



Energy and Flexibility Modelling

Hands-on 4

Please use the following citation for:

- **This exercise**

Cannone, Carla, Allington, Lucy, & Howells, Mark. (2021, March). Hands-on 4: Energy and Flexibility Modelling (Version 2.0.). Zenodo. <https://doi.org/10.5281/zenodo.4609733>

- **clicSAND Software**

Cannone, C., Allington, L., de Wet, N., Shivakumar, A., Goynes, P., Valderamma, C., & Howells, M. (2021, March 10). ClimateCompatibleGrowth/clicSAND: v1.1 (Version v1.1). Zenodo. <http://doi.org/10.5281/zenodo.4593100>

- **OSeMOSYS Google Forum**

Please sign up to the help Google forum [here](#). If you are stuck, please ask questions here. If you get ahead, please answer questions in the same forum. Please state that you are using the 'clicSAND' Interface.

Learning outcomes

By the end of this exercise, you will be able to:

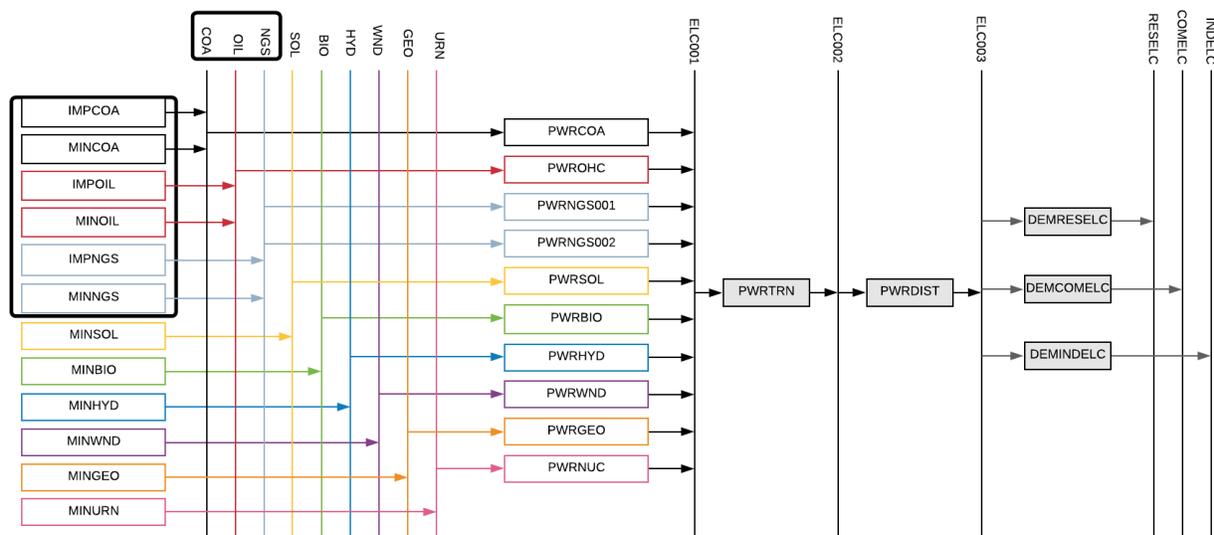
- 1) Define technologies representing the domestic production of energy commodities
- 2) Define technologies representing the import of energy commodities

We will not run the model at the end of this exercise.



Define technologies representing the domestic production of energy commodities

In Lecture 4 we learnt how to represent a technology in OSeMOSYS and which parameters characterize the primary energy supply technologies. As said, these technologies can represent domestic production/extraction or importation of fuels such as coal, natural gas and oil. In this Hands-on, we will add 6 technologies in total: 3 for the import and 3 for the domestic production of coal, natural gas and oil. We will build the highlighted part of the RES:



In order to represent a primary supply technology, remember that the following **parameters** must be considered:

- **OutputActivityRatio**: defines the fuel provided (in this first example Coal)
- **Variable Cost**: defines the cost of coal extraction
- **TotalTechnologyModelPeriodUpperLimit**: defines the level of proven coal reserves that are available for extraction throughout the entire model period (we will express it in PJ)
- **TotalAnnualMaxCapacity**: defines the maximum annual rate of production of Coal



- **CapacityToActivityUnit:** It is used to convert data related to the Capacity of technology into the Activity it can generate. For primary supply technology, this value should be set to 1.

Try it: Let's add **MINCOA** - the technology representing the domestic extraction of coal.

1. Go to SETS and in cell B4 change the name from "TEC001" to "**MINCOA**" and the description to "**Coal Domestic Production**". In this way, we added the technology which will be providing Coal (**COA**) to the model
2. Now let's add the **coal fuel** in Cell E4 following the same procedure.
3. Next, go to Parameters Sheet and filter out in Column C for **MINCOA** (as done in Hands-on 3 for the Backstop).
4. Add the data for **MINCOA** as for the table below and as given in the [DataPrep file](#).
 - a. **OutputActivityRatio:** choose the Coal Fuel row (Cell K31373) and add 1 from 2015 to 2070

Parameter	REGION	TECHNOLOGY	EMISSION	FUEL	2015	2016	2017
21262 InputActivityRatio	RE1	MINCOA		COM050	0	0	0
31124 OperationalLife	RE1	MINCOA					
31372 OutputActivityRatio	RE1	MINCOA		ELC003	0	0	0
31373 OutputActivityRatio	RE1	MINCOA		COA	1	1	1
31374 OutputActivityRatio	RE1	MINCOA		COM003	0	0	0
31375 OutputActivityRatio	RE1	MINCOA		COM004	0	0	0
31376 OutputActivityRatio	RE1	MINCOA		COM005	0	0	0

b. Variable Cost:

Parameter	REGION	TECHNOLOGY	EMISSION	FUEL	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
47220 TotalAnnualMinCapacity	RE1	MINCOA			0	0	0	0	0	0	0	0	0	0
47419 TotalAnnualMinCapacityInvestment	RE1	MINCOA			0	0	0	0	0	0	0	0	0	0
47618 TotalTechnologyAnnualActivityLowerLimit	RE1	MINCOA			0	0	0	0	0	0	0	0	0	0
47817 TotalTechnologyAnnualActivityUpperLimit	RE1	MINCOA			99999	99999	99999	99999	99999	99999	99999	99999	99999	99999
48016 TotalTechnologyModelPeriodActivityLowerLimit	RE1	MINCOA												
48216 TotalTechnologyModelPeriodActivityUpperLimit	RE1	MINCOA												
48464 VariableCost	RE1	MINCOA			3.3	3.5401	4.29278	4.22632	4.1601	4.09411	4.02926	3.964608	3.900171	3.835724

- c. **TotalTechnologyModelPeriodUpperLimit** - 400 Mt of domestic coal converted to PJ is 11723 PJ.

Parameter	REGION	TECHNOLOGY	EMISSION	MODE_OF_OPERATION	FUEL	TIMESLICE	STORAGE	REGION2	Time independent variable	2015
47021 TotalAnnualMaxCapacityInvestment	RE1	MINCOA								99999
47220 TotalAnnualMinCapacity	RE1	MINCOA								0
47419 TotalAnnualMinCapacityInvestment	RE1	MINCOA								0
47618 TotalTechnologyAnnualActivityLowerLimit	RE1	MINCOA								0
47817 TotalTechnologyAnnualActivityUpperLimit	RE1	MINCOA								99999
48016 TotalTechnologyModelPeriodActivityLowerLimit	RE1	MINCOA								0
48216 TotalTechnologyModelPeriodActivityUpperLimit	RE1	MINCOA								11723.04
48464 VariableCost	RE1	MINCOA								3.3



- d. **TotalAnnualMaxCapacity** - we will leave the default number (99999) which, being very high, means that we are not constraining the installed capacity of this technology

Parameter	REGION	TECHNOLOGY	TIMESLICE	Time independent vari	2015	2016	2017	2018
41674 ReserveMarginTagTechnology	RE1	MINCOA			0	0	0	0
41773 ResidualCapacity	RE1	MINCOA			0	0	0	0
46822 TotalAnnualMaxCapacity	RE1	MINCOA			99999	99999	99999	99999
47021 TotalAnnualMaxCapacityInvestment	RE1	MINCOA			99999	99999	99999	99999
47220 TotalAnnualMinCapacity	RE1	MINCOA			0	0	0	0
47419 TotalAnnualMinCapacityInvestment	RE1	MINCOA			0	0	0	0
47618 TotalTechnologyAnnualActivityLowerLimit	RE1	MINCOA			0	0	0	0
47817 TotalTechnologyAnnualActivityUpperLimit	RE1	MINCOA			99999	99999	99999	99999
48016 TotalTechnologyModelPeriodActivityLowerLimit	RE1	MINCOA			0			
48215 TotalTechnologyModelPeriodActivityUpperLimit	RE1	MINCOA			11723.04			
48464 VariableCost	RE1	MINCOA			3.3	3.5401	4.23278	4.22632

- e. **CapacityToActivityUnit** - set to 1

Parameter	REGION	TECHNOLOGY	TIMESLICE	Time independent vari	2015	2016
449 CapacityFactor	RE1	MINCOA	S421		1	1
450 CapacityFactor	RE1	MINCOA	S422		1	1
451 CapacityFactor	RE1	MINCOA	S423		1	1
452 CapacityFactor	RE1	MINCOA	S424		1	1
19366 CapacityOfOneTechnologyUnit	RE1	MINCOA			0	0
19565 CapacityToActivityUnit	RE1	MINCOA			1	
19764 CapitalCost	RE1	MINCOA			0.0001	0.0001
19969 EmissionActivityRatio	RE1	MINCOA			0	0
19970 EmissionActivityRatio	RE1	MINCOA			n	n

Repeat the same steps for

- 1) **MINOIL** - domestic extraction/production of Oil
- 2) **MINNGS** - domestic extraction/production of Natural Gas

Using the data provided in the [DataPrep file](#).

Voilà: you now have added 3 new technologies (MINCOA, MINOIL, MINNGS) and 3 fuels (COA; OIL, NGS) to your model.

Define technologies representing the import of energy commodities

We will repeat the exercise once more giving the example of a technology which represents the **import of coal (IMPCOA)**. When representing an Import technology, the following parameters must be considered:

- **OutputActivityRatio:** defines the rate of fuel provided (in this first example Coal)
- **VariableCost:** defines the cost of importing the fuel.



- **CapacityToActivityUnit**: used to convert data related to the Capacity of technology into the Activity it can generate. For primary supply technologies, this value should be set to 1.

Try it: let's add this technology in the model.

1. Go to SETS and add **IMPCOA** in Cell B7 (remember that you should have previously added **MINOIL** and **MINNGS**).
2. You should not add any new fuel as COA, OIL and NGS were defined in the previous section.

Technologies		Commodities	
Code	Description	Code	Description
BACKSTOP	Backstop technology	ELC003	Final Electricity demand
MINCOA	Coal domestic production	COA	Coal
MINOIL	Oil domestic production	OIL	Oil
MINNGS	Natural gas domestic production	NGS	Natural Gas
IMPCOA	Import of Coal	COM005	Additional Fuel
IMPOIL	Import of Oil	COM006	Additional Fuel
IMPNGS	Import of Natural Gas	COM007	Additional Fuel

3. Add data for **OutputActivityRatio**, **VariableCost** and **CapacityToActivityUnit** as presented in the [DataPrep file](#).
4. Repeat the same steps for **IMPOIL** and **IMPNGS** using the data provided in the [DataPrep file](#).