

CLEWs

Hands-on lecture 5: Introducing time-dependent elements

Useful links:

- 1) Link to open [Momani](#) in the local computer
- 2) [Discussion forum](#) for OSeMOSYS
- 3) [Results from this Hands-on](#)

Pre-requisites:

1. Successful completion of Hands-on lecture 4

Learning outcomes

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

- 1) Understand how time-varying demands and demand profiles are added to an energy system model
- 2) Introduce variable renewable energy sources and their techno-economic characteristics
- 3) Understand the influence of time-dependent supply and demand on the cost optimisation

Activity 1 – Check the time definition in the model

This activity does not require you to change anything in the model. You are only asked to check, and reflect upon, some input that was pre-loaded in your model template.

During Lecture 5 you learnt about the concept of TimeSlice and of YearSplit. However they are named, these concepts are often used in long-term energy system models. We have included for you the TimeSlices and the values for the YearSplit in your model template.



You can check the TimeSlices by taking the following steps:

- Next to the name of your model, click **Edit set data**
- Next to the set TIMESLICE, click **Enter data**
- Check that there is a list of TimeSlices, consisting of four elements: SD (representative summer-day), SN (representative summer-night), WD (representative winter-day), WN (representative winter-night).
- Notice that, as always with the names of sets in MoManI, the names of these TimeSlices are short, concise, **not including any spaces nor any special characters**

You can check the YearSplit by taking the following steps:

- Next to the name of your model, click **Scenarios**
- Click **Enter data**
- Look for the parameter YearSplit (you can use the search bar in the page) and click **Enter data (slices)** next to it
- Check the information you find against the image below

The screenshot shows a web interface for entering data for the parameter YearSplit. At the top, there is a title "Data entry for parameter YearSplit". Below the title, there is a "Default value" field containing the number "0". To the left of the table is a "Switch axes" button. The table has four columns representing the years 2019, 2020, 2021, and 2022, and four rows representing the TimeSlices: SD, SN, WD, and WN. Below the table are "Save" and "Cancel" buttons. At the bottom, there is a section labeled "Other parameters" with a dropdown menu currently showing "YearSplit".

	2019	2020	2021	2022
SD	0.4457	0.4457	0.4457	0.4457
SN	0.2228	0.2228	0.2228	0.2228
WD	0.1657	0.1657	0.1657	0.1657
WN	0.1657	0.1657	0.1657	0.1657

Bear in mind the two processes above: one is for checking / modifying the **SETs** of a model (i.e. the structure), another one is for checking / modifying the **parameters** (i.e. entering all the numerical data). In the next activities we will not repeat how you can get to change SETs or parameters. We will only mention whether what you need to change is a **SET** or a **parameter**. If you do not recall the steps, get back to this Activity.

Try to recall the meaning of **TimeSlice** and **YearSplit**. You will have to answer questions about it in the quiz annexed to this Hands-on session.



Activity 2 – Add a Specified Annual Demand

Before starting this Activity, clone the latest model, i.e. the one from Activity 1 of Hands-on lecture 4 (if you do not recall how, kindly refer to the instructions in the same Activity).

With this activity, you will change something that was previously included in the model. In the previous exercises, we had defined the demand for final electricity (commodity named ELC002) as an AccumulatedAnnualDemand. As you have seen in Lecture 5, the AccumulatedAnnualDemand is a type of demand defined for each year. No demand profile is associated to it, because we assume that the demand can be met at any time. This is an unrealistic assumption for the demand for electricity, which in real life must be met at precise times with a specific profiles. In OSeMOSYS, there is a parameter representing demand that must be met with a particular profile: the SpecifiedAnnualDemand. To improve the model, you will now replace the AccumulatedAnnualDemand with a SpecifiedAnnualDemand and further add a SpecifiedDemandProfile to it.

First step:

- Go to the **parameter** AccumulatedAnnualDemand and delete the four annual values now appearing for the commodity ELC002
- Click **Save**

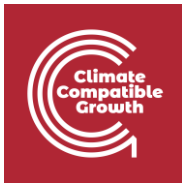
Second step:

- Go to the **parameter** SpecifiedAnnualDemand and add a demand of 100 (PJ) for each year (2019, 2020, 2021, 2022), for the commodity ELC002
- Click **Save**

Third step:

- Go to the **parameter** SpecifiedDemandProfile and add, for the commodity ELC002, the values appearing in the table below, **for all years**
- Hint: to add the values efficiently, we suggest you first fix the REGION dimension (as you should always do) and then the COMMODITY dimension (**making sure that you select ELC002 as commodity!**)
- Click **Save**

TimeSlice	Commodity: ELC002
SD	0.32



SN	0.08
WD	0.18
WN	0.42

Try to remember the meaning of AccumulatedAnnualDemand, SpecifiedAnnualDemand and SpecifiedDemandProfile, and go back to Lecture 5 if you do not recall them. Also, repeat on your own how the YearSplit and SpecifiedDemandProfile are calculated and reflect on the **difference between the two**. You will be asked questions about this in the Quizzes.

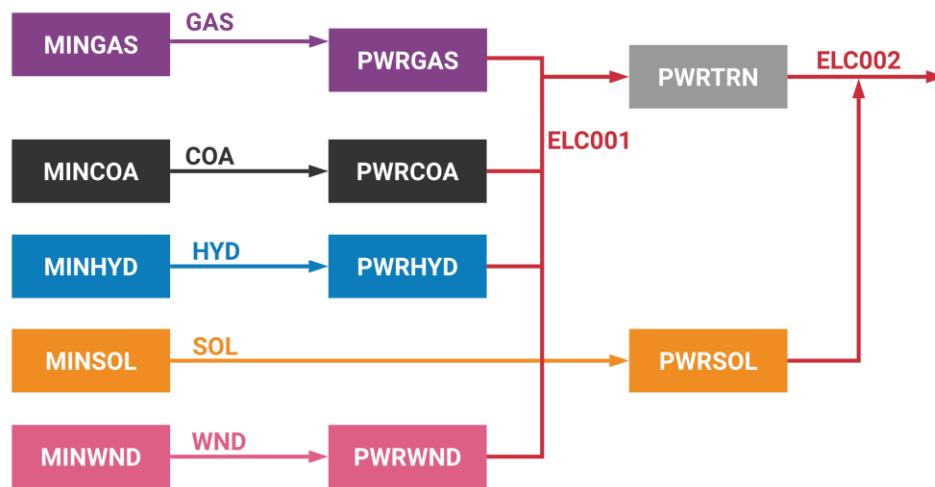
Activity 3 – Run the model

Now, download the executable of this new model and run it (if you do not recall how, kindly go back to Activity 3 of Hands-on lecture 3).

Activity 4 – Add renewable energy supply

Before starting this Activity, clone the latest model, i.e. the one from Activity 2 of this Hands-on (if you do not recall how, kindly go back to Activity 1 of Hands-on lecture 4).

With this activity, you will introduce in the model renewable energy supply technologies that could contribute to the electricity supply in parallel to the coal power plant and gas power plant. When this activity is completed, the Reference Energy System of your model will look like in the figure below. Compared to the previous stage, you will have added hydropower (PWRHYD), rooftop solar photovoltaic (PWR SOL) and wind turbines (PWRWND). Each of these taps into a resource (respectively, MINH YD, MINSOL, MINWND for hydro, solar and wind resource) and provides electricity to meet the demand.



To start, you need to **add the new technologies and related commodities to the SETs.**

For the technologies:

- For the new model you just cloned, go to the SET TECHNOLOGY
- Add to the SET the following 6 technologies: MINHYD, MINSOL, MINWND, PWRHYD, PWRSOL and PWRWND
- Click **Save**

For the commodities:

- For the new model you just cloned, go to the SET COMMODITY
- Add to the SET the following 3 commodities: HYD, SOL, WND
- Click **Save**

Now, **create the connections between the technologies and commodities** according to the figures. For creating the connections, you will need to use the InputActivityRatio and OutputActivityRatio parameters. You will assume that all these technologies have 100% efficiency. That corresponds to having **values of 1 PJ/PJ for both the InputActivityRatio and the OutputActivityRatio**. To recall how these parameters are entered, you may go back to the end of Activity 1 in Hands-on lecture 3 and recall how you did for PWRCOA and PWRGAS. Further hints are:

- MINHYD, MINSOL and MINWND will have only OutputActivityRatios, of value 1 PJ/PJ (PJ of output per PJ of activity), respectively for the commodities shown in the figure above (with arrows going outwards). **They have no inputs. Be well aware of this, as giving inputs to these technologies by mistake will make the model crash.**
- PWRHYD and PWRWND will have both InputActivityRatio and OutputActivityRatio, of value 1 PJ/PJ, respectively for the commodities shown in the figure above by the different inward-going and outward-going lines. Notice that the output electricity commodity for both these technologies is ELC001, that is, electricity that feeds into the transmission network.



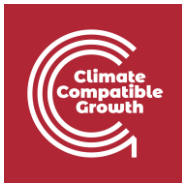
- PWR SOL will have an InputActivityRatio of 1 PJ/PJ for commodity SOL and an OutputActivityRatio of 1 PJ/PJ for the commodity ELC002, that is, the electricity for final uses. Note that, as opposed to PWRHYD and PWRWND, there is no OutputActivityRatio for ELC001, the electricity feeding into the transmission network. This is because PWR SOL represents rooftop PV and is not connected to the transmission network.

Finally, **enter the techno-economic parameters for all these technologies**. First, enter values for the parameters in the table below. Remember to enter these values **for all years**. To do this efficiently, be careful about what dimensions you fix when entering parameters in MoManI, as discussed in detail in Hands-on lecture 4.

Parameter	Units	PWRHYD	PWR SOL	PWRWND
AvailabilityFactor	Fraction	1	1	1
CapitalCost	\$/kW	2500	1200	1600
FixedCost	\$/kW/yr	60	20	40
VariableCost	\$/GJ	0	0	0
OperationalLife	Yrs	80	20	20
CapacityToActivityUnit	PJ/GW	31.536	31.536	31.536

Now, enter the capacity factors for the three electricity supply technologies, PWRHYD, PWR SOL and PWRWND, as per table below. Also in this case, remember to enter the values **for all years**.

TimeSlice	PWRHYD	PWR SOL	PWRWND
SD	0.30	0.45	0.30
SN	0.30	0.00	0.20
WD	0.50	0.35	0.25
WN	0.50	0.00	0.30



Remember that the capacity factors, in the case of renewable electricity supply, are what will indicate in the model that the resource is not always available and that only a part of the installed capacity may actually be used. Also, notice that the capacity factors have different values in different TimeSlices. This indicates that variable renewables might not always be there to meet the electricity demand, independently of what the demand profile is. That might cause other (non-renewable) power to be needed for meeting the demand. Reflect on all of this and go back to Lecture 5 for all the concept. It will help you for the quiz of this hands-on.

Activity 5 – Run the model

Now, download the executable of this new model and run it (if you do not recall how, kindly go back to Activity 3 of Hands-on lecture 3).