



# Regional policies toward energy efficiency and renewable energy sources integration: Results of a wide monitoring campaign



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## ABSTRACT

In the last 15 years, Lombardy Region has supported numerous measures for energy efficiency and installation of renewable energy sources within its territory, including the realization and the upgrade of district heating plants, the installation of solar thermal systems, the energy retrofit of existing buildings, the promotion of zero emissions buildings and the improvement of efficient heating systems. All the interventions were analysed in the framework of a wide monitoring campaign aimed at evaluating impacts, effectiveness, pros and cons of the several supporting programs. The most important characteristics, conditions and technical features of these interventions were analysed. The results obtained are described in the present work in terms of environmental, energy and economic performances, taking into account the public expenditure and the investment costs. Results demonstrate that, referring to the analysed context, these initiatives were globally effective. Many lessons were learned by such experience and interesting suggestions could be consequently provided in the field of local energy policies towards the improvement of the energy and environmental performances of communities and territories.

## 1. Introduction

Several academic studies have addressed the need and the process of energy efficiency and renewable energy integration, pointing out the set of barriers to the adoption of energy efficiency technologies and management practices. Specifically, technical barriers and financial barriers often prevent privates and public entities from undertaking energy-oriented investments. This paper intends to explore how the Administration of Lombardy Region supported the overcoming of these barriers during the period 1999–2015, in which ambits of operation, by which types of incentives, with which effects (on energy, environment and economy) and with which lessons learn. The innovation of the work lies in the following points, better described in this and in the next sections:

- the duration of the support campaign: about 15 years. In this period the energy market conditions and the technological context were affected by an evident evolution;
- the ambits of the campaign, that included many technologies: district heating, solar systems, gas heating boilers and buildings;
- the various and wide territory of the campaign;
- the number of wide and rich set of data collected and organized;
- the wide set of stakeholders involved in the process;

- the analytical method and approach (data collection, definition of a uniform database, calculation of uniform indicators, monitoring procedure).

In particular, this paper and other thematic papers previously published (Aste, Buzzetti, Caputo, & Manfren, 2014; Aste, Buzzetti, & Caputo, 2015a; Aste, Del Pero, Adhikari, & Marenzi, 2015b; Aste, Caputo, Buzzetti, & Fattore, 2016) take origin from the results of the so-called “Agreement in the field of Environment and Energy Framework Program”. The Program was developed by the Italian Ministry of Environment in collaboration with the administration of Lombardy Region in order to complete and integrate the supporting framework suggested by the ordinary energy policies. In this framework, globally 20 calls of funding were launched from 1999 to 2010. These calls were devoted to promote renewable energy sources penetration and energy efficiency interventions, but also to improve expertise and knowledge about energy issues among public administrations and citizens.

Public supports were provided as grants to finance utilities and privates, on the basis of public selections. The supported measures included the promotion of district heating (DH) plants (52.9% of the total public funding), the improvement of heating systems in buildings (8.9% of the total public funding), the installation of Solar Water Heaters (SWH) (20.2% of the total public funding) and the improvement of

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## Nomenclature

### Variables and parameters

CCGT	Combined cycle gas turbines
DH	District heating
DHW	Domestic hot water
DPB	Discounted payback time
E	Energy
f	Emission or conversion factor
GHG	Greenhouse gas
HVAC	Heating, ventilation & air conditioning
ICT	Information and communication technologies
$\eta$	Efficiency
PA	Public administration

PV	Photovoltaic system
REs	Renewable energies
RIPE	Renewables incentive paradoxical-effect
SWH	Solar water heaters
ZEmBs	Zero emissions buildings

### Subscripts and superscripts

<i>em</i>	Emission
<i>fuel</i>	Fuel
<i>N</i>	Specific lifetime
<i>p</i>	Primary
<i>th</i>	Thermal
<i>y</i>	Year

buildings energy performance (14.3% of the total public funding). Other minor actions, neglected in the present manuscript, regarded innovative fuels and sustainable mobility (3.7% of the total public funding).

Lombardy is a high-density populated region in northern Italy, with many important urban areas (i.e. Milan). Its built environment is very complex, with an important presence of all sectors: residential, commercial, industrial and urban structures. Lombardy has a large flat land but also many mountain areas, a rather cold climate during winter and a hot and humid climate during summer, especially in the flat land. Therefore, considering its climatic characteristics, the features of the built environment and its institutional dynamism, Lombardy represents an interesting case of study in the field of energy policies.

The regional energy balances in recent years highlight the remarkable stability of the total final consumption, the importance of the civil sector (43% of total consumptions) and the predominance of the heating consumptions of buildings (68% of the total energy consumptions for the civil sector) (SiReNa, 2015). The regional power plants are more than enough to cover the regional electric demand. The main energy source adopted is natural gas in big CCGT (Combined Cycle Gas Turbine) plants. Further, the most of the national hydro-electric plants are located in Lombardy. These plants and other REs installations determine a penetration of renewable energy sources in line with the European and national objectives related to the year 2020. Lombardy is also one of the most innovative and pioneer Region in the field of energy policies and regulations, as stressed also by Caputo and Pasetti (2017).

Detailed monitoring is the most important activity for verifying the effectiveness of measures aimed at improving energy efficiency, as reported also in Aberg and Henning (2011), Agrell and Bogetoft (2005), Bottio, Caminiti, Gangale, Stefanoni, and Magnelli (2008), Cansino et al. (2011), Lind (2012), Madlener (2007), Magnusson (2012) for district heating; Steinbach et al. (2013) for heating systems; Beerepoot (2007), González-Limón, Pablo-Romero, and Sánchez-Braza (2013), Roulleau and Lloyd (2008), Pablo-Romero, Sanchez-Braza, and Perez, (2013) and Valentini and Pistocchini (2011) for SWH systems; Olubunmi, Xia, and Skitmore (2016), for “green buildings” and, in general, in Alberini and Bigano (2015), Markandya, Ortiz, Mudgal, and Tinetti (2009) and Shazmin, Sipan, Sapri, Ali, and Raji (2017).

About the types of supports, Cansino, Pablo-Romero, Roman, and Yñiguez, (2011), analyses the main policy measures implemented in EU-27 countries up to 2009, i.e. subsidies, tax incentives, financial support and feed-in tariffs. The most part of the countries have adopted additional measures to promote the use of REs for heating and cooling. The implementation of such measures corroborates the opinion of those experts who explain that the increased use of REs can only be achieved if it is accompanied by increased support from government authorities.

Agrell and Bogetoft (2005) report that in Denmark the district

heating sector is characterized by heavy governmental involvement both on the supply and demand side, by subsidies for investments, fuels, preferential feed-in tariffs and connection rights. They remark the necessity of assessing environmental and economic efficiency in order to estimate the impact of governmental, market and managerial imperfections. They argue that the impact of governmental action (plant size, fuel choice, network configuration) is likely to be in the magnitude of three times more important than managerial performance. Finally, they underline also the importance of involving the consumers in the investments.

Bottio et al. (2008) underline the importance of supporting district heating plants by incentives in Italy and the need of developing a method for a uniform comparison of the different experiences.

In relation to the promotion of gas boilers in the Italian context, Alberini and Bigano (2015) evaluate incentives for to heating system replacements in residential buildings using data from an original survey among homeowners. Attention is payed to the effect of monetary and non-monetary incentives on the propensity to replace the heating equipment with a more efficient one. They affirm that respondents are more likely to agree to a replacement when the savings on the energy bills are larger and experienced over a longer horizon, and when rebates are offered to them. Reminding the respondents about possible CO<sub>2</sub> emission reductions had a little effect.

In relation to solar systems, Pablo-Romero et al. (2013) report that the measures applied in Spain have been found to be insufficient and necessitates the study of alternative methods of stimulus. The main suggestion is to promote a profound knowledge and numerical assessment of the environmental and energy advantages of using solar energy for heating and hot water in order to clarify and compare the costs and benefits of solar thermal energy.

In relation to buildings, Olubunmi et al. (2016) underline the importance of external and internal incentives in promoting “green building”. The external incentive is a forced choice whereby beneficiaries are required to fulfil specified conditions or requirements before benefitting, while the internal incentive allows beneficiaries to be incentivised out of volition because of the appeal of the benefits of “green buildings”. The external incentives, which are largely provided by the government, are divided into financial and non-financial incentives. It is found that owners are more incentivised by non-financial incentives. In terms of effectiveness, both external and internal incentives are important instruments although it is not clear which are the more effective. Also in this case the need to study in depth the effects of such mechanisms is evident.

This literature review supports the need of developing a clear procedure for monitoring the effects of supporting campaigns by public funding in all the sectors that affect the energy performance of the built environment. The expected results should be dependent on the market condition during the time and on the territorial context.

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