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Proposing an open-source model for unconventional participation to energy planning

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ABSTRACT

In this paper we present MELiSsa, a local multi-regional energy system model of a specific area: the Lombardy region. MELiSsa, implemented through an open-code modeling framework (OSeMOSYS), is built upon transparent relations and open data. Building this model is a first step towards four main goals: (i) extending the energy planning process of the region to citizens and experts usually not involved; (ii) exploiting this uncommon participation for a crowd-source development; (iii) providing a simple tool for interested local citizens to get consciousness of the technological and behavioral limits of their energy system; (iv) providing a real-case-based platform for interdisciplinary research and academic purposes possibly beyond the region boundaries. The current structure and input data of MELiSsa are presented and discussed together with a demonstrative analysis. Preliminary results show that interdisciplinary participation is enabled as an opportunity and it is needed to properly model technological dynamics as well as non-technological issues that will be relevant within the path to reach environmental, economic and social targets.

1. Introduction

Energy planning is the process that helps to properly design the development of energy systems towards established targets (e.g. economical, environmental and social goals). Though the vision of targets may not be unique and unbiased, the research of the solutions that do meet the targets can and must be objective. Energy system models are instrumental tools, from this point of view, since they can describe with impartiality the systems and their dynamics throughout established mathematical relations and data. Many energy modeling frameworks and energy models have been built and used in the past decades, as proved by the number of reviews available in the literature (see for example [1–5]). Each model however is singular because it focuses on different case studies and different scales, pursues different purposes and uses different methods. With the model presented in this work we focus on a specific Italian subnational case study: the Lombardy Region and its administrative subregions. Few comprehensive energy system models have dealt with this area to this day: (i) the MarkAl-TIMES-based *MONET* [6] that modeled the Italian energy system detailing each administrative region (based on the national power system model *MATISSE* [7]), (ii) the MarkAl-TIMES-based model of [8] that exclusively focused on the Lombardy region as a whole single area and (iii) the *PPMM* MarkAl-based model of the Province of Pavia [9] that focused only on a particular portion of Lombardy. Programs and plans for the energy system of the region have come in succession as well since the beginning of the century: (i) the program *Programma Energetico Regionale* (PER) of 2003 operated through the plan *Piano d'Azione per l'Energia* (PAE) [10], (ii) the plan *Piano Strategico delle Tecnologie per la Sostenibilitá Energetica in Lombardia* [11], (iii) the plan *Piano per una Lombardia Sostenibile* [12] and (iv) the recent program *Nuovo Programma Energetico Ambientale Regionale* (PEAR) [13]. Though the development of models, programs and plans is generally open to public consultation and participation, it is not only our opinion (see Bazilian et al. [14]) that it can be improved by making this public sharing more effective through mass communication and information technologies.

1.1. Scope of the work and outline

MELiSsa (Modello Energetico della Lombardia per la Sostenibilità) has been built on the idea that the mass communication and information potential of today can be exploited (i) to create a free platform, based on transparent relations, open data and shared assumptions; and (ii) to reach citizens usually not directly involved within the decision making process. The scope of the project around

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MELiSsa lies in two main fields: (i) improving the planning of energy systems and (ii) increasing the awareness of citizens. MELiSsa does not aim to reach them separately: by aiming at an open- and crowd-source tool it aims at two effects. The first is direct: citizens can (i) monitor the assumptions and evaluate the decisions of policy makers, (ii) actively contribute to the process by suggesting different ideas and assumptions, (iii) improve the reference database and (iv) offer manifold points of view. The second is indirect: by participating, citizens can get awareness of (i) their role in the energy systems (e.g. how much energy is consumed by households), (ii) the possibilities and limits of technologies (e.g. how much energy demand can be met by local renewable sources) and (iii) the possibilities and limits of human behaviors (e.g. to what extent car-pooling could reduce consumption and emissions related to transportation). Besides these main purposes, MELiSsa is addressed as well to the world of research and academy as they can both (i) positively affect the crowd-source development and (ii) benefit from this platform based on a real case study, for researches and teaching purposes, possibly beyond the boundaries of the region and the disciplinary sector. Aware that different important steps are needed to involve an unconventional participation in the energy planning process or debate, with this article we exclusively focus on kicking-off by building the model and by drawing attention to the necessity for participation.

The remainder of this paper is structured as follows: in Section 2 the structure and the data of the model are presented; in Section 3 the first demonstrative results are showed; in Section 4 the platform is discussed together with the analyses it can be used for and the existing experiences; finally, in Section 5 the conclusions are drawn.

2. MELiSsa model

In the present section the MELiSsa model is presented in detail. The section begins with a short description of the modeling framework that is used (Section 2.1) helping introducing and understanding the structure of the model (Section 2.2) and the code modifications (Section 2.3). The input data are then showed and the related assumptions explained (Section 2.4).

2.1. OSeMOSYS framework

OSeMOSYS (Open Source Energy Modeling System) is a long term energy system modeling framework that has been created and developed by an international team of institutes and research groups. It has been chosen for building up the MELiSsa model[1] given its simplicity and its open-source nature. A first presentation of OSeMOSYS and its mathematical formulation can be found in Howells et al. [15]. Updated features are described in Welsh et al. [16] and on the official website [17]. A brief description is given here to make the reader properly understand the structure of MELiSsa. OSeMOSYS is based on a linear optimization problem that aims to minimize the total discounted cost for satisfying the demand of energy services of a considered region, over a given period, under specific constraints. The solution of the problem is the optimal configuration of the energy system over that same period and can be constrained by the modeler to consider particular policy frameworks (e.g. upper limits on the emissions, minimum amount of renewable generation, etc.) and simulate the availability of technologies and resources. The basic logical structure, depicted in Fig. 1, is generically based on technologies that, in a given region, can use and produce energy carriers, satisfy energy services and generate emissions as byproduct. The installation of the technologies and their operation and maintenance imply a cost for the system as well as the penalties that can be related to emissions. Different inputs and outputs and different input/output ratios can be attributed to the same technology throughout different *modes of operations*. The framework includes a particular type of *technologies*, characterized by investment costs and efficiency, that can be installed and linked to the standard technologies to simulate a storage service. This basic logical structure based on technologies can be replicated as many times as needed by the modeler to virtually recreate all the different technologies and transformations of a real energy system, from a region to another, from the mining of primary resources to the generation of energy services.

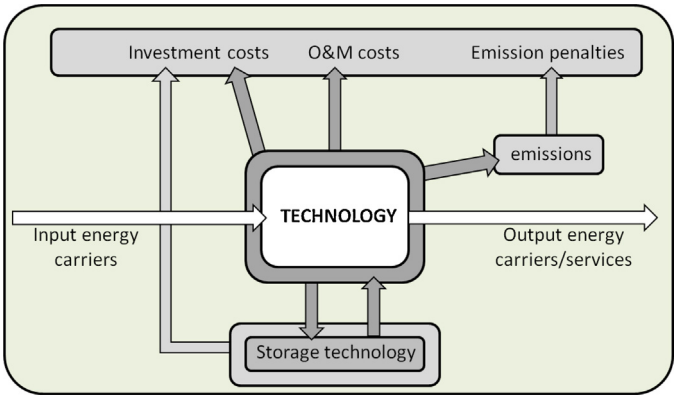

Fig. 1. Basic logical structure of the OSeMOSYS modeling framework. It can be used, throughout series and parallel combinations, to describe all the processes occurring within an energy system.

Throughout the OSeMOSYS bottom-up approach, the modeler is required to quantify the demand of energy services and descri be the technologies (in terms of efficiencies, capital and operating costs, emission factors, residual availability of technologies at the beginning of the analyzed time horizon, etc.). The optimal mix of technologies results as an output (in terms of installed capacity and use of each technology in a given period) as well as the costs, the consumptions and the emissions.

The time-horizon is made up of *time-slices* and the temporal resolution can therefore define the detail of the results but can have a strong influence on the computational burden and the resolution time. The subdivision of the time-horizon must hence be determined by the modeler according to the scope of the study.

2.2. Structure of MELiSsa

The MELiSsa model is based on the basic logical structure of OSeMOSYS depicted in Fig. 1. Throughout the use of seven different configurations of that structure, as summarized by Fig. 2, we replicated a virtual model of the processes that might occur within the next decades in the energy system of the Lombardy region.

Melissa is a multi-regional model made up of 11 areas corresponding to the administrative provinces.[2] As showed in Fig. 3, the overall time-horizon of the model spans over 45 years and is made up of 9 homogeneous five-year periods, from 2009–2013 to 2049–2053. Although OSeMOSYS is a yearly model, the code has not been modified to comply with the use of five-year periods. Input data for those parameters usually based on annual values refer, in MELiSsa, to five-year units (for instance, the CapacityToActivityUnit is multiplied by 5 whereas the OperationalLife is divided by 5).

[1] The considered version is *OSeMOSYS_2013_05_10_short*.

[2] The province of Monza and Brianza (only recently founded) is coupled with the province of Milan due to lack of data.