Energy and Flexibility Modelling

Hands-on 9

Please use the following citation for:

- **This exercise**

Cannone, Carla, Allington, Lucy, & Howells, Mark. (2021, March). Hands-on 9: Energy and Flexibility Modelling (Version 2.0.). Zenodo. https://doi.org/10.5281/zenodo.4609954

- **clicSAND Software**

Cannone, C., Allington, L., De Wet, N., Shivakumar, A., Goyns, P., Valderrama, C., Howells, M. (2021). clicSAND [computer software]. http://doi.org/10.5281/zenodo.4593100

- **OSeMOSYS Google Forum**

Please sign up to the help Google 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 'clicSAND' Interface.

- **Step-by-step explanatory video on Youtube**

A video recording of this exercise is available on the CCG Youtube channel at: HO9

Learning outcomes

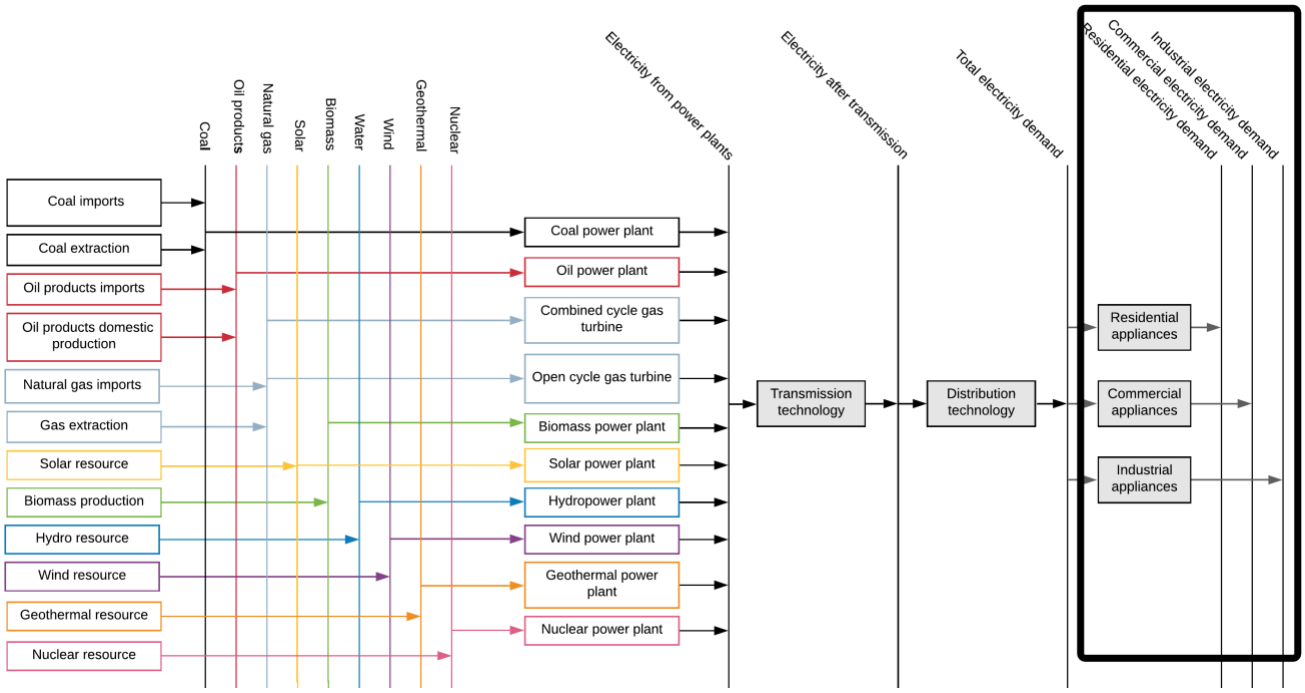
By the end of this exercise, you will be able to represent the following in OSeMOSYS:

1) Residential appliances and residential electricity demand

2) Commercial appliances and commercial electricity demand

3) Industrial appliances and industrial electricity demand

4) Resource potential



Add Sector-specific energy demands

The first step to represent energy sectors in OSeMOSYS is splitting the Total Electricity Demand (**ELC003**) by sector. In this exercise we will split the Total Electricity Demand into 3 sectors: industrial, commercial, and residential. As we learnt in **Hands-on 3**, to represent a demand in OSeMOSYS we need to define a new Commodity. Therefore, three new commodities need to be listed in SETS:

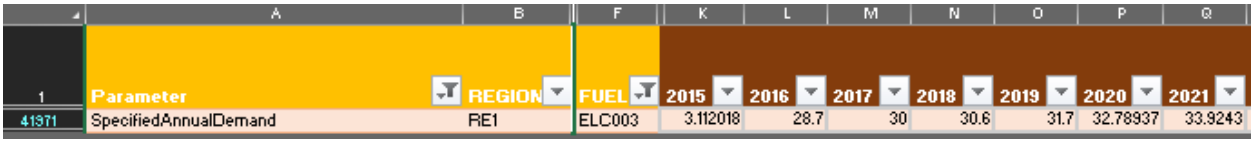
1. **INDELC** - Industrial Electricity Demand
2. **RESELC** - Residential Electricity Demand
3. **COMELC** - Commercial Electricity Demand

To avoid double-counting, we need to return the values for the **SpecifiedAnnualDemand** of **ELC003** and its corresponding **SpecifiedDemandProfile** to the original default values. This is because we will later define **SpecifiedAnnualDemand** and **SpecifiedDemandProfile** for **INDELC**, **RESELC** and **COMELC**.

Try it: remove values from **ELC003** and add three new electricity demands.

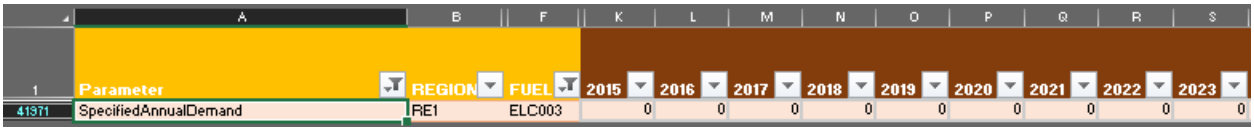
1. Go to Parameters -> In Column A, filter out for the parameter **SpecifiedAnnualDemand**

2. In Column F, filter out for ELC003. You will see that in cell K41971 there are the data that we added in the previous exercise.



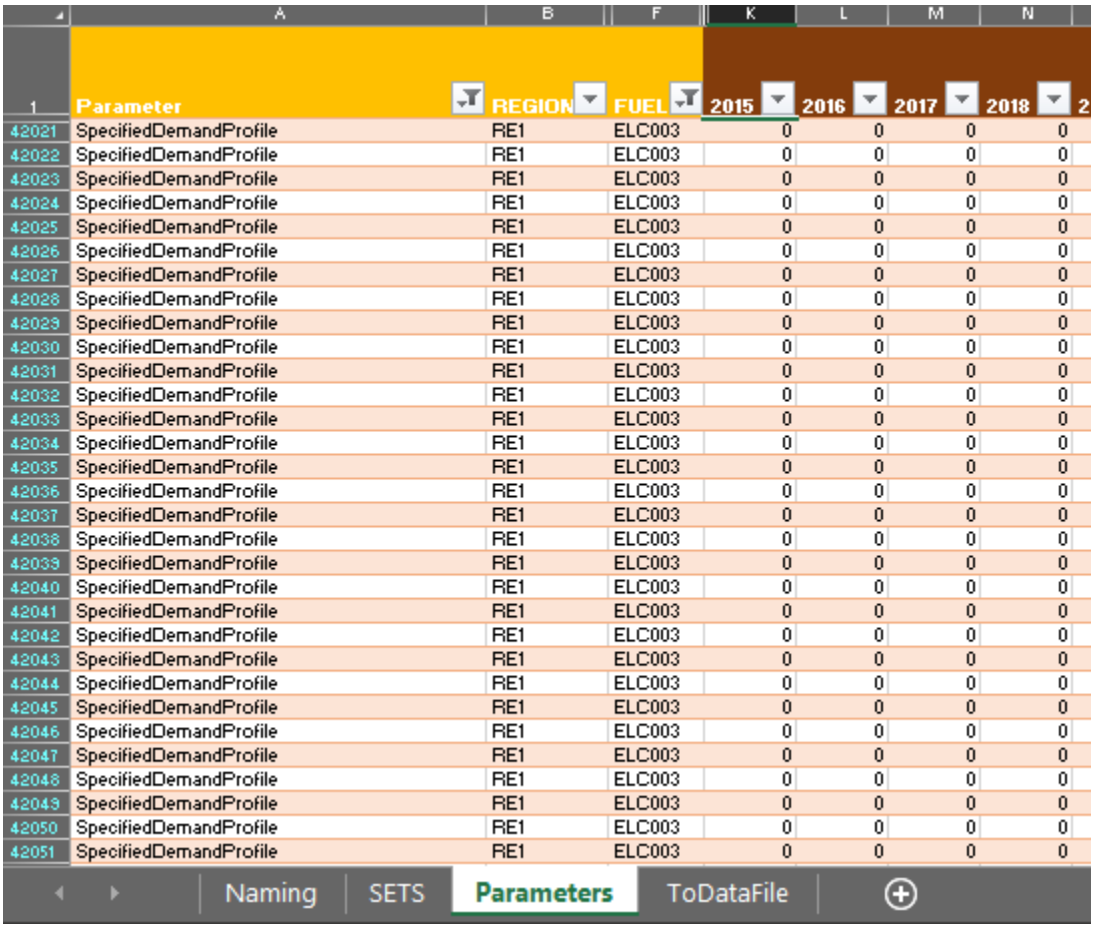
	A	B	F	K	L	M	N	O	P	Q
1	Parameter	REGION	FUEL	2015	2016	2017	2018	2019	2020	2021
41971	SpecifiedAnnualDemand	RE1	ELC003	3.112018	28.7	30	30.6	31.7	32.78937	33.9243

3. Instead of those numbers **add a 0 from 2015 to 2070**.



	A	B	F	K	L	M	N	O	P	Q	R	S
1	Parameter	REGION	FUEL	2015	2016	2017	2018	2019	2020	2021	2022	2023
41971	SpecifiedAnnualDemand	RE1	ELC003	0	0	0	0	0	0	0	0	0

4. Make sure that there are only Zeros in the **SpecifiedDemandProfile** correspondent to ELC003.



	A	B	F	K	L	M	N
1	Parameter	REGION	FUEL	2015	2016	2017	2018
42021	SpecifiedDemandProfile	RE1	ELC003	0	0	0	0
42022	SpecifiedDemandProfile	RE1	ELC003	0	0	0	0
42023	SpecifiedDemandProfile	RE1	ELC003	0	0	0	0
42024	SpecifiedDemandProfile	RE1	ELC003	0	0	0	0
42025	SpecifiedDemandProfile	RE1	ELC003	0	0	0	0
42026	SpecifiedDemandProfile	RE1	ELC003	0	0	0	0
42027	SpecifiedDemandProfile	RE1	ELC003	0	0	0	0
42028	SpecifiedDemandProfile	RE1	ELC003	0	0	0	0
42029	SpecifiedDemandProfile	RE1	ELC003	0	0	0	0
42030	SpecifiedDemandProfile	RE1	ELC003	0	0	0	0
42031	SpecifiedDemandProfile	RE1	ELC003	0	0	0	0
42032	SpecifiedDemandProfile	RE1	ELC003	0	0	0	0
42033	SpecifiedDemandProfile	RE1	ELC003	0	0	0	0
42034	SpecifiedDemandProfile	RE1	ELC003	0	0	0	0
42035	SpecifiedDemandProfile	RE1	ELC003	0	0	0	0
42036	SpecifiedDemandProfile	RE1	ELC003	0	0	0	0
42037	SpecifiedDemandProfile	RE1	ELC003	0	0	0	0
42038	SpecifiedDemandProfile	RE1	ELC003	0	0	0	0
42039	SpecifiedDemandProfile	RE1	ELC003	0	0	0	0
42040	SpecifiedDemandProfile	RE1	ELC003	0	0	0	0
42041	SpecifiedDemandProfile	RE1	ELC003	0	0	0	0
42042	SpecifiedDemandProfile	RE1	ELC003	0	0	0	0
42043	SpecifiedDemandProfile	RE1	ELC003	0	0	0	0
42044	SpecifiedDemandProfile	RE1	ELC003	0	0	0	0
42045	SpecifiedDemandProfile	RE1	ELC003	0	0	0	0
42046	SpecifiedDemandProfile	RE1	ELC003	0	0	0	0
42047	SpecifiedDemandProfile	RE1	ELC003	0	0	0	0
42048	SpecifiedDemandProfile	RE1	ELC003	0	0	0	0
42049	SpecifiedDemandProfile	RE1	ELC003	0	0	0	0
42050	SpecifiedDemandProfile	RE1	ELC003	0	0	0	0
42051	SpecifiedDemandProfile	RE1	ELC003	0	0	0	0

Naming | SETS | Parameters | ToDataFile

5. Add three new commodities in SETS:
   - **INDELC** - Industrial Electricity Demand
   - **RESELC** - Residential Electricity Demand

- **COMELC** - Commercial Electricity Demand

E	F
Commodities	
Code	*Description*
ELC003	Electricity after distribution
COA	Coal
OIL	Oil fuel
NGS	Natural Gas
ELC001	Electricity from power plants
ELC002	Electricity after transmission
BIO	Biomass
HYD	Hydro
GEO	Geothermal
URN	Uranium
SOL	Sun
WND	Wind
INDELC	Industrial Electricity Demand
COMELC	Commercial Electricity Demand
RESELC	Residential Electricity Demand

6. Go to Parameters and in Column A filter out again for the parameter **SpecifiedAnnualDemand**.
7. In column F, filter out for **INDELC, COMELC and RESELC**.
8. Add the data provided in the Data prep file.

	A	F	G	K	L	M	N	O	P
1	Parameter	FUEL	TIMESLICE	2015	2016	2017	2018	2019	2020
41983	SpecifiedAnnualDemand	INDELC		15.2	15.8	15.6	16.1	16.41592	16.73804
41984	SpecifiedAnnualDemand	COMELC		4.3	4.5	4.6	4.8	4.979539	5.165794
41985	SpecifiedAnnualDemand	RESELC		9.2	9.7	10.4	10.8	11.39391	12.02047

9. Now in Column A filter out only for the parameter **SpecifiedDemandProfile** and in Column F keep the filter on for **INDELC, COMELC and RESELC**. Add the data for SpecifiedDemandProfile of INDELC, COMELC and RESELC as in the Data prep file.

43173	SpecifiedDemandProfile	INDELC	S101	0.009187	0.009187	0.009187	0.009187	0.009187	0.009187
43174	SpecifiedDemandProfile	INDELC	S102	0.009187	0.009187	0.009187	0.009187	0.009187	0.009187
43175	SpecifiedDemandProfile	INDELC	S103	0.009187	0.009187	0.009187	0.009187	0.009187	0.009187
43176	SpecifiedDemandProfile	INDELC	S104	0.009187	0.009187	0.009187	0.009187	0.009187	0.009187
43177	SpecifiedDemandProfile	INDELC	S105	0.009187	0.009187	0.009187	0.009187	0.009187	0.009187
43178	SpecifiedDemandProfile	INDELC	S106	0.009187	0.009187	0.009187	0.009187	0.009187	0.009187
43179	SpecifiedDemandProfile	INDELC	S107	0.011323	0.011323	0.011323	0.011323	0.011323	0.011323
43180	SpecifiedDemandProfile	INDELC	S108	0.011323	0.011323	0.011323	0.011323	0.011323	0.011323
43181	SpecifiedDemandProfile	INDELC	S109	0.011323	0.011323	0.011323	0.011323	0.011323	0.011323
43182	SpecifiedDemandProfile	INDELC	S110	0.011323	0.011323	0.011323	0.011323	0.011323	0.011323
43183	SpecifiedDemandProfile	INDELC	S111	0.011323	0.011323	0.011323	0.011323	0.011323	0.011323
43184	SpecifiedDemandProfile	INDELC	S112	0.011323	0.011323	0.011323	0.011323	0.011323	0.011323
43185	SpecifiedDemandProfile	INDELC	S113	0.011323	0.011323	0.011323	0.011323	0.011323	0.011323
43186	SpecifiedDemandProfile	INDELC	S114	0.011323	0.011323	0.011323	0.011323	0.011323	0.011323
43187	SpecifiedDemandProfile	INDELC	S115	0.011323	0.011323	0.011323	0.011323	0.011323	0.011323
43188	SpecifiedDemandProfile	INDELC	S116	0.011323	0.011323	0.011323	0.011323	0.011323	0.011323
43189	SpecifiedDemandProfile	INDELC	S117	0.011323	0.011323	0.011323	0.011323	0.011323	0.011323
43190	SpecifiedDemandProfile	INDELC	S118	0.011323	0.011323	0.011323	0.011323	0.011323	0.011323
43191	SpecifiedDemandProfile	INDELC	S119	0.009187	0.009187	0.009187	0.009187	0.009187	0.009187
43192	SpecifiedDemandProfile	INDELC	S120	0.009187	0.009187	0.009187	0.009187	0.009187	0.009187
43193	SpecifiedDemandProfile	INDELC	S121	0.009187	0.009187	0.009187	0.009187	0.009187	0.009187
43194	SpecifiedDemandProfile	INDELC	S122	0.009187	0.009187	0.009187	0.009187	0.009187	0.009187
43195	SpecifiedDemandProfile	INDELC	S123	0.009187	0.009187	0.009187	0.009187	0.009187	0.009187
43196	SpecifiedDemandProfile	INDELC	S124	0.009187	0.009187	0.009187	0.009187	0.009187	0.009187
43197	SpecifiedDemandProfile	INDELC	S201	0.00905	0.00905	0.00905	0.00905	0.00905	0.00905
43198	SpecifiedDemandProfile	INDELC	S202	0.00905	0.00905	0.00905	0.00905	0.00905	0.00905
43199	SpecifiedDemandProfile	INDELC	S203	0.00905	0.00905	0.00905	0.00905	0.00905	0.00905
43200	SpecifiedDemandProfile	INDELC	S204	0.00905	0.00905	0.00905	0.00905	0.00905	0.00905

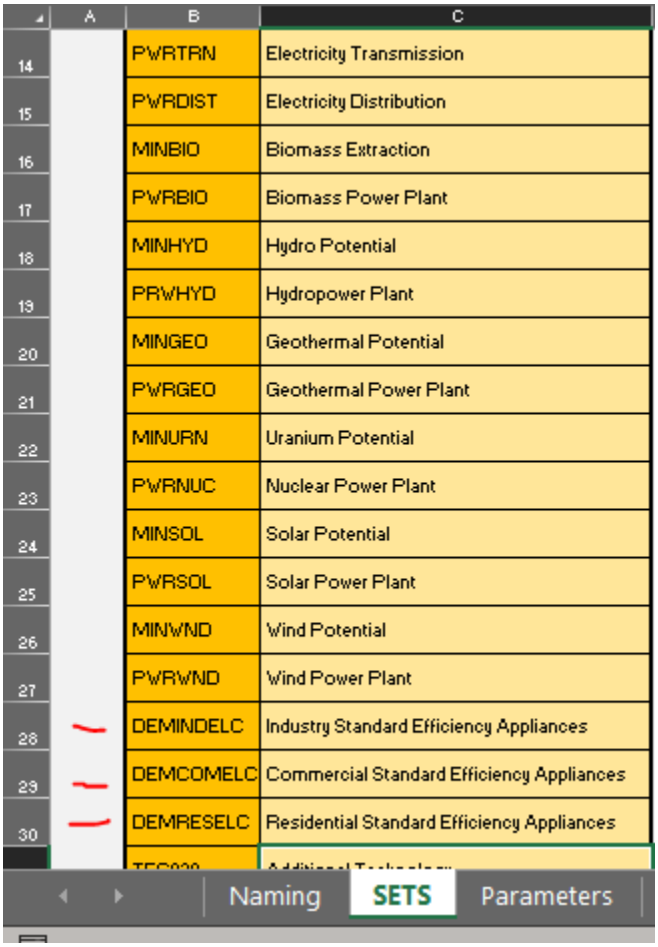
Naming | SETS | **Parameters** | ToDataFile

Voilà: you added sector specific electricity demands! Let's move to appliances.

Add energy-sector appliances

We now need to add the appliances (technologies) that address these sector-specific demands. Therefore, we will have:

1. **DEMINDELC** - Industrial Appliances (ELC003 as Input; INDELC as Output)
2. **DEMCOMELC** – Commercial Appliances (ELC003 as Input; COMELC as Output)
3. **DEMRESELC** – Residential Appliances (ELC003 as Input; RESELC as Output)



	A	B	C
14		PWRTRN	Electricity Transmission
15		PWRDIST	Electricity Distribution
16		MINBIO	Biomass Extraction
17		PWRBIO	Biomass Power Plant
18		MINHYD	Hydro Potential
19		PRWHYD	Hydropower Plant
20		MINGEO	Geothermal Potential
21		PWRGEO	Geothermal Power Plant
22		MINURN	Uranium Potential
23		PWRNUC	Nuclear Power Plant
24		MINSOL	Solar Potential
25		PWRSOL	Solar Power Plant
26		MINWND	Wind Potential
27		PWRWND	Wind Power Plant
28		DEMINDELC	Industry Standard Efficiency Appliances
29		DEMCOMELC	Commercial Standard Efficiency Appliances
30		DEMRESELC	Residential Standard Efficiency Appliances

Naming | SETS | Parameters

These appliances work as normal technologies in OSeMOSYS, so the steps needed to add them in the model are the same as the one shown in **Hands-on 5**.

You will find the data that you need in the Data Prep File.

Watch out: for simplicity we will not consider the Capital, Fixed and Variable costs of appliances in this exercise. So, these will stay at 0.

Add resources potential

We will now learn to limit the production of electricity depending on the resource potential available. To do so, we will use the parameter **TotalAnnualMaxCapacity**.

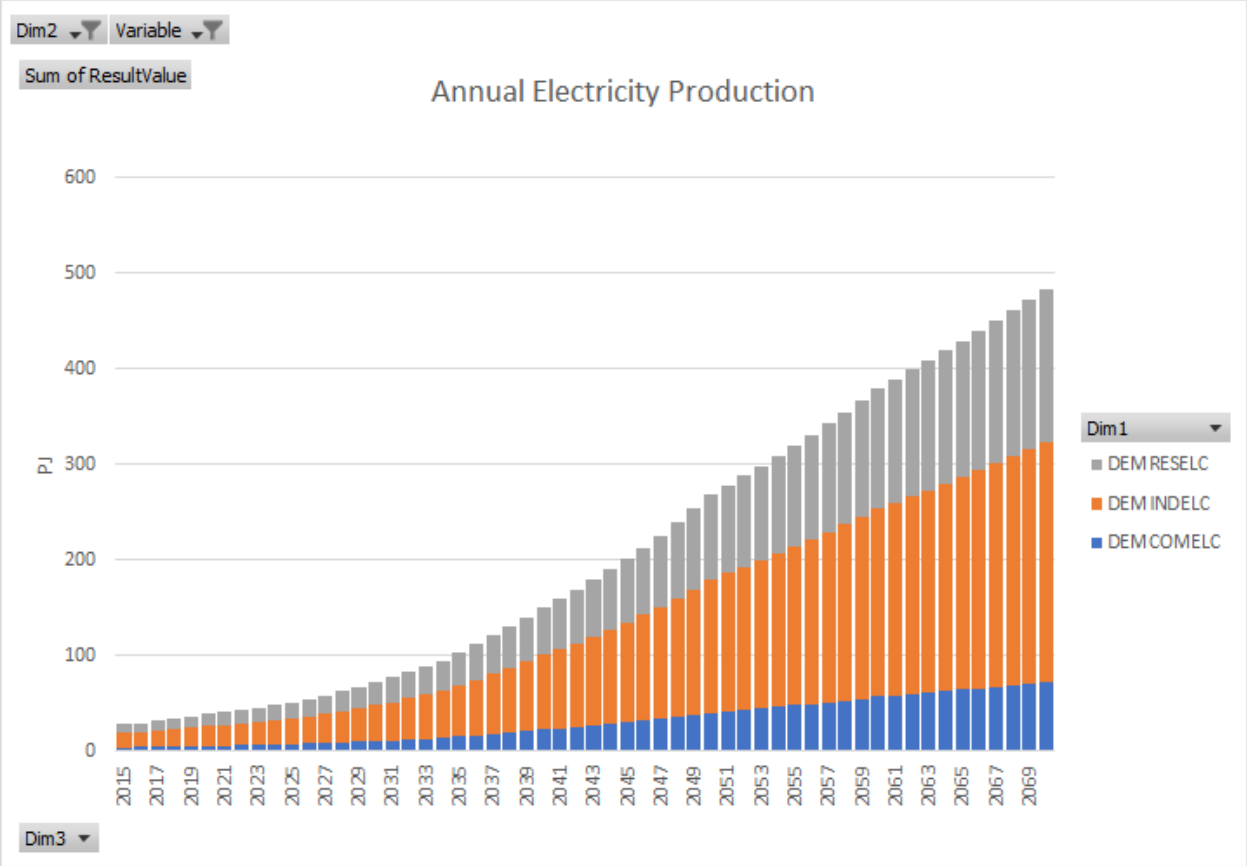
Try it:

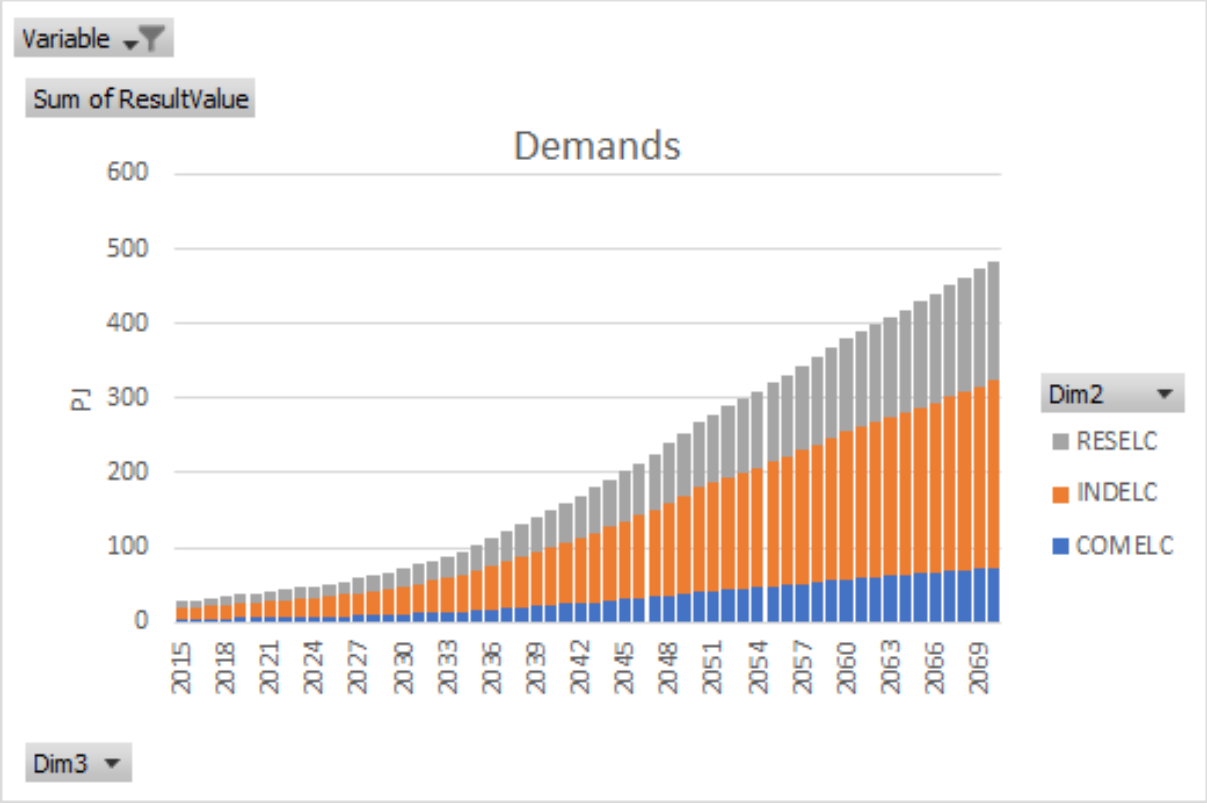
1. In column A, filter out for **TotalAnnualMaxCapacity**
2. The resource potential for **PWRGEO** is of 9 GW for all the modelling years;

3. The resource potential for **PWRHYD** is 10 GW for all the modelling years;
4. Add these data as provided in the Data Prep file.

Run the model and check the results

So, if we now check the Annual Electricity Production graph and Demands graph, we will see a similar pattern. In the drop-down menu under "Multiple Items" in cell B1, tick the new demands: INDELC, RESELC and COMELC. The only technologies producing will be the latest three we added in the model.




Variable
Sum of ResultValue
Demands
600
500
400
300
200
100
0
PJ
2015
2018
2021
2024
2027
2030
2033
2036
2039
2042
2045
2048
2051
2054
2057
2060
2063
2066
2069
Dim2
RESELC
INDELC
COMELC
Dim3