Energy System Modelling Using OSeMOSYS

Hands-on 13

Please use the following citation for:

- **This exercise**

Plazas-Niño, F., Barnes, T. (2025, February). Hands-on 13: Energy System Modelling Using OSeMOSYS (Version 1.0.). Climate Compatible Growth. DOI: 10.5281/zenodo.14871580

- **OSeMOSYS UI software**

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

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Learning outcomes

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

1) Calibrate installed capacities and energy production in an OSeMOSYS model.

2) Incorporate technology penetration rates for different technologies.

3) Review additional parameters from previous hands-on exercises to ensure an accurate representation of the energy system.

Calibrate existing capacities

In this hands-on exercise, we will not add new technologies or commodities.

IMPORTANT: Before proceeding, you must copy the model and rename it as you have done before (this time as OSeHO13).

For this case study, we will use the years 2021 to 2023 as calibration years. We will begin by calibrating the existing capacities using the Residual Capacity parameter. In previous exercises, we added the corresponding residual capacities for technologies, assuming these capacities remained constant throughout the entire modeling period.

In this activity, we will apply a simple approach to forecast the decommissioning of all technologies. Keep in mind that this is a basic exercise designed for teaching purposes. If detailed data is available, more sophisticated trajectories for residual capacities can be implemented. Additionally, sector-specific assumptions may be appropriate. For instance, hydropower plants have very long lifetimes, so assuming constant residual capacity during the modeling period might be reasonable.

For this exercise:

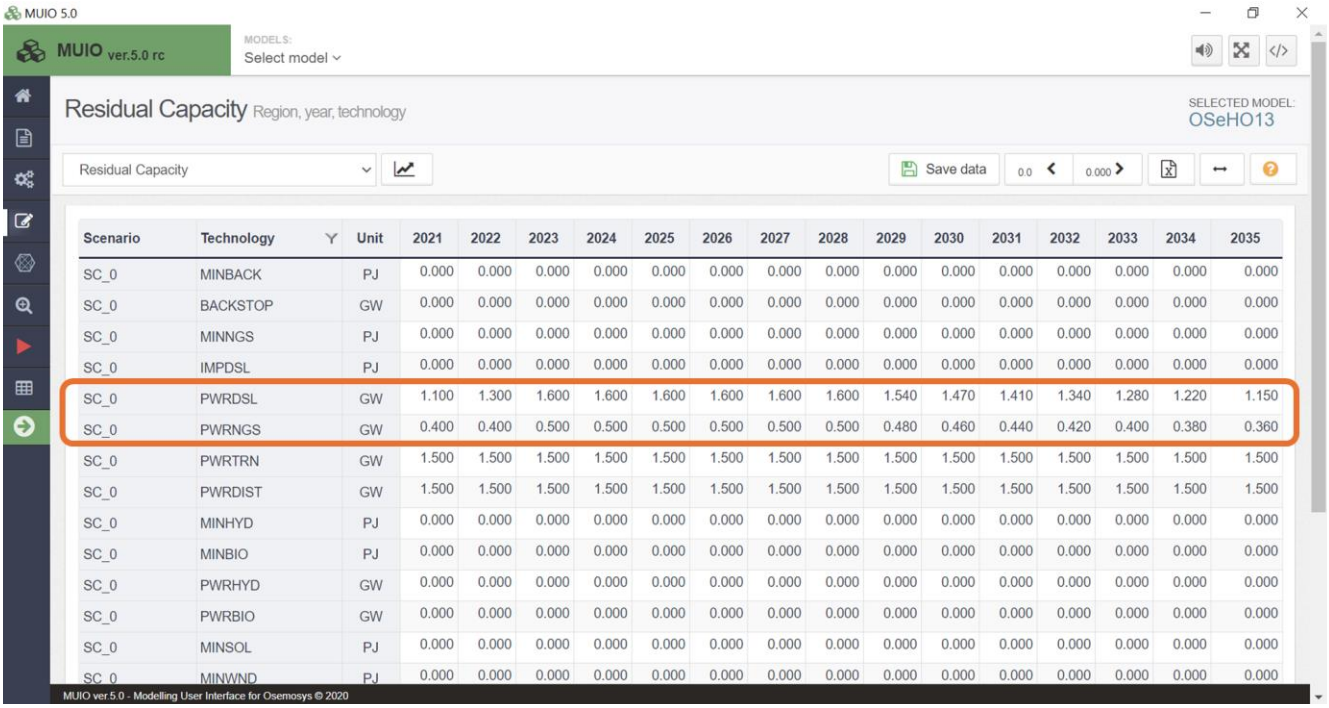
- Existing capacities are known for the calibration years (2021–2023).
- From 2024 to 2028, we will maintain the same existing capacities as in 2023.
- From 2029 to 2035, we will apply Equation 1 to decrease the existing capacity linearly.

$$Residual\ capacity_n = Initial\ Capacity - (n - Starting\ year) * \frac{Initial\ Capacity}{Operational\ life} \qquad (1)$$

$$Where\ n\ is\ a\ specific\ year\ after\ the\ starting\ year$$

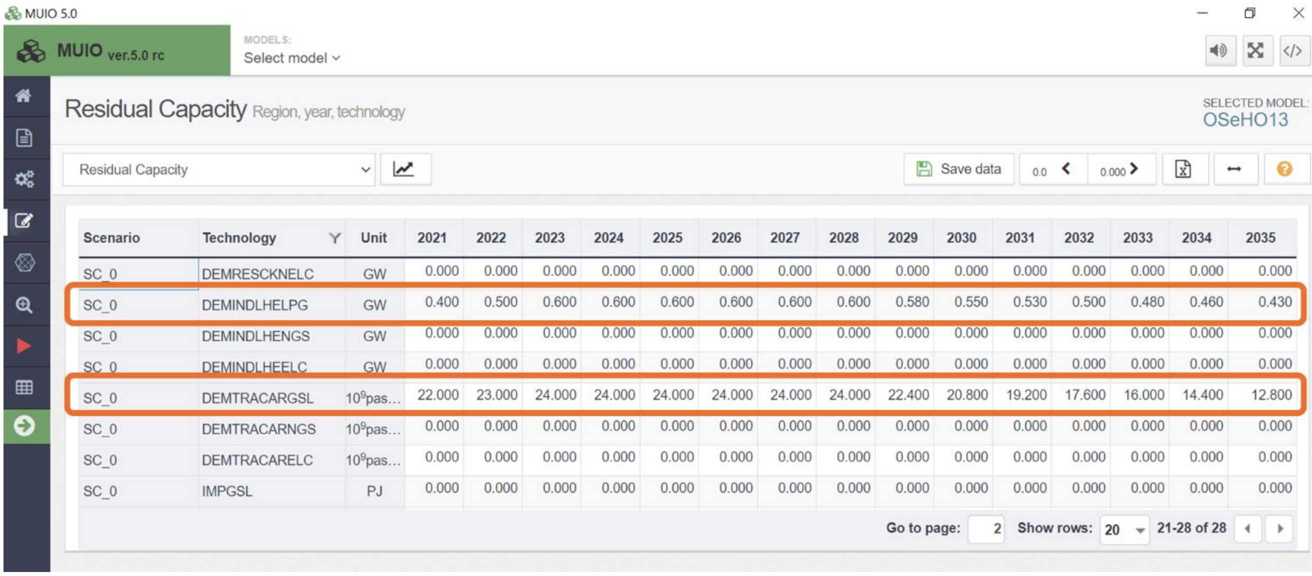
Try It: Update the data of Residual Capacity

1. Click on the data entry button, and in the search bar, type '**Residual Capacity**.' Then, navigate to that parameter.
2. Copy and paste the residual capacity data for the years 2021–2035 for the corresponding technologies from the Data Preparation file OSeHO13. **Note:** We will keep the residual capacities of PWRTRN and PWRDIST constant.
3. The input should resemble the image shown below.



Scenario	Technology	Unit	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
SC_0	MINBACK	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	BACKSTOP	GW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	MINNGS	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	IMPDSL	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	PWRDSL	GW	1.100	1.300	1.600	1.600	1.600	1.600	1.600	1.600	1.540	1.470	1.410	1.340	1.280	1.220	1.150
SC_0	PWRNGS	GW	0.400	0.400	0.500	0.500	0.500	0.500	0.500	0.500	0.480	0.460	0.440	0.420	0.400	0.380	0.360
SC_0	PWRTRN	GW	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500
SC_0	PWRDIST	GW	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500
SC_0	MINHYD	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	MINBIO	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	PWRHYD	GW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	PWRBIO	GW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	MINSOL	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	MINWND	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Scenario	Technology	Unit	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
SC_0	IMPDSL	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	PWRDSL	GW	1.100	1.300	1.600	1.600	1.600	1.600	1.600	1.600	1.540	1.470	1.410	1.340	1.280	1.220	1.150
SC_0	PWRNGS	GW	0.400	0.400	0.500	0.500	0.500	0.500	0.500	0.500	0.480	0.460	0.440	0.420	0.400	0.380	0.360
SC_0	PWRTRN	GW	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500
SC_0	PWRDIST	GW	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500
SC_0	MINHYD	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	MINBIO	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	PWRHYD	GW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	PWRBIO	GW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	MINSOL	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	MINWND	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	PWRSOL	GW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	PWRWND	GW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	BATTPWR	GW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	IMPLPG	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	DEMRESCKNLPG	GW	0.080	0.080	0.090	0.090	0.090	0.090	0.090	0.090	0.080	0.070	0.060	0.050	0.050	0.040	0.030
SC_0	DEMRESCKNBIO	GW	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.050	0.050	0.040	0.040	0.030	0.020	0.020



Scenario	Technology	Unit	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
SC_0	DEMRESCKNELC	GW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	DEMINDLHELPG	GW	0.400	0.500	0.600	0.600	0.600	0.600	0.600	0.600	0.580	0.550	0.530	0.500	0.480	0.460	0.430
SC_0	DEMINDLHENGS	GW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	DEMINDLHEELC	GW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	DEMTRACARGSL	10^9pas…	22.000	23.000	24.000	24.000	24.000	24.000	24.000	24.000	22.400	20.800	19.200	17.600	16.000	14.400	12.800
SC_0	DEMTRACARNGS	10^9pas…	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	DEMTRACARELC	10^9pas…	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	IMPGSL	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Note: Make sure to save the data and update the model each time you complete this process.

Calibrate energy production

The next step is to calibrate energy production using the Total Technology Annual Activity Lower Limit parameter. Based on data from energy balances and sectoral reports, we need to estimate the annual energy production for each technology during the calibration years.

Similar to residual capacities, we will make the same assumptions for energy production. For this exercise:

- Energy production per technology is known for the calibration years (2021–2023).
- From 2024 to 2028, we will maintain the same energy production as in 2023.
- From 2029 to 2035, we will apply Equation 2 to decrease energy production linearly.

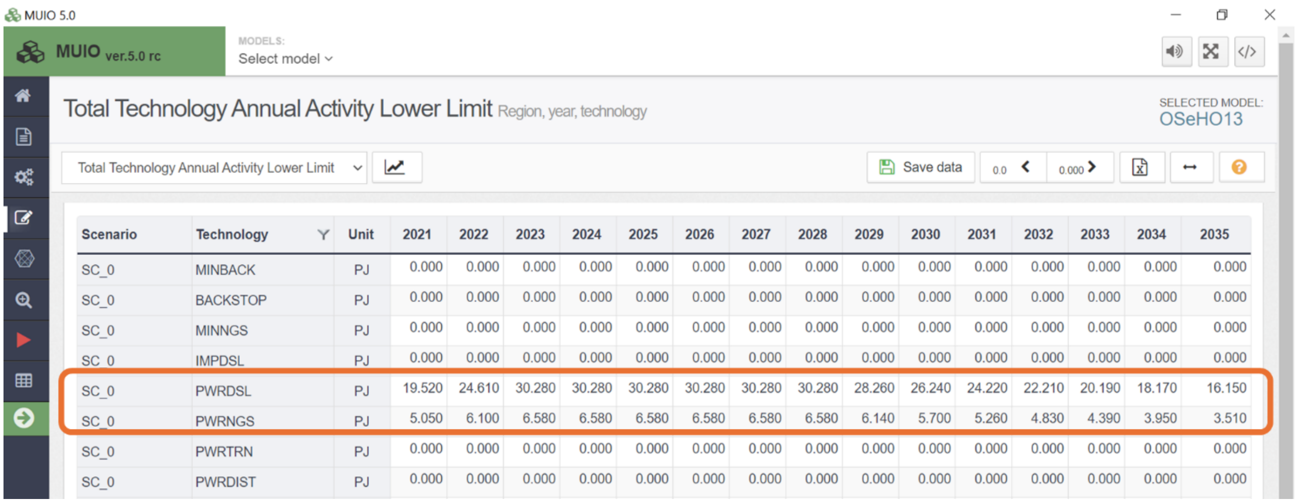
$$Energy\ production_n = Initial\ energy\ production - (n - Starting\ year) * \frac{Initial\ energy\ production}{Operational\ life} \quad (2)$$

$$Where\ n\ is\ a\ specific\ year\ after\ the\ starting\ year$$

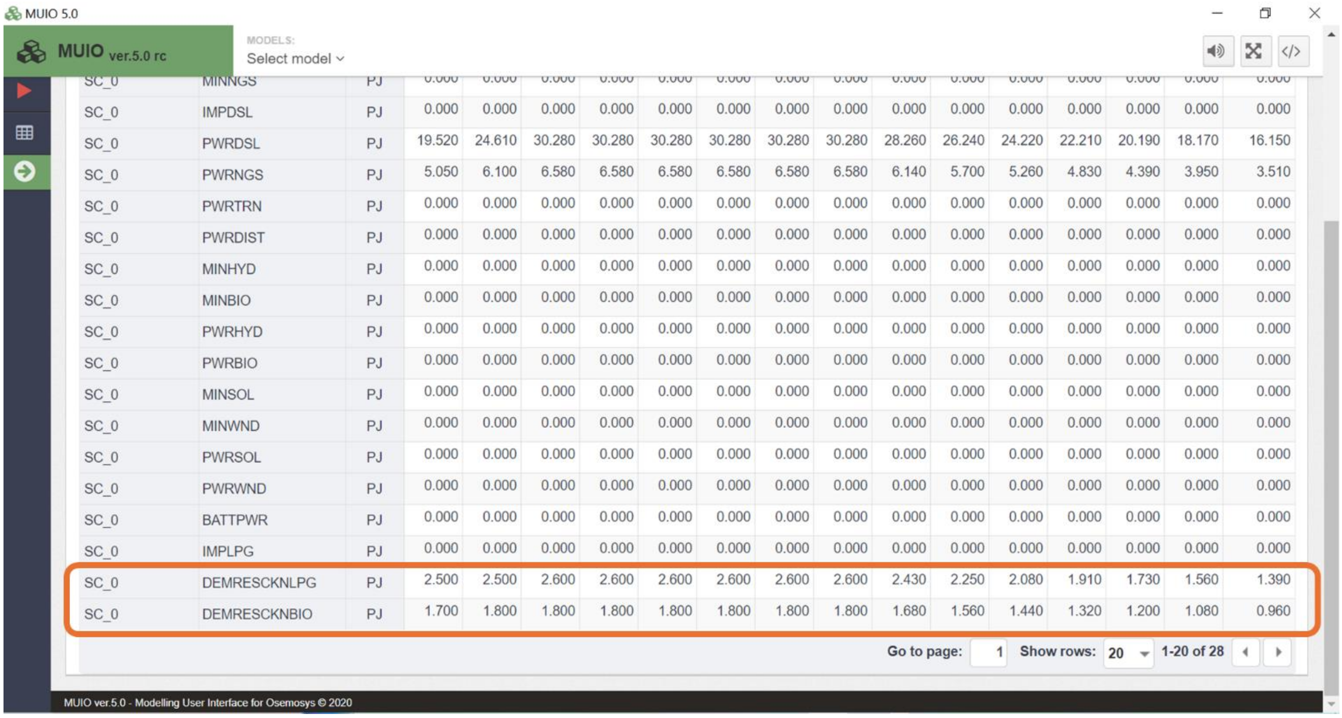
Let's remember that the Total Technology Annual Activity Lower Limit defines the minimum level of energy that must be produced. However, the model can choose to produce above this limit when optimizing the energy system.

Try It: Add the data of Total Technology Annual Activity Lower Limit

1. Click on the data entry button, and in the search bar, type '**Total Technology Annual Activity Lower Limit**.' Then, navigate to that parameter.
2. Copy and paste the energy data for the years 2021–2035 for the corresponding technologies from the [Data Preparation file OSeHO13.](#)
3. The input should resemble the image shown below.



Scenario	Technology	Unit	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
SC_0	MINBACK	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	BACKSTOP	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	MINNGS	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	IMPDSL	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	PWRDSL	PJ	19.520	24.610	30.280	30.280	30.280	30.280	30.280	30.280	28.260	26.240	24.220	22.210	20.190	18.170	16.150
SC_0	PWRNGS	PJ	5.050	6.100	6.580	6.580	6.580	6.580	6.580	6.580	6.140	5.700	5.260	4.830	4.390	3.950	3.510
SC_0	PWRTRN	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	PWRDIST	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000



SC_0	MINNGS	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	IMPDSL	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	PWRDSL	PJ	19.520	24.610	30.280	30.280	30.280	30.280	30.280	30.280	28.260	26.240	24.220	22.210	20.190	18.170	16.150
SC_0	PWRNGS	PJ	5.050	6.100	6.580	6.580	6.580	6.580	6.580	6.580	6.140	5.700	5.260	4.830	4.390	3.950	3.510
SC_0	PWRTRN	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	PWRDIST	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	MINHYD	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	MINBIO	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	PWRHYD	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	PWRBIO	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	MINSOL	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	MINWND	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	PWRSOL	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	PWRWND	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	BATTPWR	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	IMPLPG	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	DEMRESCKNLPG	PJ	2.500	2.500	2.600	2.600	2.600	2.600	2.600	2.600	2.430	2.250	2.080	1.910	1.730	1.560	1.390
SC_0	DEMRESCKNBIO	PJ	1.700	1.800	1.800	1.800	1.800	1.800	1.800	1.800	1.680	1.560	1.440	1.320	1.200	1.080	0.960

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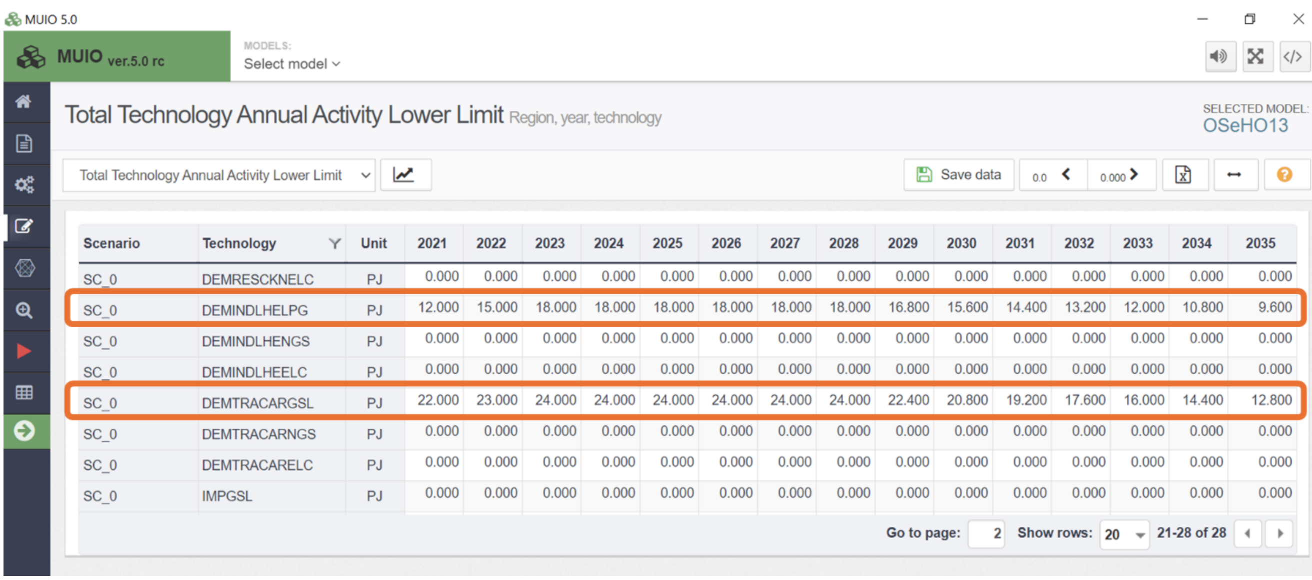

Scenario	Technology	Unit	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
SC_0	DEMRESCKNELC	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	DEMINDLHELPG	PJ	12.000	15.000	18.000	18.000	18.000	18.000	18.000	18.000	16.800	15.600	14.400	13.200	12.000	10.800	9.600
SC_0	DEMINDLHENGS	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	DEMINDLHEELC	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	DEMTRACARGSL	PJ	22.000	23.000	24.000	24.000	24.000	24.000	24.000	24.000	22.400	20.800	19.200	17.600	16.000	14.400	12.800
SC_0	DEMTRACARNGS	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	DEMTRACARELC	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	IMPGSL	PJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

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Note: Make sure to save the data and update the model each time you complete this process.

Deactivate technologies

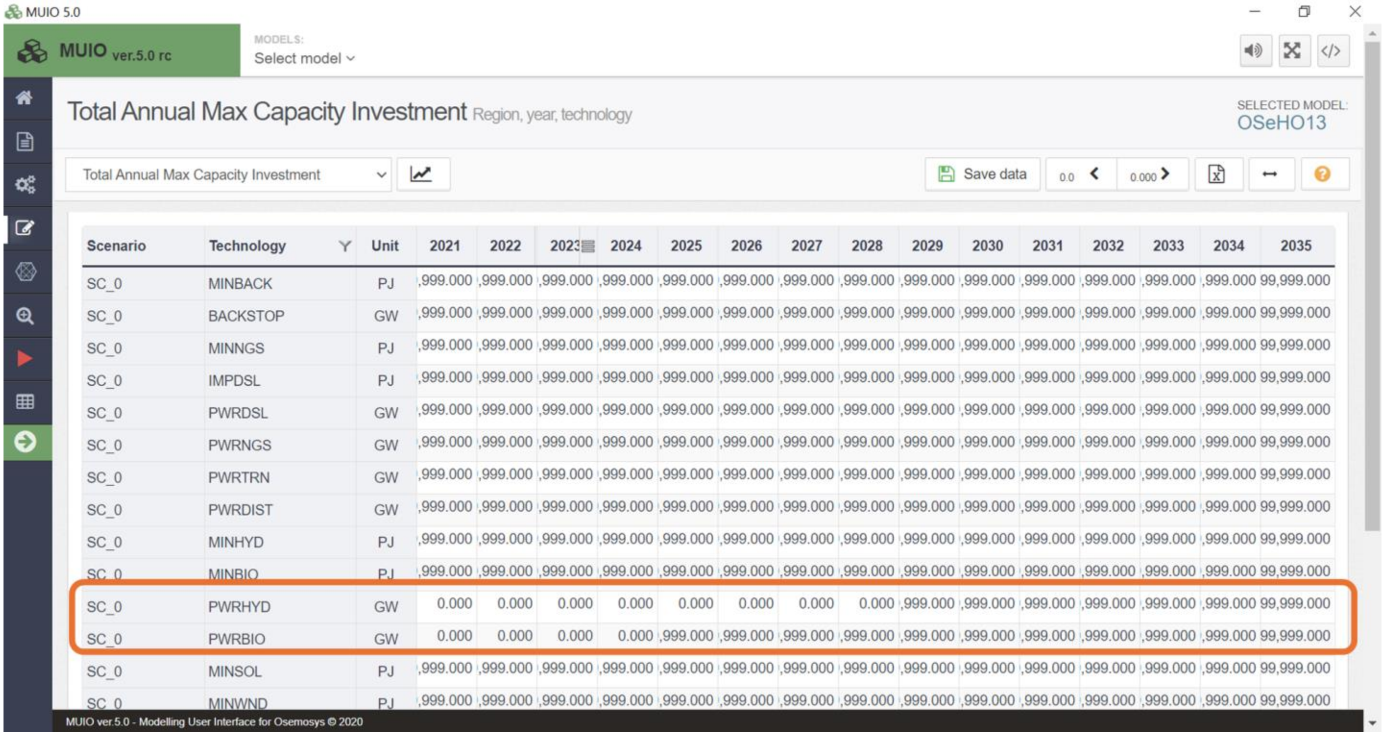
As discussed in Lecture 14, we can deactivate technologies that are not part of the energy mix during the calibration years. This is achieved using the *Total Annual Max Capacity Investment* parameter, which sets the maximum new capacity allowed for a technology in a given year. By setting this parameter to zero, we effectively prevent any new capacity additions for the specified technology.

For this exercise, we will extend the *Total Annual Max Capacity Investment* parameter for certain years beyond the calibration years based on specific assumptions:

- **2024–2028 for PWRHYD**: Reflecting the long construction times required for hydropower plants.
- **2024 for PWRBIO, PWRSOL, PWRWND, and BATTPWR**: Allowing additional time for construction.
- **2024–2025 for DEMRESCKNELC**: Providing time for potential policy design and building adaptation.
- **2024–2026 for DEMINDLHENGS and DEMINDLHEELC**: Allowing for industrial adaptation.

Try It: Add the data of Total Annual Max Capacity Investment

1. Click on the data entry button, and in the search bar, type '**Total Annual Max Capacity Investment**.' Then, navigate to that parameter.
2. Copy and paste the capacity data for the years 2021–2035 for the corresponding technologies from the Data Preparation file OSeHO13.
3. The input should resemble the image shown below.


MUIO 5.0
MUIO ver.5.0 rc
MODELS:
Select model
Total Annual Max Capacity Investment Region, year, technology
SELECTED MODEL:
OSeHO13
Total Annual Max Capacity Investment
Save data
Scenario
Technology
Unit
2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035
SC_0 MINBACK PJ
SC_0 BACKSTOP GW
SC_0 MINNGS PJ
SC_0 IMPDSL PJ
SC_0 PWRDSL GW
SC_0 PWRNGS GW
SC_0 PWRTRN GW
SC_0 PWRDIST GW
SC_0 MINHYD PJ
SC_0 MINBIO PJ
SC_0 PWRHYD GW 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
SC_0 PWRBIO GW 0.000 0.000 0.000 0.000
SC_0 MINSOL PJ
SC_0 MINWND PJ
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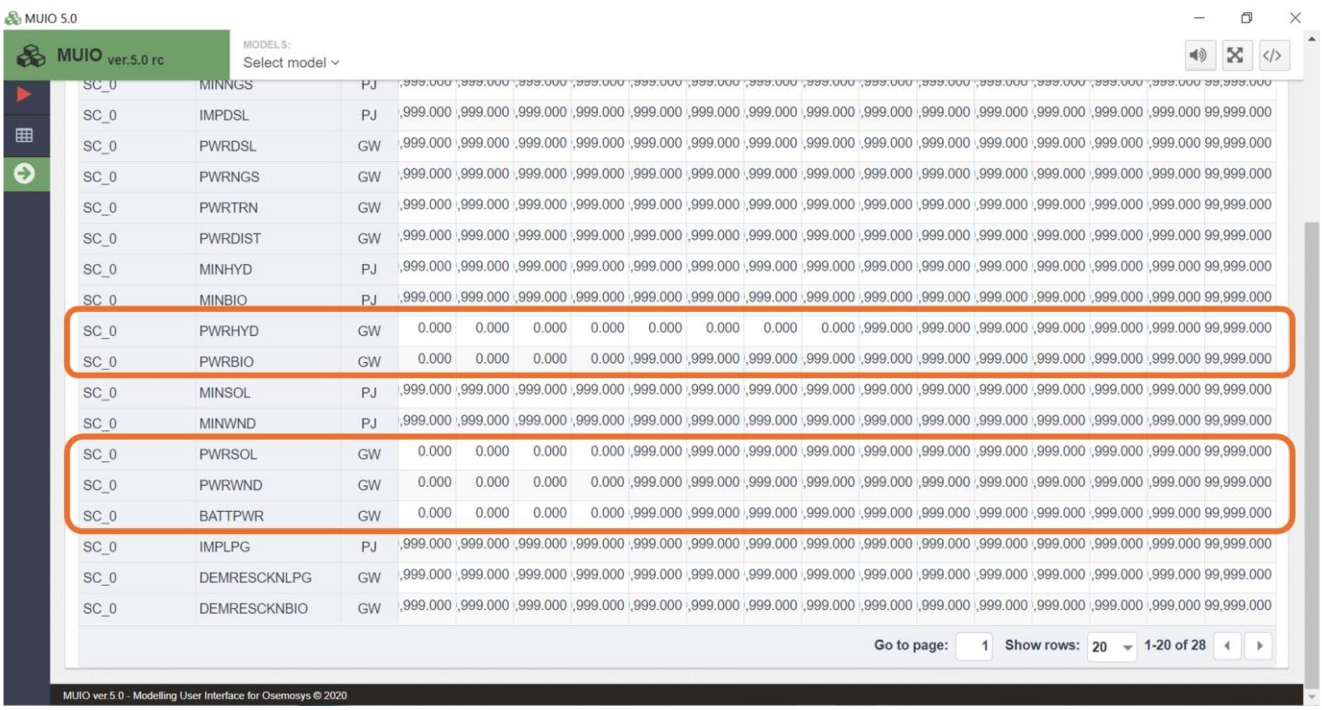
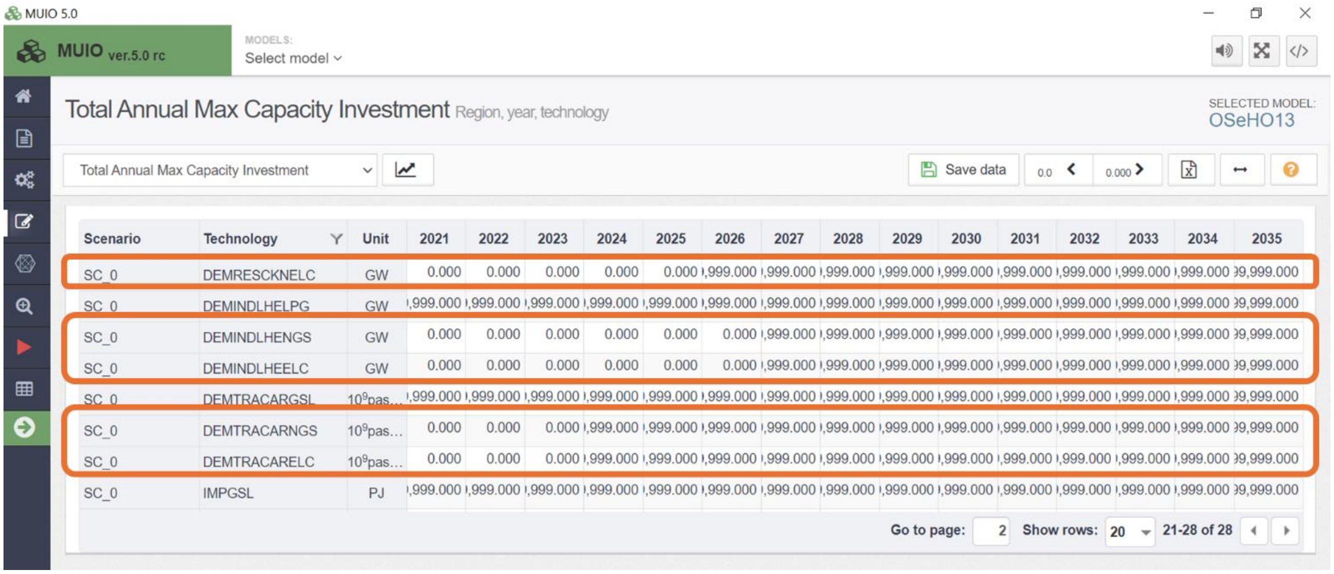

MUIO 5.0
MUIO ver.5.0 rc
MODELS:
Select model
SC_0 IMPDSL PJ
SC_0 PWRDSL GW
SC_0 PWRNGS GW
SC_0 PWRTRN GW
SC_0 PWRDIST GW
SC_0 MINHYD PJ
SC_0 MINBIO PJ
SC_0 PWRHYD GW 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
SC_0 PWRBIO GW 0.000 0.000 0.000 0.000
SC_0 MINSOL PJ
SC_0 MINWND PJ
SC_0 PWRSOL GW 0.000 0.000 0.000 0.000
SC_0 PWRWND GW 0.000 0.000 0.000 0.000
SC_0 BATTPWR GW 0.000 0.000 0.000 0.000
SC_0 IMPLPG PJ
SC_0 DEMRESCKNLPG GW
SC_0 DEMRESCKNBIO GW
Go to page: 1 Show rows: 20 1-20 of 28
MUIO ver.5.0 - Modelling User Interface for Osemosys © 2020



Scenario	Technology	Unit	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
SC_0	DEMRESCKNELC	GW	0.000	0.000	0.000	0.000	0.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	99,999.000
SC_0	DEMINDLHELPG	GW	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	99,999.000
SC_0	DEMINDLHENGS	GW	0.000	0.000	0.000	0.000	0.000	0.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	99,999.000
SC_0	DEMINDLHEELC	GW	0.000	0.000	0.000	0.000	0.000	0.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	99,999.000
SC_0	DEMTRACARGSL	10^9pas...	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	99,999.000
SC_0	DEMTRACARNGS	10^9pas...	0.000	0.000	0.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	99,999.000
SC_0	DEMTRACARELC	10^9pas...	0.000	0.000	0.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	99,999.000
SC_0	IMPGSL	PJ	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	,999.000	99,999.000

Introduce a technology penetration rate

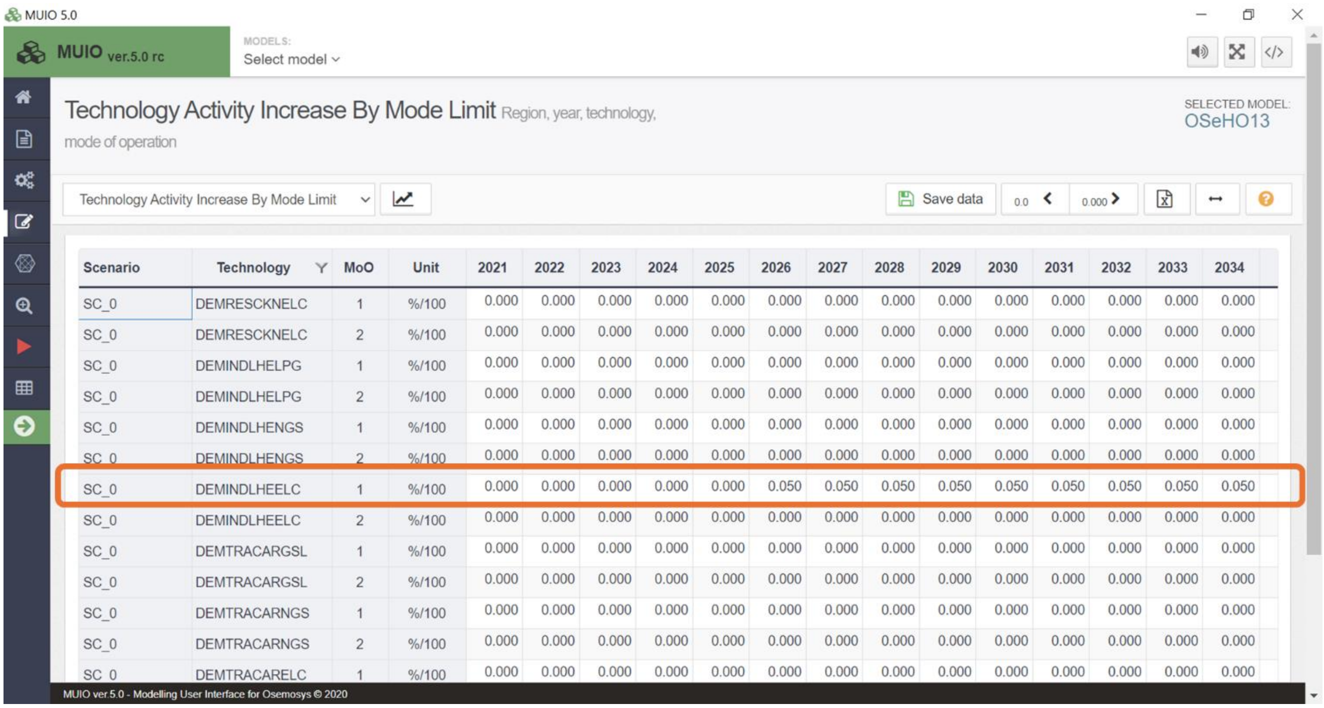
As discussed in Lecture 14, we can incorporate technology penetration rates to control how quickly a new technology can contribute to meeting a demand. In this exercise, we will explore one approach to implement these rates using the Technology Activity Increase By Mode Limit parameter. This parameter defines the maximum percentage increase in activity that a technology can achieve each year.

For example, in the case of industrial sector electrification, technical studies indicate that the annual energy production for low-heat generation should not increase by more than 5% per year between 2027 and 2035.

Try It: Add the data of Technology Activity Increase By Mode Limit

1. Click on the data entry button, and in the search bar, type '**Technology Activity Increase By Mode Limit**.' Then, navigate to that parameter.

2. Copy and paste the capacity data for the years 2027–2035 for DEMINDLHEELC from the [Data Preparation file OSeHO13.](#)
3. The input should resemble the image shown below.



Scenario	Technology	MoO	Unit	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
SC_0	DEMRESCKNELC	1	%/100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	DEMRESCKNELC	2	%/100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	DEMINDLHELPG	1	%/100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	DEMINDLHELPG	2	%/100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	DEMINDLHENGS	1	%/100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	DEMINDLHENGS	2	%/100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	DEMINDLHEELC	1	%/100	0.000	0.000	0.000	0.000	0.000	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
SC_0	DEMINDLHEELC	2	%/100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	DEMTRACARGSL	1	%/100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	DEMTRACARGSL	2	%/100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	DEMTRACARNGS	1	%/100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	DEMTRACARNGS	2	%/100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SC_0	DEMTRACARELC	1	%/100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

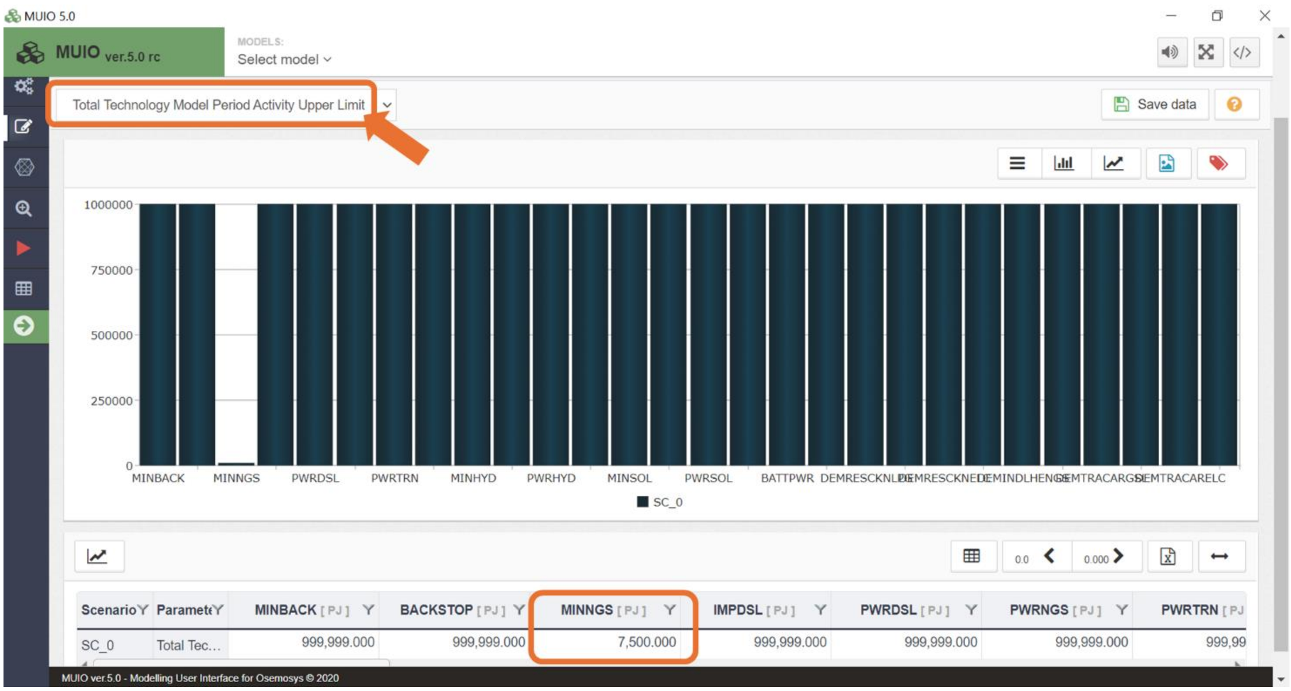
Review of additional parameters for calibration

There are additional parameters that are crucial for calibration, as they define the maximum potential for energy generation from both fossil fuels and renewable energy sources.

1. Defining Fossil Fuel Reserves

The Total Technology Model Period Activity Upper Limit parameter represents the total fossil fuel reserves. For countries or regions with proven or potential fossil fuel reserves, we must estimate the energy content of these resources. This parameter is applied to primary energy technologies, such as MINNGS (natural gas), MINOIL (oil), MINCOA (coal), and MINURN (uranium).

In our case study, we previously defined the total reserves for natural gas (MINNGS), estimated at 7,500 PJ. To verify this value, navigate to the Data Entry tab and locate the relevant parameter, as shown in the image below.



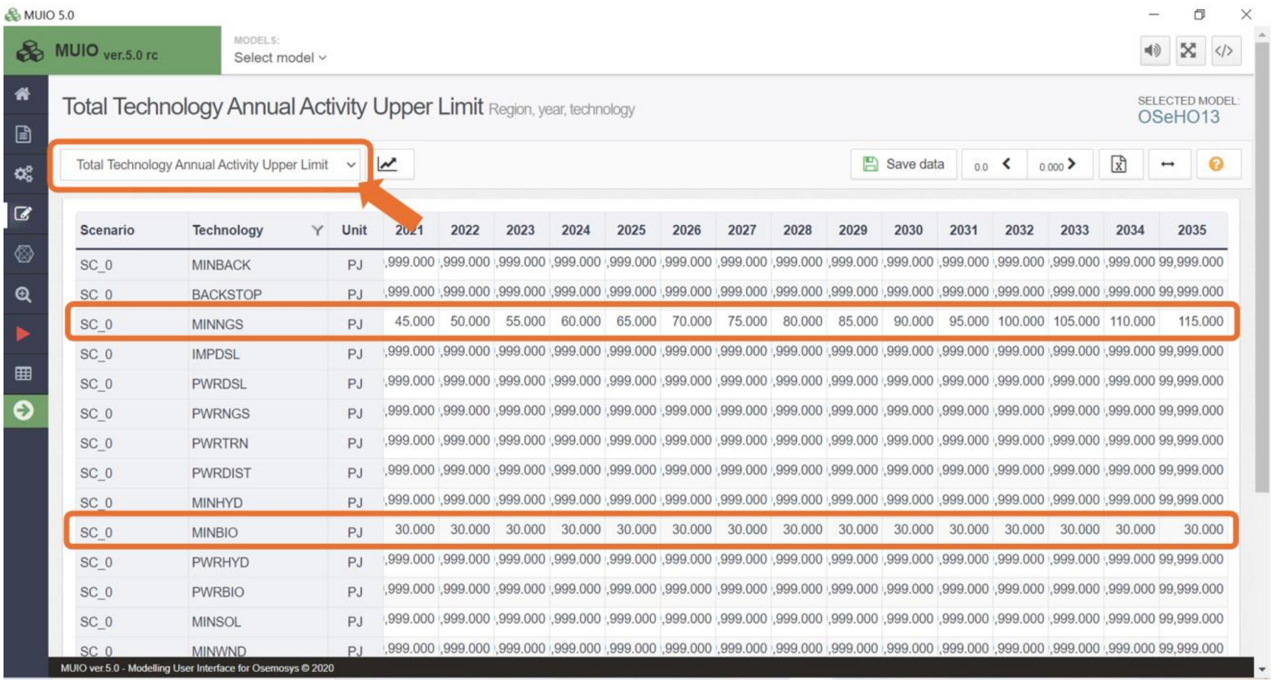
2. Defining Maximum Annual Energy Production

We can set the maximum annual energy production for each source using one of two approaches, depending on the type of data available:

a. Energy Terms

The Total Technology Annual Activity Upper Limit parameter defines the potential in energy units. For example, if biomass resources have an estimated annual production potential of 45 PJ, this parameter would be applied. This is primarily used for primary energy technologies, such as fossil fuels and biomass.

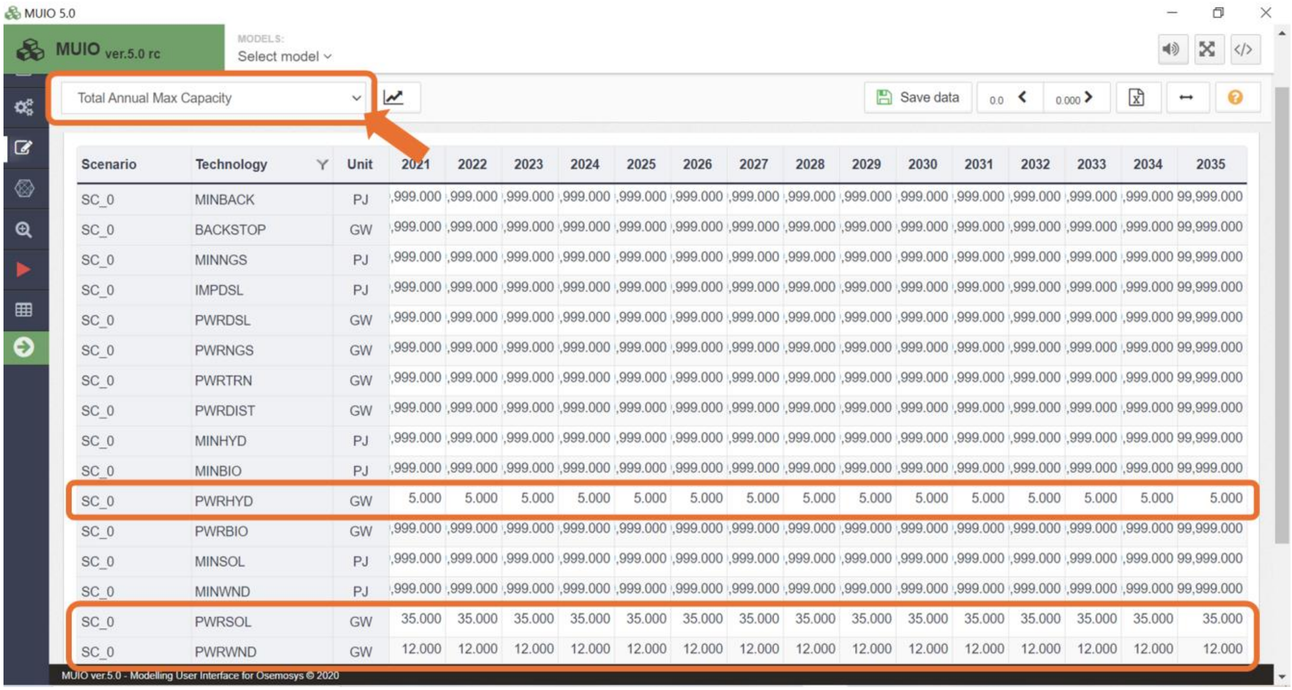
In previous exercises, we defined the Total Technology Annual Activity Upper Limit for natural gas production (MINNGS) and biomass extraction (MINBIO). To verify this value, navigate to the Data Entry tab and locate the relevant parameter, as shown in the image below.



b. Capacity Terms

For renewable energy sources, the maximum potential is often given in capacity units. For example, the technical potential for onshore wind might be calculated as 7.3 GW. In these cases, we use the Total Annual Max Capacity parameter, which sets the maximum allowable installed capacity for a technology.

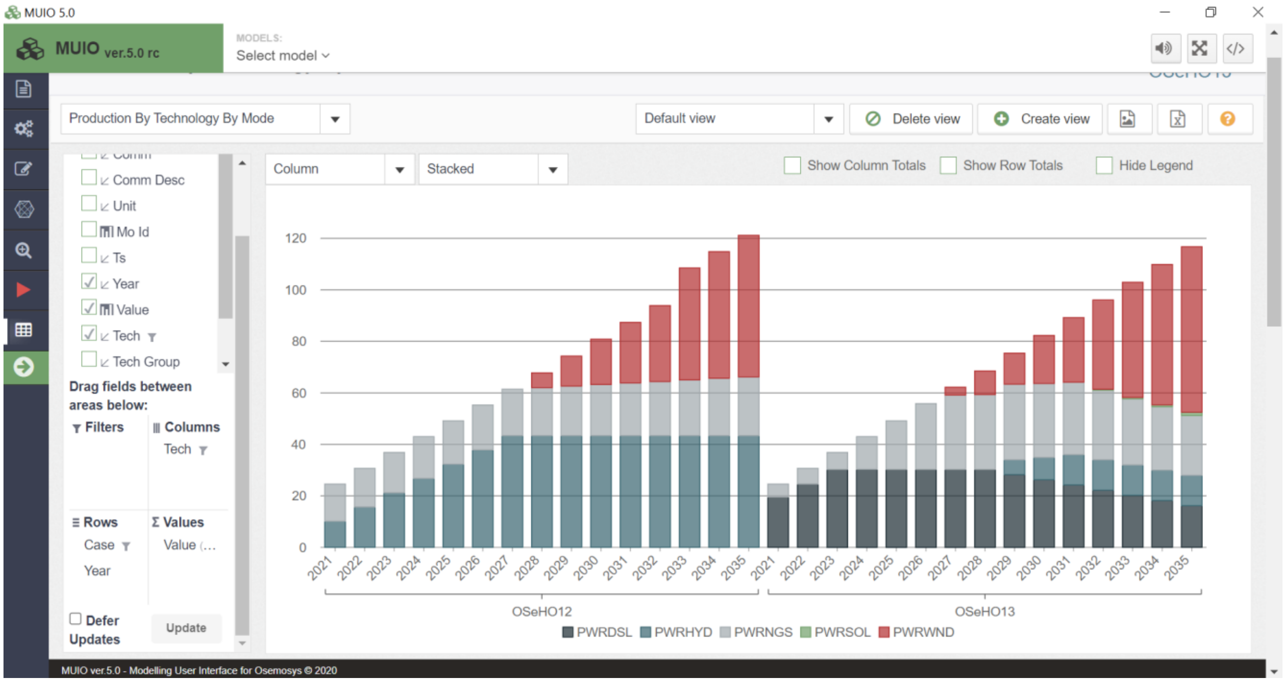
This parameter is typically applied to power generation technologies, such as PWRGEO (geothermal), PWRHYD (hydropower), PWRSOL (solar), and PWRWND (wind). In a previous hands-on exercise, we defined this parameter for solar, wind, and hydropower plants. To verify this value, navigate to the Data Entry tab and locate the relevant parameter, as shown in the image below.



Run the model and check the results

Run the model in the user interface as demonstrated in previous exercises. Since we now have four energy demands, we need to be mindful of how we plot the results for Production by Technology by Mode (PJ). First, filter for the power plants, as done previously, and compare the results between HO12 and HO13. The graph should resemble the image shown below.

Energy production in the power sector

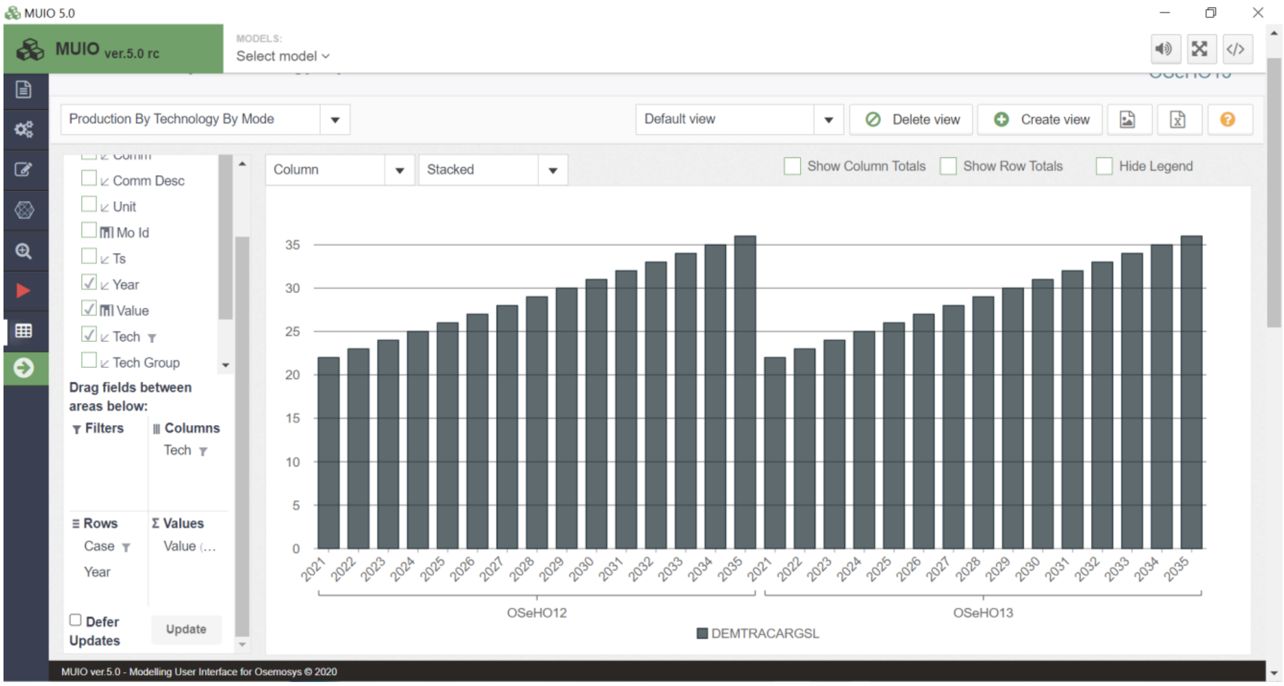


In this exercise, our model has been calibrated to reflect the system's behaviour during the calibration years. The results align with the defined residual capacities and lower limits, ensuring the expected use of diesel and natural gas power plants. Additionally, hydropower plant installations were successfully avoided in the first year, consistent with reality. As defined earlier, hydropower gradually penetrates the system until 2029.

Natural gas power plants account for a larger share of electricity generation, as natural gas becomes more available due to reduced industrial consumption for low heat generation in the initial years of the modelling period. Wind energy continues to dominate electricity generation in the latter part of the period, while a small amount of solar energy is produced in this calibrated scenario, unlike in Hands-on Exercise 12.

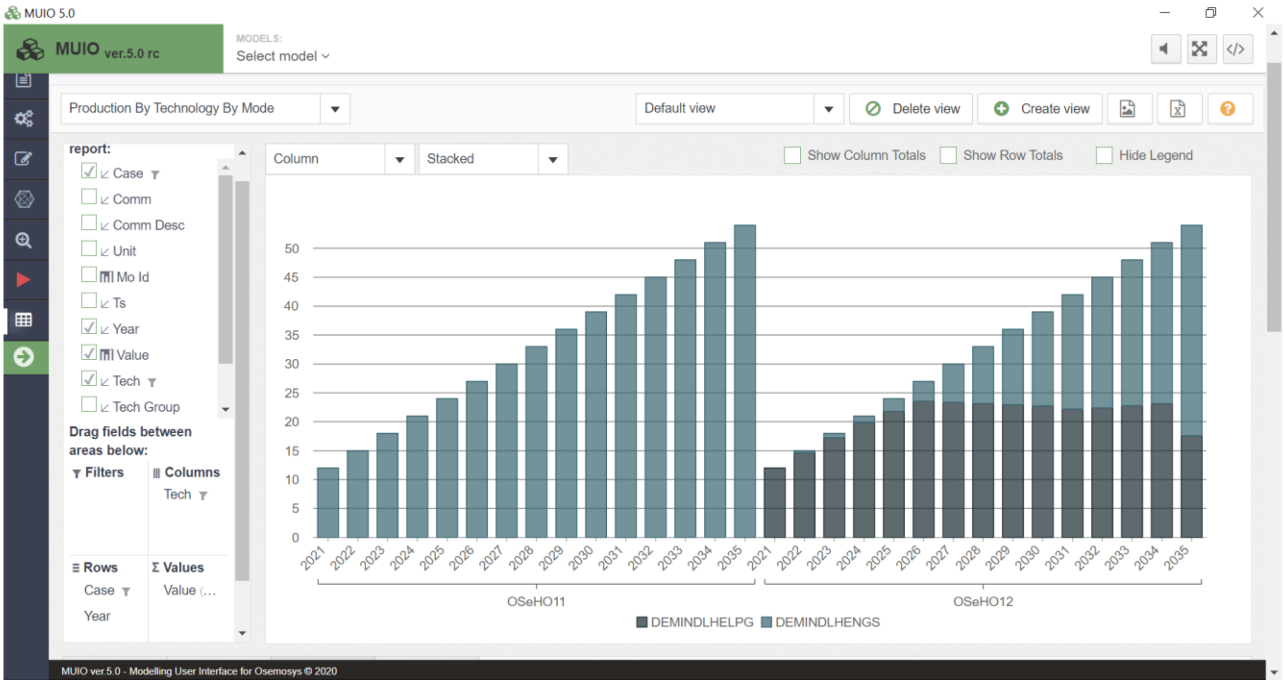
Energy production in the transport sector

There is no significant change in the transport sector, as gasoline cars remain the most cost-effective option throughout the modeling period.



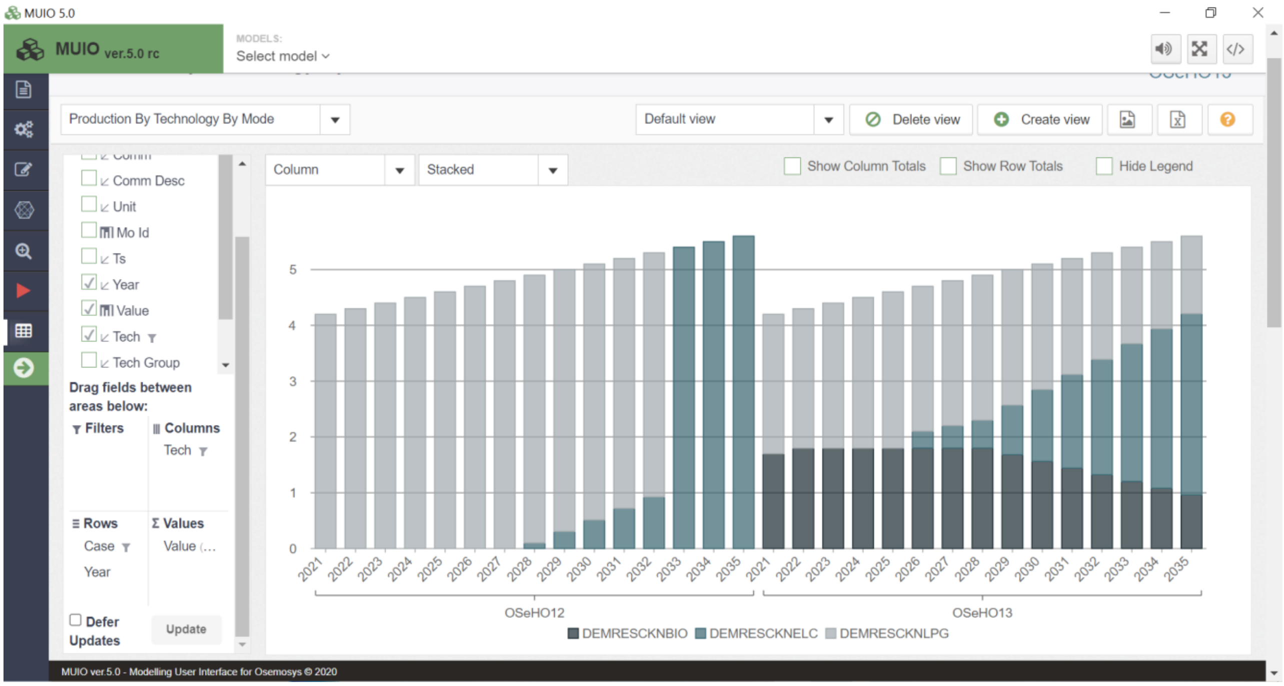
Energy production in the industrial sector

In the industrial sector, LPG is utilized at the beginning of the period due to residual capacities and lower limits. Over time, natural gas progressively replaces LPG as it becomes more competitive.



Energy production in the residential sector

In the residential sector, biomass and LPG are used in the initial years, reflecting historical data. From 2026 onward, there is a gradual electrification of the cooking service. This electrification process is noticeably smoother compared to Hands-on Exercise 12.


MUIO 5.0
MUIO ver.5.0 rc
MODELS:
Select model
Production By Technology By Mode
Default view
Delete view
Create view
Column
Stacked
Show Column Totals
Show Row Totals
Hide Legend
Comm Desc
Unit
Mo Id
Ts
Year
Value
Tech
Tech Group
Drag fields between areas below:
Filters
Columns
Tech
Rows
Case
Year
Values
Value (...
Defer Updates
Update
OSeHO12
OSeHO13
DEMRESCKNBIO
DEMRESCKNELC
DEMRESCKNLPG
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