



Assessing Power System Flexibility with IRENA FlexTool

Hands-on 1

Please use the following citation for:

- **This exercise**

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- **FlexTool software**

IRENA. (2020). FlexTool (Version v2.0.0). https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Nov/IRENA_FlexTool_v_2_0.zip

Learning outcomes

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

- 1) Install and use FlexTool on your computer
- 2) Become familiar with the tool interface and different files
- 3) Run a model on your computer and get the result file



About FlexTool

N.B. To use FlexTool, users must have Microsoft Excel installed on their machines.

IRENA FlexTool is a software package developed by IRENA and the VTT Technical Research Centre of Finland, published under the GNU Lesser General Public License (LGPL). Users are free to modify and redistribute the software under the terms of the LGPL. New versions will be published on irena.org. The main objective of the tool is to enable quick—yet thorough—assessments of potential flexibility gaps and to identify the most cost-effective mix of options to address them.

Activity 1 – Installing FlexTool

There are a few easy steps for Installing FlexTool :

1. Downloading FlexTool and extracting to disk

- a) Download FlexTool from the following link to IRENA's website:
https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Nov/IRENA_FlexTool_v_2_0.zip
- b) FlexTool can be run from anywhere on the computer. Therefore you can save the file in any place on your computer. Here we install FlexTool on "c:\FlexTool". Create a folder named "FlexTool" in your C drive and extract the downloaded zip file to it. We will call this the "root folder".

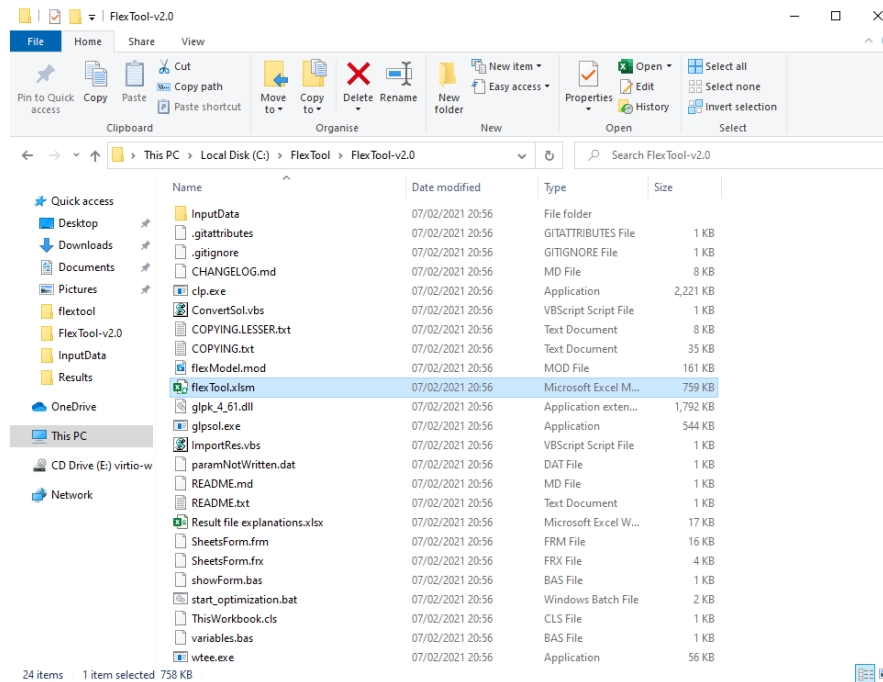
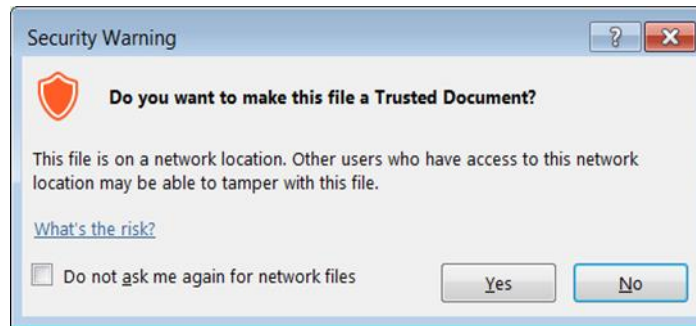


Figure 1: FlexTool root folder. The main interface file **flexTool.xlsx** is highlighted. The input file can be found in the **InputData** folder

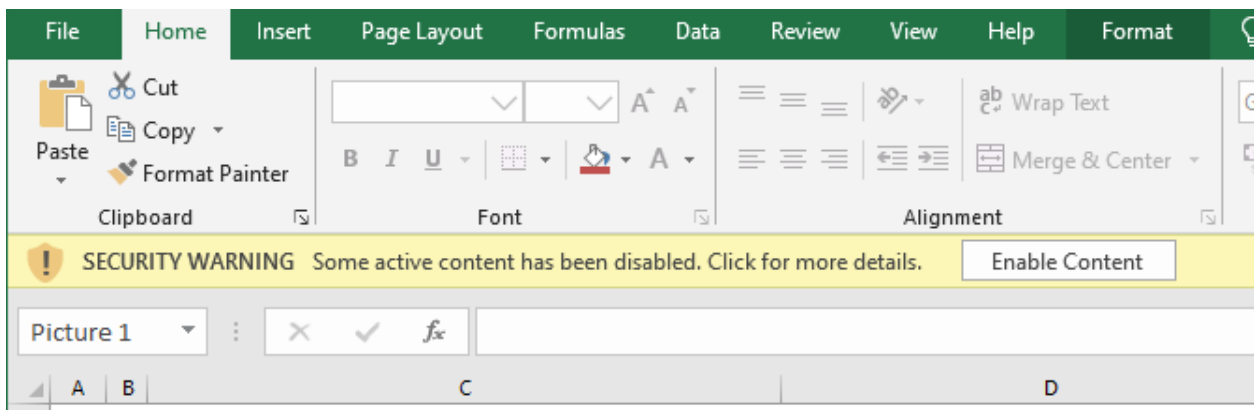
- c) The extracted folder contains an InputData folder where you can find input excel workbooks, the executable files and the main interface of the tool which is an excel file named **flexTool.xlsx** (highlighted in Figure 1).

2. Enabling macros in the main worksheet

- a) From the root folder, open “flexTool.xlsx” excel file.
- b) You may be asked if you trust the document. Click “yes”



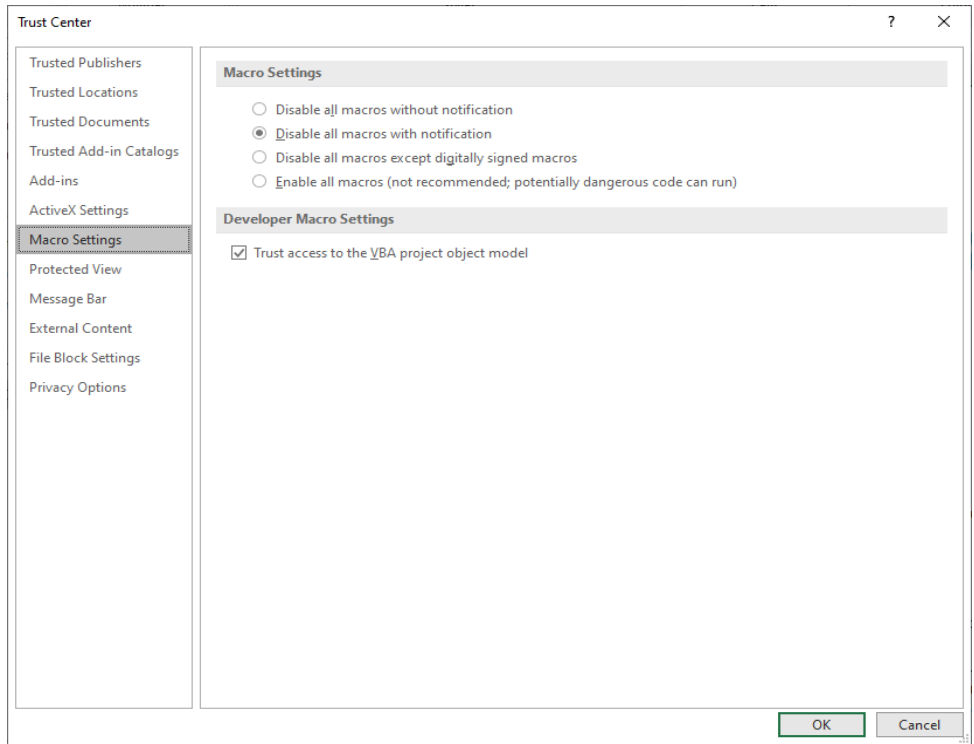
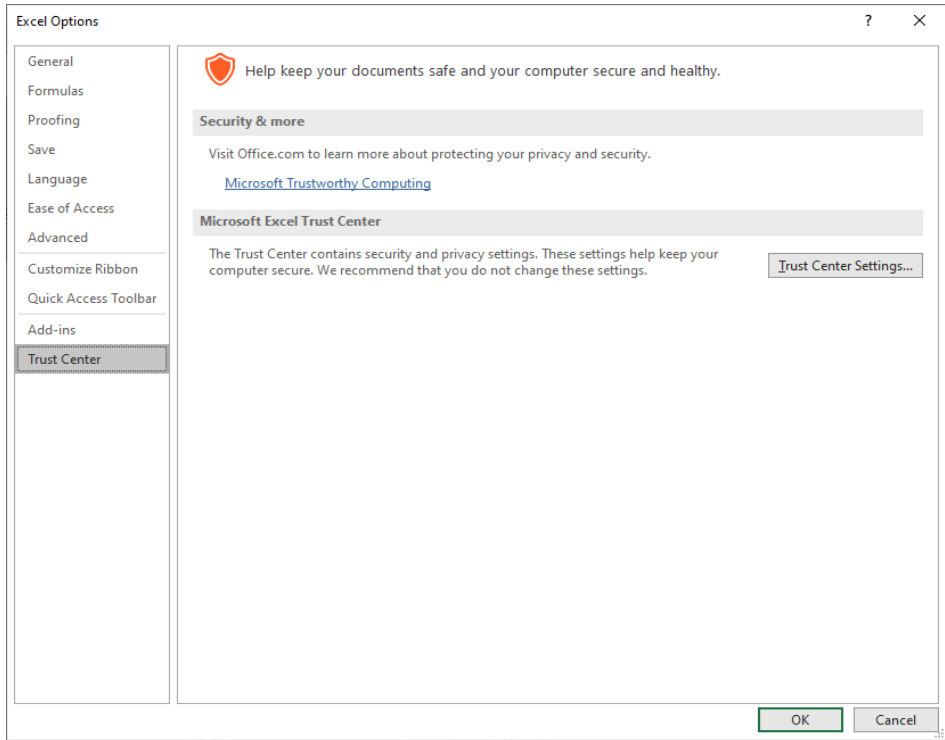
c) After opening the file you should enable content of the workbook.



d) Enable macros:

1. From excel menu go to "File" -> "Options".
2. Then from the left pane select "Trust Center"
3. Click on "Trust Center Settings"
4. A new window will open. From the left pane select "Macro Settings"
5. Enable "Trust access to the VBA project object model"
6. Click "OK" to save settings and close.

Note: These steps are needed only for the first time you run the tool.

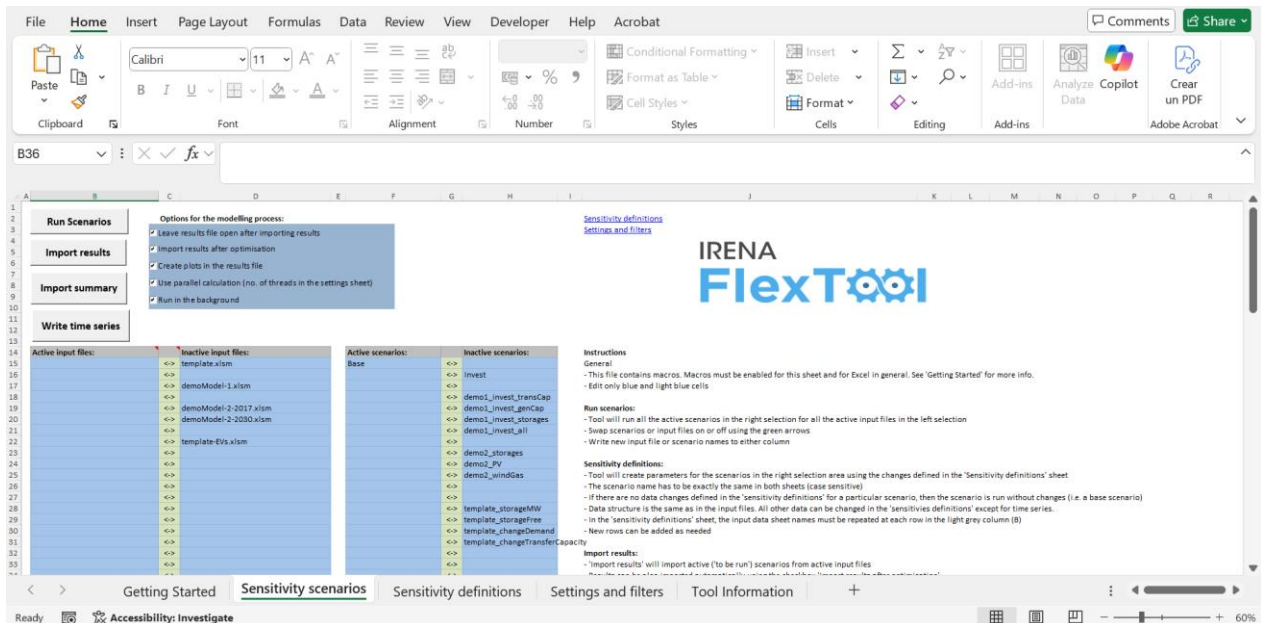


The main files

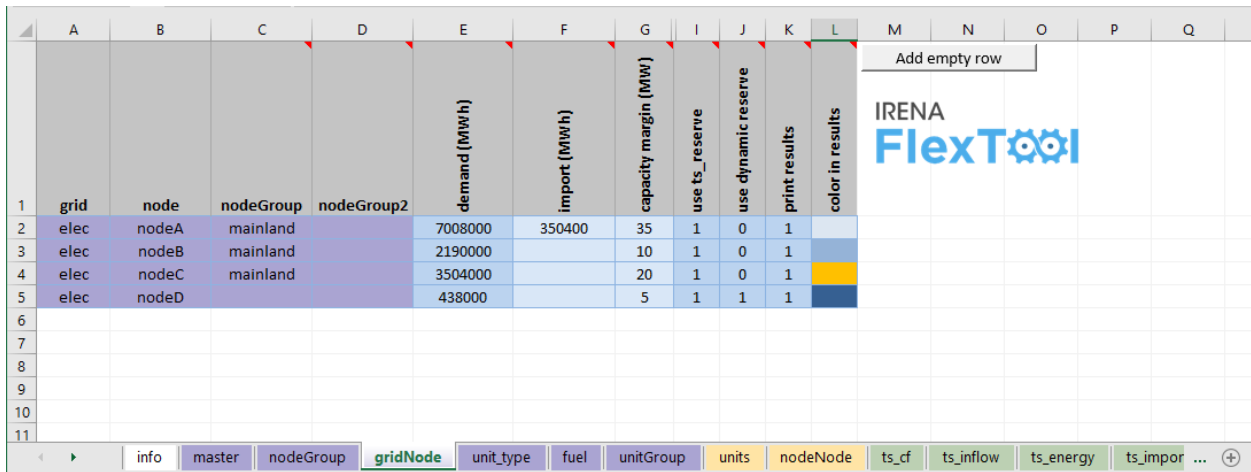
The tool includes three main MS Excel files:

- The main flexTool.xlsm file
- Input data files
- Result files

1) **The flexTool.xlsm** file acts as the interface to the tool. It is used to select the model and scenario used in the simulation, start running the model, and defining the sensitivity cases in “Sensitivity definitions” sheet.

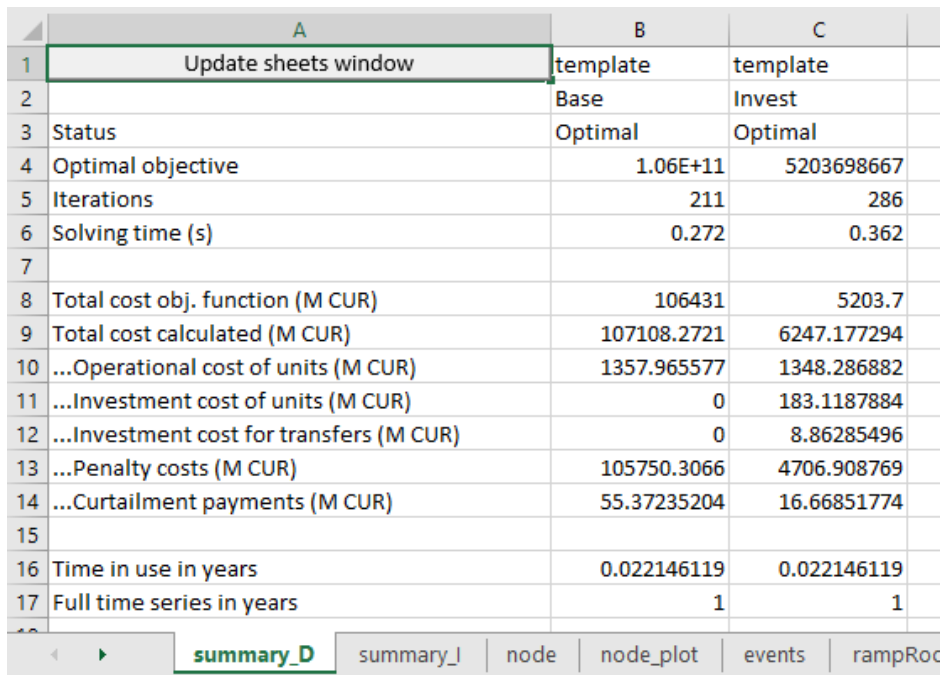


2) **Input file:** In FlexTool the Input data file define the model version. The flexTool.xlsm file is the same for all countries or regions, but input data is unique and case specific. Therefore every case, region or model year needs its own input data file (e.g., Thailand 2019, Thailand 2030).

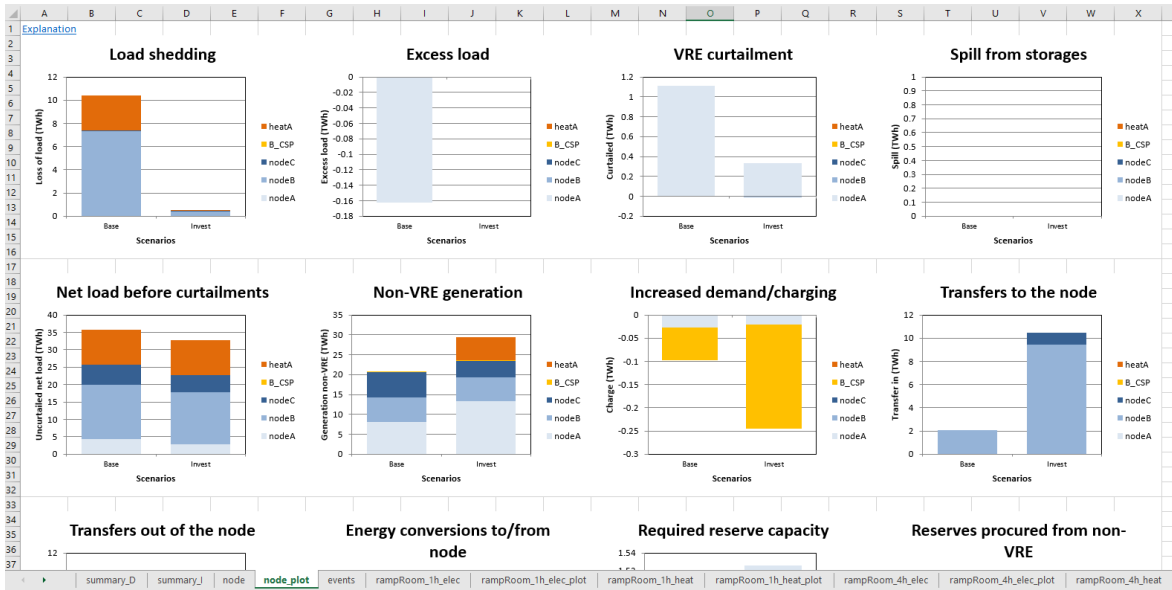


	A	B	C	D	E	F	G	I	J	K	L
1	grid	node	nodeGroup	nodeGroup2	demand (MWh)	import (MWh)	capacity margin (MW)	use ts_reserve	use dynamic reserve	print results	color in results
2	elec	nodeA	mainland		7008000	350400	35	1	0	1	
3	elec	nodeB	mainland		2190000		10	1	0	1	
4	elec	nodeC	mainland		3504000		20	1	0	1	
5	elec	nodeD			438000		5	1	1	1	

3) **Result output files:** The results file includes a diverse range of results for all the scenarios. Users have the possibility to show only one scenario or to compare results from multiple scenarios. Once you run the model a result folder is generated in the root folder which contains the result output excel files.



	A	B	C
1	Update sheets window	template	template
2		Base	Invest
3	Status	Optimal	Optimal
4	Optimal objective	1.06E+11	5203698667
5	Iterations	211	286
6	Solving time (s)	0.272	0.362
7			
8	Total cost obj. function (M CUR)	106431	5203.7
9	Total cost calculated (M CUR)	107108.2721	6247.177294
10	...Operational cost of units (M CUR)	1357.965577	1348.286882
11	...Investment cost of units (M CUR)	0	183.1187884
12	...Investment cost for transfers (M CUR)	0	8.86285496
13	...Penalty costs (M CUR)	105750.3066	4706.908769
14	...Curtailment payments (M CUR)	55.37235204	16.66851774
15			
16	Time in use in years	0.022146119	0.022146119
17	Full time series in years	1	1



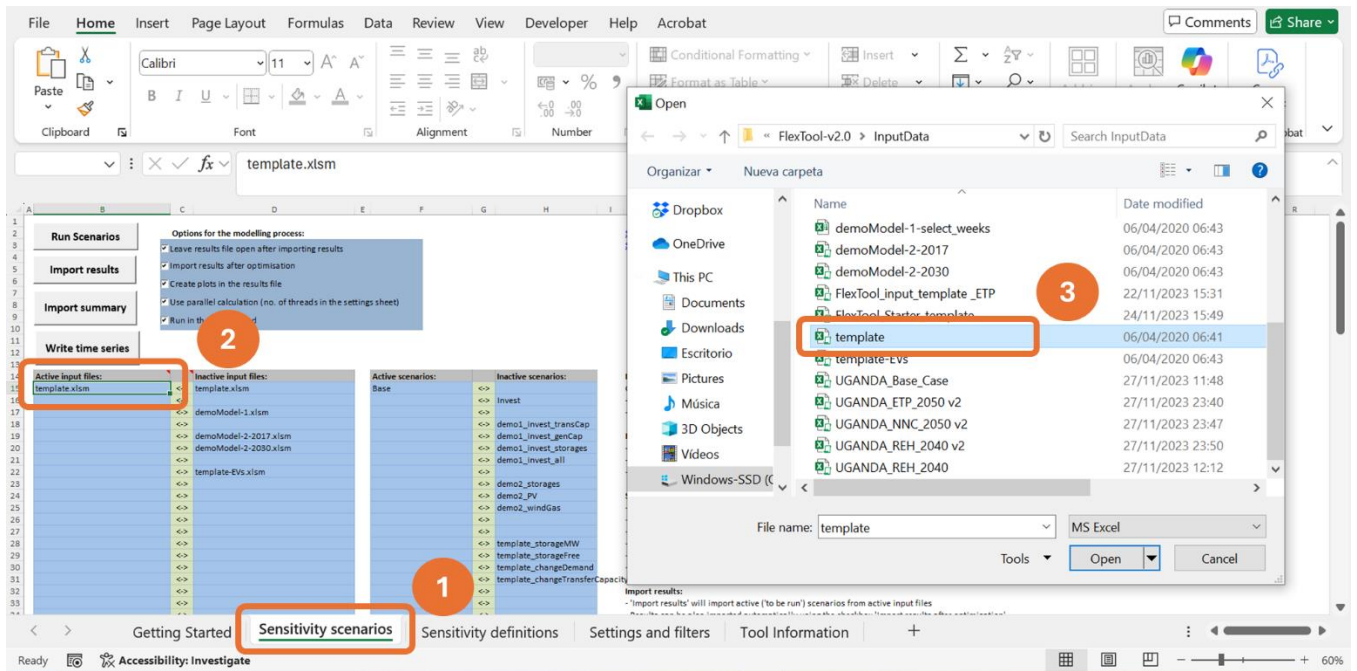
Activity 2 – Running a model

As we said in FlexTool, the input data file will define the model version. A few models and templates are included in the package and you can read them from “InputData” folder in the root folder.

- “template.xlsm” is the template to create new models
- “template-XX.xlsm” are additional example templates with specific technologies
- Other input data files such as country-specific or versions for different years demo models

To run a model:

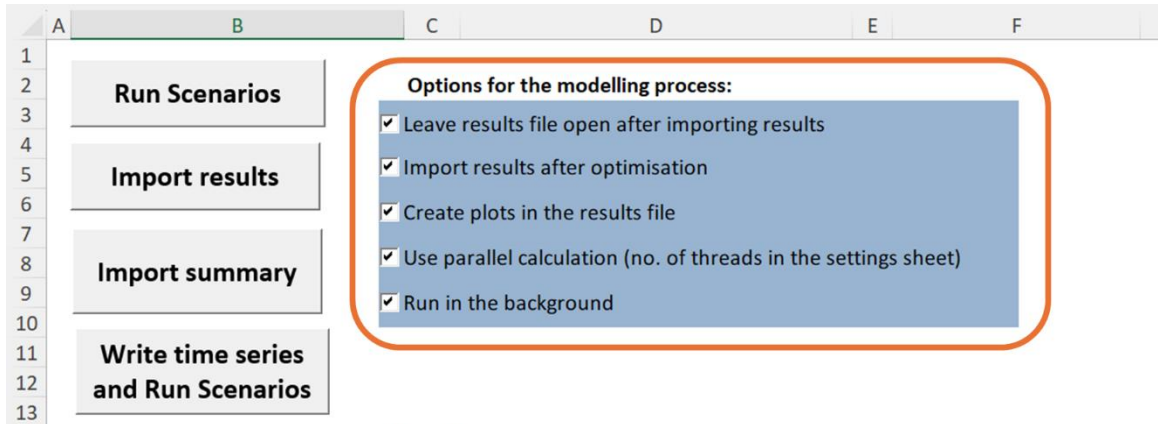
- Open the interface worksheet (“flexTool.xlsm”). Make sure macros are enabled as explained above.
- Navigate to “Sensitivity scenarios” sheet.
- Click on the first cell in “Active input files” column.
- A file picker opens. Select “template.xlsm” from InputData folder and click “Open”.



- In “Active Scenarios” column, activate the “Base” scenario.
- You can toggle scenarios active or inactive by clicking on the green arrow (“<->”).
- Only scenarios in the “Active Scenarios” column will be run by the model.

Active scenarios:		Inactive scenarios:
Base	<->	
	<->	Invest
	<->	
	<->	demo1_invest_transCap
	<->	demo1_invest_genCap
	<->	demo1_invest_storages
	<->	demo1_invest_all
	<->	
	<->	demo2_storages
	<->	demo2_PV
	<->	demo2_windGas
	<->	
	<->	

- In “Options for the modelling process” you can set various processing options



If the option is enabled, after a successful execution of the model results file is automatically opened. In any case, results are automatically saved in “Results” folder in root directory.

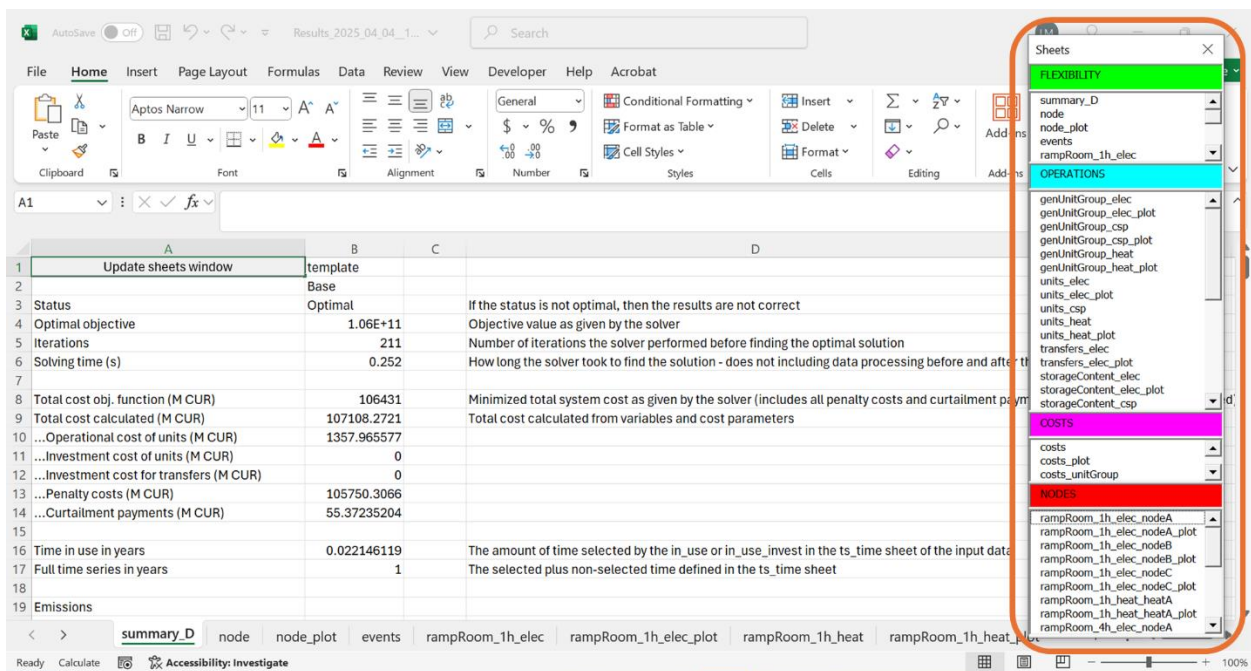
- Click on “Write time series and Run scenarios” to start running the model.
Note: Input file must be closed before running the model. If the input file is still open FlexTool will warn you to close the file.
- A prompt window will open while the model is running to display status of the execution.

```

C:\Windows\system32\cmd.exe

Total number of scenarios: 1
Scenarios started so far: 1
Scenarios not yet started: 0
Scenarios currently ongoing: 1
Scenarios failed: 0
Scenarios already finished: 0
  
```

- In the results file open 'summary_D' sheet from results file which contains the most important results. You can use the quick selection to find 'summary_D' sheet to explore the results. The attributed input data files and scenarios are shown on the top two rows.



	A	B	C	D
1	Update sheets window	template		
2		Base		
3	Status	Optimal		If the status is not optimal, then the results are not correct
4	Optimal objective	1.06E+11		Objective value as given by the solver
5	Iterations	211		Number of iterations the solver performed before finding the optimal solution
6	Solving time (s)	0.252		How long the solver took to find the solution - does not including data processing before and after
7				
8	Total cost obj. function (M CUR)	106431		Minimized total system cost as given by the solver (includes all penalty costs and curtailment payments)
9	Total cost calculated (M CUR)	107108.2721		Total cost calculated from variables and cost parameters
10	...Operational cost of units (M CUR)	1357.965577		
11	...Investment cost of units (M CUR)	0		
12	...Investment cost for transfers (M CUR)	0		
13	...Penalty costs (M CUR)	105750.3066		
14	...Curtailment payments (M CUR)	55.37235204		
15				
16	Time in use in years	0.022146119		The amount of time selected by the in_use or in_use_invest in the ts_time sheet of the input data
17	Full time series in years	1		The selected plus non-selected time defined in the ts_time sheet
18				
19	Emissions			



Activity: Continue exploring both the input file and the result file used in this short exercise to become familiar with the structure and content of each. In the following sessions, you will learn how to adjust input files and scenarios while assessing flexibility issues.