Energy and Flexibility Modelling

Hands-on 3 (macOS)

Please use the following citation for:

- **This exercise**

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- **clicSANDMac Software**

Cannone, C., Tan, N., Kell, A., de Wet, N., Howells, M., Yeganyan, R. (2021). clicSANDMac [computer software]. http://doi.org/10.5281/zenodo.5879056

- **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.

Learning outcomes

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

1. Draw a RES with a Backstop and a demand
2. Define fuels
3. Define energy demands for a specific fuel
4. Define the temporal profile of energy demands
5. Define a simple technology that satisfies the demand (Backstop)
6. Run the model and check results

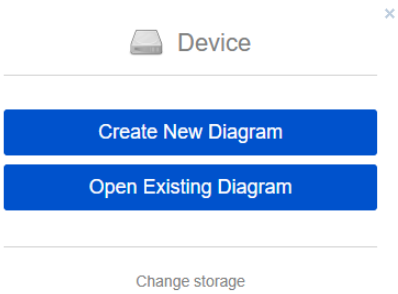
Draw RES with a Backstop and a demand

The first thing you will learn in this exercise is to draw a Reference Energy System (RES). As explained in Lecture 2, a RES is a conventional aggregated representation of a real energy system.

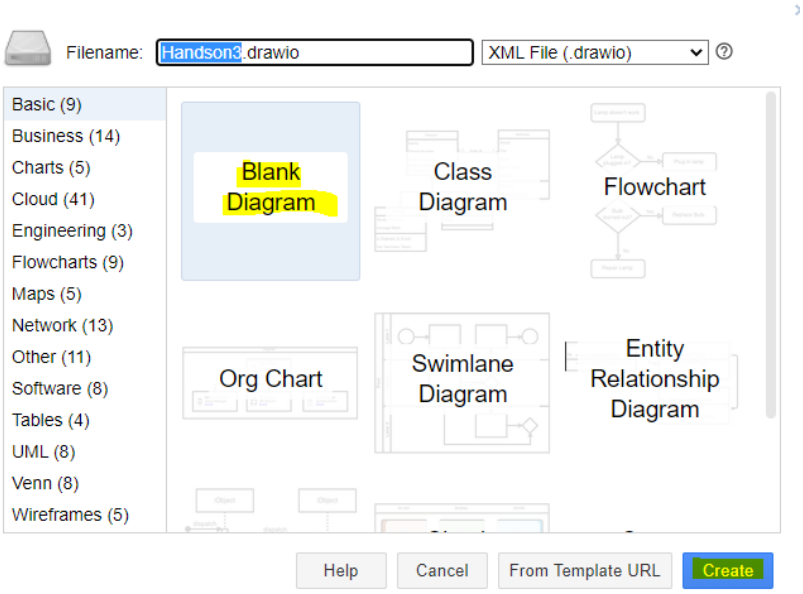
Different tools are available for this purpose, but they vary in price and functionality. For this course, we will choose Diagram.net which is a **free** software to draw diagrams.

1. Open Diagram.net in your browser and click **Start.**

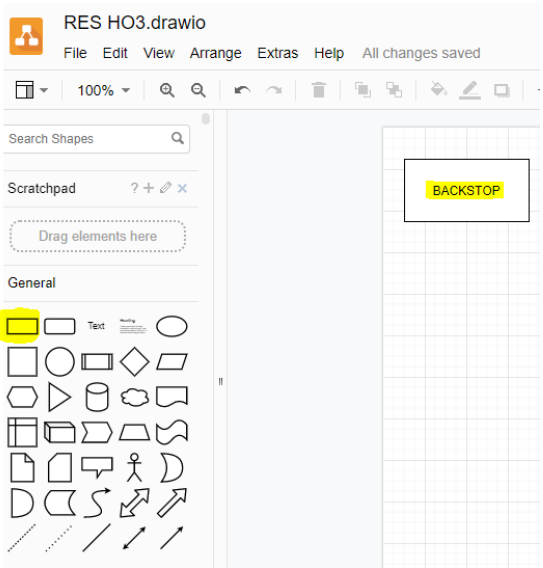
2. Click **Create New Diagram**



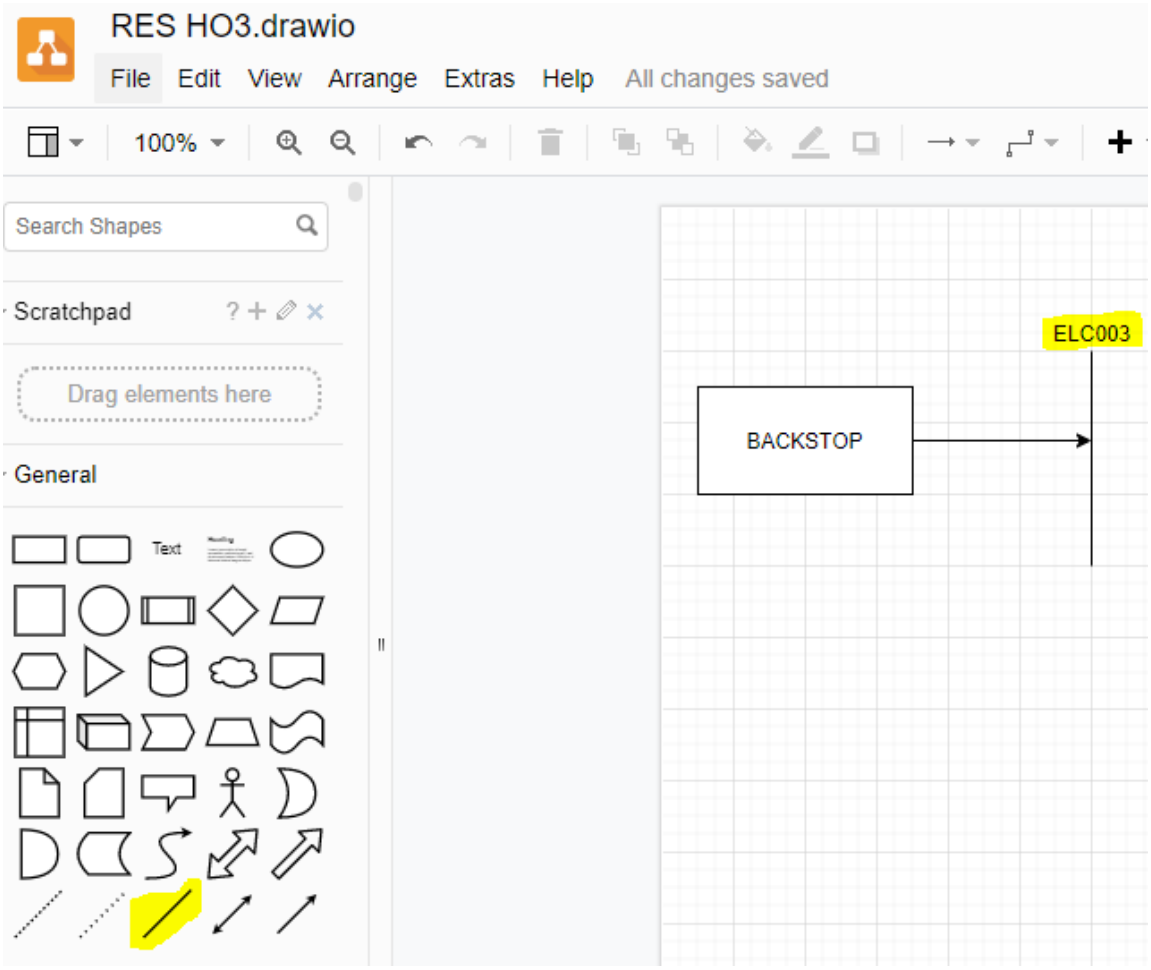
3. Change the Filename to "**HandsOn3.drawio**" and select '**Blank Diagram**'. Click on '**Create**' and save it in a folder of preference. **Tip**: create a folder for each Hands-On exercise of this course and keep building your RES, adding every piece proposed in the exercises.



4. On the left side of the tool, select a Rectangle from the General Group. Drag and drop it on the screen.
5. Double click in the middle of the **Rectangle** to add Text. Write **BACKSTOP**.



6. Let's draw the electricity demand. Select a **line** and drag and drop it on the right side of the Backstop technology. Bring your pointer on the right side of the rectangle and some **blue points** will appear. Click and drag until you reach the demand line, drawing an **arrow**. Double click on top of the demand line to add the code for the electricity demand: **ELC003** as per the **naming convention** guidelines explained in **Lecture 3**.



You have now drawn the first technology called **Backstop** and the final electricity demand (**ELC003**). The arrow that connects the two means that the output of the Backstop technology will address the final electricity demand (**ELC003**).

Define commodities

The next step is to add the names of our fuels in SAND Interface.

1. In the HO2 folder, make a copy of "**SAND_Interface_HO2**".
2. **Rename it as "SAND_Interface_HO3" and move it to a new HO3 folder** (by copying this file in the new Hands-On folder we will avoid having to re-add the data already saved in Hands-On 2). Therefore, after Hands-On 2, you will not use the SAND Interface template created by clicSAND, but you will keep adding data to what you have previously done.

   IMPORTANT: make copies when you move to the next HO and do not make edits on the same file. In this way if there is a problem, there is always a back-up version to easily find the error.

3. Go to the **SETS** Sheet. Click on Cell E3 and change the code from "**COM001**" to "**ELC003**"
4. Add a description in Cell F3 changing the text from "**Additional Fuel**" to "**Electricity after distribution**".

Commodities	
Code	*Description*
ELC003	Electricity after distribution
COM002	Additional Fuel
COM003	Additional Fuel
COM004	Additional Fuel
COM005	Additional Fuel

Tip: Repeat this process in the future to add names for other Commodities (Fuels).

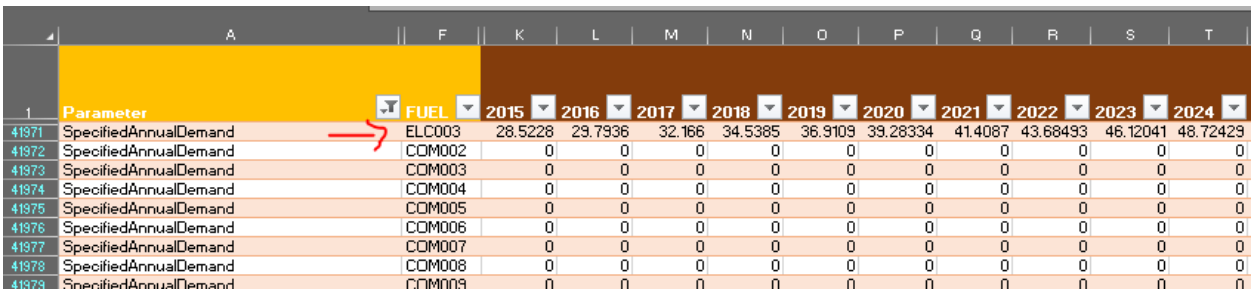
Define energy demands for a specific fuel

Your next task will be to choose the demand type. You have two options for demand type:

- **SpecifiedAnnualDemand** – used for fuels whose demand varies within the year/day e.g. electricity
- **AccumulatedAnnualDemand** – used for fuels that do not necessarily have to be provided at an exact point in time e.g. gasoline

We will add the demand for Electricity after distribution (**ELC003**).

1. Go to Parameters Sheet in SAND and filter out **SpecifiedAnnualDemand**.
2. Go on Cell K41971, correspondent to ELC003 (Fuel Column F).
3. Copy-paste the ELC003 demand data for the years 2015-2070. You can find the data in this Data_prep file (copy-paste only the data from the 'Specified Annual Demand' sheet, column J to column BN).



	A	F	K	L	M	N	O	P	Q	R	S	T
1	Parameter	FUEL	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
41971	SpecifiedAnnualDemand	ELC003	28.5228	29.7936	32.166	34.5385	36.9109	39.28334	41.4087	43.68493	46.12041	48.72429
41972	SpecifiedAnnualDemand	COM002	0	0	0	0	0	0	0	0	0	0
41973	SpecifiedAnnualDemand	COM003	0	0	0	0	0	0	0	0	0	0
41974	SpecifiedAnnualDemand	COM004	0	0	0	0	0	0	0	0	0	0
41975	SpecifiedAnnualDemand	COM005	0	0	0	0	0	0	0	0	0	0
41976	SpecifiedAnnualDemand	COM006	0	0	0	0	0	0	0	0	0	0
41977	SpecifiedAnnualDemand	COM007	0	0	0	0	0	0	0	0	0	0
41978	SpecifiedAnnualDemand	COM008	0	0	0	0	0	0	0	0	0	0
41979	SpecifiedAnnualDemand	COM009	0	0	0	0	0	0	0	0	0	0

Tip: For the same Commodity (Fuel) you should never add data for both **SpecifiedAnnualDemand** and **AccumulatedAnnualDemand**. Choose the type of demand associated with that fuel following the indications given in **Lecture 4**.

You now know how to add a **SpecifiedAnnualDemand**!

Define the temporal profile of energy demands

SpecifiedAnnualDemand is the parameter used to define a demand that changes within the year, as per the final electricity demand just seen (ELC003). Therefore, it now important to represent this time variability, and to do so we will use the **SpecifiedDemandProfile** parameter (as explained in Lecture 3).

If interested to know how the SpecifiedDemandProfile was calculated read this box

We divide the year into four representative seasons (Winter, Spring, Summer, and Autumn), further specifying the day-type (Day and Night for each of the four seasons). These eight representative day types are considered to have an equal length.

Therefore, the Year Split values for just 8 time slices are equal to ⅛ (0.125) for each timeslice and reported on the left side of the table below. The 8 numbers are then modified to obtain the Year Split values for all the 96 timeslices available in SAND.

Year Split			**Specified demand profile for electricity**	
TimeSlice	value		TimeSlice	ELC003
Winter Day	0.125		Winter Day	0.136
Winter Night	0.125		Winter Night	0.110
Spring Day	0.125		Spring Day	0.136
Spring Night	0.125		Spring Night	0.109
Summer Day	0.125		Summer Day	0.14
Summer Night	0.125		Summer Night	0.111
Autumn Day	0.125		Autumn Day	0.144
Autumn Night	0.125		Autumn Night	0.115

Following the same procedure, we now need to understand how the data for the **SpecifiedDemandProfile** was calculated for 8 timeslices and how to manipulate them to obtain a 96 time slices representation in SAND.

The data reported on the right side of the table were obtained from free hourly demand dataset called PLEXOS.

From these data we can see that the demand is higher during the Days and lower during Nights. Therefore, by using our data preparation spreadsheet we will calculate the percentage of average demand in each Time slice using the following formula:

[Specified demand profile (SD) / Year split (SD)] * Bennett Factor =

= [0.14/0.125] *0.999=112%

Data Manipulation					
Making adjustments for CCG SAND					
We'll assume equal season legnths (3 months each) and an average hourly split per season (24h)					
S1 will be winter, S2 will be spring, S3 will be summer, S4 will be autumn					
50%	or	12.0	hrs are in a summer night		
50%	or	12.0	hrs are in a winter night		
50%	or	12.0	hrs are in winter day		
50%	or	12.0	hrs are in summer day		
		% of average demand in each timeslice			
	Winter Day	109%			
	Winter Night	88%			
	Spring Day	109%			
	Spring Night	87%			
	Summer Day	112%			
	Summer Night	89%			
	Autumn Day	115%			

Now we need to pass from 8 time slices to 96 in SAND. To do so, you need to multiply the average percentage of demand in each timeslice for the year split duration of that time slice.

To give you an example:

21			% of average demand in each timeslice	
22		Winter Day	109%	
23		Winter Night	88%	
24		Spring Day	109%	
25		Spring Night	87%	
26		Summer Day	112%	
27		Summer Night	89%	
28		Autumn Day	115%	
29		Autumn Night	92%	
30				
31		Bennett Factor		0.999
32		Sum	1.0000	1.0000
33			Year Split	Specified Demand Profile
34	Winter Night	S101	0.0104	=C34*C23
35	Winter Night	S102	0.0104	0.0092

You will find the SpecifiedDemandProfile in the Data Preparation File (for all the 96 timeslices that we are using in SAND).

Let's add the demand profile to SAND.

1. Go to Parameters Sheet and filter out for SpecifiedDemandProfile parameter.
2. Go to Column F of the fuels and filter out for ELC003.
3. Go to Cell K42021 and copy-paste the data for the specified demand profile from the Data Preparation File (the data you need is in Cell D34 to D129)
4. Drag and drop until year 2070.
5. Save.

	A	F	G	K	L	M
1	Parameter	FUEL	TIMESLICE	2015	2016	2017
42021	SpecifiedDemandProfile	ELC003	S101	0.00919	0.00919	0.00919
42022	SpecifiedDemandProfile	ELC003	S102	0.00919	0.00919	0.00919
42023	SpecifiedDemandProfile	ELC003	S103	0.00919	0.00919	0.00919
42024	SpecifiedDemandProfile	ELC003	S104	0.00919	0.00919	0.00919
42025	SpecifiedDemandProfile	ELC003	S105	0.00919	0.00919	0.00919
42026	SpecifiedDemandProfile	ELC003	S106	0.00919	0.00919	0.00919
42027	SpecifiedDemandProfile	ELC003	S107	0.01132	0.01132	0.01132
42028	SpecifiedDemandProfile	ELC003	S108	0.01132	0.01132	0.01132
42029	SpecifiedDemandProfile	ELC003	S109	0.01132	0.01132	0.01132
42030	SpecifiedDemandProfile	ELC003	S110	0.01132	0.01132	0.01132
42031	SpecifiedDemandProfile	ELC003	S111	0.01132	0.01132	0.01132
42032	SpecifiedDemandProfile	ELC003	S112	0.01132	0.01132	0.01132
42033	SpecifiedDemandProfile	ELC003	S113	0.01132	0.01132	0.01132
42034	SpecifiedDemandProfile	ELC003	S114	0.01132	0.01132	0.01132
42035	SpecifiedDemandProfile	ELC003	S115	0.01132	0.01132	0.01132
42036	SpecifiedDemandProfile	ELC003	S116	0.01132	0.01132	0.01132
42037	SpecifiedDemandProfile	ELC003	S117	0.01132	0.01132	0.01132
42038	SpecifiedDemandProfile	ELC003	S118	0.01132	0.01132	0.01132
42039	SpecifiedDemandProfile	ELC003	S119	0.00919	0.00919	0.00919
42040	SpecifiedDemandProfile	ELC003	S120	0.00919	0.00919	0.00919
42041	SpecifiedDemandProfile	ELC003	S121	0.00919	0.00919	0.00919
42042	SpecifiedDemandProfile	ELC003	S122	0.00919	0.00919	0.00919
42043	SpecifiedDemandProfile	ELC003	S123	0.00919	0.00919	0.00919
42044	SpecifiedDemandProfile	ELC003	S124	0.00919	0.00919	0.00919
42045	SpecifiedDemandProfile	ELC003	S201	0.00905	0.00905	0.00905
42046	SpecifiedDemandProfile	ELC003	S202	0.00905	0.00905	0.00905
42047	SpecifiedDemandProfile	ELC003	S203	0.00905	0.00905	0.00905
42048	SpecifiedDemandProfile	ELC003	S204	0.00905	0.00905	0.00905
42049	SpecifiedDemandProfile	ELC003	S205	0.00905	0.00905	0.00905
42050	SpecifiedDemandProfile	ELC003	S206	0.00905	0.00905	0.00905
42051	SpecifiedDemandProfile	ELC003	S207	0.0113	0.0113	0.0113
42052	SpecifiedDemandProfile	ELC003	S208	0.0113	0.0113	0.0113
42053	SpecifiedDemandProfile	ELC003	S209	0.0113	0.0113	0.0113
42054	SpecifiedDemandProfile	ELC003	S210	0.0113	0.0113	0.0113
42055	SpecifiedDemandProfile	ELC003	S211	0.0113	0.0113	0.0113
42056	SpecifiedDemandProfile	ELC003	S212	0.0113	0.0113	0.0113
42057	SpecifiedDemandProfile	ELC003	S213	0.0113	0.0113	0.0113
42058	SpecifiedDemandProfile	ELC003	S214	0.0113	0.0113	0.0113
42059	SpecifiedDemandProfile	ELC003	S215	0.0113	0.0113	0.0113
42060	SpecifiedDemandProfile	ELC003	S216	0.0113	0.0113	0.0113
42061	SpecifiedDemandProfile	ELC003	S217	0.0113	0.0113	0.0113
42062	SpecifiedDemandProfile	ELC003	S218	0.0113	0.0113	0.0113
42063	SpecifiedDemandProfile	ELC003	S219	0.00905	0.00905	0.00905
42064	SpecifiedDemandProfile	ELC003	S220	0.00905	0.00905	0.00905
42065	SpecifiedDemandProfile	ELC003	S221	0.00905	0.00905	0.00905
42066	SpecifiedDemandProfile	ELC003	S222	0.00905	0.00905	0.00905
42067	SpecifiedDemandProfile	ELC003	S223	0.00905	0.00905	0.00905
42068	SpecifiedDemandProfile	ELC003	S224	0.00905	0.00905	0.00905
42069	SpecifiedDemandProfile	ELC003	S301	0.00925	0.00925	0.00925
42070	SpecifiedDemandProfile	ELC003	S302	0.00925	0.00925	0.00925
42071	SpecifiedDemandProfile	ELC003	S303	0.00925	0.00925	0.00925
42072	SpecifiedDemandProfile	ELC003	S304	0.00925	0.00925	0.00925

Naming | SETS | **Parameters** | ToDataFile

Tip: the sum of all the Year Split values for the 96 time slices should always be 1. The same is true for the SpecifiedDemandProfile values.

Define a simple technology that satisfies the demand (Backstop)

As explained in Lecture 4, Backstop technologies are a last resort option for the optimization solver, being fictitious technologies with extremely high cost. We will add a backstop technology with an output of electricity (ELC003) demand. Therefore, the backstop will be the only technology in the model able to supply the ELC003 demand we have added. To add the backstop, we need to add the data available here in the right place.

Try it: Add backstop technology

1. Go to Parameters Sheet and clear all the filters in case you didn't yet.
2. Go to SETS and in Cell B3 change "**TEC000**" to "**BACKSTOP**", and "**Additional Technology**" to "**Backstop Technology**".

	A	B	C	D	E	F
1		**Technologies**			**Commodities**	
2		*Code*	*Description*		*Code*	*Description*
3		BACKSTOP	Backstop Technology		ELC003	Electricity after distribution
4		TEC001	Additional Technology		COM002	Additional Fuel
		TEC002	Additional Technology		COM003	Additional Fuel

3. Go to the Parameters Sheet and filter out in Column C (Technology) for 'BACKSTOP'. You will now see all the parameters associated only to this technology.
4. You will need to add data in SAND as presented in the BACKSTOP Sheet of the data preparation file. Remember to copy-paste the values until 2070.

	A	B	C	D	E	F	G	H	I	J	K	L
143	CapacityFactor	RE1	BACKSTOP				S424			1	1	
144	CapacityOfOneT	RE1	BACKSTOP							0	0	
145	CapacityToActivi	RE1	BACKSTOP						1			
146	CapitalCost	RE1	BACKSTOP							9999999	9999999	999
147	EmissionActivity	RE1	BACKSTOP	EMICO2	1					0	0	
148	EmissionActivity	RE1	BACKSTOP	EMI002	1					0	0	
149	EmissionActivity	RE1	BACKSTOP	EMI003	1					0	0	
150	EmissionActivity	RE1	BACKSTOP	EMI004	1					0	0	
151	EmissionActivity	RE1	BACKSTOP	EMI005	1					0	0	
152	FixedCost	RE1	BACKSTOP							9999999	9999999	999
153	InputActivityRat	RE1	BACKSTOP		1	ELC003				0	0	
154	InputActivityRat	RE1	BACKSTOP		1	COM002				0	0	
155	InputActivityRat	RE1	BACKSTOP		1	COM003				0	0	
156	InputActivityRat	RE1	BACKSTOP		1	COM004				0	0	
157	InputActivityRat	RE1	BACKSTOP		1	COM005				0	0	
158	InputActivityRat	RE1	BACKSTOP		1	COM006				0	0	
159	InputActivityRat	RE1	BACKSTOP		1	COM007				0	0	
160	InputActivityRat	RE1	BACKSTOP		1	COM008				0	0	

Raw Data | (0) SETS | (2) Specified Annual Demand | (3) YearSplit & Profiles | BACKSTOP

5. Save your Excel file.

Tip: check cells highlighted in blue and be sure that the correspondent cell in SAND has that number! Make use of as many filters as needed for the input data process.

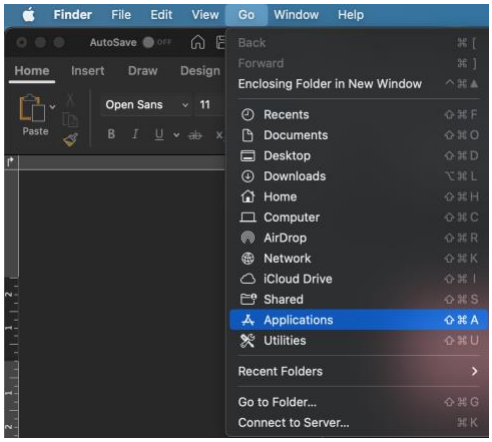
Run the model and check results on production by technology

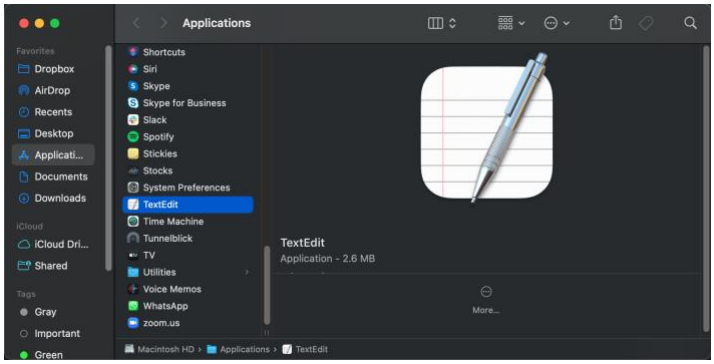
It's time to run our first model.

1. Go to the 'SETS' sheet. Paste the path of the folder you'd like your results to be saved in. This could be the HO3 folder.

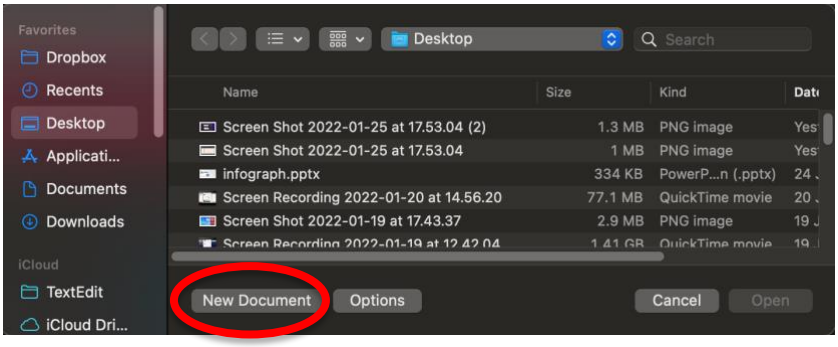
Emissions	
Code	*Description*
EMIC02	Emission factor for CO2
EMICH4	Emission factor for methane
EMIFGA	Emission factor for Fluorinated gases
EMIN2O	Emission factor for Nitrous Oxide
EMIREN	Emission factor for RET targets
Region	
RE1	Region 1
ResultsPath "C:\..\res\csv" (change it before running)	
:="/Users/naomitan/Desktop/CCG/Training/2a OSeMOSYS/Hands-On/HO3";	

2. Go to the 'ToDataFile' sheet on the SAND interface.
3. Click on the top left corner of the spreadsheet. This will select all the data within the sheet. Alternatively, you can press on the **command key (⌘) + A**.
4. Once highlighted, right click – copy. Alternatively, you can press on the **command key (⌘) + C.**
5. Now go to your 'Applications' folder and open an app called TextEdit. You will already have this app by default.

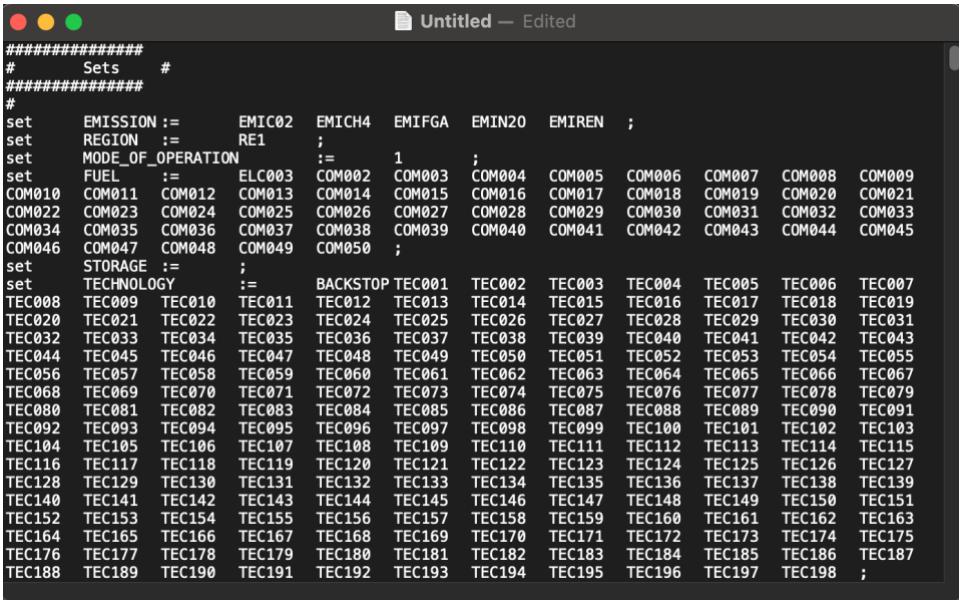




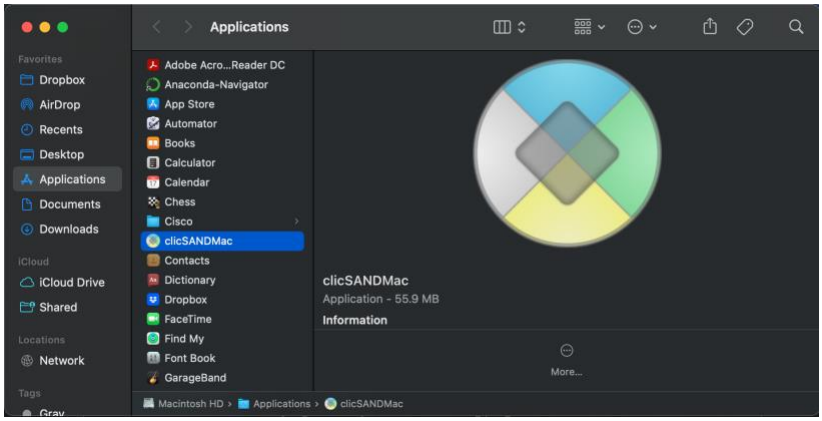
6. Click on 'New Document'.



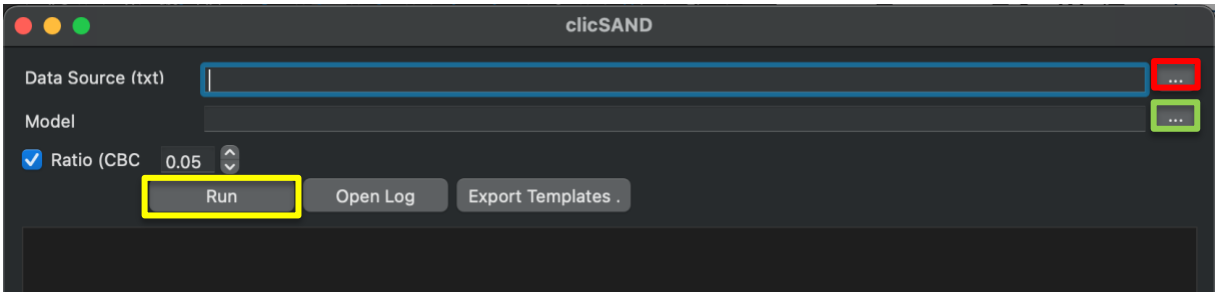
7. Once in TextEdit, right click – paste your data from the SAND interface. Alternatively, you can press on the **command key (⌘) + V.**



8. Save your new TextEdit file with a sensible name (i.e. **HO3_data**) in your new HO3 folder and close it. We now have a .txt file.
9. Now go to your 'Applications' folder and open clicSANDMac



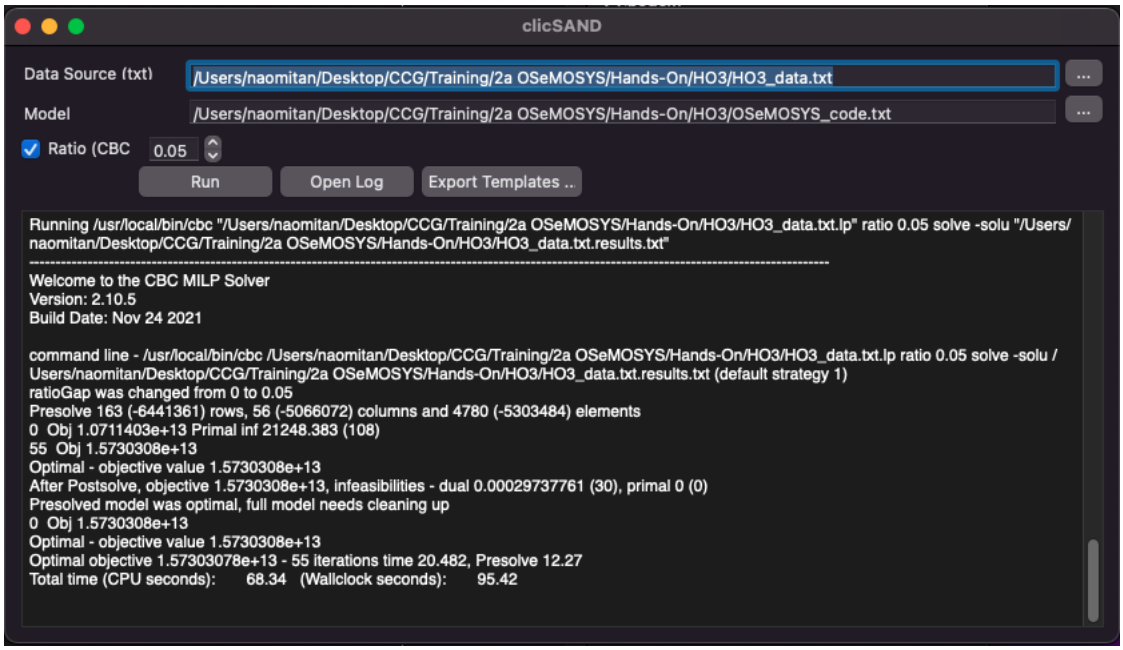
10. The screen below will show up. The button highlighted in red allows you to select the data txt file you want to run. **In this case**, we want to choose **HO3_data.txt**. The button highlighted in green allows you to select the model txt file. **In all cases**, we must choose **OSeMOSYS_code.txt**. You can obtain this coded txt file by clicking on 'Export Templates …' – as explained in Hands-On 2.



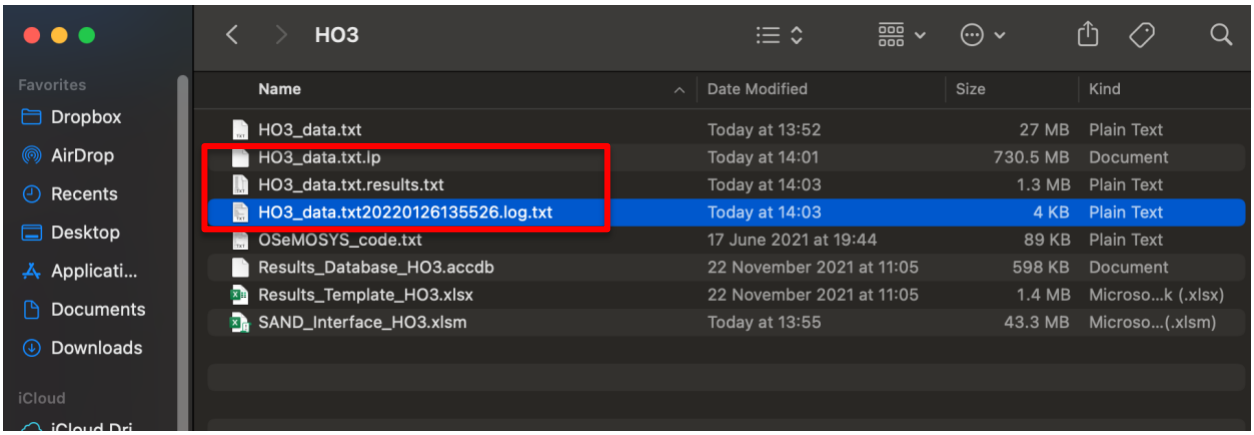
11. When you have selected these two files, click on RUN. This is the button highlighted in yellow. **TIP:** Close any high memory (or disk) consuming programs for a faster run.

12. Now wait…. The solvers (glpsol and cbc) will run the txt file with the OSeMOSYS code to find the optimal solution.

13. You will see this on clicSANDMac if the run is successful.



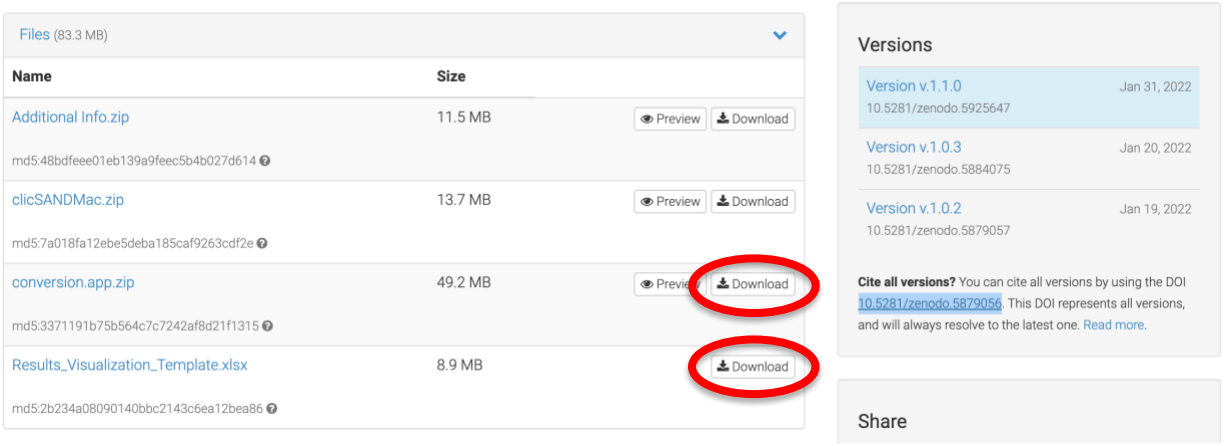
14. You will now see three new files in your HO3 folder.



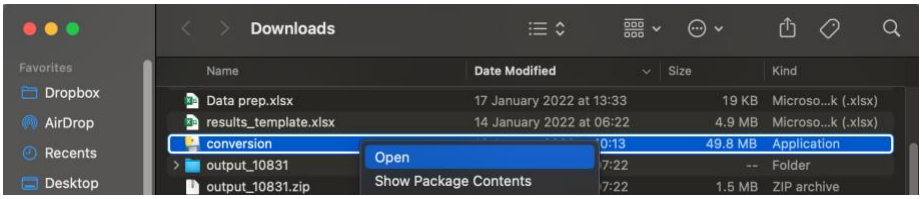
Results Visualization

We will now visualize the results from the model run.

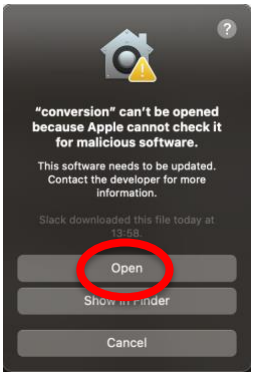
1. Go to this link to download conversion.app.zip and Results_Visualization_Template.xlsx



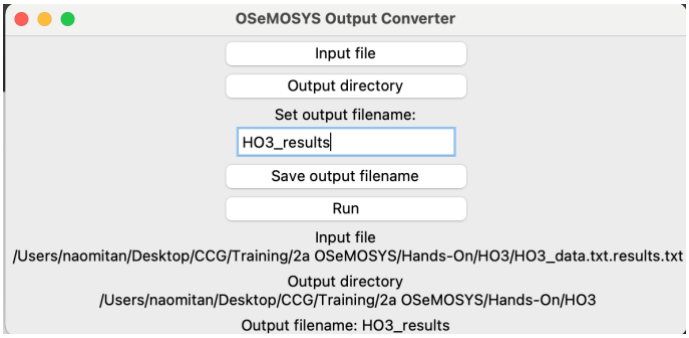
2. Once downloaded, unzip and right-click to open the conversion.app.zip file. This file will convert our results txt file to a csv file.



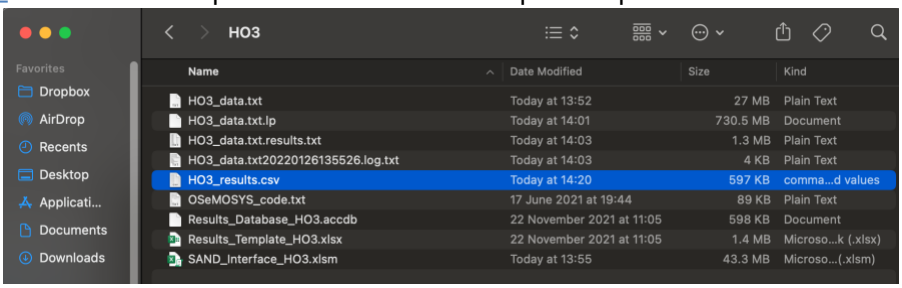
3. Click on 'Open'.



4. A window will pop-up. Click on 'Input file' and choose '**HO3_data.txt.results.txt**'. For 'Output directory', choose your HO3 folder. Now choose an output name. In this case, we can write "**HO3_results**". Now click on 'Save output filename'.



5. Click on 'Run' to finish. You will have a csv file in your HO3 folder called "**HO3_results.csv**". Open this file. This will open a spreadsheet.

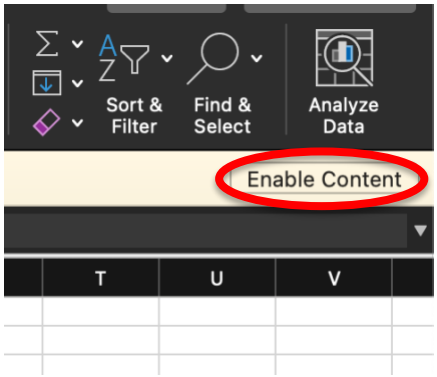


6. Click on Cell A2. Now press on the **command key (⌘) + shift + right arrow + right arrow + down arrow.** This will select all the data in Columns A to L, without the header row.

	A	B	C	D	E	F	G	H	I	J	K	L
1	Variable	Dim1	Dim2	Dim3	Dim4	Dim5	Dim6	Dim7	Dim8	Dim9	Dim10	ResultValue
2	NewCapacity	RE1	BACKSTOP	2015								32.825383
3	NewCapacity	RE1	BACKSTOP	2016								1.4625206
4	NewCapacity	RE1	BACKSTOP	2017								2.7303177
5	NewCapacity	RE1	BACKSTOP	2018								2.7303062
6	NewCapacity	RE1	BACKSTOP	2019								2.7303177
7	NewCapacity	RE1	BACKSTOP	2020								2.7303062
8	NewCapacity	RE1	BACKSTOP	2021								2.4459777
9	NewCapacity	RE1	BACKSTOP	2022								2.6195831
10	NewCapacity	RE1	BACKSTOP	2023								2.8028672
11	NewCapacity	RE1	BACKSTOP	2024								2.99667
12	NewCapacity	RE1	BACKSTOP	2025								3.2018202
13	NewCapacity	RE1	BACKSTOP	2026								4.1304394
14	NewCapacity	RE1	BACKSTOP	2027								4.414998
15	NewCapacity	RE1	BACKSTOP	2028								4.7184076
16	NewCapacity	RE1	BACKSTOP	2029								5.0417729
17	NewCapacity	RE1	BACKSTOP	2030								5.3864978

7. Copy the data by pressing **command key (⌘) + C.**
8. Now open the newly downloaded Results_Visualization_Template.xlsx file.

9. In the top ribbon, click on 'Enable Content'.



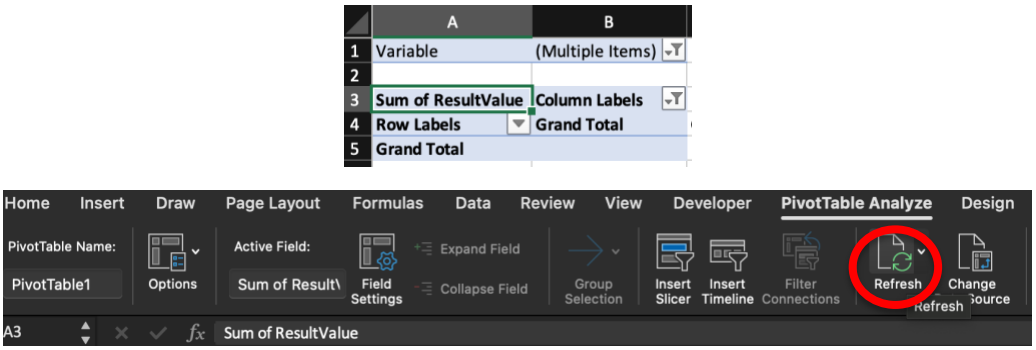
10. Click on Cell A2 and press on the **command key (⌘) + shift + right arrow + right arrow + down arrow** to highlight all the data in Columns A to L, without the header row. Now click on the delete key to delete the values.

	A	B	C	D	E	F	G	H	I	J	K	L
1	Variable	Dir	Dim2	Dim3	Dim4	Dir	Dir	Dim7	Dir	Dir	Dim	ResultValu
2	NewCapacity	RE1	MINOIL	2018								750.43416
3	NewCapacity	RE1	MINOIL	2019								750.43416
4	NewCapacity	RE1	MINOIL	2020								750.43416
5	NewCapacity	RE1	MINOIL	2021								725.41968
6	NewCapacity	RE1	MINOIL	2022								700.40521
7	NewCapacity	RE1	MINOIL	2023								675.39074
8	NewCapacity	RE1	MINOIL	2024								650.37627
9	NewCapacity	RE1	MINOIL	2025								625.3618
10	NewCapacity	RE1	MINOIL	2026								625.3618
11	NewCapacity	RE1	MINOIL	2027								625.3618
12	NewCapacity	RE1	MINOIL	2028								625.3618
13	NewCapacity	RE1	MINOIL	2029								625.3618
14	NewCapacity	RE1	MINOIL	2030								625.3618
15	NewCapacity	RE1	MINOIL	2031								625.3618
16	NewCapacity	RE1	MINOIL	2032								625.3618
17	NewCapacity	RE1	MINOIL	2033								625.3618
18	NewCapacity	RE1	MINOIL	2034								587.364
19	NewCapacity	RE1	MINOIL	2035								625.3618
20	NewCapacity	RE1	MINOIL	2036								625.3618
21	NewCapacity	RE1	MINOIL	2037								625.3618
22	NewCapacity	RE1	MINOIL	2038								625.3618
23	NewCapacity	RE1	MINOIL	2039								625.3618
24	NewCapacity	RE1	MINOIL	2040								600.34732
25	NewCapacity	RE1	MINOIL	2041								540.31259
26	NewCapacity	RE1	MINOIL	2042								531.74199
27	NewCapacity	RE1	MINOIL	2043								560.32417
28	NewCapacity	RE1	MINOIL	2044								480.27786
29	NewCapacity	RE1	MINOIL	2045								300.17366

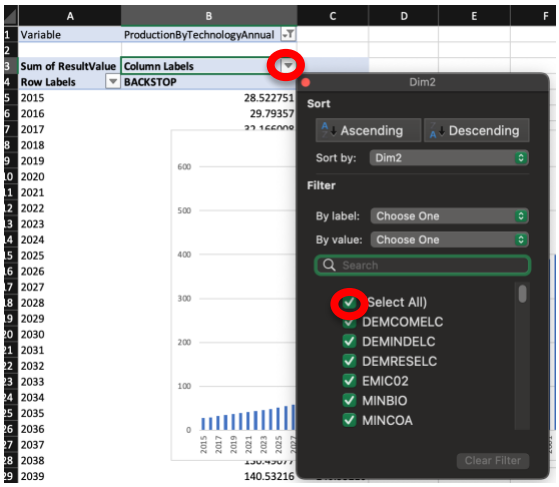
11. In a now empty Cell A2, paste the data with the **command key (⌘) + V.**

	A	B	C	D	E	F	G	H	I	J	K	L
1	Variable	Dir	Dim2	Dim3	Dim4	Dir	Dir	Dim7	Dir	Dir	Dim	ResultValu
2	NewCapacity	RE1	BACKSTOP	2015								32.825383
3	NewCapacity	RE1	BACKSTOP	2016								1.4625206
4	NewCapacity	RE1	BACKSTOP	2017								2.7303177
5	NewCapacity	RE1	BACKSTOP	2018								2.7303062
6	NewCapacity	RE1	BACKSTOP	2019								2.7303177
7	NewCapacity	RE1	BACKSTOP	2020								2.7303062
8	NewCapacity	RE1	BACKSTOP	2021								2.4459777
9	NewCapacity	RE1	BACKSTOP	2022								2.6195831
10	NewCapacity	RE1	BACKSTOP	2023								2.8028672
11	NewCapacity	RE1	BACKSTOP	2024								2.99667
12	NewCapacity	RE1	BACKSTOP	2025								3.2018202
13	NewCapacity	RE1	BACKSTOP	2026								4.1304394
14	NewCapacity	RE1	BACKSTOP	2027								4.414998
15	NewCapacity	RE1	BACKSTOP	2028								4.7184076
16	NewCapacity	RE1	BACKSTOP	2029								5.0417729
17	NewCapacity	RE1	BACKSTOP	2030								5.3864978
18	NewCapacity	RE1	BACKSTOP	2031								5.9418971

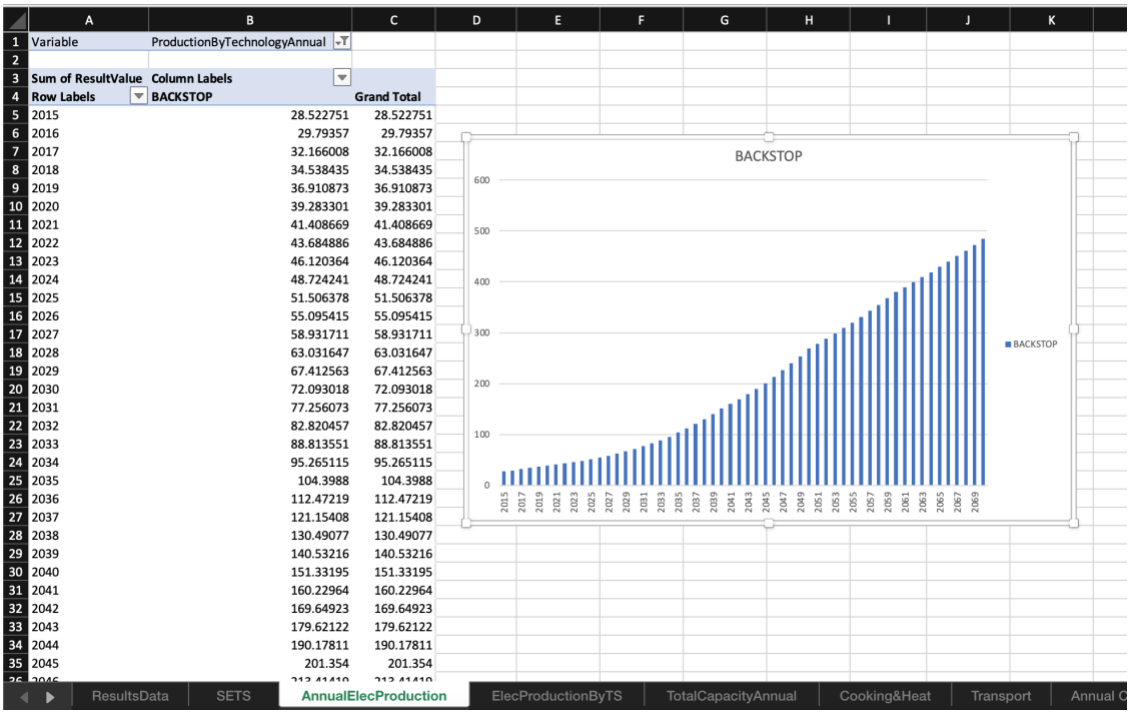
12. We will first visualize Annual Electricity Production. Go to the 'AnnualElecProduction' Sheet. Click on Cell A3. 'PivotTable Analyze' should show up in the ribbon. Click on this, then click on 'Refresh'.



13. Now go to the filter setting of 'Column Labels' in Cell B3 and tick 'Select All'.



14. You will be able to see a table and a graph. Your results for Annual Electricity Production from this exercise are now visualized! Save the file as **results_visualization_HO3.xlsx**



In this graph, you will see that the only technology producing electricity is the BACKSTOP. This is because it is the only technology that we added in our energy system to provide ELC003.

15. You will also notice that this file is made of different Sheets for each of the variable we want to obtain results for:

Annual Electricity Production	Electricity Production by Timeslice	Annual Total Capacity	Cooking & Heat
Transport	Annual CO2	Annual CO2 by Technology	Demand
Annual Fixed Operating Costs	Annual Variable Operating Costs	Capital Investment	

The steps are the same for the above graphs.