Energy and Flexibility Modelling

Hands-on 2

Please use the following citation for:

- **This exercise**

Cannone, Carla, Allington, Lucy, & Howells, Mark. (2021, March). Hands-on 2: Energy and Flexibility Modelling (Version 3.1.). Zenodo. https://doi.org/10.5281/zenodo.4605256

- **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: HO2

Learning outcomes

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

1. Create a new model in SAND Interface
2. Learn the main functionalities of SAND Interface
3. Define the duration of Time slices
4. Add Year Split values

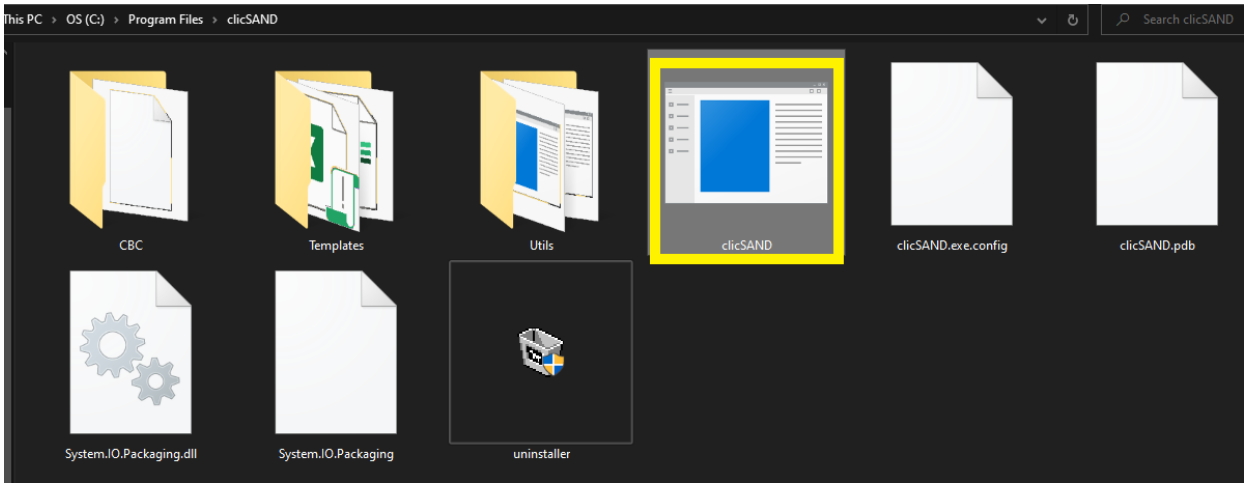
5. Check Depreciation Method and Discount Rate values

Create a new model

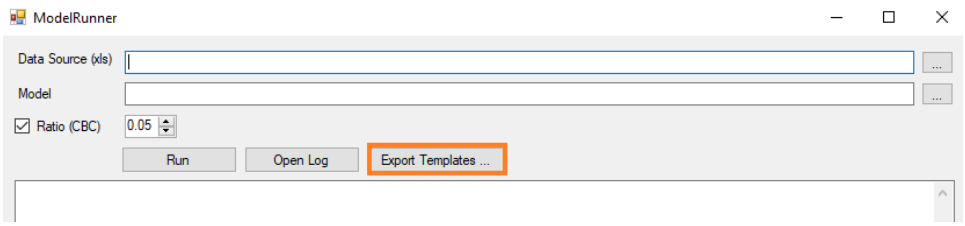
After installing the software and downloading the files needed (as for **Hands-on 1**) you are ready to create your first model in OSeMOSYS using the interface named SAND. This is an Excel-based (Macro-Enabled) file where you can input the data needed for OSeMOSYS to find the optimal solution to your problem. Let's learn how to save and manage your files.

Try it:

1. We will start by creating a folder called "**HO2**" for this Hands-on 2.
2. Then open the **clicSAND** folder -> double click on the **clicSAND.**



3. Click on "**Export Templates**" (highlighted in orange) to the HO2 folder in you created.



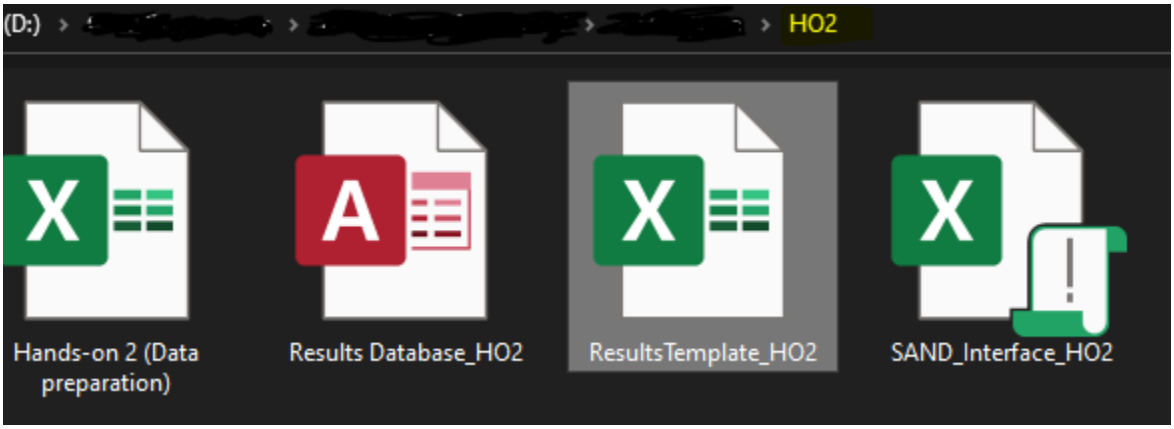
This will automatically save a blank copy of:

a. SAND Interface (Excel Macro Enabled Workbook)
b. Results Database (Access database to store the results obtained)
c. Results Template (Excel Macro Enabled Workbook)
d. OSeMOSYS_code_Hands-on (Text file)

Please rename these files as:

a. **SAND_Interface_HO2**
b. **Results_Database_HO2**
c. **Results_Template_HO2**
d. The code will be the same for all the exercise so there is no need to rename it

Watch out: Every time you make substantial changes to your model, save it as a new version in the correspondent folder. For example, if I want to test different options in my Hands-on 2 file, I will create a new file in the folder Hands-on 2 called "**SAND_Interface_HO2_v2**" and so on.



Repeat these steps for each Hands-on (New folder-> ModelRunner-> ExportTemplates in the HOX folder)

Important: The files should not be saved or sync in One Drive for clicSAND to work

Voilà: you now know how to manage your folders and files!

Main functionalities of SAND Interface

Now the next step is learning how to use SAND Interface. **Don't worry**, it looks more complicated than it really is.

SETS, **Parameters** and **ToDataFile** Sheets represent the core of the Interface, and they are entirely interconnected to each other.

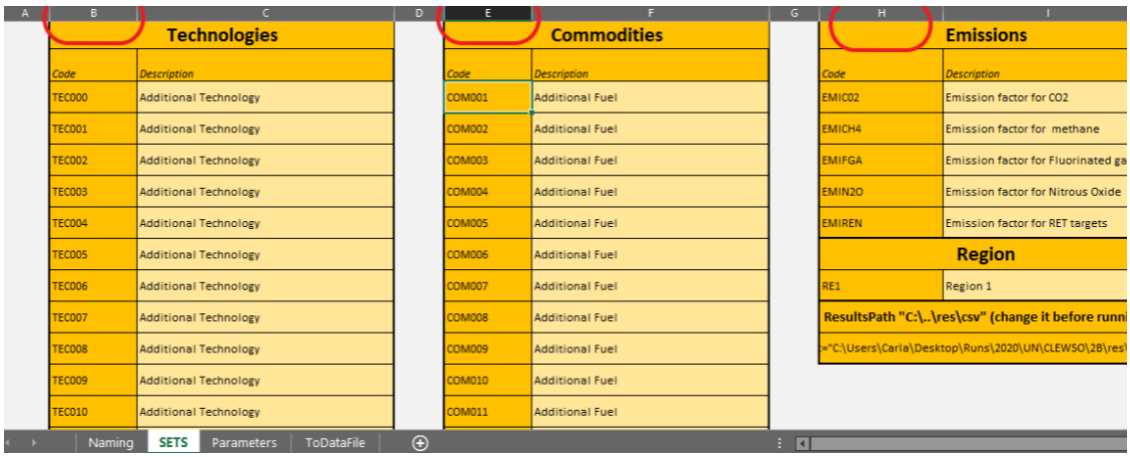
Try it: let's move around and check what we can do in each of these Sheets:

1. **SETS** - this is the place where you can define the name of your **Technologies** (in column B), **Commodities** (in column E) and **Emissions** (in column H).

These three columns are linked to the "ToDataFile" Sheet that has the format needed by the solver to find the optimal solution. Therefore, whenever you specify the name of a Technology, Commodity or Emission in these columns, it is automatically reported in the respective cell in the ToDataFile Sheet.

> You have the freedom to change names **as many times as necessary** without losing the data previously added for that specific entry.

Watch out: Technologies, Commodities and Emissions codes in your model should be named following the guidelines explained in **Lecture 3**.



Technologies	
Code	Description
TEC000	Additional Technology
TEC001	Additional Technology
TEC002	Additional Technology
TEC003	Additional Technology
TEC004	Additional Technology
TEC005	Additional Technology
TEC006	Additional Technology
TEC007	Additional Technology
TEC008	Additional Technology
TEC009	Additional Technology
TEC010	Additional Technology

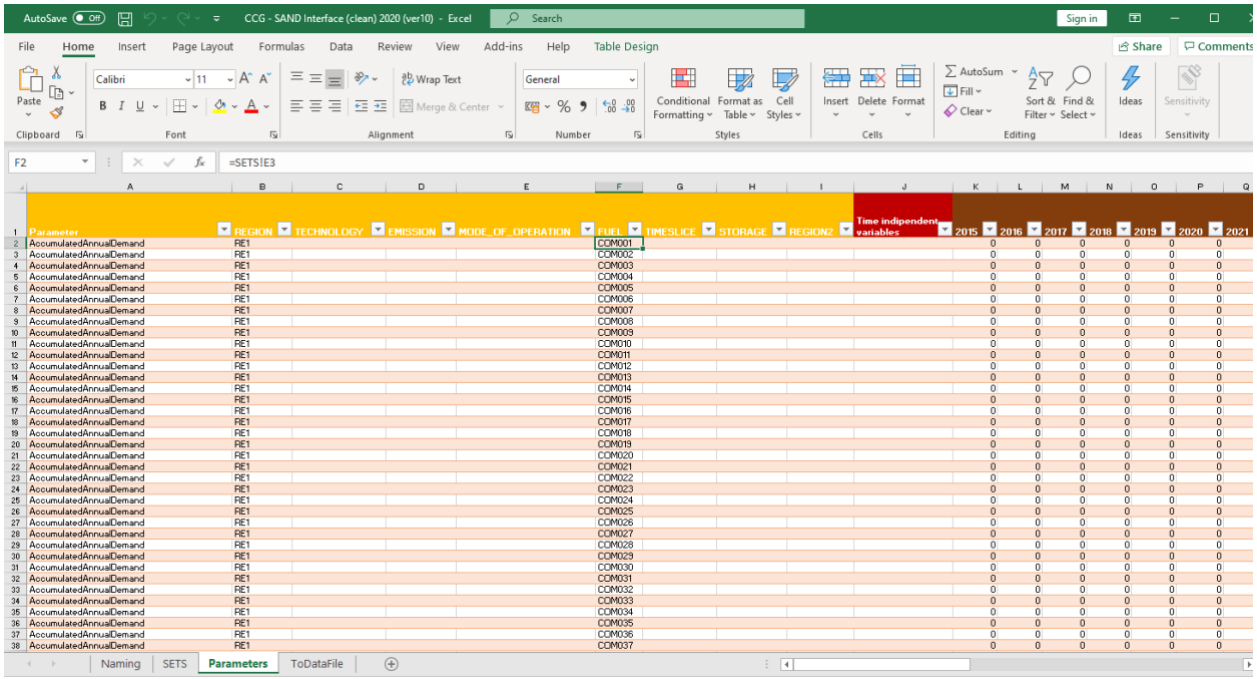
Commodities	
Code	Description
COM001	Additional Fuel
COM002	Additional Fuel
COM003	Additional Fuel
COM004	Additional Fuel
COM005	Additional Fuel
COM006	Additional Fuel
COM007	Additional Fuel
COM008	Additional Fuel
COM009	Additional Fuel
COM010	Additional Fuel
COM011	Additional Fuel

Emissions	
Code	Description
EMIC02	Emission factor for CO2
EMICH4	Emission factor for methane
EMIFGA	Emission factor for Fluorinated ga
EMIN2O	Emission factor for Nitrous Oxide
EMIREN	Emission factor for RET targets
Region	
RE1	Region 1
ResultsPath "C:\..\res\csv" (change it before runni	
="C:\Users\Carla\Desktop\Runs\2020\UN\CLEWSO\2B\res	

Naming | SETS | Parameters | ToDataFile

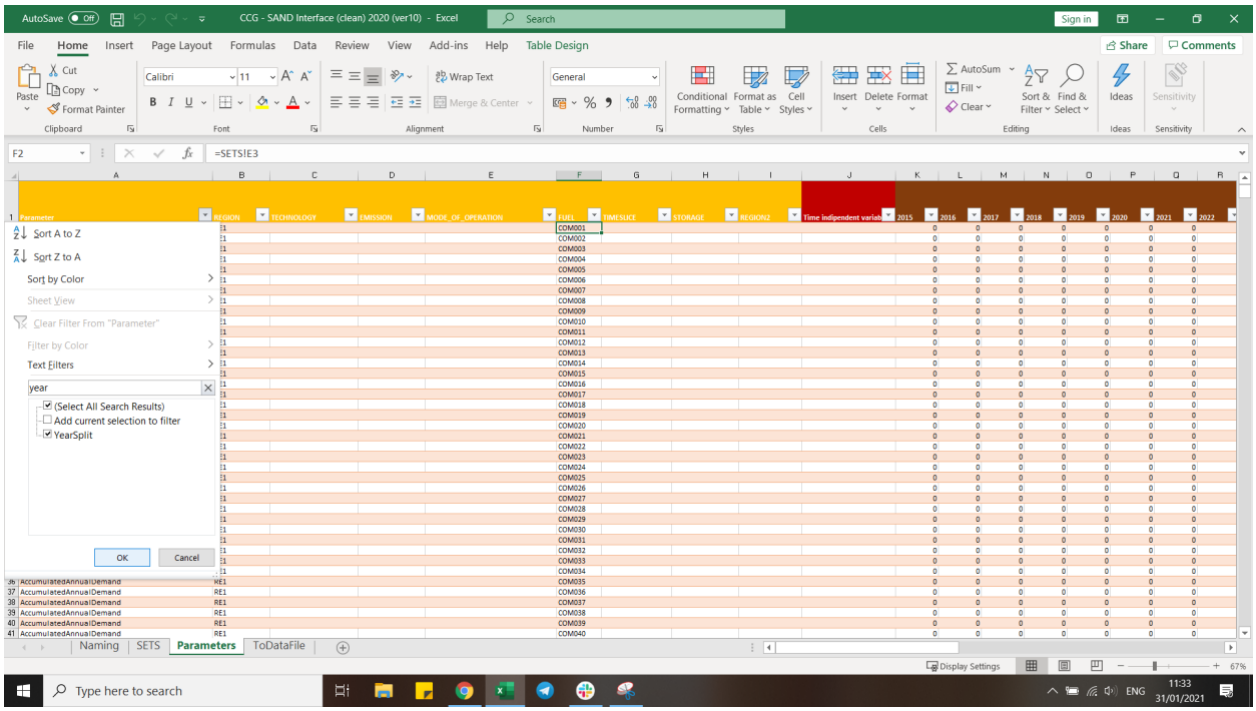
2. **Parameters** - this is a giant Sheet where you will be adding data for each OSeMOSYS parameter. To make things easier and faster for you, there are filters at the top of each column where you can filter for either **Parameter (column A),**

Technology (Column C), Commodities/Fuel (Column F). Columns K to BN is where you can insert data from 2015 to 2070.

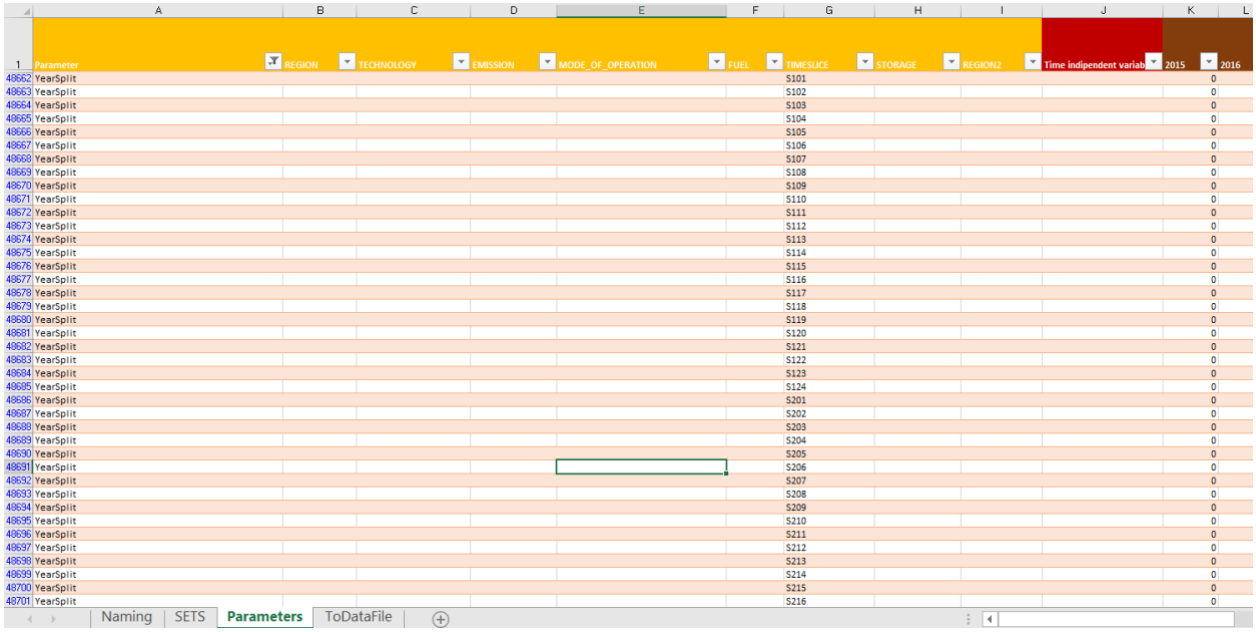


Parameter	REGION	TECHNOLOGY	EMISSION	MODE_OF_OPERATION	FUEL	TIMESLICE	STORAGE	REGION2	Time indipendent variables	2015	2016	2017	2018	2019	2020	2021
AccumulatedAnnualDemand	RE1				COM001					0	0	0	0	0	0	0
AccumulatedAnnualDemand	RE1				COM002					0	0	0	0	0	0	0
AccumulatedAnnualDemand	RE1				COM003					0	0	0	0	0	0	0
AccumulatedAnnualDemand	RE1				COM004					0	0	0	0	0	0	0
AccumulatedAnnualDemand	RE1				COM005					0	0	0	0	0	0	0
AccumulatedAnnualDemand	RE1				COM006					0	0	0	0	0	0	0
AccumulatedAnnualDemand	RE1				COM007					0	0	0	0	0	0	0
AccumulatedAnnualDemand	RE1				COM008					0	0	0	0	0	0	0
AccumulatedAnnualDemand	RE1				COM009					0	0	0	0	0	0	0
AccumulatedAnnualDemand	RE1				COM010					0	0	0	0	0	0	0
AccumulatedAnnualDemand	RE1				COM011					0	0	0	0	0	0	0
AccumulatedAnnualDemand	RE1				COM012					0	0	0	0	0	0	0
AccumulatedAnnualDemand	RE1				COM013					0	0	0	0	0	0	0
AccumulatedAnnualDemand	RE1				COM014					0	0	0	0	0	0	0
AccumulatedAnnualDemand	RE1				COM015					0	0	0	0	0	0	0
AccumulatedAnnualDemand	RE1				COM016					0	0	0	0	0	0	0
AccumulatedAnnualDemand	RE1				COM017					0	0	0	0	0	0	0
AccumulatedAnnualDemand	RE1				COM018					0	0	0	0	0	0	0
AccumulatedAnnualDemand	RE1				COM019					0	0	0	0	0	0	0
AccumulatedAnnualDemand	RE1				COM020					0	0	0	0	0	0	0
AccumulatedAnnualDemand	RE1				COM021					0	0	0	0	0	0	0
AccumulatedAnnualDemand	RE1				COM022					0	0	0	0	0	0	0
AccumulatedAnnualDemand	RE1				COM023					0	0	0	0	0	0	0
AccumulatedAnnualDemand	RE1				COM024					0	0	0	0	0	0	0
AccumulatedAnnualDemand	RE1				COM025					0	0	0	0	0	0	0
AccumulatedAnnualDemand	RE1				COM026					0	0	0	0	0	0	0
AccumulatedAnnualDemand	RE1				COM027					0	0	0	0	0	0	0
AccumulatedAnnualDemand	RE1				COM028					0	0	0	0	0	0	0
AccumulatedAnnualDemand	RE1				COM029					0	0	0	0	0	0	0
AccumulatedAnnualDemand	RE1				COM030					0	0	0	0	0	0	0
AccumulatedAnnualDemand	RE1				COM031					0	0	0	0	0	0	0
AccumulatedAnnualDemand	RE1				COM032					0	0	0	0	0	0	0
AccumulatedAnnualDemand	RE1				COM033					0	0	0	0	0	0	0
AccumulatedAnnualDemand	RE1				COM034					0	0	0	0	0	0	0
AccumulatedAnnualDemand	RE1				COM035					0	0	0	0	0	0	0
AccumulatedAnnualDemand	RE1				COM036					0	0	0	0	0	0	0
AccumulatedAnnualDemand	RE1				COM037					0	0	0	0	0	0	0

Try it: in **Column A**, filter for **Parameters** -> Tick **Year Split** -> OK. You will see that now only data associated with the parameter called Year Split are shown on the table. You can add as many filters as wanted. Play around with filters and get confident with this functionality!



And this is what you will see if you filter out for the Parameter **Year Split**:



You see that from column K to column BN there are default values added: in this case 0. We will add data for the year split at the end of this hands-on.

3. **ToDataFile** - this Sheet has the format needed by the solver to find the optimal solution to your problem.

Watch out: never add data to this **ToDataFile** Sheet - data should only be added to the **Parameters** and **SETS** sheets. The interface is made up in a way that all the entries will be automatically read by the **ToDataFile** sheet.

4. **Naming** – here you will find the description of the parameters used in SAND Interface. We are not going to use all the parameters listed here.

Define the duration of time slices

To carry out a modelling exercise with OSeMOSYS, it is necessary to assign values to the set called **Timeslices**, which represents periods of the year with a similar demand. In this model, the year was initially divided into 4 timeslices, representing two periods of 6 months (two representative seasons) each of which has similar demand, further sub-divided into day and night periods, called: **Summer Day (SD)**, **Summer Night (SN)**, **Winter Day (WD)**, **Winter Night (WN)**.

However, in SAND Interface it is possible to define up to 96 timeslices, so these initial data were manipulated to obtain a 24-hour representation of a reference day for each of SD, SN, WD, and WN (24 hours each * 4 = 96 timeslices). Therefore, each year is divided into 96 periods instead of the previous 4.

It was assumed each season has an equal length, with an average hourly split per season (24h representative). Therefore obtaining:

4 Seasons/year * 24h of a representative day/season = **96 Timeslices/Year**

Each Timeslice represents an equal fraction of the Year in the following way, defined as the Year Split:

1 Year / 96 Timeslices = 0.0104

Therefore, you should add this number to the Year Split column for each year.

Watch out! To help you deal with all the data, there is a **Data Preparation Spreadsheet** that will allow you to copy-paste the data in a faster way. Click on the link and below the preview you will see the tab called "Files". Click Download next to **Data_Prep_HO2.xlsx**

IMPORTANT: Unfortunately, you cannot copy paste all the data in one go, so you need to copy paste each line individually. This is because, when filters are applied, Excel will not copy-paste the data into the correct rows of the spreadsheet if multiple lines are copy-pasted at the same time. Therefore, if you select all the data at once, instead of line-by-line, you will add data for completely wrong parameters and the model will not work.

To help you with this task, check the blue cells in the Data preparation file that highlight the data you need to change every time.

Add Year Split values

After defining the duration of each time slice and calculating the Year Split profile we need to add these values in SAND Interface.

Try it: let's add the data for Year Split.

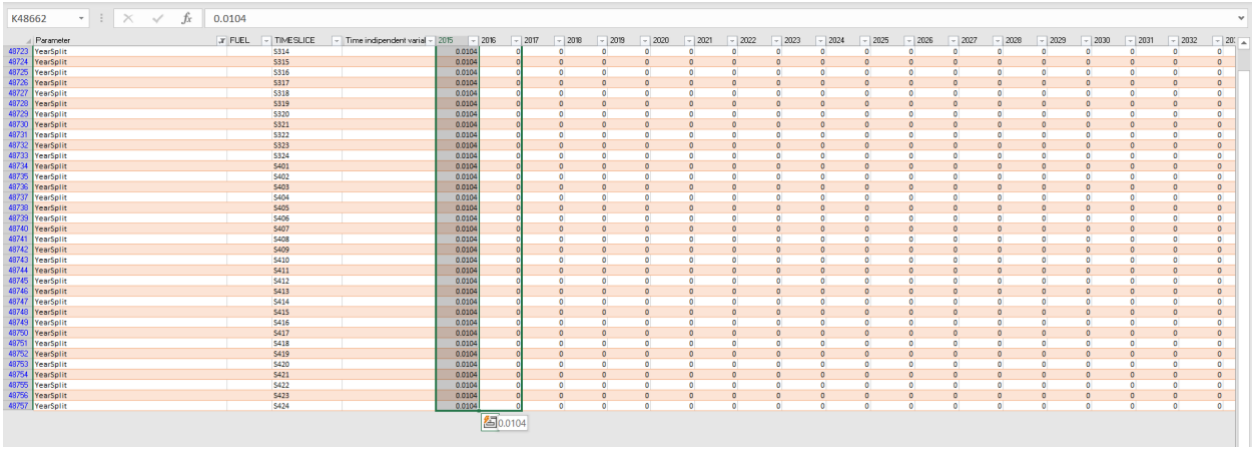
1. Go in Parameters Sheet and filter for **Year Split** (in Column A).
2. Copy-paste data obtained in Column C of the **Data Preparation File** to Column K of SAND interface, corresponding to the year 2015.

   IMPORTANT: right click on Cell K48662 and **PASTE VALUES (second icon from the left).**

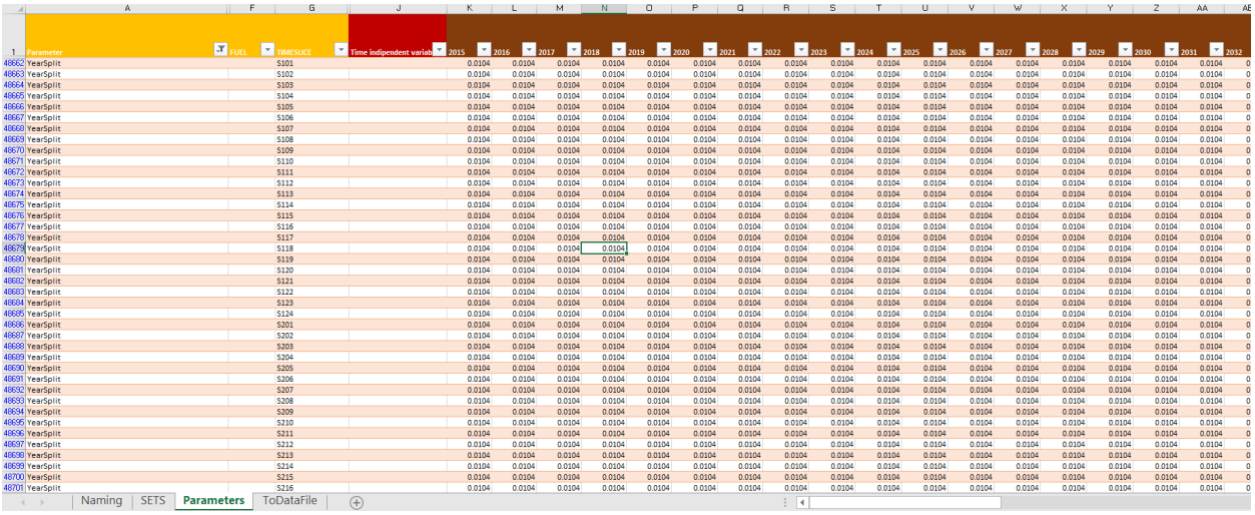
	A	F	G	J	K	L	M	N
1	Parameter	FUEL	TIMESLICE	Time indipendent variab	2015	2016	2017	2018
48662	YearSplit		S101		0.0104	0	0	0
48663	YearSplit		S102		0.0104	0	0	0
48664	YearSplit		S103		0.0104	0	0	0
48665	YearSplit		S104		0.0104	0	0	0
48666	YearSplit		S105		0.0104	0	0	0
48667	YearSplit		S106		0.0104	0	0	0
48668	YearSplit		S107		0.0104	0	0	0
48669	YearSplit		S108		0.0104	0	0	0
48670	YearSplit		S109		0.0104	0	0	0
48671	YearSplit		S110		0.0104	0	0	0
48672	YearSplit		S111		0.0104	0	0	0
48673	YearSplit		S112		0.0104	0	0	0
48674	YearSplit		S113		0.0104	0	0	0
48675	YearSplit		S114		0.0104	0	0	0
48676	YearSplit		S115		0.0104	0	0	0
48677	YearSplit		S116		0.0104	0	0	0
48678	YearSplit		S117		0.0104	0	0	0
48679	YearSplit		S118		0.0104	0	0	0
48680	YearSplit		S119		0.0104	0	0	0
48681	YearSplit		S120		0.0104	0	0	0
48682	YearSplit		S121		0.0104	0	0	0
48683	YearSplit		S122		0.0104	0	0	0
48684	YearSplit		S123		0.0104	0	0	0
48685	YearSplit		S124		0.0104	0	0	0
48686	YearSplit		S201		0.0104	0	0	0
48687	YearSplit		S202		0.0104	0	0	0
48688	YearSplit		S203		0.0104	0	0	0
48689	YearSplit		S204		0.0104	0	0	0
48690	YearSplit		S205		0.0104	0	0	0
48691	YearSplit		S206		0.0104	0	0	0
48692	YearSplit		S207		0.0104	0	0	0
48693	YearSplit		S208		0.0104	0	0	0
48694	YearSplit		S209		0.0104	0	0	0
48695	YearSplit		S210		0.0104	0	0	0
48696	YearSplit		S211		0.0104	0	0	0
48697	YearSplit		S212		0.0104	0	0	0
48698	YearSplit		S213		0.0104	0	0	0
48699	YearSplit		S214		0.0104	0	0	0
48700	YearSplit		S215		0.0104	0	0	0
48701	YearSplit		S216		0.0104	0	0	0

Naming | SETS | **Parameters** | ToDataFile

3. Go to Cell K48662; click **ctrl+alt+down-arrow** to select only the data in column K. Drag and drop to copy them for the other years by moving to the right side until column BK for the year 2070.



You should have now added the Year Split values for all 96 time slices available in SAND Interface for every model year from 2015-2070.



Voilà: you added the data for the parameter Year Split from 2015 to 2070

Check Depreciation Method and Discount Rate values

We will leave default values for Depreciation Method and Discount Rate. In the future, you are free to change them following these steps.

Try it:

1. Go to **Parameters** Sheet -> In Column A filter out for "**Depreciation Method**" and "**Discount Rate**" parameters -> click **OK**. You will see the following. Do not change these numbers, we will use these defaults values.

	A	B	J	K	L	M	N	O	P
1	Parameter	REGION	Time indipendent variables	2015	2016	2017	2018	2019	2020
19962	DepreciationMethod	RE1	1						
19963	DiscountRate	RE1	0.1						

The depreciation method will have a value of 1 and the discount rate of 0.1 (10% discount rate). These are time independent variables; you will therefore see their value in Column J.

When a variable is time dependent instead, no values will be in Column J and there will be a value for each of the modelling years (Column K to Column BN).

Name	Description
YearSplit	Duration of a modelled time slice, expressed as a fraction of the year. The sum of each entry over one modelled year should equal 1.
DiscountRate	Region specific value for the discount rate, expressed in decimals (e.g. 0.1)
DepreciationMethod	Binary parameter defining the type of depreciation to be applied. It has value 1 for sinking fund depreciation, value 2 for straight-line depreciation.