PhD in ENERGETICS

Research Title: Development of new sustainability paradigms for bottom-up energy system modeling

CoFunded by	DENERG

Supervisor	Prof. Laura Savoldi // Prof. Francesco Quatraro (UniTo)

Contact	www.mahtep.polito.it

Context of the research activity	Energy planning through scenario analysis is becoming increasingly important for governments worldwide for the development of compelling energy strategies in line with the short- and long-term decarbonization objectives [1]. In this context, the European Union (EU) has the target to become the first supranational entity to adopt a precise scheme to put into force an effective ecological transition and fight the risks and effects of climate change, leading Europe to be the climate-neutral continent. This purpose is currently pursued in the framework of the European Green Deal, an action plan that will transform the EU into a modern and efficient economy through technological innovation [2]. The EU Green Deal promotes an efficient use of resources through the implementation of circular and clean economic schemes, in order to restore biodiversity and to reduce anthropogenic pollution with the main target of achieving net-zero greenhouse gases emissions by 2050. Beside environmental targets, that will envisage deep changes in all the supply and demand sectors of the economy, the transition is also going to allow the decoupling of the economic growth from the use of natural resources, and to be just and inclusive from the social point of view. The current political commitment under the Green Deal has also been proposed to be turned into a legal obligation for all the EU members. Moreover, as the transition would be ineffective if technological innovation is not put into force to consider, the feasibility and effects of those measures need to be studied within a quantitative assessment framework, identified in bottom-up energy system models, which allow the interaction of economy and technological detail. However, the current energy system modelling framework is limited to the traditional macroeconomic and environmental schemes and needs to consider the involvement of a broader spectrum of sustainability dimensions.

	Indeed, most of the existing models aim to find the least-cost energy system, usually incorporating multi-level environmental issues within a single constraint concerning CO2 and/or other greenhouse gases emissions [3]. That is not sufficient anymore if climate change objectives must also embrace economic and social sustainability issues [4]. The capabilities of the currently existing energy system modeling frameworks can be extended using open-access tools, whose reliability and capability to replicate the results of commercial tools (such as the TIMES model generator) has already been proved, as in the case of e.g., Temoa [5] or OSeMOSYS [6]. The high flexibility of those codes, and the possibility to easily access and modify their mathematical formulation, make them valuable tools to consider the extension of the traditional modelling framework. [1] F. A. Felder, C. J. Andrews, and S. D. Hulkower, 'Which Energy Future?', in Energy, Sustainability and the Environment, Elsevier Inc., 2011, pp. 31–61. [2] European Commission, 'A European Green Deal', 2019. https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en. [3] R. Loulou, G. Goldstein, A. Kanudia, A. Lettila, and U. Remme, 'Documentation for the TIMES model: Part I. Energy Technology Systems Analysis Programme', no. July, p. 151, 2016, [Online]. Available: https://iea-etsap.org/docs/Documentation_for_the_TIMES_Model-Part-I_July-2016.pdf. [4] International Atomic Energy Agency, United Nations Department of Economic and Social Affairs, International Energy Agency, Eurostat, and European Environment Agency, 'Energy indicators for sustainable development: guidelines and methodologies', 2005. [5] J. Decarolis, K. Hunter, and S. Sreepathi, 'The TEMOA Project : Tools for Energy Model Optimization and Analysis', Energy Econ., vol. 40, pp. 339–349, 2010, doi: DOI: 10.1016/j.eneco.2013.07.014. [6] KTH-dESA, OSeMOSYS Documentation. 2021.

Objectives	The main objectives of the project is to expand the economic paradigm behind the current macro-scale optimization models including the social, environmental and economic dimensions related to the sustainable development. The process for the integration of new sustainability metrics in an open modeling framework will envisage: - The study of currently existing models which already take into account the analysis of a set of sustainability dimensions not limited to the simple modelling of emissions-related parameters and the implementation of economic paradigms other than minimum cost optimization; - The study of a set of sustainability parameters for the integration in bottom-up energy system modeling schemes. The bottom line could be the integration of sustainability as a new objective function in the energy system modeling formulation.

	- The development of an open-source tool which includes a sustainability paradigm in a macro-scale energy system model. Test of the model in case studies. - The development of new integrated evaluation metrics for energy scenarios based on selected sustainability dimensions. - The development of quantitative indicators to assess the response of the system to sustainability indicators in short and long term and on different spatial scales. The tool will be then applied to assess through suitable scenario analysis if and to what extent nuclear fusion could be a "sustainable" option in the European energy mix.

Skills and competencies for the development of the activity	The candidate should have a know-how in global energy models, also from the TIMES family, and should be skilled in energy scenarios analysis.