Introduction to CLEWs

Hands-on lecture 9: Energy, Land and Water system interlinkages

V2.0

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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 8.

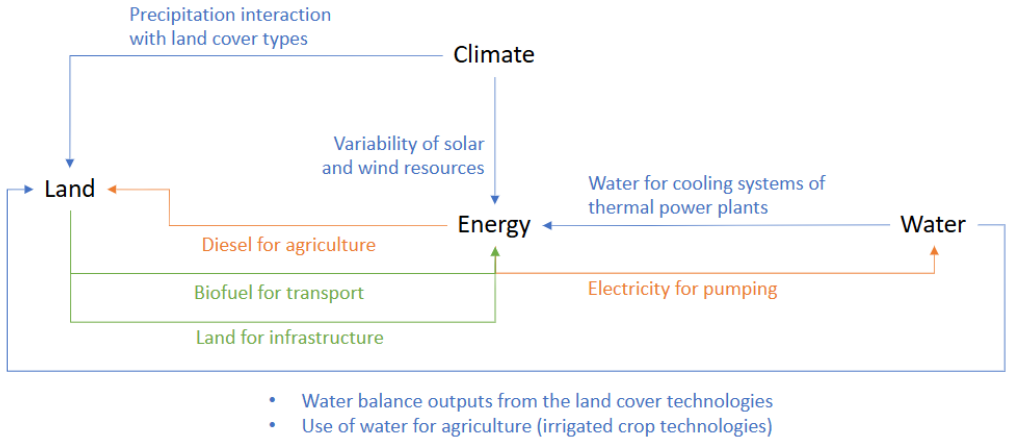
Learning Outcomes

By the end of this Hands-on, you will be able to:

1) Understand the linkages between the energy, water, and land systems.
2) Represent the interlinkages between the resource systems in a modelling setup.
3) Reflect upon the importance of the linkages between the CLEWs systems for the implementation of coherent policies.

Context:

Interlinkages between CLEW systems have been represented in the exercises developed up until now (in blue). In this exercise, interlinkages between land and energy, and energy and water, will be added. The links between the systems are really where the value of CLEWs lies; these links are going to add costs to one system due to the developments in another system, and as such are going to modify the cost-optimal solution. Being able to 'see' these links and their effects makes it possible to 'show' these links to policy makers and then argue for the value of cross-sectoral planning and policy coherence.



Activity 1 – Energy for Land

In this activity, you will:

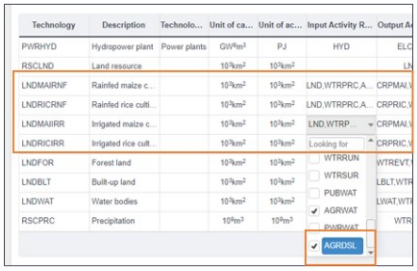
- Create 1 additional commodity (AGRDSL) and 1 additional technology (DEMAGRDSL), with the relevant input and output activity ratios.
- Then add **"Variable Cost"** to DEMAGRDSL.

1. In "**Configure model**" create the commodity **'AGRDSL'** (Diesel for agriculture, PJ)
2. Now add the technology "DEMAGRDSL" with the details in the table below. **Update the model to save your edits.**

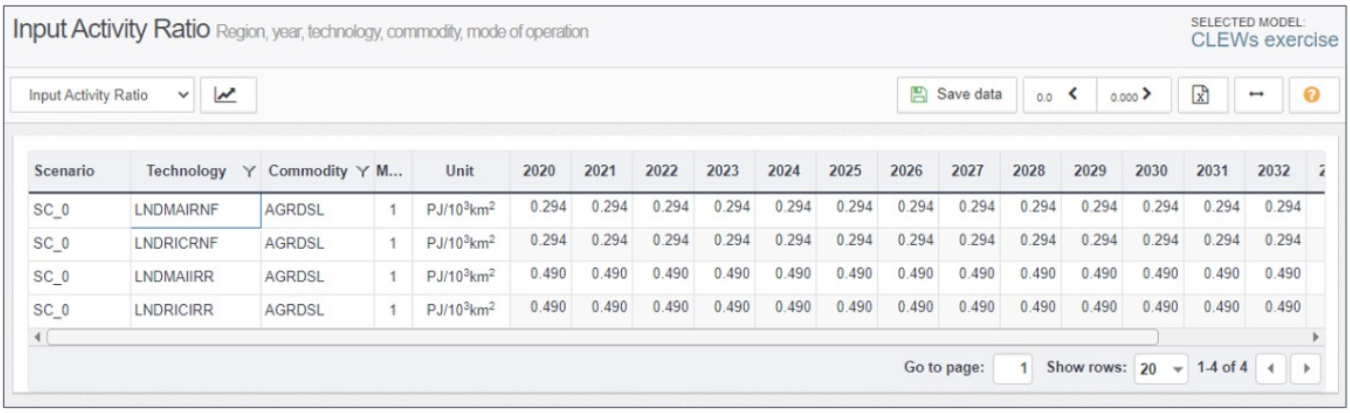
Technology	Description	Technology Group	Unit Capacity	Unit Activity	Input Activity Ratio	Output Activity Ratio
DEMAGRDSL	Diesel for agriculture	-	PJ	PJ	-	AGRDSL

3. In the "Technologies" tab, update the inputs of the cropland technologies to include the new commodity AGRDSL. Update the model to save your edits.

Technology	Description	Unit Capacity	Unit Activity	Input Activity Ratio	Output Activity Ratio
LNDMAIRNF	Rainfed maize cultivation	10^3 km^2	10^3 km^2	LND, WTRPRC, AGRDSL	CRPMAI, WTREVT, WTRGWT, WTRRUN
LNDRICRNF	Rainfed rice cultivation	10^3 km^2	10^3 km^2	LND, WTRPRC, AGRDSL	CRPRIC, WTREVT, WTRGWT, WTRRUN
LNDMAIIRR	Irrigated maize cultivation	10^3 km^2	10^3 km^2	LND, WTRPRC, AGRWAT, AGRDSL	CRPMAI, WTREVT, WTRGWT, WTRRUN
LNDRICIRR	Irrigated rice cultivation	10^3 km^2	10^3 km^2	LNLND, WTRPRC, AGRWAT, AGRDSL	CRPRIC, WTREVT, WTRGWT, WTRRUN



4. Go to "Data entry" and set the "Output Activity Ratio" for DEMAGRDSL, and the commodity AGRDSL, to the value 1.
5. Go to "Data entry" and set the "Input Activity Ratio" for the crop technologies, considering the values in the table below.



Note: For this table view, a filter was applied to "Commodity" to show technologies with input of "AGRDSL".

6. Add the price of diesel to the DEMAGRDSL technology as a "Variable Cost". Go to "**Data entry**" and search the parameter "**Variable Cost**" and insert the value of **28 MUSD/PJ** (equivalent to 1.00 USD/l) in the technology DEMAGRDSL. Click on "Save data" to save your edits. Click on "Save data" to save your edits.

7. You can now view the model diagram in dynamic (or simple) view if you wish to.

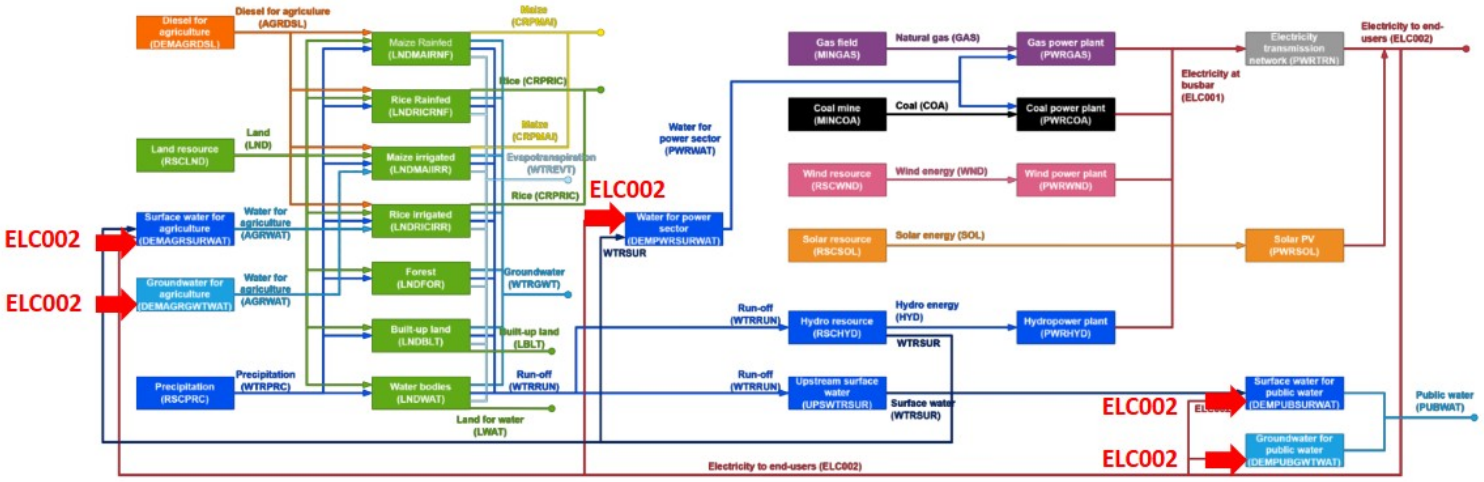
8. You can now visualise results for the energy requirements of land (crop cultivation) technologies and compare results of land investments when energy use is considered, versus when it is not. Explore the following **variables:**

   - **Use by Technology By Mode:** This shows the use of input commodities to a technology by mode of operation. Compare the use of land by crop cultivation technologies of this activity to the previous activity for the water hands-on worksheet.

   - **Production By Technology By Mode**: This shows the number of outputs produced by a technology. Visualise the results for diesel imported for use in the agriculture sector.

Activity 2 – Energy for Water

You will build into your model the representation of electricity use for the pumping of water to meet the requirements of different water users (agriculture, power sector, public supply). The commodity **"ELC002"** will be added as an input to water supply technologies.



1. In "**Configure model**", go to the tab "**Technologies**" and add the commodity "**ELC002**" as an input to the water supply technologies DEMAGRSURWAT, DEMAGRGWTWAT, DEMPWRSURWAT, DEMPUBSURWAT, and DEMPUBGWTWAT.

2. Click on "Update model" to save your edits.

3. Go to "**Data entry**" and add the values in the table below as "**Input Activity Ratio**" for the water demand technologies and the commodity "**ELC002**". Save your edits.

Technology	Commodity	Mode of Operation	Unit	Input Activity Ratio (2020-2035)
DEMPUBSURWAT	ELC002	1	PJ / 10^9 m^3	2.82
DEMPUBGWTWAT	ELC002	1	PJ / 10^9 m^3	4.23
DEMAGRSURWAT	ELC002	1	PJ / 10^9 m^3	0.86
DEMAGRGWTWAT	ELC002	1	PJ / 10^9 m^3	1.08
DEMPWRSURWAT	ELC002	1	PJ / 10^9 m^3	2.82

4. Again, you can view the model diagram in dynamic (or simple) view. But now you should run the model and view the results. In this activity, **the results for the variables below should be explored:**

- **Use by Technology By Mode:** This shows the use of input commodities to a technology by mode of operation. Visualise the use of electricity for water supply technologies.
- **New Capacity**: This shows the investments in a technology throughout the modelling period. Compare the investments in water supply technologies with electricity use, from this activity, and without electricity use, from the previous hands-on for water. *Did anything change?*

Activity 3 – Land for Energy Production

Overview:

- Create a new commodity **(TRABIO)**
- Create a new technology **(DEMTRABIO)**
- Edit and add input and output activity ratios, then add an **Accumulated Annual Demand**.

Instructions:

1. In "**Configure model**", go to the tab "**Commodities**" and create the commodity "**TRABIO**", with the following characteristics:
    - **TRABIO**, Biofuel for transport, PJ
2. Click on "Update model" to save your edits.
3. In "**Configure model**", go to the tab "**Technologies**" and create the technology "**DEMTRABIO**" with the characteristics
4. Click on "Update model" to save your edits.
5. Add the "Input" and "Output" Activity Ratios data to the "DEMTRABIO" technology, according to the information in the table below.

Technology	Commodity	Mode of Operation	Unit	Input Activity Ratio (2020-2035)	Output Activity Ratio (2020-2035)
DEMTRABIO	CRPMAI	1	Mt / PJ	1	-
DEMTRABIO	TRABIO	1	PJ / PJ	-	8.44

6. Click on "Save data" to save your edits.
7. Define the biofuel (bioethanol) annual demand, adding data for "TRABIO" in the parameter "Accumulated Annual Demand". Go to the CLEWs data Excel file, and in sheet "2.Assumptions", find the TRABIO demand below line #222.

8. Click on “Save data” to save your edits.

9. Update the **“Residual Capacity”** for the **maize** technologies. It is assumed that 90% of the biofuel produced comes from rainfed agriculture, and the remainder from irrigated practices. Go to the CLEWs data Excel file, and in the sheet “4.2. Land”, search for the maize technologies LNDMAIRNF and LNDMAIIRR, and the Residual Capacity for the exercise “HANDS ON 9”. **Save and update your model!**

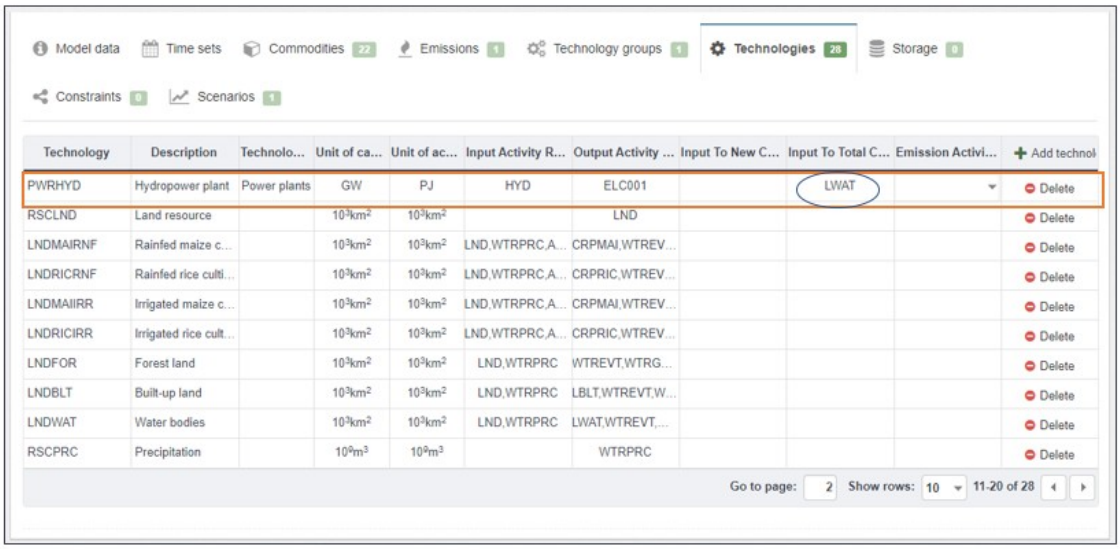
10. Run model and interpret results related to the use of land for energy production (biofuel from maize). In this exercise, the results for the **variables below** will be explored:

- **Use by Technology By Mode:** This shows the use of input commodities to a technology by mode of operation. Arrange the pivot view to compare the use of land to cultivate maize to meet the biofuel and crop demands (from this activity) versus just the crop demand (the previous activity). Also, compare the results for this exercise and the previous exercise for irrigation water and diesel use in agriculture.
- **New Capacity:** Shows new technology investments. Arrange the pivot view to compare the investments in the use of land to cultivate maize to meet the biofuel and crop demands (this activity) versus just the crop demand (previous activity).

Activity 4 – Land Use for Energy

You are now going to look at adding the use of land for energy infrastructure, specifically land occupied by the hydropower reservoir, applying the parameter “Input to Total Capacity”.

1. In “**Configure model**”, go to the tab “**Technologies**” and assign the commodity “**LWAT**” as an “**Input to Total Capacity Ratio**” to the technology “**PWRHYD**”.
2. Click on “Update model” to save your edits.



Technology	Description	Technolo...	Unit of ca...	Unit of ac...	Input Activity R...	Output Activity ...	Input To New C...	Input To Total C...	Emission Activi...	
PWRHYD	Hydropower plant	Power plants	GW	PJ	HYD	ELC001		LWAT		Delete
RSCLND	Land resource		10^3km^2	10^3km^2		LND				Delete
LNDMAIRNF	Rainfed maize c...		10^3km^2	10^3km^2	LND,WTRPRC,A...	CRPMAI,WTREV...				Delete
LNDRICRNF	Rainfed rice culti...		10^3km^2	10^3km^2	LND,WTRPRC,A...	CRPRIC,WTREV...				Delete
LNDMAIIRR	Irrigated maize c...		10^3km^2	10^3km^2	LND,WTRPRC,A...	CRPMAI,WTREV...				Delete
LNDRICIRR	Irrigated rice cult...		10^3km^2	10^3km^2	LND,WTRPRC,A...	CRPRIC,WTREV...				Delete
LNDFOR	Forest land		10^3km^2	10^3km^2	LND,WTRPRC	WTREVT,WTRG...				Delete
LNDBLT	Built-up land		10^3km^2	10^3km^2	LND,WTRPRC	LBLT,WTREVT,W...				Delete
LNDWAT	Water bodies		10^3km^2	10^3km^2	LND,WTRPRC	LWAT,WTREVT,...				Delete
RSCPRC	Precipitation		10^9m^3	10^9m^3		WTRPRC				Delete

3. Go to “Data Entry” and search for the parameter **“Input to Total Capacity Ratio”.** Assuming the area occupied by the reservoir of 1 GW of hydropower corresponds to 0.007 thousand km2, add **0.007** as the “Input Total Capacity Ratio”.

NOTE: *The area occupied by reservoirs is site-specific, and this is just an assumption.*

4. Now you can run the model and view the results for the **variables listed below**:

- **Production By Technology By Mode**: This shows the number of outputs produced by a technology. Visualise the results for producing the commodity “LWAT”, an output of the technology “LNDWAT”, which corresponds to the land used for water bodies, and the sum of the exogenous LWAT demand and the endogenous LWAT demand introduced in the exercise for reservoirs.
- **Input to Total Capacity**: This shows the number of inputs needed per capacity of a technology. Visualize the land used by “PWRHYD” for the commodity “LWAT”.