Energy System Modelling Using OSeMOSYS

Hands-on 5

Please use the following citation for:

- **This exercise**

Plazas-Niño, F., Alexander, K. (2025, February). Hands-on 5: Energy System Modelling Using OSeMOSYS (Version 1.0.). Climate Compatible Growth. DOI: 10.5281/zenodo.14871174

- **OSeMOSYS UI software**

Climate Compatible Growth. (2024). MUIO (Version v5.0.0). GitHub. https://github.com/OSeMOSYS/MUIO/releases

- **OSeMOSYS forum**

Please sign up to the help 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 MUIO Interface.

Learning outcomes

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

(1) Define existing thermal power plants taking in fuel to generate electricity
(2) Define the existing transmission network

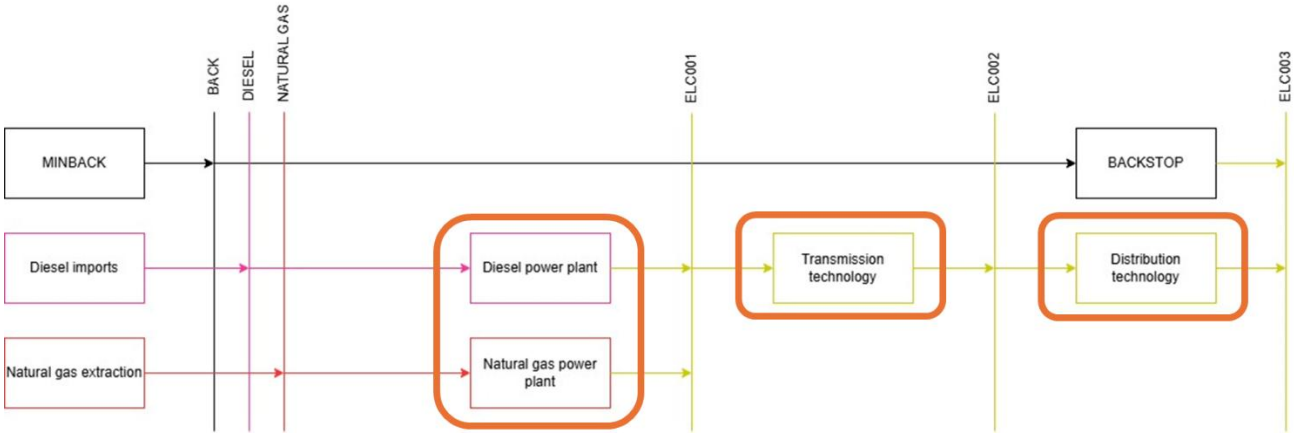
(3) Define the existing distribution network

(4) Run the model and check results on production by technology and installed capacity of each technology

Define existing thermal power plants taking in fuel to generate electricity

In Lecture 6, we learnt how to represent a technology in OSeMOSYS, and which parameters characterize thermal power plants and transmission and distribution technologies.

In this Hands-on, we will add 4 technologies in total: 2 thermal power plants, 1 technology representing the transmission system and 1 for the distribution network. Two new fuels will be added to the model: ELC001 (Electricity coming directly from power plants) and ELC002 (Electricity after transmission). We will build the part of the RES highlighted below. **Note:** Update your RES in diagrams.net.



In order to represent a thermal power plant, remember that the following **parameters** must be considered:

- **InputActivityRatio**: defines the rate of fuel consumed (e.g., diesel)
- **OutputActivityRatio**: defines the fuel provided (i.e., Electricity)

- **CapacityToActivityUnit**: used to convert data related to the Capacity of technology into the Activity it can generate (for power generation, e.g., PWRDSL, this value should be set to 31.536).
- **Fixed Cost**: defines the fixed Operation & Maintenance cost ($/kW)
- **CapitalCost**: defines the overnight investment cost of the plant ($/kW)
- **OperationalLife**: defines the lifetime of the technology (in years)
- **ResidualCapacity**: defines the existing capacity of the technology (in GW) and its expected decommissioning.
- **Capacity Factors**: represents the variability in generation at each point in time.

IMPORTANT: Before you can do anything else, you must copy the model and rename it in the same way you have before (OSeHO5 this time).

Try it: Let's add **PWRDSL** - the technology representing a diesel power plant.

1. Firstly, as you have already added **'DSL'** as a commodity (as well as NGS), you do not need to this again.
2. Now let's add **'ELC001'** (*Description: Electricity from Power plants*) as a commodity.
3. Then go to the technologies tab of the model configuration page and add '**PWRDSL**'.
4. In this way, we added the technology which will be transforming diesel (**DSL**) into electricity (**ELC001**) to the model. So, add the relevant inputs and outputs on the technologies tab. Keep the unit of capacity as GW and the unit of activity as PJ.
5. Next, you must enter the data through the data entry tab on the side of the model configuration page for **PWRDSL** (as done previously with other technologies).
6. Add the data for **PRWDSL** as given in the Data Preparation File OSeHO5. Pay close attention to the CapacityFactor values, as you will need to enter the values for all four timeslices per technology.

NOTE: With Capacity Factor, you have to select rows at the bottom and select 1000 rows. Unfortunately, you cannot yet filter out technologies on the data entry tab. So, follow these steps:

a. **Scroll down to find PWRDSL**. When you find it, you will see RD next to PWRDSL below another technology. ADD the data to the next tile along (should be a value of 1). If you copy-paste correctly, it **should** fill all of the capacity factor data for **PWRDSL.**

b. When you add the data, it will take you back to the top of the page (a current flaw in the UI). **But at least it reminds you to SAVE DATA!**

c. Follow the previous steps when you add **PWRNGS** using the data provided in the Data Preparation File OSeHO5.

d. Then update your model after adding all 2 techs.

Voilà: You now have added 2 thermal power plants (**PWRDSL, PWRNGS**) and 1 commodity (**ELC001**) to your model.

Define the existing transmission network

We will repeat the exercise once more giving the example of a technology which represents the **transmission network (PWRTRN)**. When representing the transmission technology, the following parameters must be considered:

- **InputActivityRatio**: defines the rate of fuel consumed (i.e., Electricity from power plants)
- **OutputActivityRatio**: defines the fuel provided (i.e., Electricity)
- **CapacityToAcitivityUnit**: It is used to convert data related to the Capacity of technology into the Activity it can generate. For transmission technology, this value should be set to 31.536.
- **Fixed Cost**: defines the fixed Operation & Maintenance cost ($/kW)
- **CapitalCost**: defines the overnight investment cost of installed capacity ($/kW)
- **OperationalLife**: defines the lifetime of the technology (in years)
- **ResidualCapacity**: defines the existing capacity of the technology (in GW) and its expected decommissioning

Try it: Let's add **PWRTRN** - the technology representing the transmission grid.

1. Firstly, you need to add a new commodity which is **'ELC002'**. As PWRTRN has an input of ELC001 and output of ELC002 (electricity after transmission).
2. Now you need to add the technology **'PWRTRN'.**

3. With the input being ELC001 and output ELC002. Keep the unit of capacity as GW and the unit of activity as PJ. Update the model.
4. Add the data for **PWRTRN** as given in the Data Preparation File OSeHO5, in the same way you have previously. Remembering to save data and update model each time.

NOTE: Add data to all 7 parameters listed above. This time you do not need to add capacity factors like you did in this first part of hands-on 5.

Define the existing distribution network

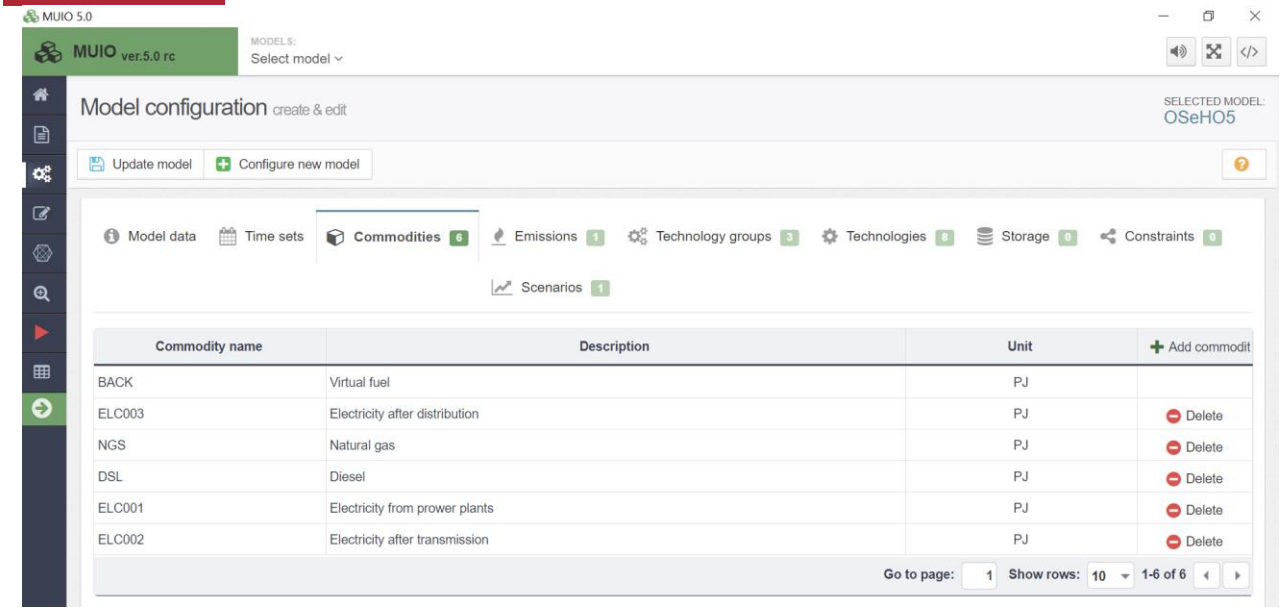
We will repeat the exercise once more giving the example of a technology which represents the **distribution network (PWRDIST)**. (Very similar to **PWRTRN**)

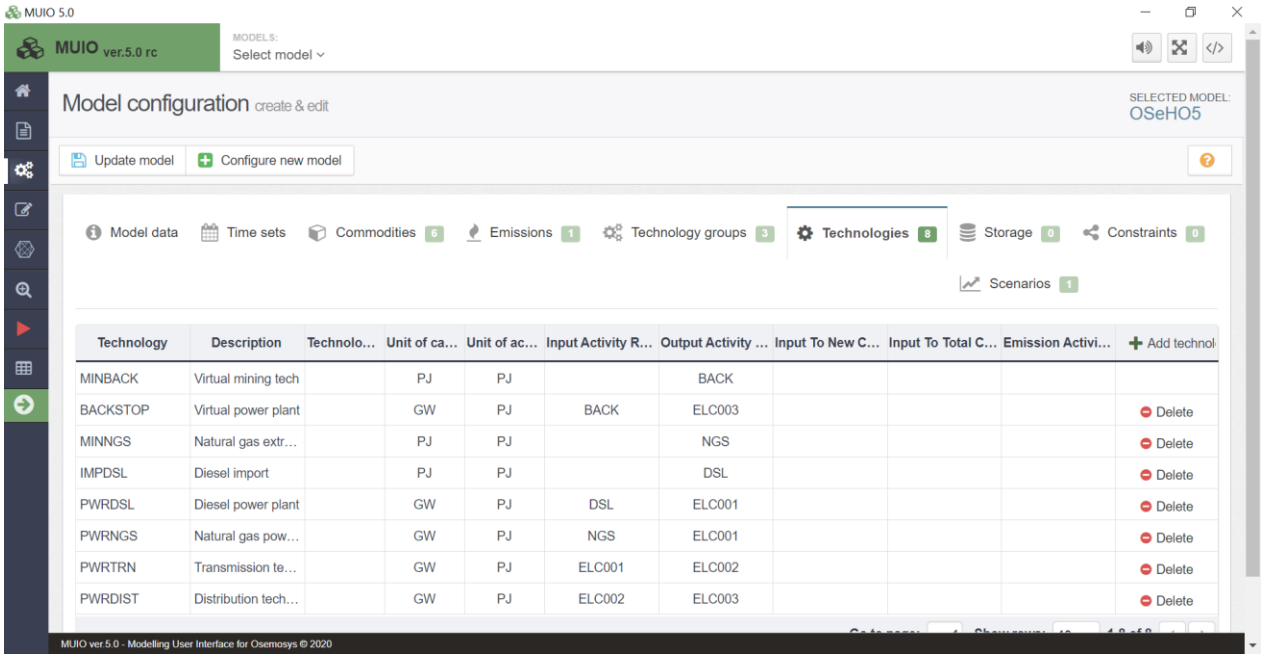
Try it: Let's add **PWRDST** - the technology representing the distribution network

1. As you already have ELC002 and ELC003, you do not need to add anymore commodities for this hands-on.
2. You just need to add the technology **'PWRDST'**.
3. Then you must set the input as ELC002 and output as ELC003. Keep the unit of capacity as GW and the unit of activity as PJ.
4. Add the data for **PWRDST** as given in the Data Preparation File OSeHO5.

NOTE: Add data to all 7 parameters listed above. This time you do not need to add capacity factors like you did in this first part of hands-on 5 (this is the same as PWRTRN).

Your model config page for commodities and technologies, should now look like the images below (as well as the data all being correct if you have followed the steps correctly).

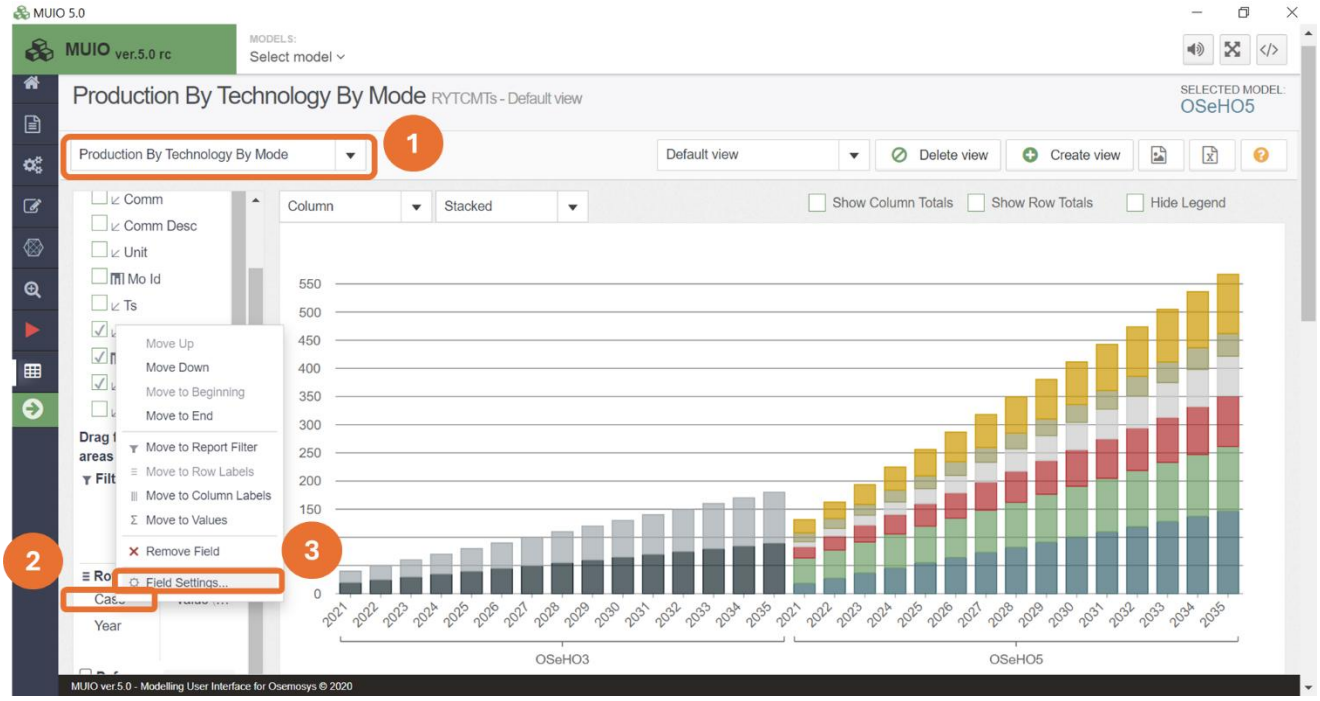

MUIO 5.0
MUIO ver.5.0 rc
MODELS:
Select model
Model configuration create & edit
SELECTED MODEL:
OSeHO5
Update model
Configure new model
Model data
Time sets
Commodities 6
Emissions 1
Technology groups 3
Technologies 8
Storage 0
Constraints 0
Scenarios 1
Commodity name
Description
Unit
Add commodit
BACK
Virtual fuel
PJ
ELC003
Electricity after distribution
PJ
Delete
NGS
Natural gas
PJ
Delete
DSL
Diesel
PJ
Delete
ELC001
Electricity from prower plants
PJ
Delete
ELC002
Electricity after transmission
PJ
Delete
Go to page: 1
Show rows: 10
1-6 of 6

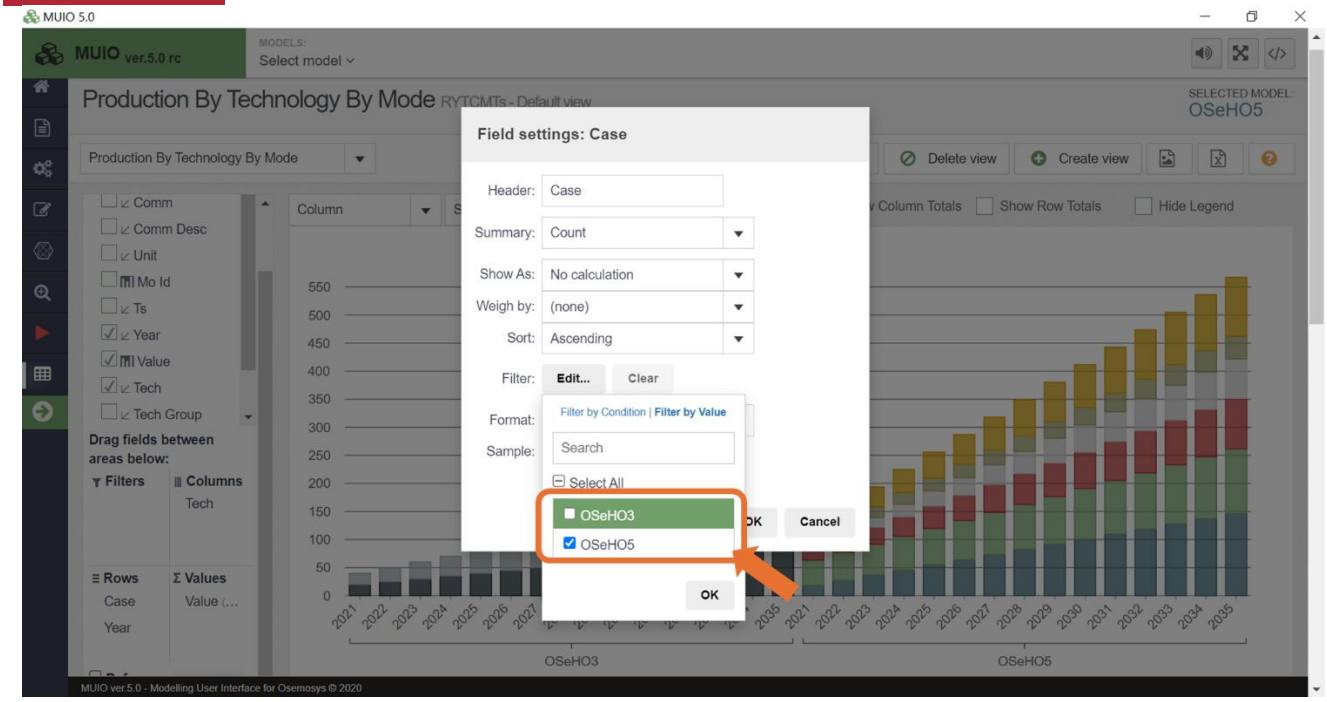

MUIO 5.0
MUIO ver.5.0 rc
MODELS:
Select model
Model configuration create & edit
SELECTED MODEL:
OSeHO5
Update model
Configure new model
Model data
Time sets
Commodities 6
Emissions 1
Technology groups 3
Technologies 8
Storage 0
Constraints 0
Scenarios 1
Technology
Description
Technolo...
Unit of ca...
Unit of ac...
Input Activity R...
Output Activity ...
Input To New C...
Input To Total C...
Emission Activi...
Add technol
MINBACK
Virtual mining tech
PJ
PJ
BACK
BACKSTOP
Virtual power plant
GW
PJ
BACK
ELC003
Delete
MINNGS
Natural gas extr...
PJ
PJ
NGS
Delete
IMPDSL
Diesel import
PJ
PJ
DSL
Delete
PWRDSL
Diesel power plant
GW
PJ
DSL
ELC001
Delete
PWRNGS
Natural gas pow...
GW
PJ
NGS
ELC001
Delete
PWRTRN
Transmission te...
GW
PJ
ELC001
ELC002
Delete
PWRDIST
Distribution tech...
GW
PJ
ELC002
ELC003
Delete
MUIO ver.5.0 - Modelling User Interface for Osemosys © 2020

Run the model and check results on production by technology and installed capacity of each technology

You should obtain the results by running the model in the user interface as learnt in the hands-on 3.

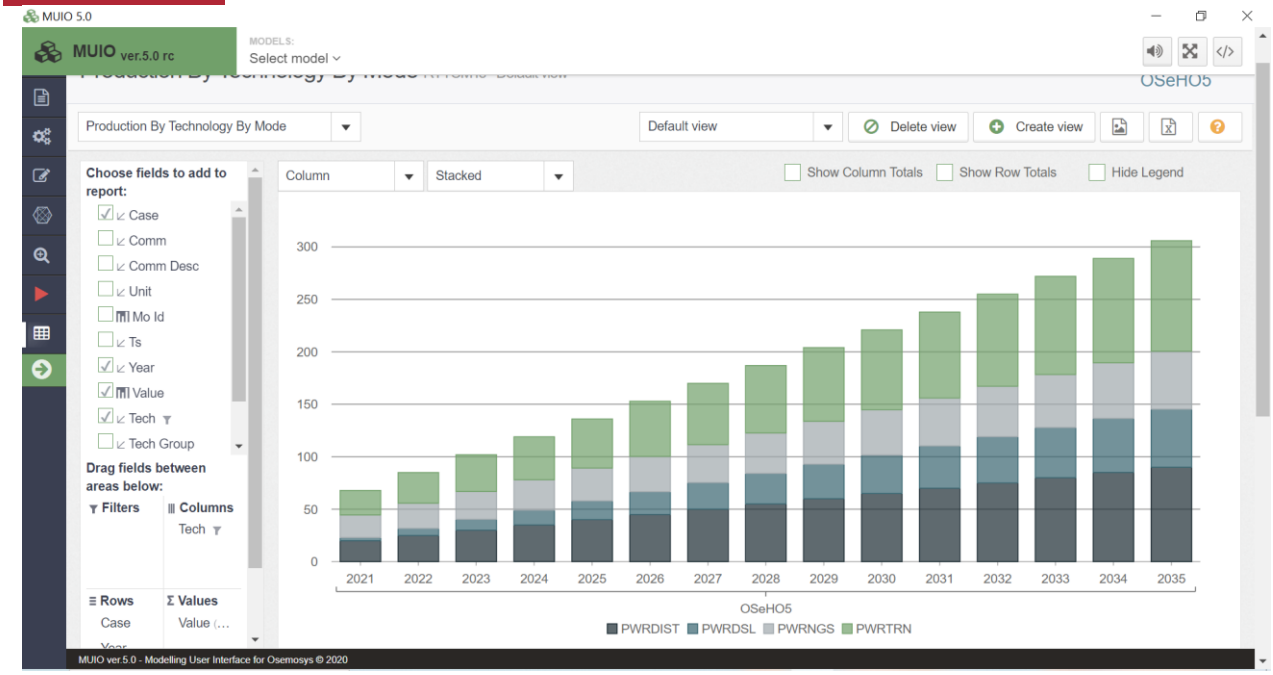
1. Firstly, you may have to filter the 'case' to choose only the one you just ran, as it may show all previous runs. Do this by clicking on 'case' in the rows tab and select the 'Field Settings' option, and a box will pop up on your screen. Then, you need to click edit and untick unwanted cases (e.g., OSeHO3 case).





NOTE: You can also delete previous cases in the Run tab on the sidebar.

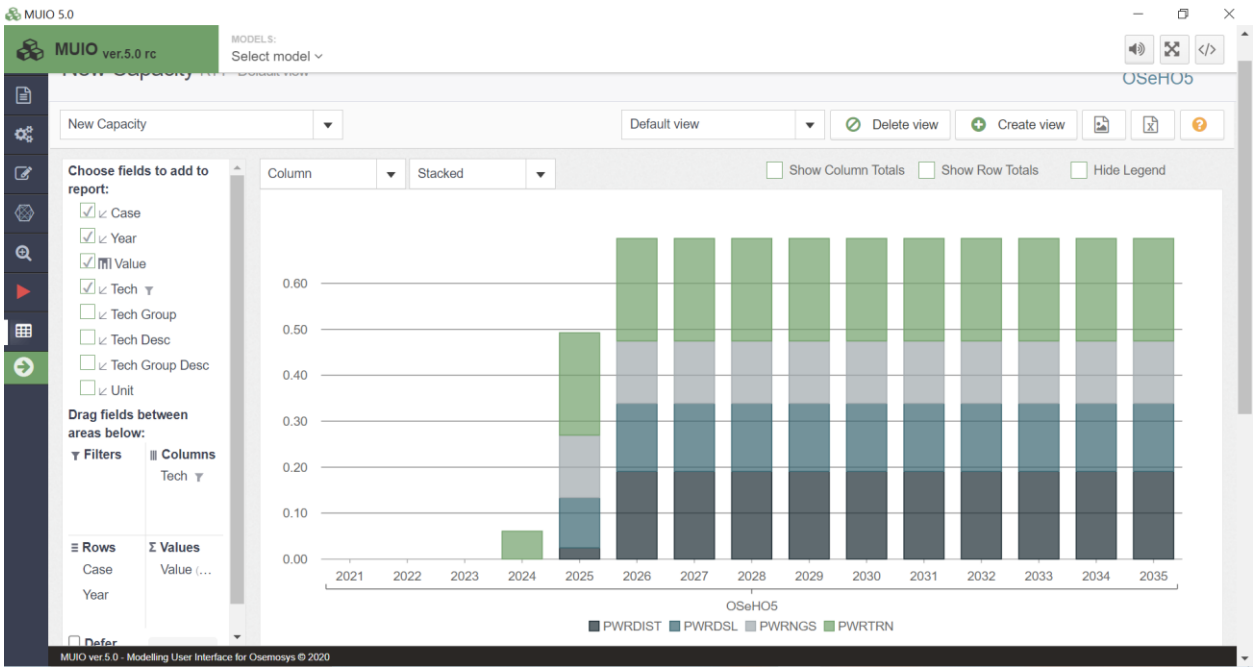
2. After this, you can also filter the technologies to only **PWRDSL, PWRNGS, PWRTRN, and PWRDIST. NOTE:** If you cannot remember how to do this, follow the steps in hands-on 3. Your graph should look like the one below.



Notice that the production of PWRDIST is equivalent to the electricity demand, as this technology delivers the final electricity to the system. Conversely, you can verify that the electricity production of ELC002 by PWRTRN equals the energy demand multiplied by the input activity ratio of PWRDIST, since the transmission system must supply both the electricity demand and the losses in the distribution system.

Similarly, the combined electricity production of PWRDSL and PWRNGS equals the electricity delivered by the transmission system multiplied by the input activity ratio of PWRTRN. This is because power plants must supply electricity to the transmission system, accounting for losses within the system.

3. Repeat the process to visualize the graph of New Capacity. In this case, you can observe that from 2021 to 2023, there is no need for new investments in power plants or transmission-distribution systems. This indicates that the current installed capacity is sufficient to meet the projected electricity demand for the first three years. However, starting in 2024, the need for augmenting installed capacities in both power generation and electricity transportation begins to increase progressively. By 2026, the growth in new infrastructure becomes steady, reflecting a constant increase in electricity demand and the complete utilization of all residual capacities.

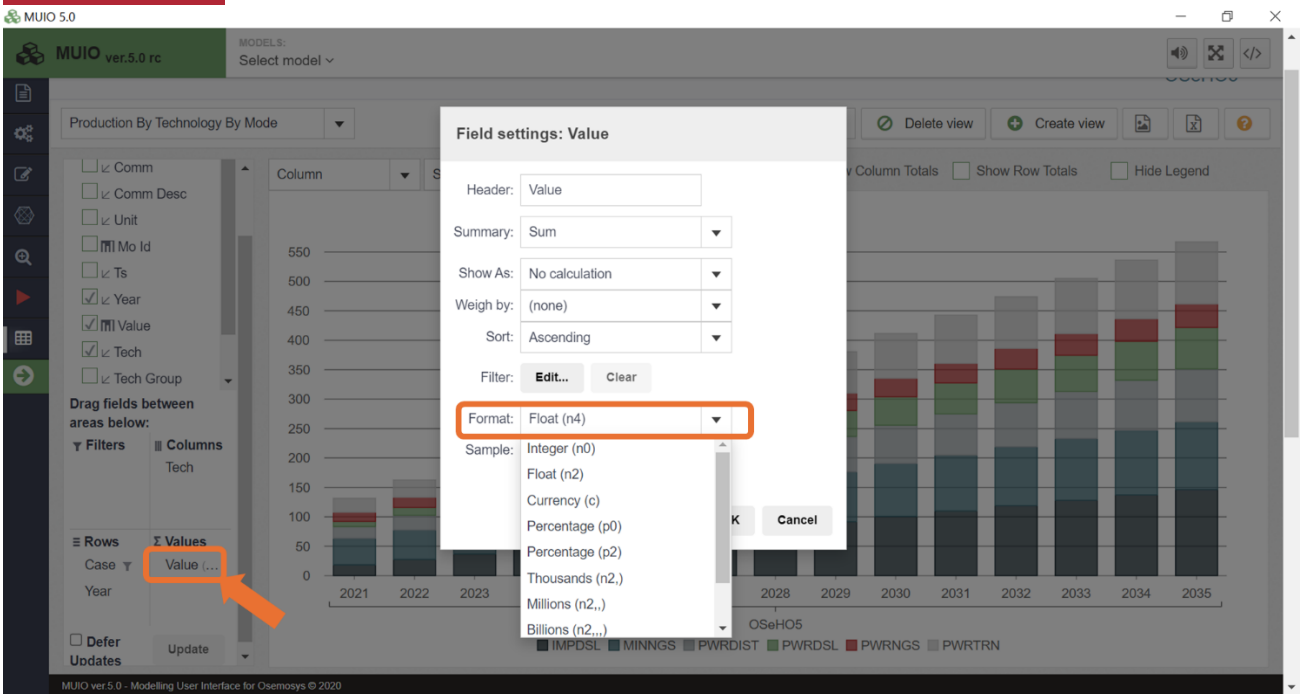


Question to consider: Why is the newly installed capacity of diesel power plants higher than that of natural gas power plants, even though the capital and fixed costs are the same, and the variable cost of importing diesel is significantly higher than producing natural gas?

Two things to note when visualizing in the UI:

1. Make sure to play around with the filters and graph types (as there is a good amount of customization options).

2. Underneath the graph you will see a table that states the values specific to the technologies on that graph. These numbers are rounded up or down to a whole number, so they may not always be most useful. Therefore, you can select the number of decimal places to be shown by changing the format in the field settings option of the filter Values in the Values tab.


MUIO 5.0
MUIO ver.5.0 rc
MODELS:
Select model
Production By Technology By Mode
Delete view
Create view
Column
Column Totals
Show Row Totals
Hide Legend
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Comm Desc
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Value
Tech
Tech Group
Drag fields between areas below:
Filters
Columns
Tech
Rows
Case
Year
Values
Value (...
Defer Updates
Update
Field settings: Value
Header: Value
Summary: Sum
Show As: No calculation
Weigh by: (none)
Sort: Ascending
Filter: Edit... Clear
Format: Float (n4)
Sample:
Integer (n0)
Float (n2)
Currency (c)
Percentage (p0)
Percentage (p2)
Thousands (n2,)
Millions (n2,,)
Billions (n2,,,)
Cancel
550
500
450
400
350
300
250
200
150
100
50
0
2021
2022
2023
2028
2029
2030
2031
2032
2033
2034
2035
OSeHO5
IMPDSL MINNGS PWRDIST PWRDSL PWRNGS PWRTRN
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