Energy system modelling with focus on hard-to-abate sectors to study the impact of the energy transition at Italian level

Background

Energy planning and scenarios generation have two main goals: to provide guidance and material for discussion about future energy systems and to support decision-makers in developing short and long-term energy strategies. An added value is certainly transparency where not only assumptions, input data and model outputs should be readable but, also the numerical approach implemented in the model. Over the last 20 years, the number of energy system models used for scenarios generation has significantly increased thanks to the increased computational capabilities.

In order to classify energy system models, a first distinction that can be made regards the analytical approach: Top-down versus Bottom-up models. Top-down models are typically adopted by economists and public administrations. These models focus on connecting the energy system to other macro-economic sectors. They are usually characterized by a simplified representation of the components and complexity of the energy system. Their application field is the evaluation of the impacts of energy and climate policies on socio-economic sectors as social growth, public welfare, employment etc. An opposite approach is provided by bottom-up models which analyze in detail the components and interconnections between the different energy sectors. These detailed models from a techno-economic point of view allow the user to compare the impact of different technologies on the energy system and to evaluate the best future alternatives to lower GHG emissions for the achievements of the energy targets.

PyPSA-Eur (https://github.com/PyPSA/pypsa-eur) is a bottom-up energy system model of the European power system. The model is suitable both for operational studies and generation and transmission expansion planning studies. The continental scope and highly resolved spatial scale enables a proper description of the long-range smoothing effects for renewable power generation and their varying resource availability.

The master thesis will be in collaboration with Eurac research (Bolzano), Institute for renewable energy, energy system modelling and e-mobility research group where the candidate will spend 3 months working full time on the selected topic. The complete duration of the MSc thesis work will be 6-9 months.

Thesis

The scope of the thesis is the development of different scenarios with high penetration of variable renewable energy sources using the PyPSA-Eur bottom-up energy system model. An open dataset of the European countries is provided with the model. The student will have to carry out the following activities:

i. Literature review on energy system modelling.
ii. Check of the input dataset of the PyPSA-Eur model and validation.
iii. Becoming familiar with python programming language (coding language of PyPSA-Eur) and first runs of the model.
iv. Analysis of the industrial sector (with focus on hard-to-abate segments like steel/metals, cement, chemical, etc.) with the goal of building a classification of the industries based on key parameters (e.g. demand profile, possibility of heat integration, etc.)
v. Implementation of the industrial sector in the PyPSA model.
vi. Expansion capacity optimization analysis to understand the most cost-efficient solutions to decarbonize the coupled power and industry sectors.