D7.3

OSeMBE – An open-source engagement model

August 2018

About this report

This report presents the Open Source energy Model Base for the European Union (OSeMBE), built in Open Source energy Modelling SYStem (OSeMOSYS).

Authors

Hauke Henke (KTH Royal Institute of Technology).

REEEM partners

About REEEM

REEEM aims to gain a clear and comprehensive understanding of the system-wide implications of energy strategies in support of transitions to a competitive low-carbon EU energy society. This project is developed to address four main objectives: (1) to develop an integrated assessment framework (2) to define pathways towards a low-carbon society and assess their potential implications (3) to bridge the science-policy gap through a clear communication using decision support tools and (4) to ensure transparency in the process.

The REEEM project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691739. This publication reflects only the views of its authors, and the European Commission cannot be held responsible for its content.

Contents

List of figures

List of tables

1 Introduction

Anthropogenic climate change and increased awareness of health hazards in human's daily life and their long-term effects are main drivers for the transition to a low carbon energy system. However, also renewable energy technologies affect human life and the environment and can be a health hazard. From the technological point of view renewable energies and in particular variable renewable energies (VRE) are challenging to integrate into energy systems due to their intermittent availability. Their distributed character creates a larger visual impact in the landscape and might be perceived as disturbing. Taking all this aspects together an integrated planning, that includes techno-economic analyses with strong interconnections between different planning stages as well as involvement of the public and key stakeholders is necessary (IRENA 2017b). A public dialogue requires publicly available information and transparency of tools and data used to allow an informed debate about options and alternatives and to foster acceptance of measures taken.

The Open-Source energy MOdelling SYStem (OSeMOSYS) stands for an approach of full data transparency and easy as well as freely accessible tools (Howells et al. 2011). Within the H2020 project REEEM OSeMOSYS was used to build OSeMBE. OSeMBE is purposefully and in accordance with the grant agreement of REEEM designed as an engagement model. As an engagement model it gives on the one hand the opportunity of access and usage to stakeholders as well as the public while covering the key dynamics of the more detailed tools applied within the project. Figure 1 illustrates the position and the interlinkage of OSeMBE (OSeMOSYS T7.3) with the other modelling tools applied in the project. However, in contrast to TIMES Pan-EU, OSeMBE does not aim to bring the detailed insights of the different modelling and planning tools together to one large and detailed picture. OSeMBE aims to promote understanding of the complex energy nexus by simplifying the system but picturing it as a whole and covering the most relevant dynamics and relationships.

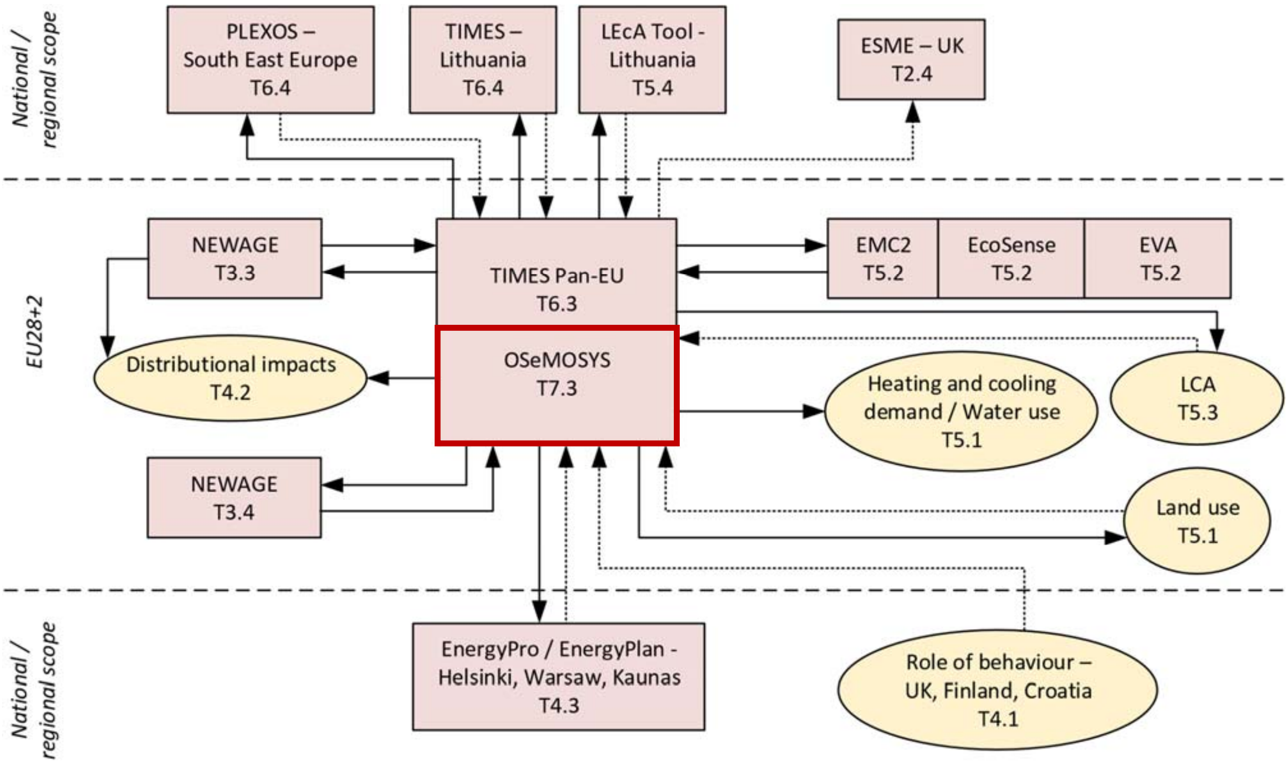


Figure 1. REEEM modelling framework

2 OSeMBE in brief

Table 1. Fact sheet OSeMBE

	Item	OSeMBE
1	**General Information**	
1.01	Model name	The Open-Source energy Model Base for the European Union
1.02	Acronym	OSeMBE
1.03	Institution(s)	KTH
1.04	Author(s) (institution, working field, active time period)	Hauke Henke (KTH, all, 2016 onwards)
1.05	Current contact person	Hauke Henke
1.06	Contact (e-mail)	haukeh@kth.se
1.07	Website	http://www.osemosys.org/osembe.html
1.08	Primary purpose	(Stakeholder) engagement in energy modelling
1.09	Support / Community / Forum	Website: http://www.osemosys.org/osembe.html Forum: https://www.reddit.com/r/optimuscommunity/
1.1	Framework	OSeMOSYS
1.11	User Documentation	http://osemosys.readthedocs.io/en/latest/
1.12	Developer/Code Documentation	http://www.osemosys.org/get-started.html
2	**Openness**	
2.01	Open Source	The source code is available at: http://www.osemosys.org/get-started.html
2.02	License	Modelling framework: Apache License 2.0, more information Model data: Open Data Commons Attribution License 1.0, more information
2.03	GitHub	Not yet, planned to be

2.04	Data provided	The model data is available at: http://www.osemosys.org/osembe.html
2.05	Number of developers	1
2.06	Number of users	2
3	**Software**	
3.01	Modelling software	GNU MathProg
3.02	External optimizer	GLPK, CPLEX
3.03	GUI	Model Management Infrastructure (MoManI), available here
4	**Coverage**	
4.01	Modelled energy sectors (final energy)	Electricity
4.02	Modelled demand sectors	National electricity
4.03	Modelled energy commodities	Bio fuel (BF), Biomass (BM), Coal (CO), Electricity (EL), Electricity 1 (E1), Electricity 2 (E2), Geothermal (GO), Heavy fuel oil (HF), Hydro (HY), Natural gas (NG), Nuclear (NU), Ocean (OC), Oil (OI), Sun (SO), Uranium (UR), Waste (WS), and Wind (WI)
4.04	Modelled technology types: components for generation or conversion	Combined cycle (CC), Combined heat and power (CH), Conventional (CV), Distributed PV (DI), Dam (DM), Pumped Storage (storage not modelled, considering the capacity with identical characteristics as hydro dam) (DS), Fuel cell (FC), Gas cycle (GC), Generation 2 (G2), Generation 3 (G3), Internal combustion engine with heat recovery (HP), Offshore (OF), Onshore (ON), Steam cycle (ST), Utility PV (UT), Wave power (WV)
4.05	Modelled technologies: components for transfer, infrastructure or grid	Transmission and distribution (TD), trans-border electricity transmission, oil refinery (RF)
4.06	Network representation	Net transfer capacities
4.07	Modelled technologies: Components for storage	-
4.08	Changes is efficiency	Defined exogenously, it can change across years
4.09	Geographic resolution	Austria (AT), Belgium (BE), Bulgaria (BG), Switzerland (CH), Cyprus (CY), Czech Republic (CZ), Germany (DE), Denmark (DK), Estonia (EE),

		Spain (ES), Finland (FI), France (FR), Greece (GR), Croatia (HR), Hungary (HU), Ireland (IE), Italy (IT), Lithuania (LT), Luxembourg (LU), Latvia (LV), Malta (MT), Netherlands (NL), Norway (NO), Poland (PL), Portugal (PT), Romania (RO), Sweden (SE), Slovenia (SI), Slovakia (SK), United Kingdom (UK)
4.1	Time resolution	5 seasons; one typical day per season; Night, Day, and Peak
4.11	Observation period	2015 to 2050
5	**Mathematical properties**	
5.01	Model class	Mono-objective LP
5.02	Mathematical objective	Net present cost minimisation over the whole space and time domain
5.03	Typical computation time	16 hours
5.04	Typical computation hardware	RAM and CPU (256GB, 3.5 GHz and 4 cores)
6	**Model integration and general data information**	
6.01	Interfaces	MoManI (only for data entering at the moment)
6.02	Model file format	.txt file
6.03	Integration with other models	No
6.04	Input/output data file format	Input data on a separate .txt file in form of matrices and called by the solver along with model file; all outputs of the model on another .txt and selected outputs on a csv file
6.05	Data input	Annual electricity demand by country, demand profile by timeslice, technology performance and cost data, generation constraints, emission constraints and costs
6.06	Model specific properties	Model simple to understand and accessible to all kinds of users, long pre-processing time to build the matrix of the LP, simplified system structure
6.07	Primary outputs	Global net present cost of the system, capacity and generation mix in every country, year, and time slice, primary fuels consumption
7	**References**	
7.01	Validation	Pending

7.02	Literature and data sources	(EC 2014; Andersson, Boulouchos, and Bretschger 2011; EPA 2015; IEA 2014; EC 2016; IEA ETSAP 2010; IRENA 2015c, 2015b; S&P Global Platts 2015; EWEA 2016; IRENA 2017a, 2015a; IEA-ETSAP and IRENA 2013; DECC 2015; World Nuclear Association 2016; ENTSO-E 2018; Staffell and Pfenninger 2016; Pfenninger and Staffell 2016b; Bosch, Staffell, and Hawkes 2017; Pfenninger and Staffell 2016a; EEA 2018; Eurostat 2018; EEA 2016; *Gesetz über die friedliche Verwendung der Kernenergie und den Schutz gegen ihre Gefahren (Atomgesetz)* 2018; CenSES and FME 2015; CenSES and IFE 2015; SFOE 2018, 2015, 2016; Geothermie-Schweiz n.d.; Schweizerischer Wasserwirtschaftsverband 2016; OECD 2015; Norwegian Ministry of Petroleum and Energy 2015; Tuuleenergia.ee 2015; VTT 2015; Siyal et al. 2015) See below for more details
7.03	Publications	1. Henke, H., Howells, M., Shivakumar, A., (2018) "The Base for a European Engagement Model – An Open Source Electricity Model of seven Countries around the Baltic Sea", CYSENI2018, ISSN 1822-7554, May 2018, Pages 226-247, link 2. Henke, H., (2018) "An indicative study on the opportunities of Pan-European electricity exchange in context of a decarbonised economy", IEW2018, presentation, link

3 Sample Reference Energy System

A common approach in (energy systems) modelling is to represent the modelled system in a graphical way to indicate the system boundaries and the elements considered. On the following pages the reference energy system (RES) of Germany is shown. The RES is kept slightly simpler than the model. Most fuels can be converted to electricity in different types of power plants.

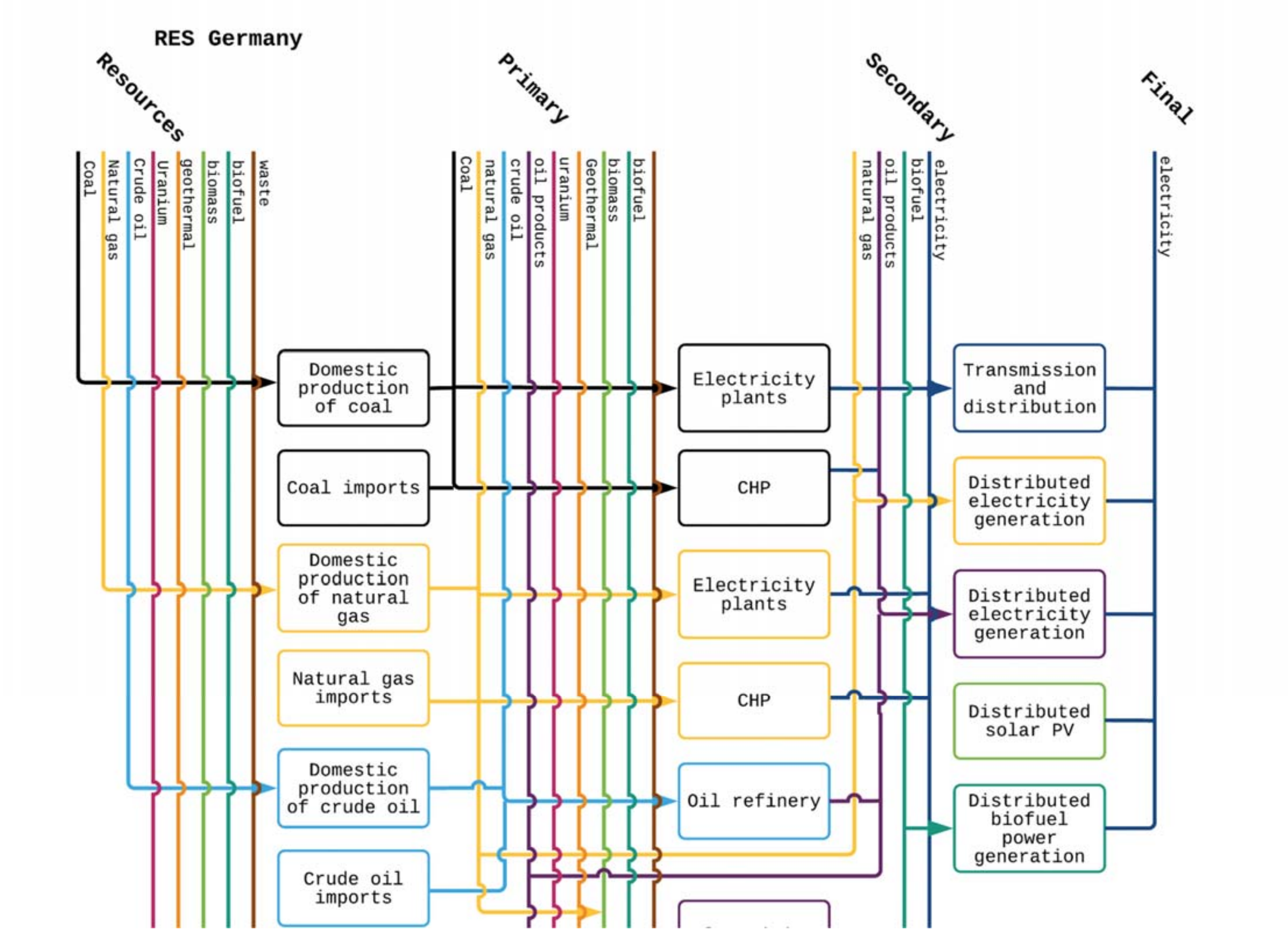
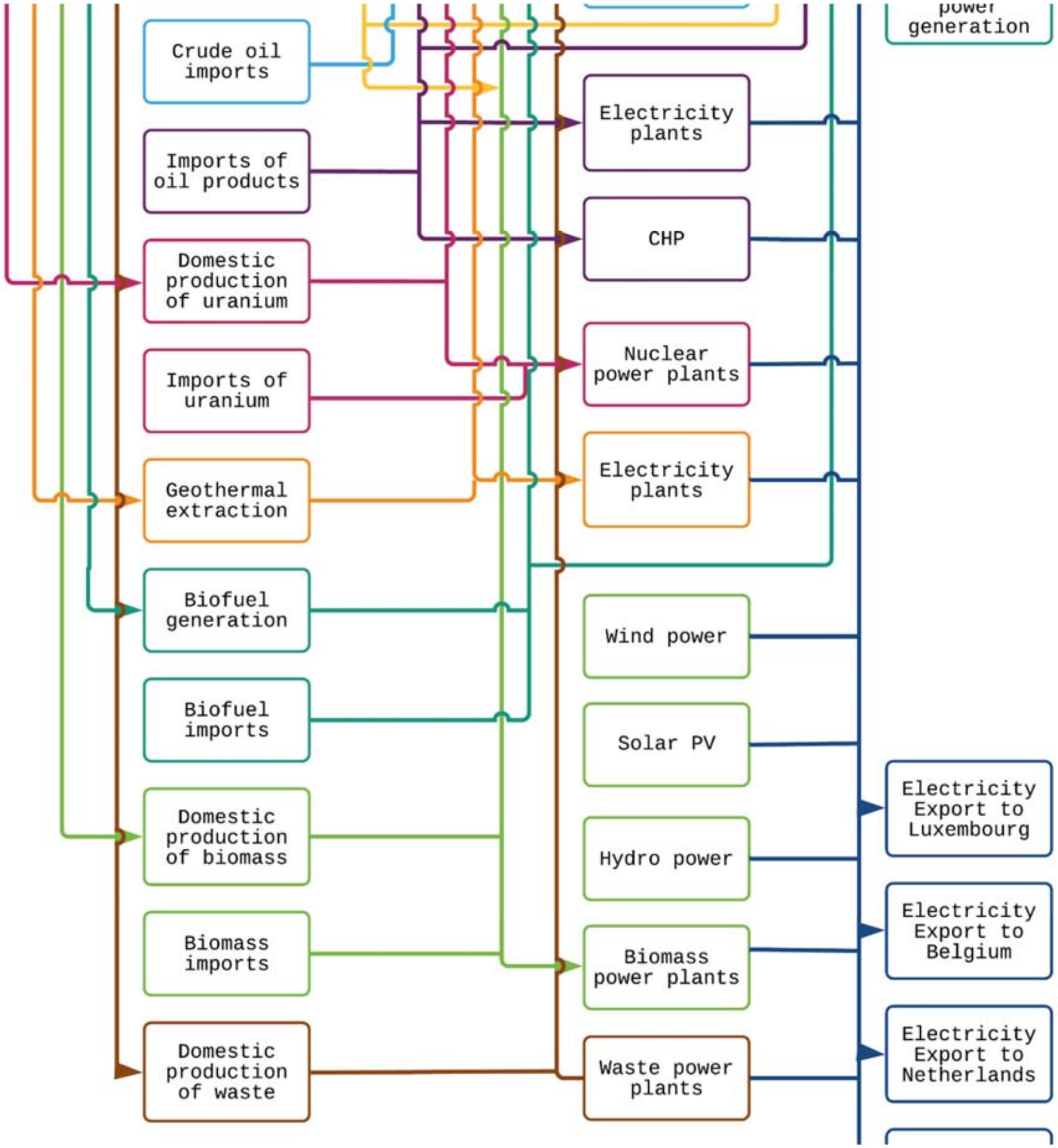
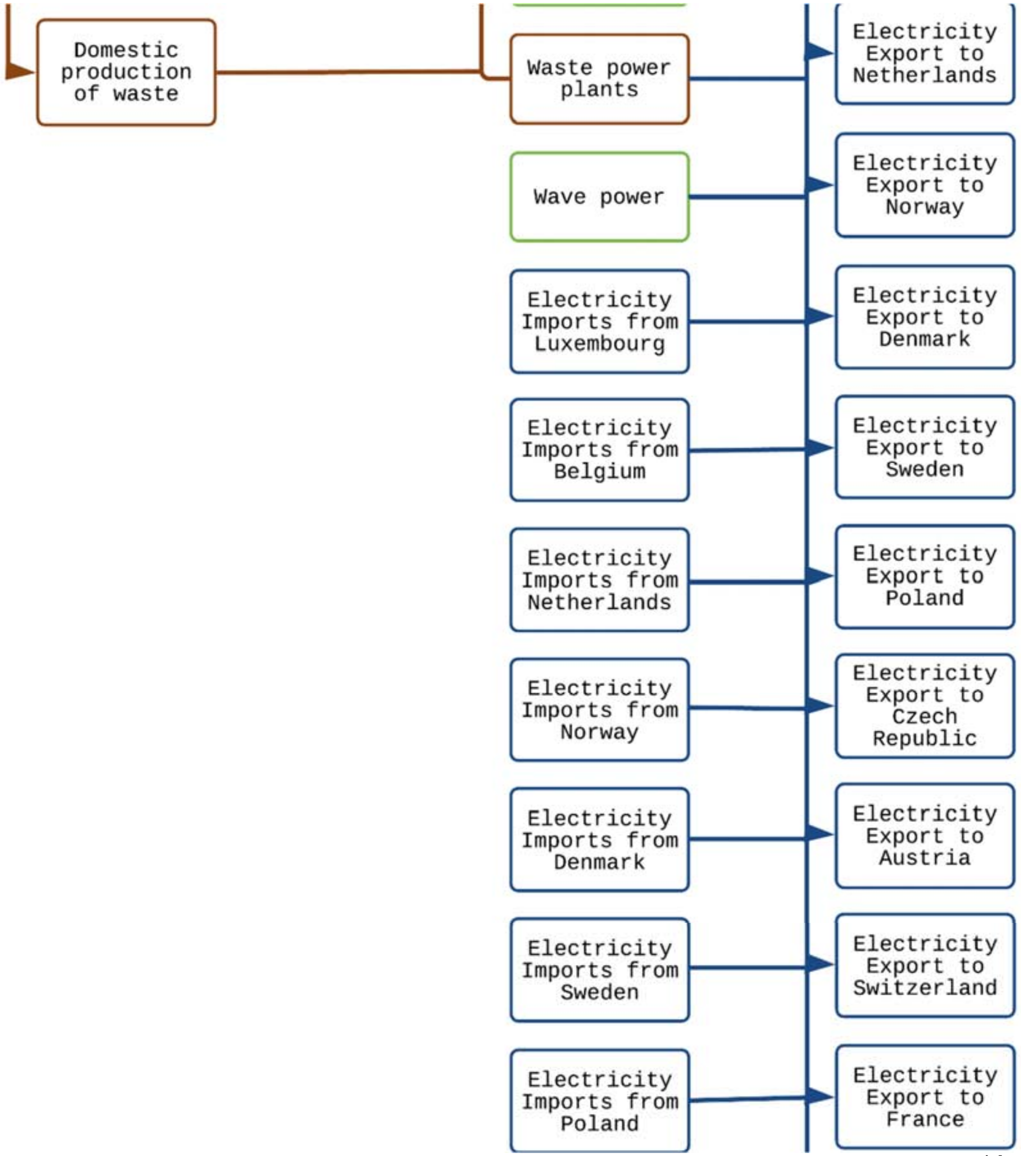
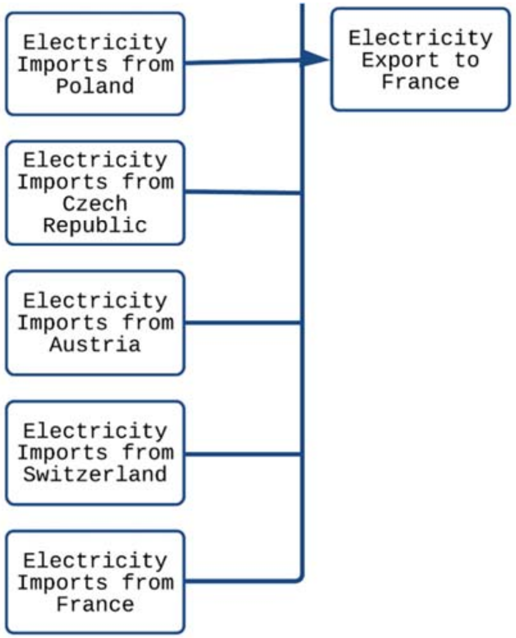


Figure 2. Reference energy system Germany


power
generation
Crude oil
imports
Imports of
oil products
Domestic
production
of uranium
Imports of
uranium
Geothermal
extraction
Biofuel
generation
Biofuel
imports
Domestic
production
of biomass
Biomass
imports
Domestic
production
of waste
Electricity
plants
CHP
Nuclear
power plants
Electricity
plants
Wind power
Solar PV
Hydro power
Biomass
power plants
Waste power
plants
Electricity
Export to
Luxembourg
Electricity
Export to
Belgium
Electricity
Export to
Netherlands


Domestic production of waste
Waste power plants
Wave power
Electricity Imports from Luxembourg
Electricity Imports from Belgium
Electricity Imports from Netherlands
Electricity Imports from Norway
Electricity Imports from Denmark
Electricity Imports from Sweden
Electricity Imports from Poland
Electricity Export to Netherlands
Electricity Export to Norway
Electricity Export to Denmark
Electricity Export to Sweden
Electricity Export to Poland
Electricity Export to Czech Republic
Electricity Export to Austria
Electricity Export to Switzerland
Electricity Export to France



Sources: http://www.iea.org/statistics/statisticssearch/report/?year=2013&country=GERMANY&product=Coal, http://world-nuclear.org/information-library/nuclear-fuel-cycle/mining-of-uranium/world-uranium-mining-production.aspx

4 Naming convention

4.1 Technology naming

Technologies in OSeMBE are named according to the following structure:

Table 2. Technology naming convention

AA	BB	CC	D	E	F		AABBCCDEF
Country	Commodity	Technology/connected country	Energy level	Age	Size	→	Technology name

The codes for the modelled countries, commodities, and technologies can be found in Table 1. The energy level is either *P* if a primary energy commodity is the output, or *F* if final electricity is the output, *I* indicates an import technology, and *X* an extraction or generation technology.

4.2 Commodity naming

Commodities in OSeMBE are named according to the following structure:

Table 3. Commodity naming convention

AA	BB		AABB
Country	Commodity	→	Commodity name

The codes for the modelled countries and commodities can be found in Table 1.

5 Data sources

Table 4. Data sources

	Source(s)
Demands	(EC 2016; CenSES and IFE 2015; CenSES and FME 2015; Andersson, Boulouchos, and Bretschger 2011)
Resource availability	(EC 2016; EWEA 2016; Geothermie-Schweiz n.d.; IRENA 2015c, 2015b; Norwegian Ministry of Petroleum and Energy 2015; CenSES and FME 2015; OECD 2015; Pfenninger and Staffell 2016b; Schweizerischer Wasserwirtschaftsverband 2016; Siyal et al. 2015; Staffell and Pfenninger 2016; Tuuleenergia.ee 2015; VTT 2015; World Nuclear Association 2016)
Fuel prices	(DECC 2015; World Nuclear Association 2016; IRENA 2015a; IEA-ETSAP and IRENA 2013)

Technology cost	(EC 2014; IEA 2014; EPA 2015)
Existing power generation capacities	(S&P Global Platts 2015; EWEA 2016)
Legal situation of nuclear power	(*Gesetz über die friedliche Verwendung der Kernenergie und den Schutz gegen ihre Gefahren (Atomgesetz)* 2018; SFOE 2016)
Trans-border transmission capacities	(ENTSO-E 2018)
Demand profiles	(ENTSO-E 2018)
Solar and wind fluctuation	(Pfenninger and Staffell 2016a, 2016b; Staffell and Pfenninger 2016; Bosch, Staffell, and Hawkes 2017)

6 Future development

The here presented first version of OSeMBE is kept simple due to its purpose as an engagement model. The future development has not aim the to change this purpose and therefore also not the fundamental structure. Nevertheless, there are many aspects that can be improved or added without changing the generic structure. In the following the planned and possible coming next steps are described.

6.1 Extension

Currently there are no plans for adding further countries. However, it would be possible to, e.g. add new member states of the EU.

6.2 Validation

An initial validation of the results of OSeMBE has been carried out. The results of the initial year were compared to the real world production mix indicated by IEA for 2015 (IEA 2018), and adjusted where necessary. Specific aspects addressed are listed in

Table 5. Measures taken during calibration

Issue	Measure taken
Very large capacity investments in single years	TotalAnnualMaxCapacityInvestment, implemented for technologies in countries where large investments observed in general a limit of 5 GW per year and country, for Nuclear 3 GW per country and year
Significant share of Coal in the UK	Consideration of UK Carbon price floor of 18£/tonCO2

Very low levels of natural gas usage	For the first six years (2015-2020) introduction of TotalTechnologyAnnualActivityLowerLimit for Gas import and extraction technologies to maintain at least the gas demand of 2015 following IEA numbers. Namely in BE, DE, DK, ES, FI, UK, FR, IT, NL, PL, and RO
Large shares of electricity by solar PV in Switzerland and Austria	Country specific limits for electricity generation by solar PV

However, the calibration is an ongoing process and is strongly related to input data improvements. It will be continued by KTH dESA, but voluntary contributions to this process are more than welcome.

6.3 Technology addition

Currently preparatory work is underway to enhance the model by adding storage technologies. Potential bottle necks on this path of development are limitations of the graphical user interface (GUI) MoManI and the process of converting the entered data to a matrix containing file that serves as the input to mathematical solver.

6.4 Data improvement

Without changes in the model structure data improvements are possible. Technology cost data and fuel prices are so far mostly generic. For certain aspects like for example the price of domestic resources such data could be made country-specific to improve the accuracy.

Data improvement could also imply to improve the representation of technologies, since some technologies in this version of OSeMBE are modelled in a very simplified way. A starting point for such improvements could be the improvement of transmission and distribution technologies for electricity but also fuel conversion processes like oil refineries.

6.5 Sector addition

Of potential interest is also the addition of sectors like heating and cooling, or transport. However, in context of this the above mentioned bottlenecks in terms of GUI limitations and calculation procedure need to be taken into account.

7 Engagement and openness

The first and direct use of OSeMBE shall be to provide data to be used in the REEEM Game. The REEEM Game is an option for engagement with stakeholders or in academia to increase understanding of the energy nexus and doesn't require modelling knowledge. But the model itself is also available to the public, stakeholders and academia. Especially in the later the model will be used for educational purposes to provide the base for in-course case studies but also to work on answering research questions in thesis projects and workshops.

The openness of the model facilitates easy access and usage of the model for the above described purposes. To continue the model's development, to foster engagement and usage of the model a potential goal is to integrate the model within the OpTIMUS community (www.optimus.community) and to build a community of users and developers around the model.

8 References

Andersson, Göran, Konstantinos Boulouchos, and Lucas Bretschger. 2011. 'Energiezukunft Schweiz'. ETH Zürich.

Bosch, Jonathan, Iain Staffell, and Adam D. Hawkes. 2017. 'Temporally-Explicit and Spatially-Resolved Global Onshore Wind Energy Potentials'. *Energy* 131 (July): 207–17. https://doi.org/10.1016/j.energy.2017.05.052.

CenSES, and FME. 2015. 'CenSES Energy Demand Projections towards 2050 - Reference Path'. 978-82-93198-09–3. Trondheim, Norway: Centre for Sustainable Energy Studies (CenSES - NTNU), Forskningssenter for Miljøvennlig Energi (FME), Institute for Energy Technology (IFE), UIO Centre for Technology, Innovation and Culture - University of Oslo, Høgskulen i Sogn og Fjordane. https://www.ntnu.edu/documents/1261967833/1262617931/Position-paper_Energy-Projections_utenbleed.pdf/0949b222-5d1b-4b06-9217-9287cb578b6a.

CenSES, and IFE. 2015. 'Forecast of Energy Demand in Norway towards 2050'. Centre for Sustainable Energy Studies (CenSES) and Institutt for energiteknikk (IFE). https://www.ntnu.edu/documents/1261967833/1262617931/Energy+demand+in+Norway+towards+2050.pdf/80f05210-7380-4c19-b9ed-52801b9d3fe1.

DECC. 2015. 'DECC 2015 Fossil Fuel Price Assumptions'. Department of Energy & Climate Change (DECC). https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/477958/2015_DECC_fossil_fuel_price_assumptions.pdf.

EC. 2014. *Energy Technology Reference Indicator (ETRI) Projections for 2010-2050*. Luxembourg: European Commission (EC). http://dx.publications.europa.eu/10.2790/057687.

———. 2016. *EU Reference Scenario 2016: Energy, Transport and GHG Emissions: Trends to 2050.* Luxembourg: European Commission (EC). http://bookshop.europa.eu/uri?target=EUB:NOTICE:MJ0115793:EN:HTML.

EEA. 2016. 'CO2 Emission Intensity'. Data Visualization. European Environment Agency. 20 June 2016. https://www.eea.europa.eu/data-and-maps/daviz/co2-emission-intensity-3.

———. 2018. 'EU Emissions Trading System (ETS) Data Viewer'. Dashboard (Tableau). European Environment Agency. 15 May 2018. https://www.eea.europa.eu/data-and-maps/dashboards/emissions-trading-viewer-1.

ENTSO-E. 2018. 'ENTSO-E Transparency Platform'. 2018. https://transparency.entsoe.eu/.

EPA. 2015. 'Catalog of CHP Technologies'. U.S. Environmental Protection Agency (EPA) Combined Heat and Power Partnership. https://www.epa.gov/sites/production/files/2015-07/documents/catalog_of_chp_technologies.pdf.

Eurostat. 2018. 'Total Gross Electricity Generation'. Eurostat. 27 June 2018. http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&plugin=1&language=en&pcode=ten00087.

EWEA. 2016. 'Wind in Power - 2015 European Statistics'. EWEA - The European Wind Energy Association. https://windeurope.org/wp-content/uploads/files/about-wind/statistics/EWEA-Annual-Statistics-2015.pdf.

Geothermie-Schweiz. n.d. 'Potenzial – Geothermie Schweiz'. Geothermie Schweiz. Accessed 10 July 2018. https://geothermie-schweiz.ch/waermestrom/petrothermal/potenzial/.

Gesetz über die friedliche Verwendung der Kernenergie und den Schutz gegen ihre Gefahren (Atomgesetz). 2018. https://www.gesetze-im-internet.de/atg/AtG.pdf.

Howells, Mark, Holger Rogner, Neil Strachan, Charles Heaps, Hillard Huntington, Socrates Kypreos, Alison Hughes, et al. 2011. 'OSeMOSYS: The Open Source Energy Modeling System'. *Energy Policy* 39 (10): 5850–70. https://doi.org/10.1016/j.enpol.2011.06.033.

IEA. 2014. 'World Energy Outlook 2014 - Power Generation Investment Assumptions'. International Energy Agency (IEA). http://www.worldenergyoutlook.org/weomodel/investmentcosts/.

———. 2018. 'Statistics | United Kingdom - Electricity Generation by Fuel'. International Energy Agency (IEA). 2018. https://www.iea.org/statistics/?country=UK&year=2015&category=Key%20indicators&indicator=ElecGenByFuel&mode=chart&categoryBrowse=false.

IEA ETSAP. 2010. 'IEA ETSAP - Technology Brief E03'. IEA Energy Technology Systems Analysis Programme (ETSAP). http://109.73.233.125/~ieaetsap/E-TechDS/PDF/E03-Nuclear-Power-GS-AD-gct.pdf.

IEA-ETSAP, and IRENA. 2013. 'Production of Liquid Biofuels - Technology Brief'. Paris, France: IEA-Energy Technology Systems Analysis Programme (IEA-ETSAP) and International Renewable Energy Agency (IRENA).

IRENA. 2015a. 'Renewable Power Generation Costs in 2014'. International Renewable Energy Agency (IRENA). http://www.irena.org/publications/2015/Jan/Renewable-Power-Generation-Costs-in-2014.

———. 2015b. 'REmap 2030 Renewable Energy Prospects for Poland'. Abu Dhabi, UAE: International Renewable Energy Agency (IRENA). http://www.irena.org/publications/2015/Oct/REmap-2030-Renewable-Energy-Prospects-for-Poland.

———. 2015c. 'Renewable Energy Prospects: Germany, REmap 2030 Analysis'. Abu Dhabi: International Renewable Energy Agency (IRENA). http://www.irena.org/publications/2015/Nov/Renewable-Energy-Prospects-Germany.

———. 2017a. *Renewable Energy Statistics 2017*. Abu Dhabi, UAE: The International Renewable Energy Agency. http://www.irena.org/DocumentDownloads/Publications/IRENA_Renewable_Energy_Statistics_2017.pdf.

———. 2017b. *Planning for the Renewable Future: Long-Term Modelling and Tools to Expand Variable Renewable Power in Emerging Economies*. Abu Dhabi, UAE: International Renewable Energy Agency (IRENA). http://www.irena.org/menu/index.aspx?mnu=Subcat&PriMenuID=36&CatID=141&SubcatID=3805.

Norwegian Ministry of Petroleum and Energy. 2015. 'Facts 2015 Energy and Water Resources in Norway'. Norway: Norwegian Ministry of Petroleum and Energy. https://www.regjeringen.no/en/aktuelt/fakta-2015-energi--og-vannressurser-i-norge/id2395568/.

OECD. 2015. 'Municipal Waste', March. https://doi.org/10.1787/data-00601-en.

Pfenninger, Stefan, and Iain Staffell. 2016a. *Renewables.Ninja*. English. https://www.renewables.ninja.

———. 2016b. 'Long-Term Patterns of European PV Output Using 30 Years of Validated Hourly Reanalysis and Satellite Data'. *Energy* 114 (November): 1251–65. https://doi.org/10.1016/j.energy.2016.08.060.

Schweizerischer Wasserwirtschaftsverband. 2016. 'Wasserkraftpotenzial der Schweiz'. Faktenblatt. Schweizerischer Wasserwirtschaftsverband. https://www.swv.ch/wp-content/uploads/2018/03/Faktenblatt-Wasserkraftpotenzial_SWV.pdf.

SFOE. 2015. 'Geothermal Energy Switzerland'. Swiss Federal Office of Energy (SFOE). 15 November 2015. http://www.bfe.admin.ch/themen/00490/00501/index.html?lang=en.

———. 2016. 'Nuclear Energy'. Swiss Federal Office of Energy (SFOE). 12 July 2016. http://www.bfe.admin.ch/themen/00511/index.html?lang=en.

———. 2018. ‘Electricity Statistics’. Swiss Federal Office of Energy (SFOE). 10 July 2018. http://www.bfe.admin.ch/themen/00526/00541/00542/00630/index.html?lang=en&dossier_id=04840.

Siyal, Shahid Hussain, Ulla Mörtberg, Dimitris Mentis, Manuel Welsch, Ian Babelon, and Mark Howells. 2015. ‘Wind Energy Assessment Considering Geographic and Environmental Restrictions in Sweden: A GIS-Based Approach’. *Energy* 83 (April): 447–61. https://doi.org/10.1016/j.energy.2015.02.044.

S&P Global Platts. 2015. ‘Platts World Electric Power Plants Database’.

Staffell, Iain, and Stefan Pfenninger. 2016. ‘Using Bias-Corrected Reanalysis to Simulate Current and Future Wind Power Output’. *Energy* 114 (November): 1224–39. https://doi.org/10.1016/j.energy.2016.08.068.

Tuuleenergia.ee. 2015. ‘Wind Energy in Estonia | Tuuleenergia’. Estonian Wind Power Association. 31 December 2015. http://www.tuuleenergia.ee/en/windpower-101/statistics-of-estonia/.

VTT. 2015. ‘Wind Energy Statistics in Finland’. VTT Technical Research Centre of Finland Ltd. 2015. http://www.vttresearch.com/services/low-carbon-energy/wind-energy/wind-energy-statistics-in-finland.

World Nuclear Association. 2016. ‘The Economics of Nuclear Power’. 2016. http://www.world-nuclear.org/information-library/economic-aspects/economics-of-nuclear-power.aspx.