



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

EU Framework Program for Research and Innovation actions (H2020 LCE-21-2015)



MEDEAS

MODELING THE RENEWABLE ENERGY TRANSITION IN EUROPE

Project Nr: 691287

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

D4.2 Annexes 1-3: Exogenous Energy Intensity Targets, Fuel Replacement conditions, imports and other minor corrections in the MEDEAS EU model

Version 3.0.0

Due date of deliverable:

Actual submission date: 30/05/2019



Disclaimer of warranties and limitation of liabilities

This document has been prepared by MEDEAS project partners as an account of work carried out within the framework of the EC-GA contract no 691287. The information and views set out in this report are those of the author(s) and do not necessarily reflect the official opinion of the European Union. Neither the European Union institutions and bodies nor any person acting on their behalf may be held responsible for the use which may be made of the information contained therein.

Neither Project Coordinator, nor any signatory party of MEDEAS Project Consortium Agreement, nor any person acting on behalf of any of them:

- (a) makes any warranty or representation whatsoever, express or implied,
 - (i). with respect to the use of any information, apparatus, method, process, or similar item disclosed in this document, including merchantability and fitness for a particular purpose, or
 - (ii). that such use does not infringe on or interfere with privately owned rights, including any party's intellectual property, or
 - (iii). that this document is suitable to any particular user's circumstance; or
- (b) assumes responsibility for any damages or other liability whatsoever (including any consequential damages, even if Project Coordinator or any representative of a signatory party of the MEDEAS Project Consortium Agreement, has been advised of the possibility of such damages) resulting from your selection or use of this document or any information, apparatus, method, process, or similar item disclosed in this document.

Document info sheet

Lead Beneficiary: University of Valladolid

WP: 4, Model building and models implementation

Task: 4.2, MEDEAS Model and IOA implementation at European geographical level

Authors:

UVA: Ignacio de Blas, Iñigo Capellán-Pérez, Óscar Carpintero, Carlos de Castro, Fernando Frechoso, Luis Fernando Lobejón, Pedro L. Lomas, Margarita Mediavilla, Luis Javier Miguel, Jaime Nieto, Paula Rodrigo González

Dissemination level : Public



Annex 1: Exogenous energy intensity targets

In previous versions of MEDEAS, the evolution of energy intensities was estimated dynamically based on historical trends and the changes that can be produced on them due to the market conditions of the final energy types or due to the energy policies.

As in the case of the global medeas_w 1.3 version, in the medeas_eu 1.2 version, a modification has been introduced and the energy intensity targets in a given year can be defined exogenously, so that the model evolves towards them. Thus, for the energy intensities (sectoral and household), three options can be selected in the model:

- 1) The energy intensities remain constant with the value of the last historical year.
- 2) Dynamic evolution of energy intensities (option selected by default).
- 3) Introduction of energy intensity targets for a specific year, so that the model evolves towards it.

At the same time, two options for the energy intensity target can be selected:

- 1) The energy intensity target is directly chosen by the user according to particular targets.
- 2) The energy target is defined by the variation of the energy intensity over the value of a specific year.

In the case that specific energy intensity targets are defined for a certain year, the scarcity perception and fuel replacement activation can produce a different result not arriving to the objective or arriving previously.

Annex 2: Modelling of fuel replacement

How to measure the scarcity or abundance of natural resources has been a controversial issue in economics for a long time (Neumayer, 2000). Ecological Economics criticizes the mainstream approach considering prices as a reliable indicator of scarcity of natural resources, given its theoretical and empirical weaknesses. Energy and mineral prices are subject to multiple influences (institutional framework, oligopolistic market structure, etc.), which prevent perfect competition to happen neither in the short nor long-term (Norgaard, 1990; Reynolds, 1999). Moreover, given the inertia and rigidities in the productive processes highly dependent on natural resources, important adjustments in the economic system are produced with *quantity* changes (instead of prices), as post-Keynesian approaches have highlighted (Lavoie, 2014). For both reasons, MEDEAS applies an alternative "biophysical" perspective to model fuel replacement which takes into account the evolution of the extraction of natural resources and their physical availability/scarcity (Campbell and Laherrère, 1998; Valero et al., 2014).

There is a first allocation mechanism in MEDEAS models at primary energy level for the generation of electricity, assuming that, given infrastructure available, different fuels can contribute to the electricity mix. Given that priority is given by default to renewable energy sources and nuclear, the remaining supply is allocated between oil, natural gas and coal. The adjustment for heat is modelled directly at final energy level given that the large majority of heat is not traded and is thus subject to the infrastructure at final user level.

There is a second allocation mechanism in MEDEAS models at final energy level, by replacing those fuels, which are scarcer, by fuels that are not/less scarce. This is performed through the variation of the final energy intensities. This variation is modelled on top of the exogenous trends for its future variation set by the user through the inputs.xlsx (see MEDEAS deliverables D4.1 (Capellán-Pérez et al., 2017), D4.2 (de Blas Sanz et al., 2018) and D4.3 (Álvarez Antelo et al., 2018)). Additionally, fuel scarcity also has the effect of accelerating efficiency use for this fuel. These fuel replacements and efficiency improvements are limited, in the standard version of the model, by the historical maximum from WIOD time-series (Genty et al., 2012; Timmer et al., 2012)).

Fuel scarcity for fuel i (primary and final) is defined as follows:

$$scarcity_i(t) = 1 - abundance_i(t)$$

$$abundance_i(t) = 1 - \frac{demand_i(t) - supply_i(t)}{demand_i(t)}$$

The perception of inter-fuel energy scarcities are modelled through the balance of the effect of the sensitivity to scarcity and the forgetting factor (see Figure 1 for the loop diagram of the modelling for final energy scarcities).

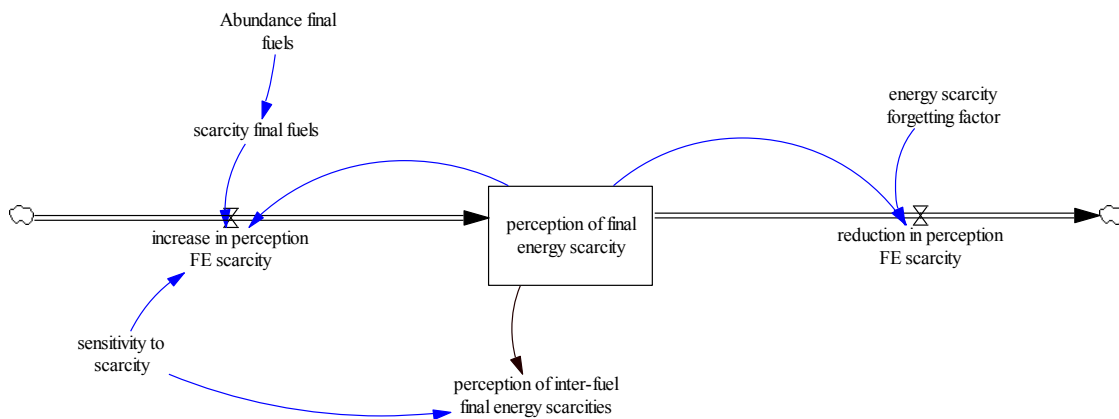


Figure 1: Loop diagram of the modelling of the perception of inter-fuel final energy scarcities in MEDEAS. Own elaboration.

Both parameters can be edited by the user through the inputs file excel sheet:

- **Sensitivity to scarcity:** this parameter reflects that economic agents and households may have different perceptions of scarcity and accordingly react differently (i.e., at a different speed) in a situation of fuel scarcity. 3 levels are pre-defined for the user: low, middle and high.
- **Forgetting factor:** this parameter reflects that the perception of scarcity of the economic agents is also influenced by the persistence in the memory of past events of fuel scarcity. A by default value of 5 years is assumed.

Annex 3: Imports

Since MEDEAS-World (medeas_w) logically does not use trade, all the energy consumed is produced at the same regional level. Thus, net energy final consumption could not trespass the biophysical boundary imposed by energy availability in the same region (the entire world). In MEDEAS-EU model (medeas_eu), it is not so simple. Boundaries can be artificially trespassed thanks to international trade, i.e. EU28 is able to consume more energy than produced. In fact, this is the current situation of the EU, and one of the main vulnerabilities in a context of world energy depletion. Hence, in order to take into account of global limits on energy consumption, different scenarios can be applied, as summarised in Table 1.

Table 1. Energy-economy feedback under different scenarios.

Scenarios	Features
No limits	EU28 can import energy limitless.
Current shares	EU28 can import energy at current levels.
Fixed share	EU28 can import energy with a user-fixed level.

Source: own elaboration.

In the ‘No limits’ scenario, there are no restrictions for EU28. Thus, EU28 is allowed to import as much energy as it needs to consume, regardless if it is consuming even the 100% of world energy for each type. On the contrary, the two other scenarios do impose boundaries to energy consumption.

Furthermore, ‘Current shares’ implies that, for each final energy source, EU28 can import no more than the current proportion of EU28 consumption over the world supply.

Finally, ‘Fixed share’ let the user to fix that proportion over the world extraction at his or her preference, no matter if over or under current levels.

How the energy consumption is distributed amongst regions is also a measure of equality and has deep implications on the issue of a fair transition.

Annex 4: Other minor corrections

Minor corrections have been introduced in the medeas_eu v1.2 model with relation to the materials submodule (material intensity (kg/new MW) of glass for the construction phase of solar PV and the energy consumption per unit of material consumption of Ga and Te), and with relation to the calculation of the EROI of the system.



References

Álvarez Antelo, D., de Blas Sanz, I., Capellán-Pérez, I., Carpintero Redondo, Ó., De Castro, C., Frechoso, F., Lobejón, L.F., Lomas, P.L., Mediavilla, M., Miguel, L.J., Nieto, J., Parrado, G., Rodrigo González, P., 2018. D4.3 MEDEAS Model and IOA implementation at country level: the cases of Austria and Bulgaria (Deliverable MEDEAS project, <http://www.medeas.eu/deliverables>). GEEDS, University of Valladolid.

Campbell, C.J., Laherrère, J., 1998. The end of cheap oil. *Scientific American* 278, 60–65.

Capellán-Pérez, I., de Blas, I., Nieto, J., De Castro, C., Miguel, L.J., Mediavilla, M., Carpintero, Ó., Rodrigo, P., Frechoso, F., Cáceres, S., 2017. MEDEAS Model and IOA implementation at global geographical level (Deliverable MEDEAS project, <http://www.medeas.eu/deliverables> No. D4.1). GEEDS, University of Valladolid.

de Blas Sanz, I., Capellán-Pérez, I., Carpintero Redondo, Ó., De Castro, C., Frechoso, F., Lobejón, L.F., Lomas Huertas, P.L., Mediavilla, M., Miguel, L.J., Nieto, J., Rodrigo, P., 2018. MEDEAS Model and IOA implementation at European geographical level (Deliverable MEDEAS project, <http://www.medeas.eu/deliverables>). GEEDS, University of Valladolid.

Genty, A., Arto, I., Neuwahl, F., 2012. Final database of environmental satellite accounts: technical report on their compilation. WIOD Deliverable 4.6, Documentation, downloadable at http://www.wiod.org/publications/source_docs/Environmental_Sources.pdf.

Lavoie, M., 2014. *Post-Keynesian Economics: New Foundations*. Edward Elgar Publishing.

Neumayer, E., 2000. Scarce or Abundant? The Economics of Natural Resource Availability. *Journal of Economic Surveys* 14, 307–335. <https://doi.org/10.1111/1467-6419.00112>

Norgaard, R.B., 1990. Economic indicators of resource scarcity: A critical essay. *Journal of Environmental Economics and Management* 19, 19–25. [https://doi.org/10.1016/0095-0696\(90\)90057-6](https://doi.org/10.1016/0095-0696(90)90057-6)

Reynolds, D.B., 1999. The mineral economy: how prices and costs can falsely signal decreasing scarcity. *Ecological Economics* 31, 155–166. [https://doi.org/10.1016/S0921-8009\(99\)00098-1](https://doi.org/10.1016/S0921-8009(99)00098-1)

Timmer, M., Erumban, A.A., Gouma, R., Los, B., Temurshoev, U., de Vries, G.J., Arto, I., Genty, V.A.A., Neuwahl, F., Francois, J., others, 2012. *The world input-output database (WIOD): contents, sources and methods*. Institute for International and Development Economics.



Valero, Antonio, Carpintero, Ó., Valero, Alicia, Calvo, G., 2014. How to account for mineral depletion. The exergy and economic mineral balance of Spain as a case study. *Ecological Indicators* 46, 548–559. <https://doi.org/10.1016/j.ecolind.2014.07.021>

