



MEDEAS

MODELING THE RENEWABLE ENERGY TRANSITION IN EUROPE

A NEW OPEN-SOURCE ENERGY MODELLING SYSTEM TO GUIDE THE TRANSITION TOWARD A LOW CARBON EUROPE

MEDEAS (Modelling the Energy Transition under Environmental and Socioeconomic constraints) uses advanced modelling techniques to produce a flexible tool to help decision makers steering the European economy towards a low carbon future under different policy, technology, resource availability and consumption scenarios.

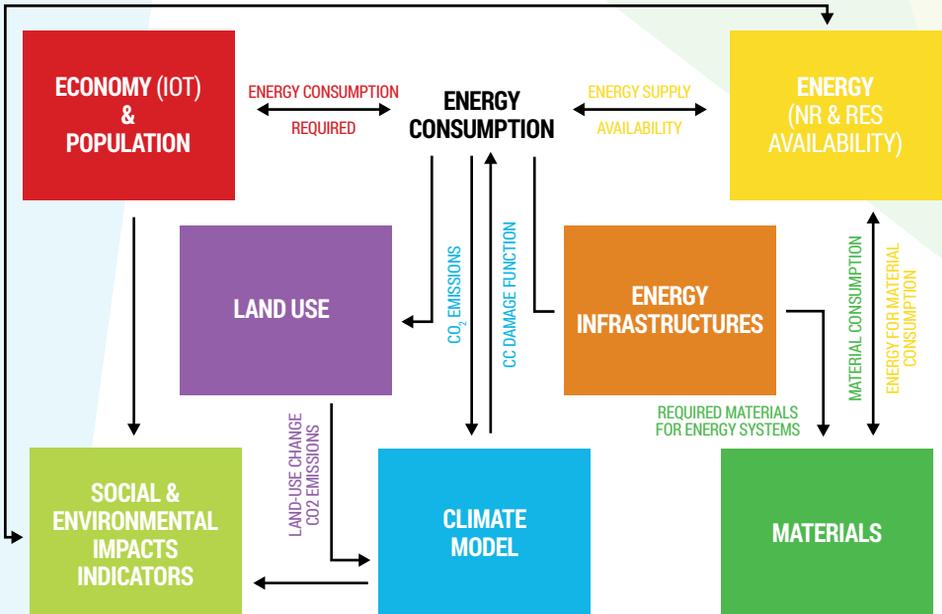
MEDEAS ENERGY-ECONOMY-RESOURCES

- A suite of **MEDEAS models system** nested in four geographical domains: World, Europe, Bulgaria and Austria in python programming language: pymedeas_w; pymedeas_eu; pymedeas_at; pymedeas_bg (<http://www.medeas.eu/model/medeas-model>). The models have also been programmed and are available in Vensim software.
- The **MEDEAS database management system** (<https://medeas.cmima.csic.es/medeas/>), to allow users to store, retrieve and manage the data generated within the MEDEAS project publicly.
- An **online portal forum**, to give support to pymedeas users and provide information on project achievements (<http://www.medeas.eu/forum>).
- A **Massive Open Online Course (MOOC)** that will take place in March-April 2019 (<http://www.medeas.eu/model/mooc-course>). The aim of the course is to introduce the stakeholders in the use of the MEDEAS models system.
- A **White Book of policy recommendations** that will be released in October 2019 (<http://www.medeas.eu/model/impacts-policies>) aimed to guide policy implementations to achieve a low-carbon economy by 2050.

Pymedeas models (pymedeas_w and pymedeas-eu) have been released and are available to download at <http://www.medeas.eu/model/medeas-model>.

Structure of the MEDEAS models

MEDEAS models have been designed applying System Dynamics, which allows for a top down non-linear approach and integrates feedbacks between variables and subsystems.



Overview of MEDEAS system by modules and the modelled linkages between them.

MEDEAS modelling system consists of a modular and flexible structure, where each module can be expanded/simplified/replaced by another version or submodel and new modules can be added.

The models are structured into 7 submodules:

- **Economy:** The economy is modelled following a post-Keynesian approach assuming disequilibrium, demand-led growth and supply constraints. The economic structure is captured by the integration of a detailed input-output model (consisting of 35 industrial sectors and households) within the system dynamics approach.
- **Energy:** This module includes the potential of renewable and non-renewable energy resources taking into account biophysical and temporal constraints. In total, 5 energy sources are included (electricity, heat, solids, gases and liquids) and a diversity of energy technologies are modelled.
- **Infrastructure:** Different energy infrastructures of power plants to generate electricity and heat are explicitly modelled.
- **Materials:** MEDEAS tracks the material requirements for the construction and operations & maintenance of the energy infrastructures. Extraction demands are compared with estimates of reserves and resources.
- **Land Use:** This model accounts for land requirements of Renewable Energy Sources (RES).
- **Climate Change:** This module projects the climate change levels due to anthropogenic greenhouse gas emissions and provides often ignored feed-back to the economy through damage functions.
- **Social and Environmental Impacts:** This module translates the “biophysical” results of the simulations into social (e.g. jobs associated to RES technologies) and environmental impacts (e.g. CO₂ emission per unit of value added).

MEDEAS-World model (MEDEAS_w)

The MEDEAS-World model is a global, one region economy-energy-environment model (or Integrated Assessment Model, IAM) which runs from 1995 to 2050.

The MEDEAS-World model has the following distinct features:

- Input-Output tables are integrated in the Economy submodel within a System Dynamics structure.
- Energy Return On Energy Invested (EROEI) – the net energy available after discounting the energy invested in its generation – is estimated. This is a novelty in the field of energy modelling, since most models consider EROEI as an exogenous input.
- Supply-demand closures model implementation. The scarcity of energy resources is fed back into the economic module, which can limit economic growth.
- Comprehensive estimation of the EROEI of those RES technologies for the generation of electricity with more potential. The consumption of final energy by final fuel is covered by a mix of technologies, which derives in the consumption of primary energy. Special attention is devoted to those technologies which seem to be realistically available and with a positive net energy balance.
- Comprehensive analysis of the techno-sustainable potential of RES for electricity and heat.
- The deployment of technologies is not directly constrained by material availability, but estimation of potential material scarcity is provided and alternatives are proposed for technologies that depend on potential scarcity of resources.

- The effects of climate change provide feedback into energy consumption.
- Socio-economic indicators are implemented in the model.
- Most modules have bi-directional linkages, except for Land-use and Social and Environmental impacts indicators, which mainly report outputs from the simulations without providing feedback to the rest of the structure.

MEDEAS_w incorporates three limits to growth that are rarely considered in literature: declining Energy return on energy invested (EROI) levels, climate change impacts and energy availability.

MEDEAS-Europe model (MEDEAS_eu)

MEDEAS_eu has been built for the EU-28, its structure is based on the world model and it also runs from 1995 to 2050.

MEDEAS_eu presents the following features in its framework compared to MEDEAS_w:

- The global hypothesis and scenarios, the results and projections and the data considered and obtained in MEDEAS_w are introduced into MEDEAS_eu.
- The commercial relations of Europe are modelled through Input-Output Tables (IOT), as trade and energy exchanges are taken into account and imports and exports in the economy and energy modules are firstly introduced in MEDEAS_eu.
- The climate change module of MEDEAS_w is replaced by a GHG emissions module in MEDEAS_eu.
- Policies are not represented, but they will ultimately be relevant for the model and will provide the framework in which each module develops.

MEDEAS PARTNERS



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This project has received funding from the European Union's Horizon 2020 research and innovation action programme under grant agreement No 691287. MEDEAS project forms part of the LCE21-2015 group: Modelling and analysing the energy system, its transformation and impacts (social, environmental and economic aspects of the energy system).