Introduction to CLEWs

Hands-on lecture 11: Climate change scenarios and policies

V2.0

Kane Alexander [a], Diki Darmawan [b], Godswill Ifeanyi [b], Shreyas Savanur [b], Camilla Lo Guidice [b], Francesco Gardumi [b], Eunice Ramos [c], Thomas Alfstad [c], Leigh Martindale [ad]

[a] *Imperial College, London, United Kingdom*

[b] *KTH Royal Institute of Technology, Stockholm, Sweden*

[c] *United Nations Department of Economic and Social Affairs,*

New York, United States

[d] *Loughborough University, Loughborough, United Kingdom*

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Tags: CLEWs; Climate; Land; Energy; Water; Systems Modelling; Integrated; Policy Coherence; Installation; Hands-on; Climate Compatible Growth; Open Source; Teaching Kit.

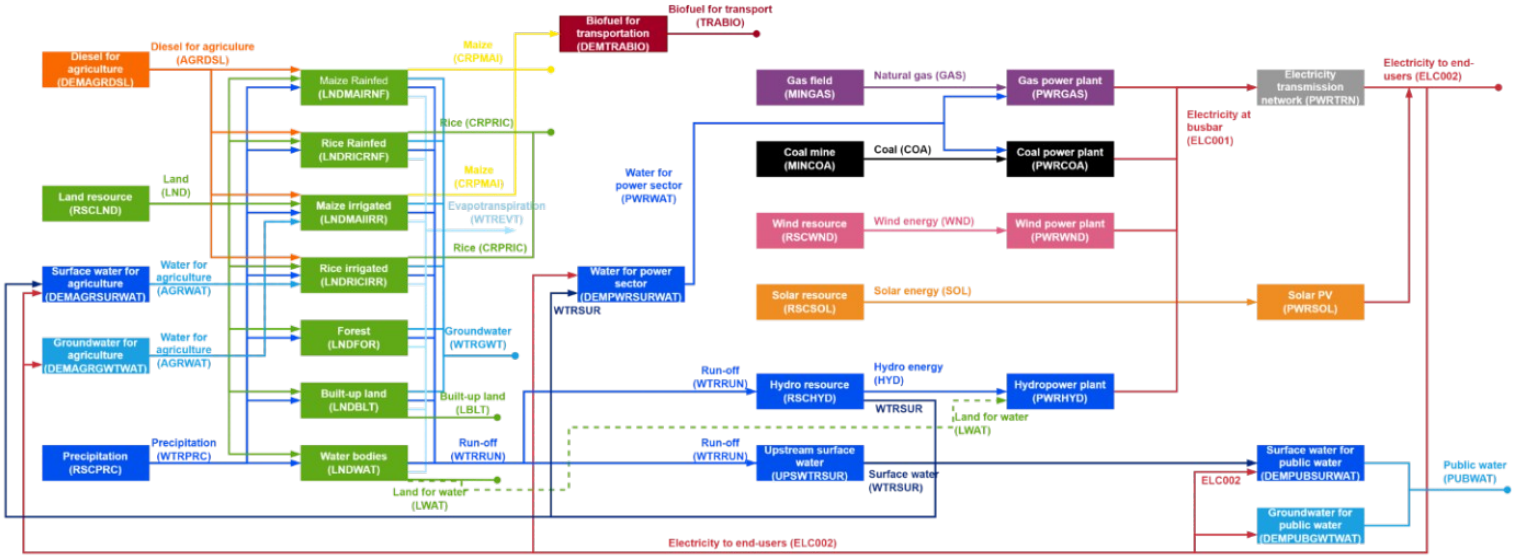
Useful links:

1) Hands-on solutions can be found here.
2) Energy Modelling Community (EMC) Discourse Forum – please use this for any CLEWs-related discussions, especially troubleshooting queries!
3) EMC LinkedIn.
4) CCG YouTube.
5) Data file here
6) Results File here

Pre-requisites:

1) Successful completion of all the activities under Hands-on lecture 10.

Previous activities focused on building an integrated model that captures the biophysical characteristics of energy, water, land, and climate systems. This provides a useful foundation to then explore the impacts of different approaches to achieve user-defined objectives. The figure below illustrates the model you should have built:



NOTE: The model created by the end of Hands-on Lecture 10 will now be referred to as the baseline. Please **rename 'SC_0'** in scenarios under the model configuration page to **'Baseline'**.

Activity 1 – Scenarios RE targets with User-Defined Constraints (UDC)

Learning Outcomes

a) Know how to create scenarios in the interface.

b) Know how UDCs are defined.

c) Understand how to create UDCs and manipulate the related elements for a particular purpose (i.e., RE target).

Overview of User-Defined Constraints

Parameters:

- **UDC Constant**: Value to be respected in the defined constraint.
- **UDC Multiplier Activity:** The factor by which the Total Technology Annual Activity of a Technology is multiplied by, as defined by the user.
- **UDC Multiplier Capacity:** The factor by which the New Capacity and Total Capacity Annual are multiplied by, as defined by the user.

Defined in Model Configuration:

- **UDC Tag:** Identifies the relationship (equality vs inequality) between the UDC Constant and the sum of UDC multipliers times their respective parameters.
- Selection of technologies to be part of the UDC constraint.

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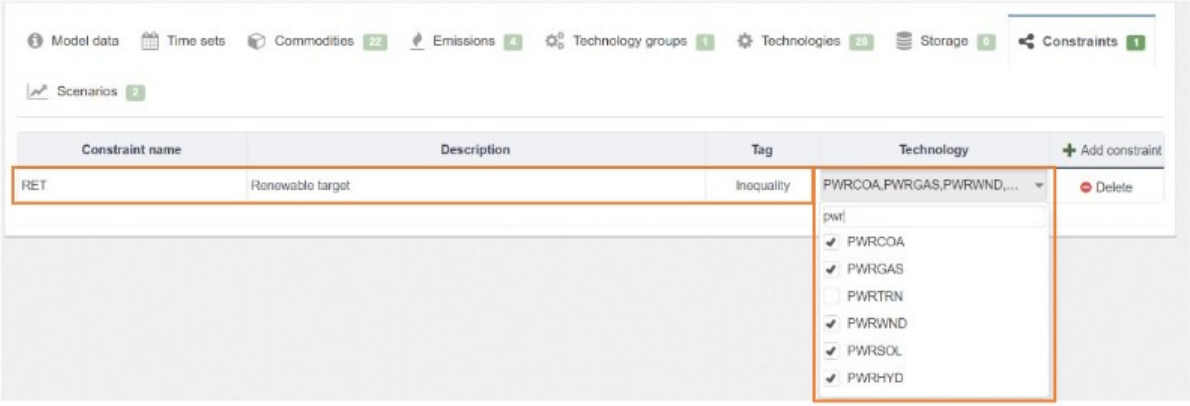
1. In "**Configure model**", go to the tab "**Scenarios**" and select "Add scenario" to create the scenario of this exercise (RE_Target). Click on **"Update model"** to save your edits.
2. In "**Configure model**", go to the tab "**Constraints**" and create a constraint named "RET" - note that it is important to have different names between scenarios and constraints
3. For the "**Tag**" select "**Inequality**", and in the column "Technologies", select all the power generation technologies: PWRCOA, PWRGAS, PWRWND, PWRSOL, and PWRHYD.

4. **Click on "Update model" to save your edits.**



Using User-Defined Constraints to set RE targets

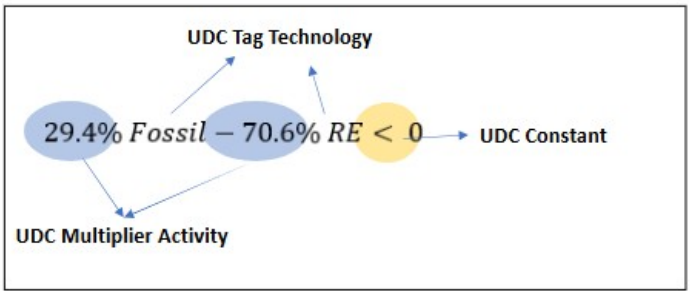
In the Base scenario, in 2020, fossil-fuelled generation represents ***29.4%*** of the total electricity generation.

In the RE target scenario, the RE generation is to represent 80% by 2035, increasing gradually from 29.4% in 2020.

$$Total\ ELC\ production\ (TEP) = Fossil\ (gas + coal) + RE\ (hydro, wind, solar)$$

$$70.6\%\ TEP = Fossil \Leftrightarrow TEP = \frac{Fossil}{70.6\%}; and, TEP = \frac{RE}{29.4\%}, \text{ which means that:}$$

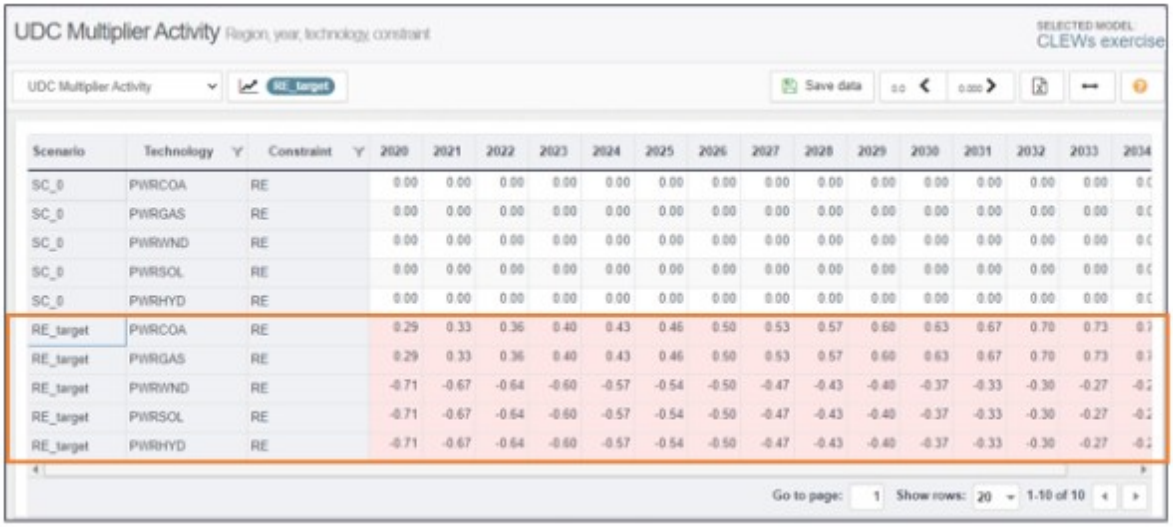
$$\frac{Fossil}{70.6\%} = \frac{RE}{29.4\%} \Leftrightarrow$$



5. In "**Data Entry",** search for "**UDC Constant**". You will be working on "scenario" mode. This means that when you access the parameter, you need to select the scenario under which you want to add a different parameter value (right next to the parameter name). You will need to do this every time you manipulate a parameter that refers to a specific scenario. If not, you'll overwrite the data in the Base scenario.

Since the UDC Constant value is to be "0", you do not need to add "0" in the RE target scenario data (shaded in light red). If a different value were to be considered, you would need to add them to the respective scenario.
Note that "n/a" means that the scenario value is the same as for the Base scenario (SC_0).)

6. In "**Data Entry**", search for "**UDC Multiplier Activity**". You will be working on "scenario mode". Go to the CLEWs data excel, and to the sheet "5. Scenarios" and in line 65 find the values of the UDC multipliers for the respective technologies. Note that you will need to add these values under the scenario "RE target".
7. Click on "Save data" to save your edits.



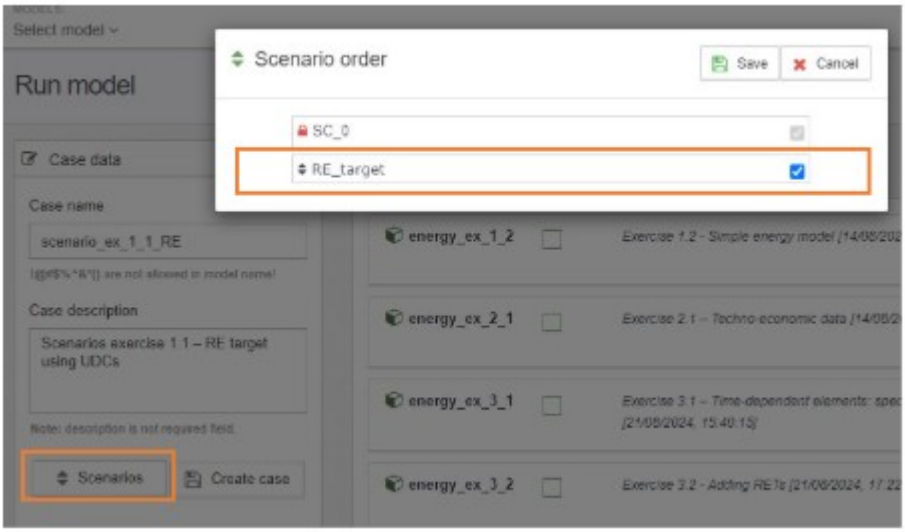
8. Now run your model and compare the results for electricity generation and capacity investments between the base and the RE scenario. In this exercise, **the results for the variables below will be explored:**

1) **Production by Technology By Mode:** This shows the number of output(s) a technology produces.
   a) Compare the results of the base and RE scenarios for power plants' electricity production.
2) **Total Capacity Annual / New Capacity:**
   a) Compare capacity investments on power plant technologies in the base and RE scenarios.
3) **New Capacity**
   a) Compare new capacity investments on power plant technologies in the base and RE scenarios.
4) **Capital Investment / 5) Annualized Investment Cost:**
   a) Compare investments and annualized investment costs between scenarios.

Instructions – running the model:

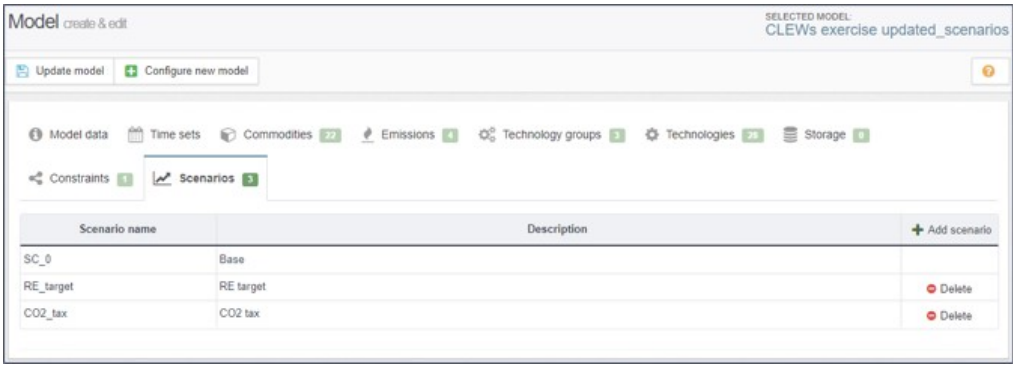
A. The model can now be run. To do so, create a "**Case**" by selecting "**Run**" in the left-hand side menu.
B. Name the case "**HO11_A1**" and describe it as "**Hands on 11 – Activity 1: RE target using UDCs**".

C. Select “Scenarios” and make sure the scenario you want to run is selected.
D. Select “**Create Case**”.
E. Select the exercise from the list by ticking the box to the right of its name and then create the “**Data File**”.
F. Once the data file is generated, click “**Run Model**”.



Activity 2 – Impact of a CO2 Emissions Tax

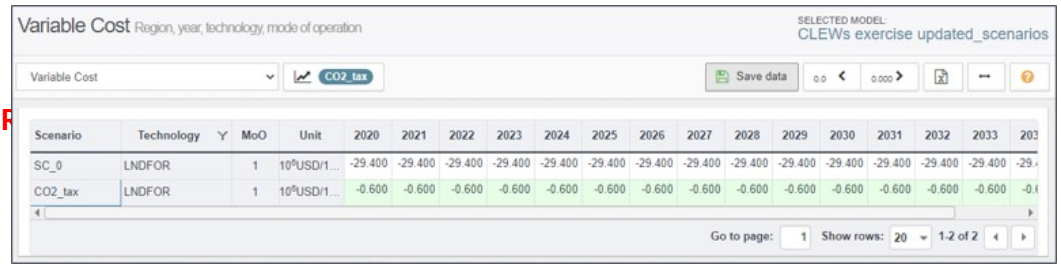
1. In “**Configure model**”, go to the tab “**Scenarios**” and select “**Add scenario**” to create the scenario of this exercise, named **‘CO2_Tax’**.
2. Click on “Update model” to save your edits.



3. The carbon tax is added to the parameter "**Emissions Penalty**" and to **CO2EQ**.
4. Go to the *'CLEWs OU Data'* Excel file and the sheet "5. Scenarios" and copy the values of carbon tax, which are in line #9.
5. In the interface, go to "Data entry" and search for the parameter "**Emissions Penalty**". **Activate the scenario "CO2_tax".**
6. Then, paste the values copied in step 4, and paste them under the emission "CO2EQ".
7. Click on "Save data" to save your edits.

Scenario	Emission	Uni	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
SC_0	CO2	10⁶U...	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	N2O	10⁶U...	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	CH4	10⁶U...	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	CO2EQ	10⁶U...	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
CO2_tax	CO2	10⁶U...	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
CO2_tax	N2O	10⁶U...	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
CO2_tax	CH4	10⁶U...	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
CO2_tax	CO2EQ	10⁶U...	0.025	0.026	0.027	0.027	0.028	0.029	0.030	0.031	0.032	0.033	0.034	0.035	0.036	0.037

8. Update the **variable cost** for **"LNDFOR"** under the scenario "CO2_tax" to -0.6 MUSD/103 km2. This is because the Base scenario value considers a carbon tax of 25 USD/tCO2, which needs to be removed in this scenario to avoid double accounting for the benefit of absorbing CO2.
9. R



Scenario	Technology	MoO	Unit	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	203
SC_0	LNDFOR	1	10⁶USD/1...	-29.400	-29.400	-29.400	-29.400	-29.400	-29.400	-29.400	-29.400	-29.400	-29.400	-29.400	-29.400	-29.400	-29.400	-29.
CO2_tax	LNDFOR	1	10⁶USD/1...	-0.600	-0.600	-0.600	-0.600	-0.600	-0.600	-0.600	-0.600	-0.600	-0.600	-0.600	-0.600	-0.600	-0.600	-0.

the carbon tax scenario for this run! In this exercise, **the results for the variables below will be explored:**

1) **Annual Technology Emission**: This shows the number of emissions by a technology, considering the emissions by activity change.
   a) Visualize and compare the results of CO2EQ emissions for all technologies with assigned emissions for the baseline scenario and the CO2_tax scenario.

2) **Use By Technology By Mode:**

a) Visualize the land use results for the CO2_tax scenario, for all land cover types and crop technologies.

3) **Production By Technology Annual:**
   a) Visualize and compare the electricity generation results for the baseline and CO2_tax scenarios.

Activity 3 – Impact of Decreased Precipitation

1. In "Model configuration" and in the tab **"Scenarios", create a new scenario** named **"Low_PRC".** Click on **"Update model"** to save your edits.

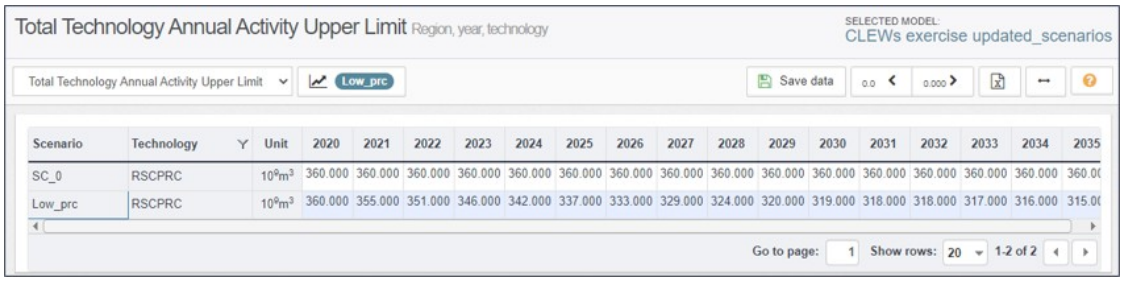
2. Several parameters need to be adjusted in scenario mode to implement a decrease in precipitation throughout the modelling period:
   a. **Total Technology Annual Activity Upper Limit** for the precipitation resource technology (RSCPRC) that defines the maximum volume of water available as precipitation each year.
   b. **Input Activity Ratio** for the commodities precipitation (WTRPRC) and water for agriculture (AGRWAT) for all land cover technologies.
   c. **Output Activity Ratio** for outputs of the water balance (evapotranspiration, run-off, and groundwater recharge).

NOTE: It is assumed that the yield of irrigated crops is constant between scenarios, and the water deficit is met through irrigation.

3. Find the new parameter data in the CLEWs data Excel file, in the sheet “5. Scenarios”, starting in line #235 (Parameter input data).

- **Total Technology Annual Activity Upper Limit:** RSCPRC
- **Input Activity Ratio:** WTRPRC
- **Input Activity Ratio:** AGRWAT
- **Output Activity Ratio:** WTREVT
- **Output Activity Ratio:** WTRRUN
- **Output Activity Ratio:** WTRGWT
- **Output Activity Ratio:** CRPRIC
- **Output Activity Ratio:** CRPMAI

4. Add each parameter data and select the scenario created. For example, for the Total Technology Annual Activity Upper Limit for the technology RSCPRC, **the data should appear as follows:**



5. **NOW RUN THE MODEL** and visualise your results, for instructions on how to view scenarios, refer back to previous activities… In this exercise, **the results for the variables below will be explored:**

    1) **Production By Technology By Mode**

a) Impact on water production: Visualize and compare water production (Baseline vs Low_PRC) by technology and by water use.
b) Impact on electricity generation: Visualize and compare electricity generation (Base vs Low_PRC) by technology.

2) **New Capacity**
   a) Visualize and compare electricity generation investments (Base vs Low_PRC).

3) **Use By Technology By Mode:**
   a) Impact on crop technology mix: Visualize and compare cropland land use (Base vs Low_PRC).