



# Energy and Flexibility Modelling

Hands-on 4 (macOS)

Please use the following citation for:

- **This exercise**

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- **clicSANDMac Software**

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- **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.

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## Learning outcomes

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

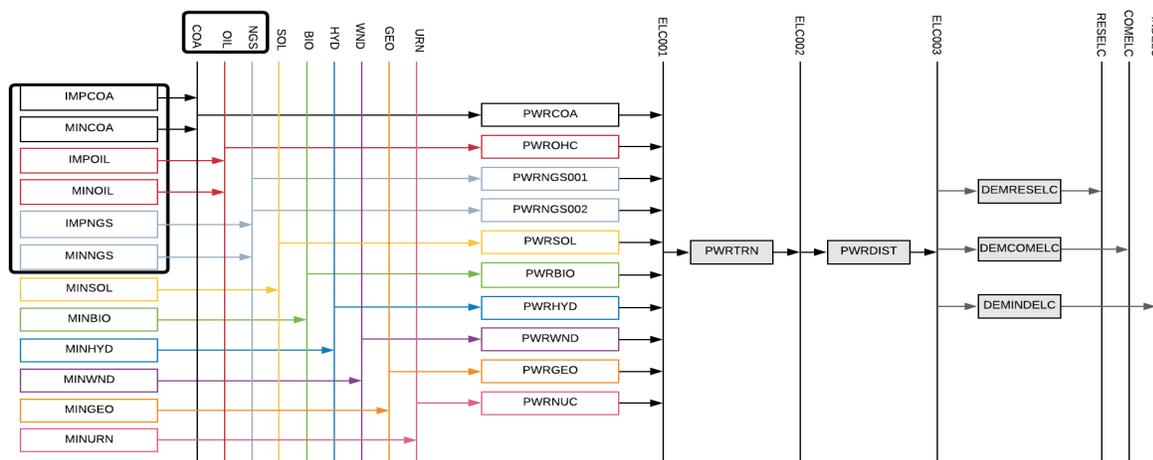
- 1) Define technologies representing the domestic production of energy commodities
- 2) Define technologies representing the import of energy commodities

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. 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 imports 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**: 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.



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 add 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.

| Technologies |                          | Commodities |                                |
|--------------|--------------------------|-------------|--------------------------------|
| Code         | Description              | Code        | Description                    |
| BACKSTOP     | Backstop Technology      | ELC003      | Electricity after distribution |
| MINCOA       | Coal domestic production | COA         | Coal                           |
| TEC002       | Additional Technology    | COM003      | Additional Fuel                |

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** like the tables below and as given in the [DataPrep file](#).
  - a. **OutputActivityRatio**: choose the Coal Fuel row (Cell K31373) and paste 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 | 3.836724 |

- 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     |          |                   |      | 1         |         |         |                           | 3.3      |



- d. **TotalAnnualMaxCapacity** - we will leave the default number (99999) which by 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        |        |         |         |
| 48216 TotalTechnologyModelPeriodActivityUpperLimit | RE1    | MINCOA     |           |                       | 11723.04 |        |         |         |
| 48484 VariableCost                                 | RE1    | MINCOA     |           |                       | 3.3      | 3.5401 | 4.29278 | 4.22632 |

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

| Parameter                         | REGION | TECHNOLOGY | TIMESLICE | Time independent vari | 2015   | 2016   |
|-----------------------------------|--------|------------|-----------|-----------------------|--------|--------|
| 449 CapacityFactor                | RE1    | MINCOA     | S421      |                       |        | 1      |
| 450 CapacityFactor                | RE1    | MINCOA     | S422      |                       |        | 1      |
| 451 CapacityFactor                | RE1    | MINCOA     | S423      |                       |        | 1      |
| 452 CapacityFactor                | RE1    | MINCOA     | S424      |                       |        | 1      |
| 19366 CapacityOfOneTechnologyUnit | RE1    | MINCOA     |           |                       |        | 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](#).

You have now 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.

Now 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](#).