georges? [...] there is a global warming, [...] we must do something, and we ask the states to make the climate plan, the famous *three times twenty*. [...] And so we educated our people, we [told] them why there will be a wind farm in Saint-Georges "(J. Pallas, Mayor of Saint-Georges-sur-Arnon, June 2015). Awareness of the impacts of human activities on the environment, translated at the State level through the implementation of various recommendations, directives and laws, is reflected at the local level by the implementation of renewable energies, like wind power here. In the case of France, there are no obligations for local and regional authorities (municipalities and communities of communes) to develop renewable energies on their territory. This development is chosen by the territories, notably through deliberations that are taken by the municipalities and EPCI to give their approval or not to the development of the projects. In the case of Saint-Georges-sur-Arnon, this development was chosen by the elected officials. Nevertheless, this process was carried out following an upstream meeting with the Nordex development company (developer of the two projects in the municipality) which proposed to the municipal council the possibility of setting up a wind farm on the territory. The municipality is more generally involved in the contribution to fulfill the objective of "3 times 20"[9], with the setting up of an eco-district or the carrying out of energy audits.

The will of the Saint-Georges-sur-Arnon municipal council to contribute to limiting global warming has resulted in the support of the project promoter, as well as the association of the habitants through phases of information and consultation, which allowed the habitants to dispel their fears.
Interviews with habitants were carried out to understand their perception of wind power, and in particular on the first park in operation and its extension. Since the sample is small, it is not a question of making an exhaustive list of the opinions gathered but only of illustrating the main positive and negative points that emerge from the survey. The habitants we encountered had a more nuanced opinion on the wind energy. Indeed, most recognize that it is necessary to develop renewable energies, but have doubts about the capacity of the wind energy sector to respond to the electrical issues of the territory "anyway we will never be using wind energy only" (a resident of Saint -Georges-sur-Arnon, June 2015), another inhabitant of the commune mentioning "I do not think that electricity production by wind turbines is the thing that will save the industries and then the economy in general. In any case they are subjected to the wind, what will happen if there is no more wind? "(An inhabitant of Saint-Georges-sur-Arnon, December 2015). The perceived impacts of the wind turbines according to the habitants questioned relate to the distances between the wind turbines and the houses, judged sometimes too weak "I am not against the wind turbines but I am totally against their installation near the dwellings. The French regulations impose a minimum distance of 500 meters between the installation of a wind turbine and a house. This distance, judged sometimes too low by the habitants, is linked to another impact perceived by the latter: the potential noise of a machine too close to the houses: "Anyway they must not be too close to the houses because it is true that when there is wind we can already hear them a little bit "(a resident of Saint-Georges-sur-Arnon, June 2015). These first elements indicate that the population, although favorable to wind, expresses doubts about the technology (electricity production in particular) and its potential impacts (distance and noise). On the other hand, as far as the visual and potential impacts on the landscape are concerned, very few elements have been mentioned on this theme, we encountered judging the landscape as an element to be protected (non-aesthetic landscape according to the habitants, even if they are attached to it). Other doubts and fears were emitted by the habitants encountered, but do not seem to play an important role in their perception of wind energy.

[9] The "three times twenty" refers to the objectives set in the climate change package, defined in 2007 by the European Union. These objectives are to reduce greenhouse gas emissions by 20% compared to 1990, improve energy efficiency by 20% and have a renewable energy share of 20% in energy production.

On the other hand, it is important to consider the perception of the habitants encountered in regard with the process of information and consultation which, according to the mayor of the commune, were essential elements in the acceptability of the projects developed.

3.2. Information and consultation, the main negative point of wind energy development in Saint-Georges-sur-Arnon

The habitants we interviewed had a different opinion than the mayor on the process of information and consultation. It turns out that, according to them, although there was an information process carried out by the municipality and by the wind energy development company, they were not "associated" to the project development process, "We were told all of a sudden that there was going to be a project, we heard about it here but really the population was not concerted", another inhabitant putting forward the difficult to get information "We really have to seek the information and that's the whole problem I think people do not make the effort to move" (a resident of Saint-Georges-sur-Arnon, June 2015). These two examples (other habitants have issued these same elements, but are not present to avoid overloading the analysis) illustrate the difficulty of obtaining information on the projects according to the habitants. Meanwhile, attendance at meetings is often low or moderate, but it appears that many people are not interested in wind energy, which may explains this low participation. During the public inquiry about the second wind project, only 18 people participated (12 favorable, 3 unfavorable and 3 neutral), for a total population of 576 habitants, representing a 3.1% participation. However, information procedures (exhibition, meeting, communal information) have been carried out and, even if they are considered as insufficient by certain habitants, is more important than in the other projects studied, where very often no information was provided (Such as exhibitions or public meetings), which marks a significant difference with the Saint-Georges-sur-Arnon wind energy projects, which have benefited from information that can be described as important.

Beyond the information obtained about the project, the consultation with the habitants and their participation is problematic. One the one hand, participation is relatively low in the various meetings and public inquiries and, on the other hand, there does not seem to have been a real integration of the habitants in the process of development of the project, which does not allow a total appropriation of this last. Information is not enough to have an acceptability of the project, it seems that the participation of the public, at least the public interested in the wind energy, is paramount to the process of acceptance. There was little involvement of the public upstream. On the other hand, downstream participation in the wind farm in operation was made possible by the purchase by local players (public and private, through the creation of a mixed economy company, SEMER 36) of five wind farms, whose capital has been opened to citizens. Thus, they can invest in the wind farm on their commune. To date, 33 people have invested in this park for a total of 100,000 euros (source: https://je-souscris.energie-partagee.org/decouvrir-nos-projets/detail/semer-des-tilleuls). This investment by the various players in the wind farm allowed additional spin-offs in the region (the "basic" spin-offs of a park are the various taxes paid by the operating company to local authorities). Indeed, the profits realized by the SEMER 36 are reinvested for a part in the local economy, which allowed to finance several developments in the municipality (EcoQuartier, renovation of the cultural house) or to reduce the local taxation. The commune of Saint-Georges-sur-Arnon has also seen its population increase since the early 1990s, a trend that continued after the installation of the 19 wind turbines in 2009, indicating that the presence of wind turbines had no negative impact on the demographic level.

Information and participation appear to be two key elements for the acceptability of wind projects. Indeed, if we refer to the definition of the social acceptability of wind energy, the authors indicated the importance for a project to meet the expectations from the habitants in order to construct the elements "recognized as legitimate" by the different actors (here, it includes the habitants, the local elected representatives and the project development society). In this way, it is necessary to determine how effective consultation should be carried out.

4. Public participation and crowdfounding in wind energy development : local remedy for the acceptability of this sector ?

Consultation is a way to make a wind energy project acceptable, and to involve all stakeholders in the project. Consultation emerged following a combination of several factors: the appearance of local conflicts about infrastructure projects, the difficulty of defining the general interest due to conflicting views on the interest of infrastructures. Faced with these problems, the conceptual framework for development has evolved, with the emergence of the concept of sustainability in 1987 in the Brundtland report and then in 1992 in Rio, and with a legal framework that was established on the theme of consultation. It brings together "processes and procedures that go through, or aim to, involve the public, civil society actors or institutional actors in decision-making processes on sustainable development. Included in its scope are consultations, public inquiries, joint instructions, public debates, citizen conferences, negotiations associated with decision-making processes, electronic discussion devices, etc. "(Mermet, 2008).
The dialogue is supposed to involve all the stakeholders in decision-making on a subject that concerns them. It can thus make appear oppositions during its course, whose origins which were defined by the ADEME:

- "conflict based on uncertainties (potential impacts of policy or project, such as risks);
- the procedural conflict (calling into question the absence of transparency, of dialogue, etc.);
- substantial conflict (questioning the nature of the project, political choices, etc.);
- structural conflict (challenge of the legitimacy of decision-makers, expertise, definition of the general interest ...) ".

We find the characteristics of these conflicts in wind energy projects, the uncertainties about the risks of wind turbines on health for example, the questioning of an "industrial" project in the territory, or the challenge of the legitimacy of decision makers, when for a wind farm the mayor is also a farmer on the studied area and receives income from wind turbines .... These arguments, whether well founded or not, are frequent in some public meetings or in other types of consultation.

In its study, ADEME highlights the emergence of new players who increasingly take part in these exercises of participation in public life: "the positive evolution of the educational level of the French, leading to a more frequent speaking to the detriment of populations with lower educational or socio-economic resources who tend to exclude themselves from dialogue ". Changing patterns of work, structuring in association, and increasingly easy access to information are all factors that lead citizens to have an opinion on the subject and to express it in public. This consultation is necessary to make the tensions and oppositions appear but also the possible supports to the project, in order to take them into account in a better way thereafter. "Conflicting events are stages of coordination between actors and a way to reintegrate new players into decision-making mechanisms and construction of territorial development projects" (Torre et al., 2010, p.3). It is therefore essential to take into account all opinions, including those of opponents, in order to make the project acceptable, or at least to mitigate "negative noise". Concertation must take place as soon as possible in a project, in particular under the Aarhus Convention. Nevertheless, the reasons for opposition can vary according to the progress of the project, so there are no rules in terms of time to achieve it and get the best result. Opinions can change on wind power, between a global perception of wind power, when one does not have machines "at home", and a local perception, when the impacts of a project are palpable. Depending on the stage of the project, it will be perceived differently by the population, hence the need to carry out a consultation in several stages. On the contrary, solidarity and the presence of common objectives abolish physical distances, in particular for the networks of pros and anti-windmills. That is, a common battle for or against a subject (wind turbines, for example) erases distances and brings people closer together. Civil society plays an important role in the acceptability of wind farms, either individually or collectively, and organized through associations. On the other hand, these same opponents, especially city dwellers, are often fervent defenders of the environment, rejections of Co2 ... hence a subcultural ambiguity that makes them reject a "clean" and renewable energy.

To achieve effective consultation, it is necessary to know the people on the territory. S. Le Floch determined three profiles of people, "figures of participation" (Le Floch, 2011). These are the residents, the resident and the citizen, three types of people who will have different interests in the development of wind projects, different representations.

The author puts forward a paradox in the information to the public: on the one hand, he is considered as a layman, that is to say he must be informed about the project and the sector. On the other hand, this desire to inform is faced with a fear: to see the emergence of oppositions, negative reactions to this information, which would hinder the implementation of the wind farm. "Thus, the public is generally perceived as a passive receptacle from which a few reacting individuals are likely to emerge".

Consultation is a way to make wind projects acceptable. This must fulfill several conditions and must not be limited to simple information on the development of wind turbines. It must in fact make the population and put it at the center of the decision-making process so that development is recognized as legitimate by the population concerned.

5. Conclusion

Wind energy development in Champagne Berrichonne is dynamic, and contributes to the objectives set by France in terms of the development of renewable energies. However, the opposition is important, although it is uneven across projects. For example, on conventional projects carried out by a company and where information and public participation processes are reduced, opposition movements are strong, whereas they are reduced when the population is integrated into the project, Either in the establishment of effective and dense information, or in forms of public participation, in particular with participatory financing. However, public participation is insufficient to make wind projects acceptable. Indeed, it is essential to fulfill several conditions, such as the type of project carried out (size, number of wind turbines, distance), the strengthening of local economic benefits, for example. These elements are also specific to each territory, here they are presented for Champagne Berrichonne. It is therefore necessary to know the territory and the population before developing a wind farm to meet these specific expectations.

Wind development, in order to be accepted by the population as a whole, must take account of expectations at the local level (distance, information). However, some expectations on the part of the population are difficult to take into account for wind development companies. For example, the population in Berry Champagne wants to see projects far from their homes, but too much distance between machines and houses leads to a significant reduction in potential areas (they are too small), which significantly reduces The possibilities of developing this type of renewable energy.

Saint-Georges-sur-Arnon is an example where the development of wind farms has been relatively well accepted by the population: machines are far from the residences (more than 800 meters on average), information and consultation have been effective and regular.

Adaptation must therefore be twofold: rural areas must adapt to this new type of electricity production, as well as the sector, in order to meet the challenges of the energy transition.

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Glossary :

ADEME : Agency for the Environment and Energy Management (Agence de l'environnement et de la maîtrise de l'énergie)

DDT : departmental direction of the territories

DREAL : Regional Directorate for the Environment, Planning and Housing (Direction Régionale de l'Environnement, de l'Aménagement et du Logement)

ICPE : classified installation for the protection of the environment (installation classée pour la protection de l'environnement)

IFR : Impôt frfaitaire sur le revenu (flat tax on income)

SEMER : Société d'Economie Mixte Energies Renouvelables (Renewable Energy Mixed Economy Society)

WPD : Wind Power Development

DOCUMENTS

Geoprogress Global Forum

2nd edition:
"SUSTAINBILITY AND ENERGY ISSUES"

The "Geoprogress Global Forum (GGF)" is an international initiative promoted by the *Geoprogress Journal,* which is an open access e-journal, submitted to a double-blind peer review, edited by Geoprogress. This is a non-profit organisation founded by Italian academics out of various disciplines and universities for contributing to the progress of humanity, namely to build a better world, and enhance peace and well-being, interdependence between nations, emancipation from starvation and other humiliating deprivations.

The GGF is open to scientists, experts, politicians and anyone around the World who wants to contribute to overcome the above problems. Furthermore, it would contribute to initiate a people global network with the same world concept and intentions and therefore help to urge the international policies of their States in the same direction. Each edition focuses on different problems of territory development, from local to global scale, and debates policies, management models and action proposals.

The second edition, opened with the international conference of Brussels on "Sustainability and Energy Issues", held in September 7th**,** intends to focus on energy security and sustainability needs facing the present market and resistances to change. In particular, it aims:

- to analyse current energy geography, which involves great differences in energy problems in different territories and requires different solutions and overall a new re-launch of co-operation among people for a sustainable development;
- to discuss the strategies of energy security for humanity in sustainability and put forward policies and regulations, nationally and internationally.

Its purpose is not only to give continuity to the debate concerning the global environment issues that should be constantly in the spotlight of the scholars and public decision makers; but also, to try to further involve the scientific community in the global problems. This community should contribute not only to find techniques, of production and organization, that are increasingly sustainable, but also to identify and remove resistances and obstacles toward the diffusion of such techniques and toward the satisfaction the energy needs of billion people.

This international conference was the first one important moment of the Forum that continued with the publication of the first contributions of the scientific community, experts and public decision-makers in the and developing the debate over the web. In 2018, the Forum will continue with other initiatives - such as workshops and round tables on specific topics and issues organized with the collaboration of interested Institutions, University Departments, Associations, etc. - and with the publication in the GeoProgress Journal of new important contributions consistent with the following call for papers.

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The 2nd GGF organization committee encourages the submission of original manuscripts, commentary and essays devoted to the examination of theoretical or empirical issues related to energy production, distribution and consumption, and their social and environmental impacts, mainly in the fields of Environmental, Economical, Technical, Political and Geographical Studies.

Key issues to be discuss are around:

- how to provide energy (electricity, natural gas and oil) world needs in sustainability;
- how to help poor countries to develop more sustainable energy and to meet the energy requirement to illuminate millions of homes that are still lacking;
- how to finance energy and ecological transition worldwide.
- how to stop short-term increase the consumption of fossil fuels and to reduce it long-term;
- in what ways, with what technical innovations, you can reduce the energy intensity;
- what are the best policies to incentivize energy efficiency;

<u>The several topics related to the above issues include:</u>

Geography of sources of production and consumption (current situation and trends);

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Unbundling in energy markets;

Regulation of transmission and distribution systems;

Smart grid technologies;

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Impact of renewable and distributed generation on networks;

Geopolitics of energy sources;

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