MEDEAS

MODELING THE RENEWABLE ENERGY TRANSITION IN EUROPE

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691287

18/01/2017

Guiding European Policy toward a low-carbon economy. Modelling sustainable Energy system Development under Environmental And Socioeconomic constraints.

Jordi Solé

Rutgers Universtity, January 23, 2017

iCM CSIC · KANE CRES CENTRE FOR RENEWABLE ENERGY SOURCES AND SAVING · circe · BSERC · IIASA · Hnutí DUHA · Blue4You

Outline

1) MEDEAS consortium and ICM-CSIC group at Barcelona
2) Novelty
3) Model construction
4) Coverage
5) Data
6) MEDEAS model
7) Marine Energy
8) Conclusions

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691287

MEDEAS partners

ICM-CSIC (Spain)

INSTM (Italy)

CRES (Greece)

CIRCE (Spain)

MU (Czech Rep)

UVA (Spain)

ARU (UK)

BSERC (Bulgaria)

IIASA (Austria)

DUHA (Czech Rep.)

AEA (Austria)

B4Y (Belgium)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691287

ICM-CSIC team

The Institute of Marine Sciences (ICM, Barcelona) coordinates the MEDEAS project. The ICM-CSIC team it's a group of the Physical Oceanography department in ICM:

- Jordi Solé (PI)
- Teresa Madurell (Project Manager)
- Oleg Osychenko (Postdoc)
- Joaquim Ballabrera (Scientist)
- Antonio García-Olivares (Scientist)
- Antonio Turiel (Scientist)
- Emilio García-Ladona (Scientist)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691287

Novelty beyond the state of the art (I)

- To **develop** a leading-edge policy **modelling tool based on a system dynamics approach**. Using WoLiM, TIMES, LEAP models and Input-Output Analysis.

- A **modular design** to deal with different levels of complexities and interests of stakeholders at great sectorial and spatial detail.

- **Transparency** through Open access freeware distribution of the model based on the open access programming language (Python), including free internet courses and learning materials.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691287

Novelty beyond the state of the art (II)

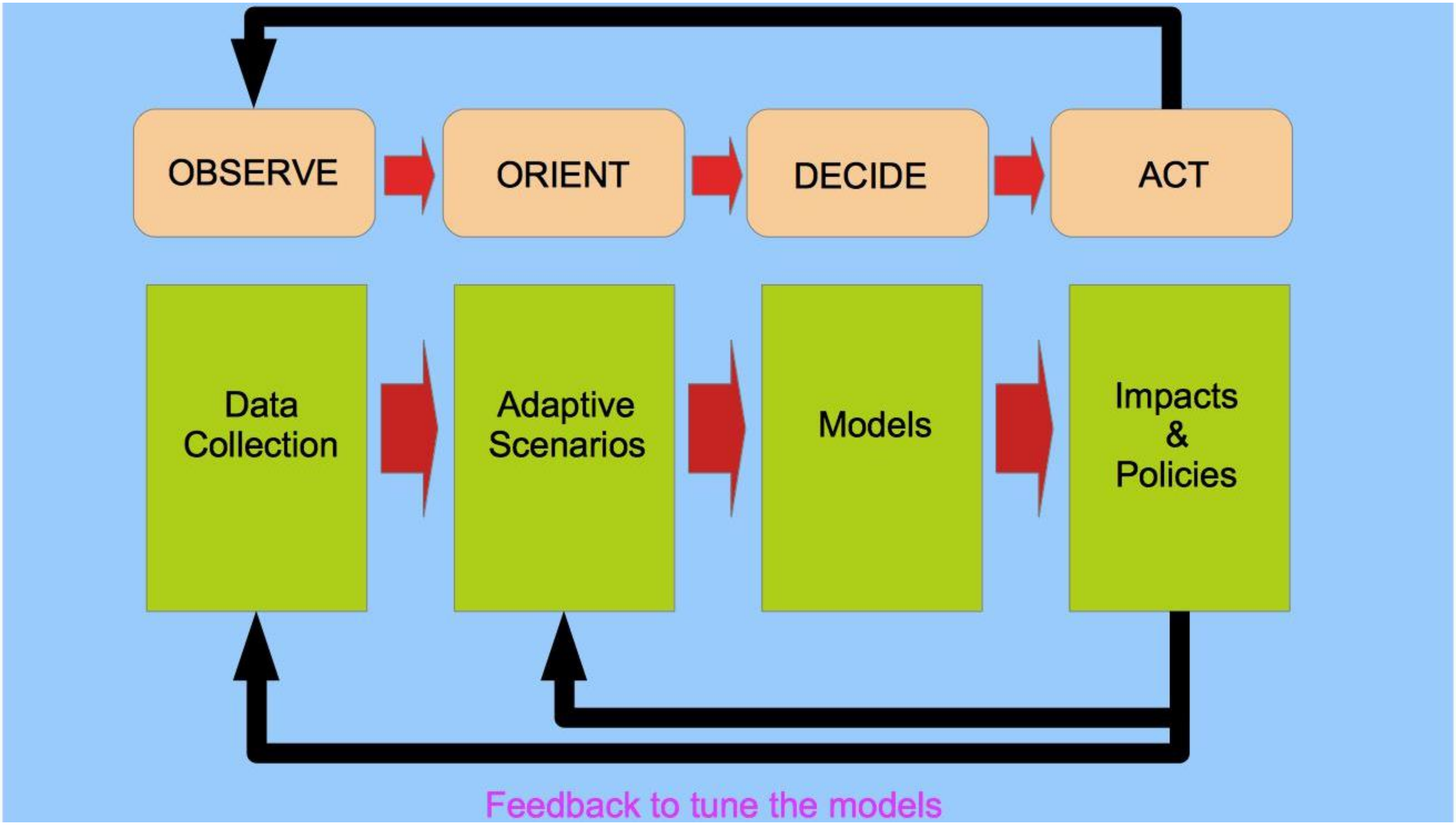
- Help to **close the gap between policy design and model implementation** and then, provide support analysis in policy issues regarding RES, fossil fuels and new energy forms.

- Feedback between **energy system and socio-economic variables** will be considered.

- **MEDEAS model will be constructed** using the information provided by key data analysis (using Partially Aggregated Variables, PAV) and selected scenarios, and improved using models inter-comparisons and impacts/policies analysis.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691287

MEDEAS model construction conceptual scheme



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691287

Coverage (I)

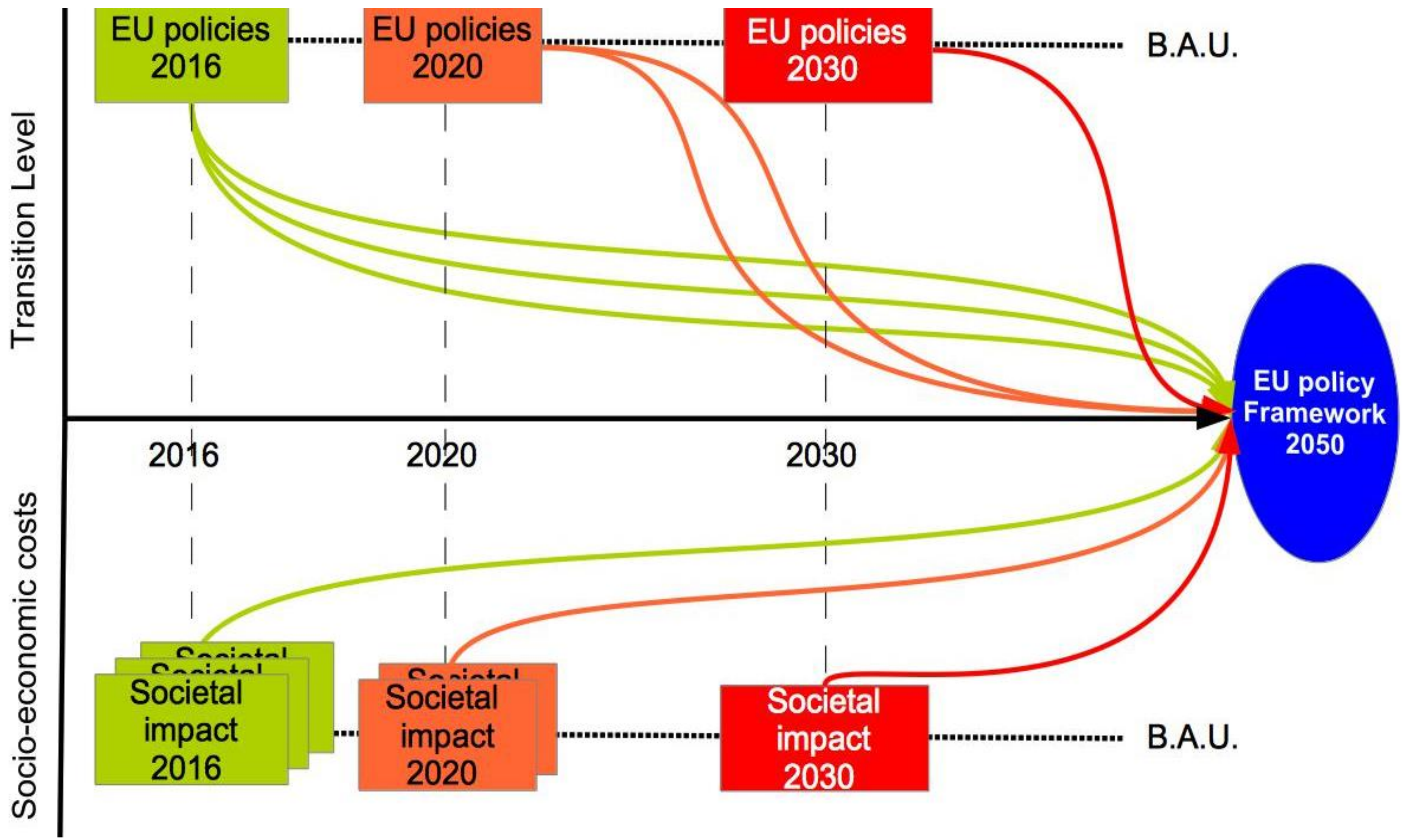
Essential elements to cover: Energy production and raw materials limitations in the energy transition to RES, socio-economical constraints, environmental impacts (CO2 emissions, ecosystems impacts).

Scenarios: Three main general scenarios and pathways will be proposed: B.A.U., full renewable transition (total de-carbonisation) and mid-level transition. **All energy sources will be considered** (non-renewable and renewable) to design the initial scenarios and the transition mid-term scenarios :

- a)To explore and study the different situations (scenarios) and temporal evolution (pathways) for each selected initial policy framework in order to be able to achieve the **objective of a low carbon economy in 2050.**
- b)The **physical constraints** identified in data analysis will be used to evaluate the possible variability of the PAVs of each scenario.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691287

Scenarios and pathways in MEDEAS



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691287

Coverage (II)

Integrated models: modeling at **three geographic nested levels**: World, Europe and Country.

The MEDEAS model will consider **key materials cycles in the energy generation via implementation of exergy variables** in the model.

After preliminary tests the **MEDEAS model will be placed online.**

EROI evaluation of each energy source and raw materials requirements will be considered. Mid-term scenarios will be used as a reference to compare the different model simulations.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691287

Data issues and databases

- *Exogenous data and data quality.* Collection of appropriate data necessary to design the adaptive scenarios and to quantify the initial starting points for the simulations. Identification of Partially Aggregated Variables (PAV) to be considered leading to a simple description, that nevertheless is suitable for reproducing essential parts of the social system and the energy/economy interplay

- *Sources of data*: Data will be collected from well recognized and highly prestigious international, European and other organizations, such as: International Monetary Fund (IMF), The World Bank, Organization for Economic Co-operation and Development (OECD) and basic EUROSTAT data or other different institutions that are collecting data from different public agencies (for instance www.indexmundi.com).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691287

Data (II)

Granularity of data in space and time. In space at three simulation levels (World, Europe and country). In time a yearly evolution of the selected PAVs.

To evaluate the energy demand for the future scenarios and pathways and future change in energy mixes, some key issues should be explored:

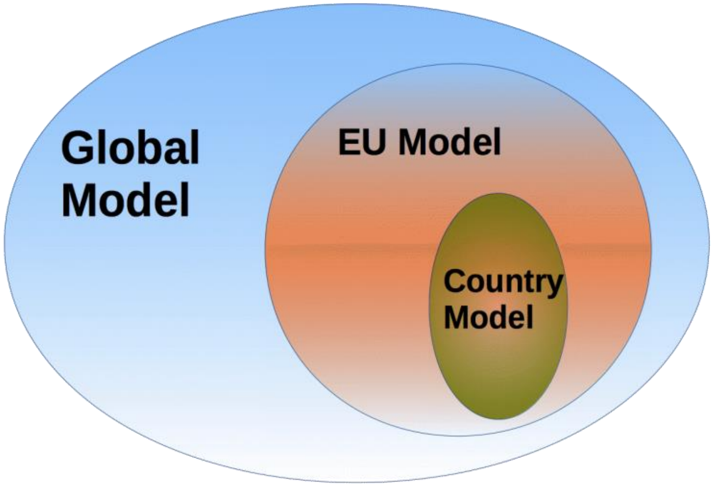
- Electricity sector transformation
- Transportation
- Total primary energy extraction
- Industry, residential and commercial energy requirements
- Social welfare and environmental impacts indicators analysis

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691287

Challenges in model construction

1) Nesting geographical levels/models:

- How to exchange information between parent and child model: one way or two way nesting?
- Model structure and feedback loops at the different levels
- Allocation (and reallocation) of resources between economic sectors due to energy scarcity per level
- Stability of the different models (possible phase transitions or tipping points)



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691287

Challenges in model construction

2) **Python** translation: coding, solvers and documentation

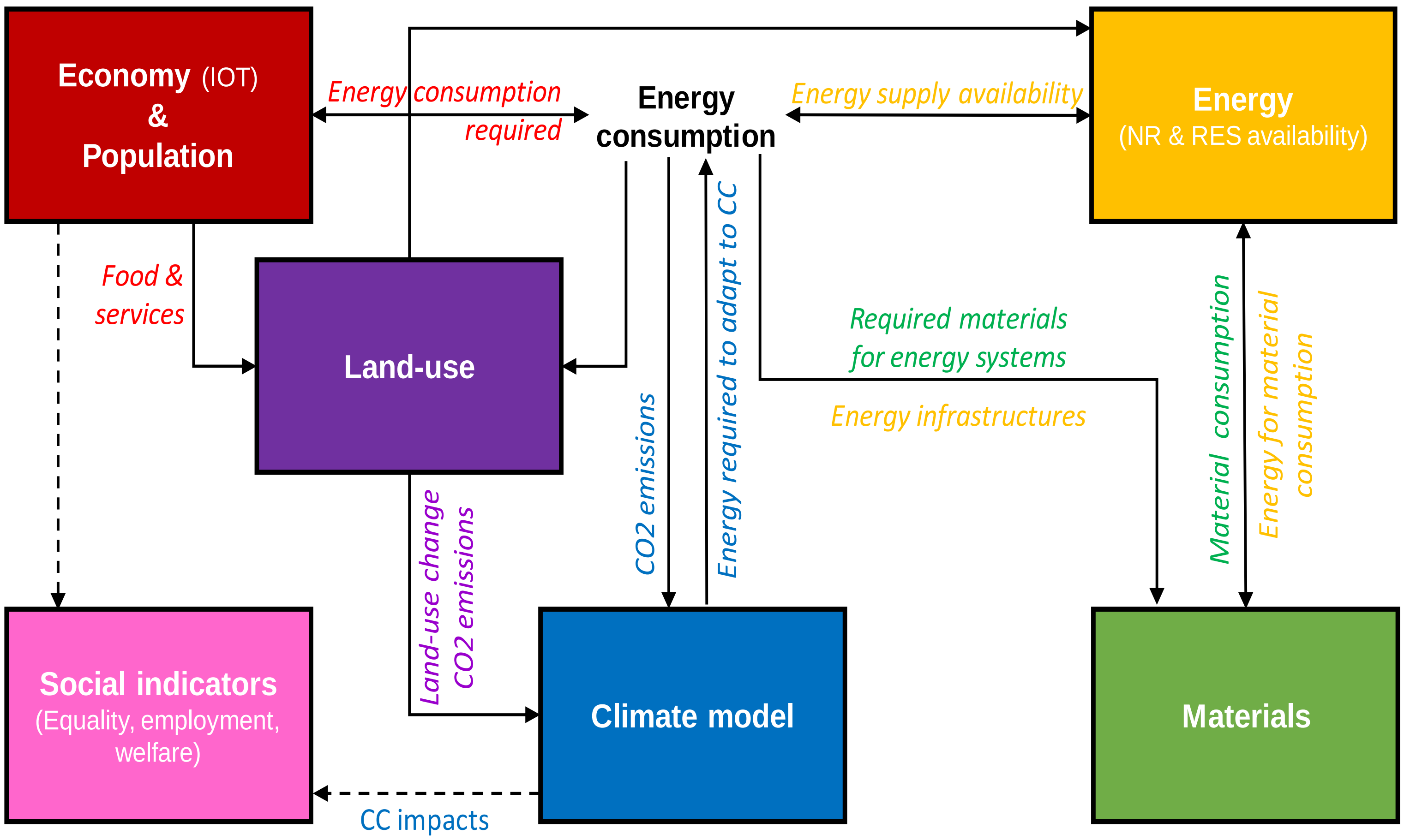
3) **Uncertainties** in variables: how the uncertainties of the data collected for model run propagate through the model variables

4) **Model validation** and models comparison: qualitatively and statistically

5) **Database** management

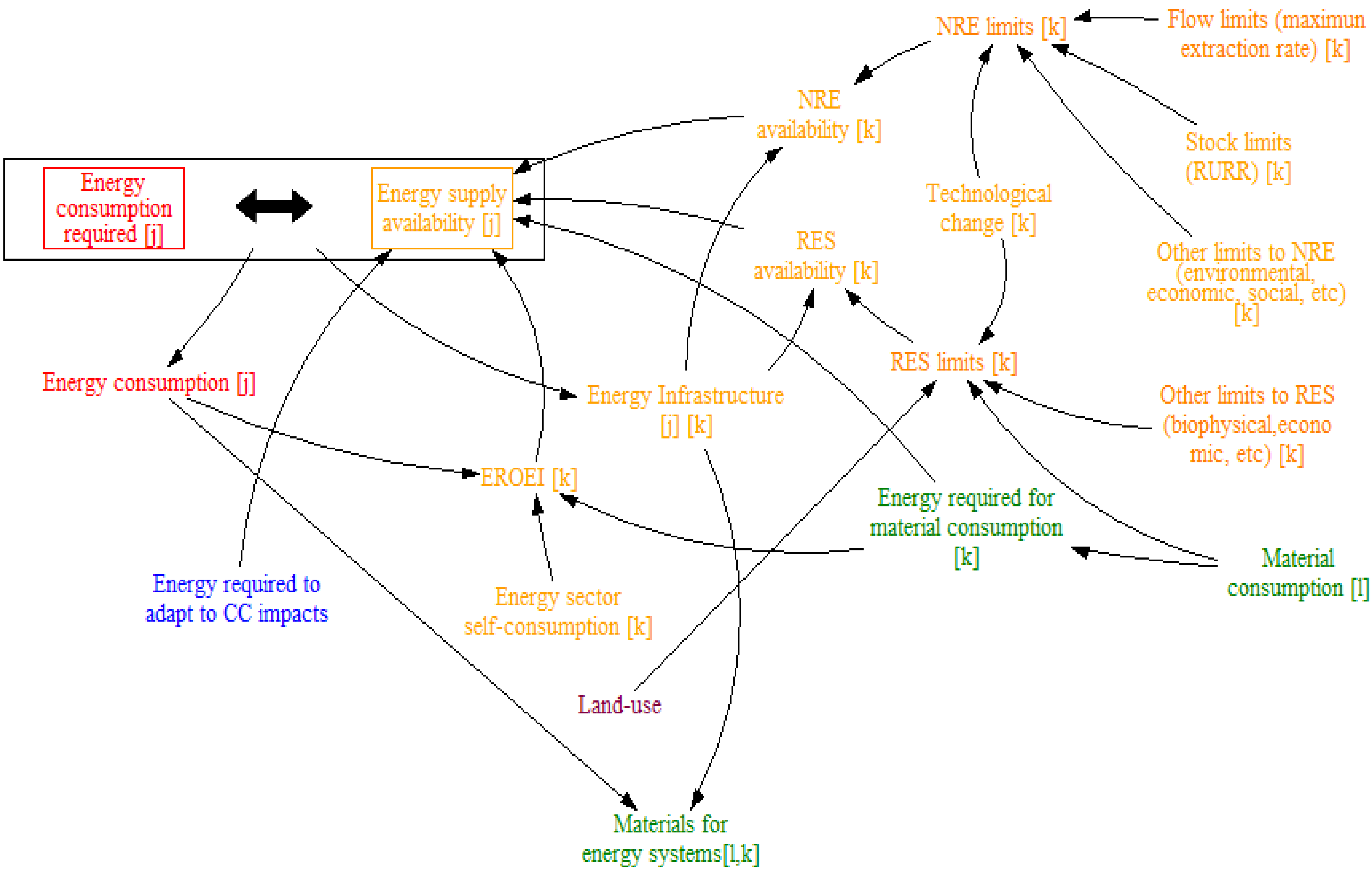
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691287

MEDEAS model structure



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691287

Energy module



Climate/Environment module: ocean applications

MEDEAS model and Ocean/climate applications:

Applications/implementations for the ocean in the current version of the MEDEAS model could be grouped in two main areas:

1) **Impacts** of the installation of RES in the Ocean.

-Climate model (currently MAGICC model) and the role of the ocean in the climate model for the CO_2 emissions analysis in the MEDEAS model.

-Environmental and ecological impacts of RES deployment at large scale. This could be considered under the Climate or Land-use modules.

2) **Potential** for scaling up the marine energy as a growing part of RES. International Energy Agency (IEA) estimates that there is a global potential for marine energy of 20 to 80,000 TWh (the current electricity demand is 17,500 TWh). **There is a need for resource mapping.**

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691287

Climate/Environment module: ocean applications

Marine Tidal and Wave power: modeling the potential for scaling up such technologies.

Current Levelised Cost Of Energy (LCOE) from ocean energy technologies are high in comparison to other renewable energy alternatives.

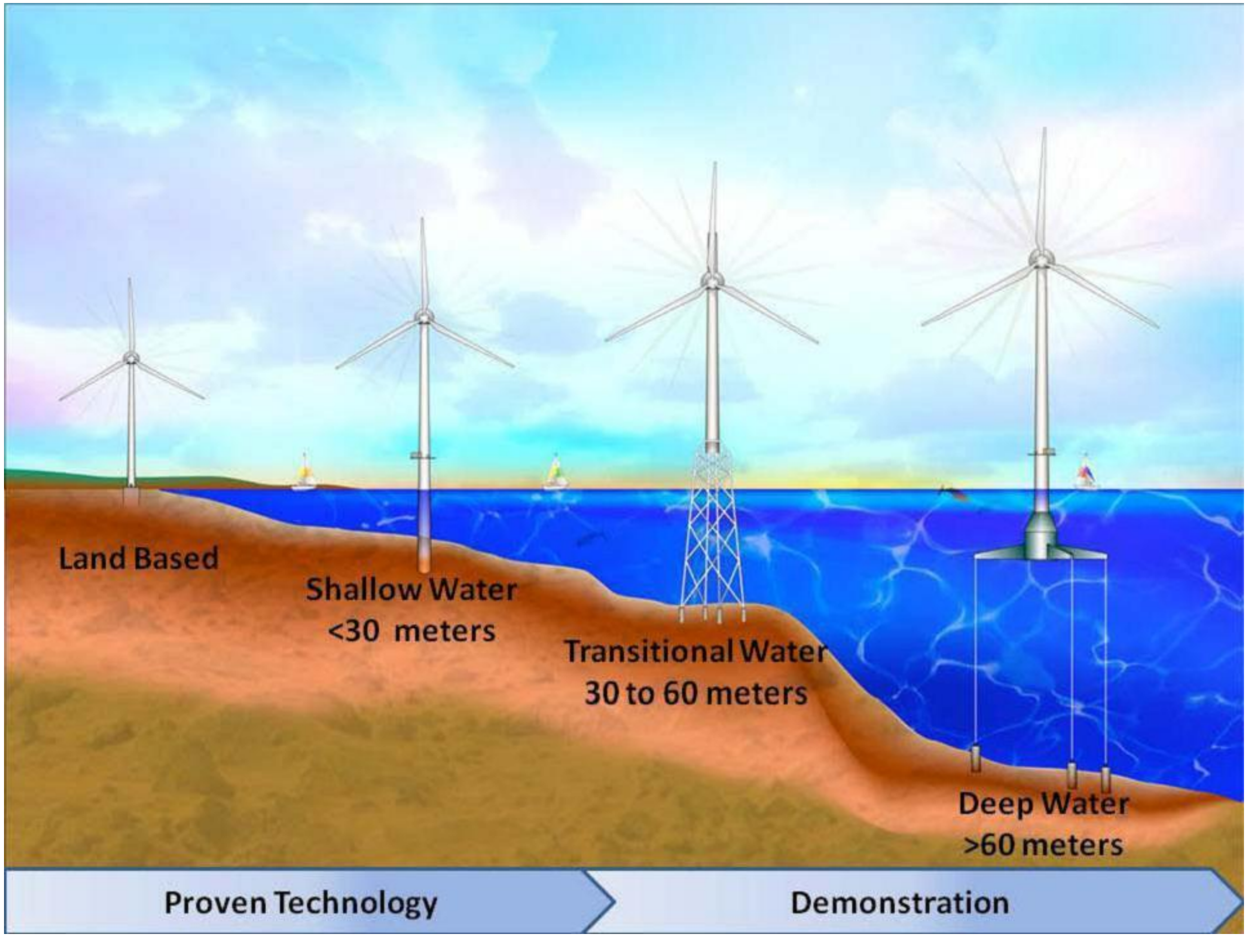
Wave power different prototypes are in development in EU projects and private initiatives, one example is the project Opera (www.opera-h2020.eu), which pretends, by deploying on site prototypes, to gain experience and obtain enough data for the improvement of security, reliability and performance of such devices. Estimated potential of Wave power 7500 TWh.

Marine Tidal and currents. The potential (tides) and kinetic (currents) energy can be harnessed constructing barriers (tidal) or modular systems (current). Estimated 3600 TWh of global potential. Ecological issues.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691287

Wind offshore another marine application

Wind offshore development: the potential of implementation and installation of wind farms offshore in deep waters.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691287

USA and EU projects currently on wind off-shore

EU projects on wind offshore

-More than 91% (11,028 MW) of the world's offshore wind power is currently installed off northern Europe, in the North, Baltic and Irish Seas, and the English Channel.

-In the first six months of 2016, Europe fully grid connected 114 commercial offshore wind turbines with a combined capacity totaling 511 MW. Overall 13 commercial wind farms were under construction which once completed will have a total capacity of over 4.2 GW

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691287

USA and EU projects currently on wind offshore

USA projects of wind offshore

-In 2016 the first US offshore wind farm start to operate in the Rhode Island

-In USA there are different projects that aims to develop the wind offshore potential. In May 2014, the United States Department of Energy chose three offshore wind projects to receive up to $47 million apiece over a four-year period:

Fisherman's Energy Atlantic City Windfarm (New Jersey)
Principle Power Wind farm-floating wind turbine (Oregon)
VOWTAP (Virginia)

Other proposed projects:

Bay State Wind (Massachusetts), 1.6 GW
Cape Wind (Massachusetts) 430 MW
Deepwater One South Fork (New York).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691287

Modeling marine and offshore wind energy

-Application of ocean models to assess marine energy scaling up potential

-Impacts of the development of both marine and offshore wind need to be analyzed

-More data and on site studies about the development of marine and wind energy are necessary

-Links/couplings between energy models and ocean models to evaluate impacts

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691287

Concluding remarks

-MEDEAS project is implementing an open source model at three geographical levels. This model will be community based and will be a tool to analyze the energy transition to RES in Europe.

-The global version of the MEDEAS model will be available this year. Its modularity and the programming language used, together with additional resources (MOOC, manual and users forum) pretends to give to the users enough resources to easily learn and use it.

-MEDEAS model is composed of 5 main modules, which are pretended to be the core model for the other nested models (European and country level).

-The RES of the ocean have a great potential for development: mainly waves and floating offshore wind farms prototypes are currently being developed.

-There is a great potential future research for exploring the links and scale up of marine and offshore wind in energy/economy models.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691287

Thank you!

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691287