THE MEDEAS FAMILY OF INTEGRATED ASSESSMENT MODELS

Lukas EGGLER[1], Martin BAUMANN[2]

Introduction

The transition to a low-carbon economy confronts us with multiple, sometimes conflicting targets. A key conflict is the need for CO2 emission reductions that are fast enough to reach the Paris target and limit global temperature increase to well below 2°, and the simultaneous sustainment of global economic activity. As the current energy system heavily depends on fossil fuels, a complete reorganization of both the economic (electrification, energy efficiency, sector coupling) and the energy sector (Integration of large amounts of intermittent energy sources, storage, etc.) is required. Systemic changes at the envisioned magnitude and the required rate unavoidably puts enormous pressure on the economic-, social- and environmental system. The question if the energy transition is feasible seems to be well justified – let alone how to reach it.

Methodology

The MEDEAS project aimed to add to this discussion by providing a set of models that is addressing the implications of an energy transition towards a low-carbon economy on different geographic levels while accounting for the most important biophysical constraints of such a transition:

- Detailed representation of economic activity (including international Trade) disaggregated into 35 economic sectors via Input-Output analysis (based on the World Input Output Database, WIOD [1])
- Accounting for climate change damage by considering a feedback between global temperature rise and economic activity
- Accounting for planetary boundaries by considering the remaining ultimately recoverable resources (RURR) and the impacts of eventual energy scarcity on the economy
- Flagging up when world material consumption of exceeds currently known resources
- Calculating the material- energy- and land footprint of 6 key renewable energy (RE) technologies required for the energy transition
- Accounting for additional energy demand required for provisioning renewable energy generation capacities by considering the Energy Return on Energy Invested of the System (EROI) [2]

The MEDEAS models are structured into 7 sub-models (see figure 1) in a modular structure. The geographical disaggregation follows a nested model approach, considering three geographical levels: MEDEAS World generates the boundary conditions for MEDEAS EU (which is the core of the model). MEDEAS World and EU define the boundary conditions for the country level models (that are currently only available for Austria and Bulgaria). All models have been developed using a System Dynamics approach, which is well suited to integrate knowledge from different perspectives and views. The models were originally built in Vensim DSS Software but have been translated to Python under an open source licence [3] to ensure the availability to the general public, together with accompanying internet learning courses and documentation.

[1] Österreichische Energieagentur,Mariahilfer Straße 136, 1150 Wien, T +43 (0)1-586 15 24 - 148, lukas.eggler@energyagency.at, www.energyagency.at
[2] Österreichische Energieagentur,Mariahilfer Straße 136, 1150 Wien, T +43 (0)1-586 15 24 - 148, martin.baumann@energyagency.at, www.energyagency.at

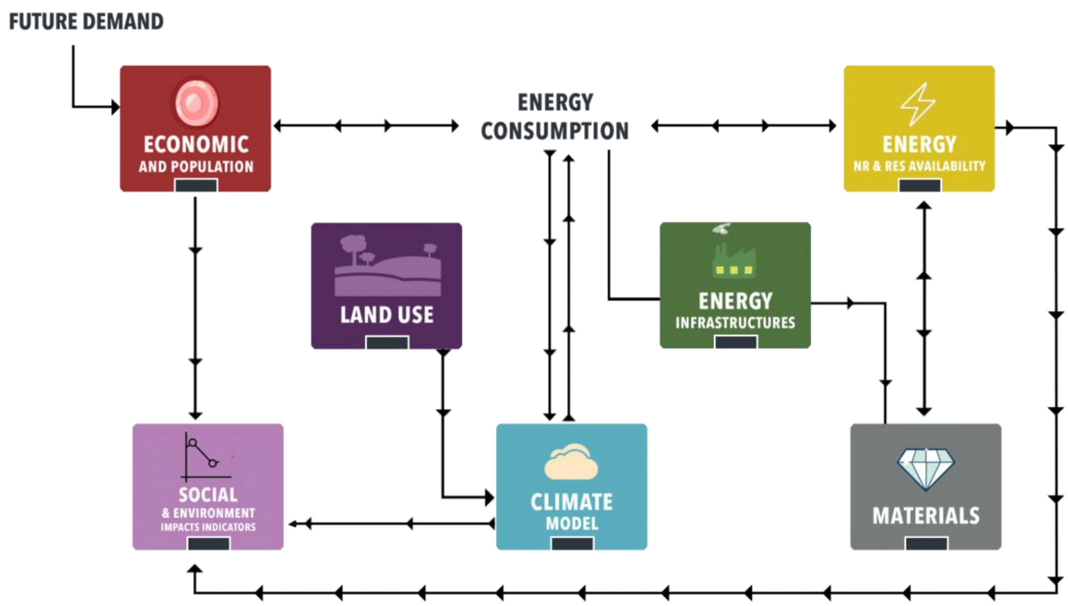

Figure 1:The MEDEAS model is structured into 7 sub-models in a modular and flexible structure.

Results

Within the MEDEAS project, three scenarios were developed to explore the transition towards a low carbon economy:

- Business as Usual (BAU): extrapolation of current technological and economic trends
- Green Growth (GG): moderate increase of RE technologies starting from 2020, moderate energy efficiency
- Transition Scenario (TRANS): Stagnation of overall economic activity, massive (!) increase of RE technologies, almost complete electrification of the economy

The results show that in the BAU scenario GHG emissions rise, leading to an economic recession after 2035-2040. In the GG scenario, economic growth can be sustained within the given horizon of 2050, but emission reductions to sustainable levels cannot be achieved. Only in the TRANS scenario the GHG emissions can be reduced to almost zero by 2050, while maintaining a stable economy.

From the results it can be concluded that current renewable energy implementation rates have to be increased to both ensure the achievement of the goals of the Paris agreement and economic prosperity. Another finding is that the increased implementation of RE technologies is accompanied by a strong increase of the mineral- and material demand and very high land requirements for its deployments.

References

[1] E. Dietzenbacher, B. Los, R. Stehrer, M. Timmer, G. Vries, „The Construction of World Input–Output Tables in the WIOD Project.", Economic Systems Research 25:1, 71–98, 2013. doi:10.1080/09535314.2012.761180

[2] Iñigo Capellán-Pérez, Carlos de Castro, Luis Javier Miguel González, "Dynamic Energy Return on Energy Investment (EROI) and material requirements in scenarios of global transition to renewable energies", Energy Strategy Reviews 26, 2019, https://doi.org/10.1016/j.esr.2019.100399

[3] Project MEDEAS – Modelling the Renewable Energy Transistion in Europe, Available: https://www.medeas.eu/ [Accessed: Nov. 2019].