Energy Policy 41 (2012) 303–315

Contents lists available at SciVerse ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Municipal scale scenario: Analysis of an Italian seaside town with MarkAL-TIMES

G. Comodi [a,*], L. Cioccolanti [a], M. Gargiulo [b,1]

[a] Dipartimento di Ingegneria Industriale e Scienze Matematiche, Università Politecnica delle Marche, via Brecce Bianche, 60131 Ancona, Italy
[b] e4sma s.r.l. (Energy Engineering Economic Environment Systems Modeling and Analysis S.r.l.), C.so Principe Eugenio 36, I-10122 Torino, Italy

ARTICLE INFO

Article history:
Received 15 November 2010
Accepted 27 October 2011
Available online 1 December 2011

Keywords:
Local energy planning
Micro-chp
Energy efficiency

ABSTRACT

This work presents three 25-year energy scenarios developed with the TIMES model generator for Pesaro, a seaside municipality in central Italy. It evaluates the effectiveness of local-scale energy policies in three sectors: households, transport, and the public sector (PS). Since the local energy demand is affected by summer tourism, seasonal consumption by holiday homes was also studied. Three scenarios were hypothesized: Business as Usual (BAU), Exemplary Public Sector (EPS), and Exemplary Municipality (EM). The EPS scenario models the exemplary role that recent European directives attribute to the PS in setting energy efficiency and technology penetration targets for itself; the EM scenario extends these targets to the household sector. In particular, the study underscores the potential of micro-cogeneration technologies in achieving local environmental targets, even though their diffusion would involve an increase in local energy consumption due to internalization of the primary energy used to produce electricity, which would no longer be wholly imported from outside municipal boundaries. The study provides information to local decision-makers by estimating the cost of implementing a number of energy policies. Finally, the study discusses the adequacy of TIMES as a tool to analyse municipal-scale scenarios.

1. Introduction

National as well as larger-scale environmental targets can be achieved using both a top-down and a bottom-up approach (IPCC, 2007; Dilly and Hüttl, 2009). The former approach defines a regulatory framework where policy goals are set for the short, medium, and long term. For instance, European energy policies originate in the European Commission and Parliament as Directives, which must then be adopted by member States (European Parliament and Council, 2004, 2009a,b,c). Once the regulatory framework is in place, the bottom-up approach is applied on a local scale through implementation of best practices and policies (UN Department of Economic and Social Affairs, 2002). Here municipal energy plans play an important role in refining and adapting the energy policies to the local context, taking advantage of local administrators' thorough knowledge of the territory in terms of resources as well as economic structure (IEA, 2000; Stenlund Nilsson and Mårtensson, 2003; Ivner, 2009; Sperling et al., 2011). Clearly, energy planning would also greatly benefit from investigations into the connections of Energy-Economy-Engineering-Environment (Barker et al., 2005). The Italian legislation (Italian Parliament, 1991) requires each Region to draw up a Regional Environmental and Energy Plan (REEP) to improve energy efficiency and develop renewable sources. Article 5 of the recent European Directive 2006/32/EC (European Parliament and Council, 2006) attributes to the public sector (PS) an exemplary role in implementing and promoting good energy practices. The REEP of Marche (Marche Region Parliament, 2005), an Adriatic region in central Italy, sets targets for energy efficiency and energy production from renewable sources, providing financial support for the draughting of a Municipal Environmental and Energy Plan (MEEP) by towns with more than 50 000 inhabitants.

The present work, which is part of the MEEP of Pesaro (Pesaro Municipality, 2008), a coastal town of Marche with more than 90 000 inhabitants, describes three medium- to long-term (up to 2030) energy scenarios developed for the city. The study was carried out using the TIMES model generator (ETSAP; Loulou et al., 2005). Analysis of the energy scenario on the municipal scale is an unusual application of the MarkAL and MarkAL-TIMES models, which are commonly applied to (i) evaluate national-level energy scenarios, policies and incentives mechanisms (Farinelli et al., 2005; Contaldi et al., 2007; Blesl et al., 2007; Cosmi et al., 2009; Assoumou and Maïzi, 2011); (ii) assess the impacts of technologies in a nation-wide context (Naughten, 2003; Nguyen, 2007; Rafaj and Kypreos, 2007; Vaillancourt

* Corresponding author. Tel.: +39 71 220 4761; fax: +39 71 220 4770.
E-mail addresses: g.comodi@univpm.it (G. Comodi), maurizio.gargiulo@e4sma.com (M. Gargiulo).
[1] Tel.: +39 349 446 0897.

0301-4215/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.enpol.2011.10.049

et al., 2008), and (iii) project energy demand trends (Dutta and Mukherjee, 2010; Jia et al., 2011). Regional and municipal scenarios have already been developed with MarkAL, but not with TIMES; for instance, Salvia et al. (2004) and Pietrapertosa et al. (2003) have published region-based studies, whereas Cosmi et al. (2003) have analysed on the municipal scale the feasibility of introducing renewable technologies in an urban area. The present study is different in that it examines on the municipal scale the amount and type of energy consumed by municipal PS users, by households and by the transport sector with a view to identifying the role of energy efficiency in curbing primary energy consumption. The paper is organized as follows: after Section 1, Section 2 outlines the local energy system; Section 3 describes the demand by the different sectors and the scenario assumptions; and Section 4 presents the results analysis; finally, in Section 5 the results are discussed and commented on; in particular, given the uncommon application of the TIMES in this study, the pros and cons of using it on such a small scale are discussed in a separate paragraph.

2. The local energy system

Pesaro, one of the five provincial capitals of Marche (east-central Italy), is a coastal town with a population > 90 000, which summer tourism swells by about 11% (Pesaro Municipality, 2005). According to Marche's REEP, Pesaro lies in the Region's most energy-intensive district. Nevertheless, no energy is produced in the territory of Pesaro, apart from a negligible fraction from renewable sources, mainly photovoltaic (PV). For this reason, nearly all the primary energy used to meet the local demand for heat and electricity is imported from outside the municipality. Since the year for which the energy demand and supply data of the municipal energy balance (MEB) are most abundant was 2004, 2004 was chosen as the base year for model calibration. The consumption of energy commodities in 2004 is indicated in Table 1.

Table 2 reports the consumption of electrical and thermal energy commodities divided by sector.

Table 3 reports the fuel consumption related to municipal transport, a major local user.

According to the "Urban mobility plan" (Pesaro Municipality, 2003), consumption by public transport means accounts for < 1% of total fuel consumption by the transport sector.

Table 1
MEB in 2004.

Commodity	(GJ)	Per cent consumption in base year (%)
Electricity	1 543 241	24
Vehicle fuel	1 937 107	31
Natural gas	2 818 602	45
TOTAL	6 298 950	100

Since the present study was carried out in collaboration with Pesaro municipality, the thermal and electrical energy consumed by municipal users was analysed in detail (Table 4).

As regards energy production, PV and solar thermal plants were the sole renewable technologies used in the area. The total PV power installed in 2004, predominantly by private users, was a mere 350 kWe. Assuming an electricity production of 1250 kWhe per nominal kW installed, these plants accounted for just 0.1% of the electricity consumed in 2004. Table 5 reports the trend of the nominal PV power installed in the municipality (GSE, 2011) and an estimate of the electrical energy produced. An increase in installed PV power after 2004 is quite common in Italy, due to the launch in 2005 of the feed-in tariff, an incentive known in Italy as "*Conto Energia*". The table shows separately the PV

Table 3
Share of fuel consumed by the municipal transport sector, in 2004.

Fuel	2004 (GJ)	Per cent of fuel consumed (%)
Diesel fuel	796 471	40.7
Lpg	33 245	1.7
Unleaded petrol	1 107 392	56.6
Natural gas	19 170	1.0
TOTAL	1 956 278	100.0

Table 4
Energy consumed by municipal users in 2004.

	Thermal energy (GJ)	Electrical energy (GJ)	Total energy (GJ)
Street lighting	–	25 881	25 881
Traffic lights and cemeteries	–	1537	1537
Schools	30 206	4168	34 374
Municipal offices	8486	4752	13 238
Other uses	9254	10 555	19 809

Table 5
Trend of installed PV power and energy produced in Pesaro municipality.

	< 20 kWp		All sizes	
	Installed (kWp)	Energy produced (TJ)	Installed (kWp)	Energy produced (TJ)
2008	111.1	0.5	534.5	2.4
2009	170.9	0.8	170.9	0.8
2010	398.8	1.8	3821.2	17.2
2011[a]	311.0	1.4	3067.2	13.8
Total	991.8	4.5	7593.8	34.2

[a] Provisional (August 2011).

Table 2
Share of electrical energy and natural gas consumed by the main users in 2004.

Sector	Electricity (GJ)	Per cent of total electrical energy consumed (%)	Natural gas (GJ)	Per cent of total thermal energy consumed (%)	Total (GJ)	Per cent of total energy consumed (%)
Agriculture	4630	0.3	0	0.0	4630	0.1
Households	429 021	27.8	1 203 543	42.7	1 632 564	37.4
Industry	526 245	34.1	1 288 101	45.7	1 814 346	41.6
Services	583 345	37.8	326 958	11.6	910 303	20.9
TOTAL	1 543 241	100.0	2 818 602	100.0	4 361 843	100.0