

# PROCESS SIMULATION CUP PSC2020- OPTIMAL CONTROL

STEP BY STEP INSTRUCTIONS



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# OUTLINE

- ☰ **General Information**
- ☰ Phase 1 Scenarios
  - ☰ Overview
  - ☰ Scenario 1: Set-point step change
  - ☰ Scenario 2: Disturbance of the flowrate
  - ☰ Scenario 3: Shutdown of one engine
- ☰ Plant performance with the initial controller settings

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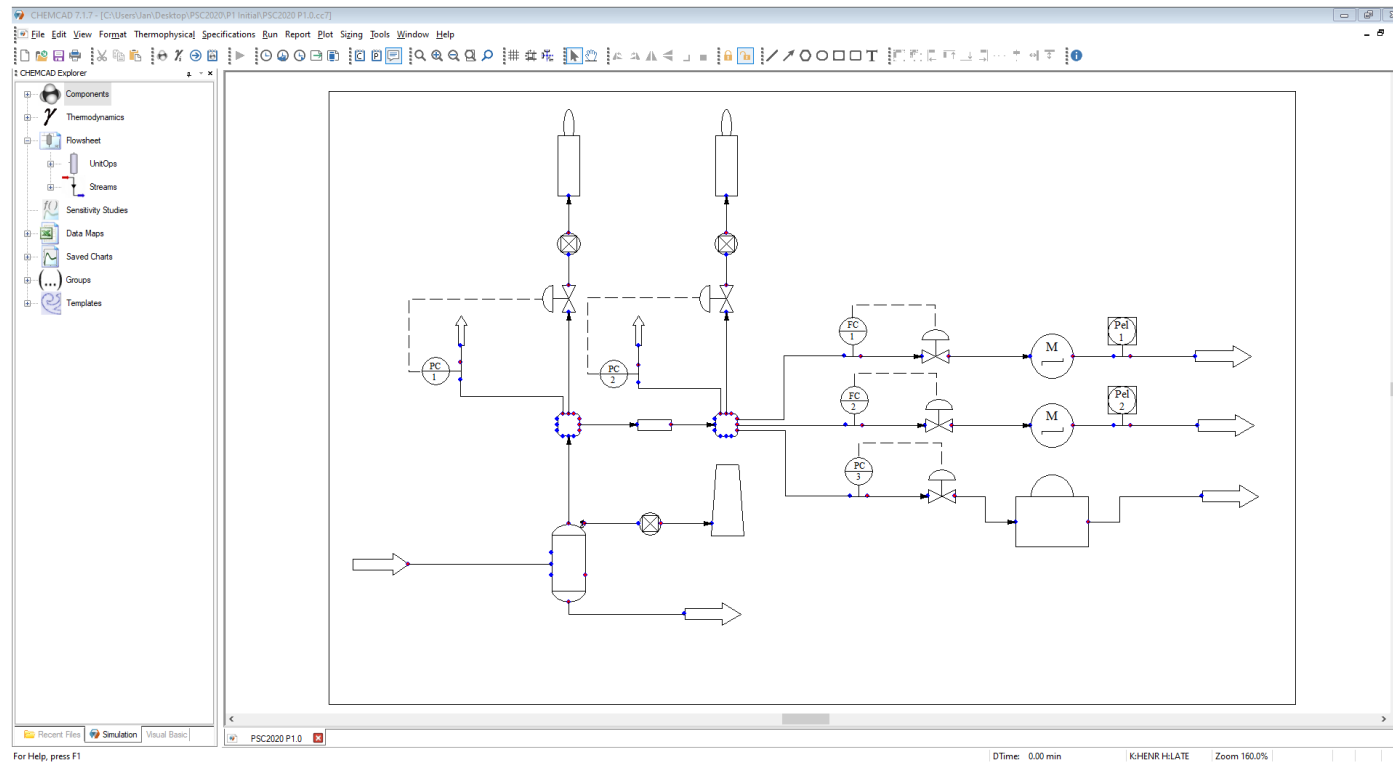
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# IS THIS DOCUMENT FOR ME?

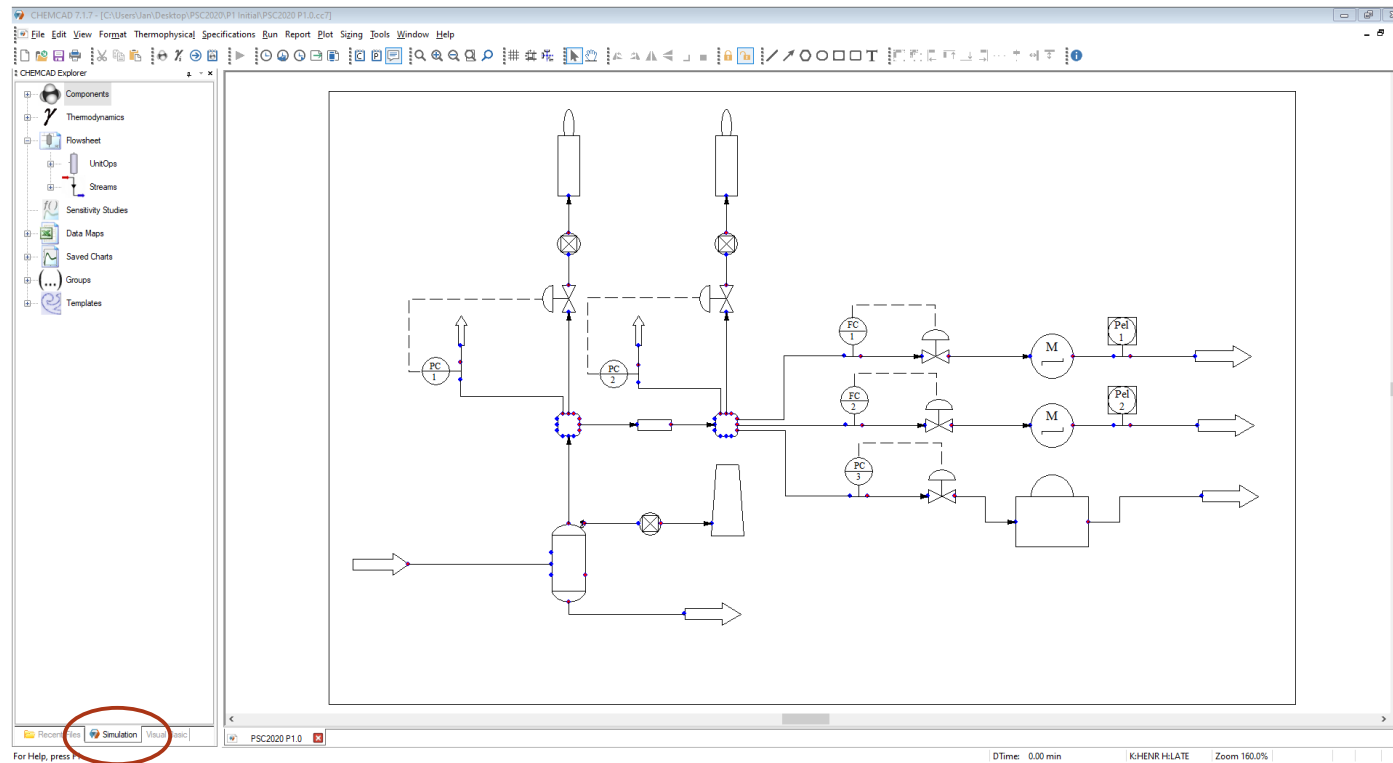
- This document is for you, if you want to
  - learn how to simulate the scenarios of PSC2020 in CHEMCAD
  - understand how Data Maps work and how CHEMCAD and MS Excel communicate
  
- This document
  - is a tutorial for using Data Maps to run different scenarios in one flowsheet
  - shows the 23 steps you must follow to calculate the PSC2020 objective function in phase 1

The document only shows the steps required for phase 1 of PSC2020. However, the workflow is easily applicable to more scenarios and parameters, as they will come up in the subsequent phases of PSC2020.

# 1: OPEN THE FLOWSHEET

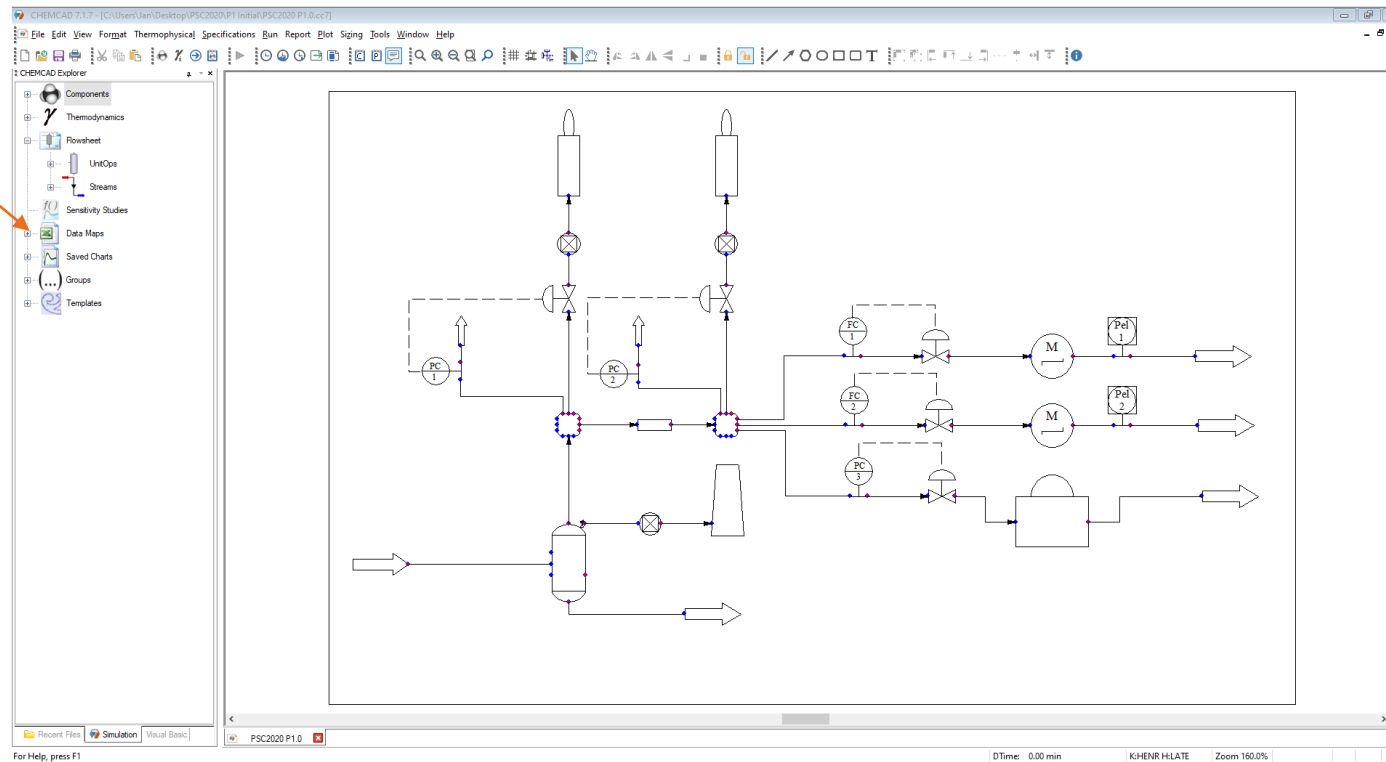


# 2: EXPLORE FLOWSHEET ELEMENTS

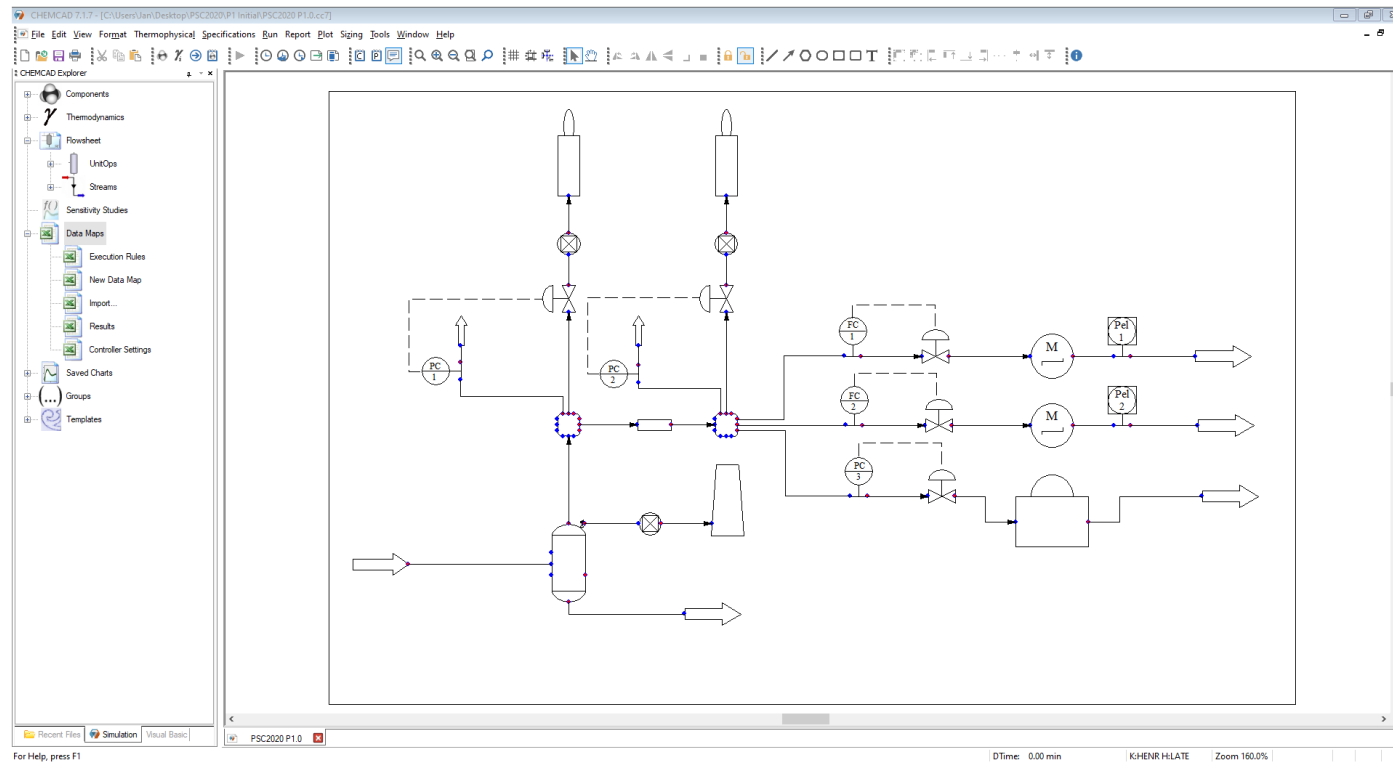


# 3: EXPLORE FLOWSHEET COMPONENTS

Click here



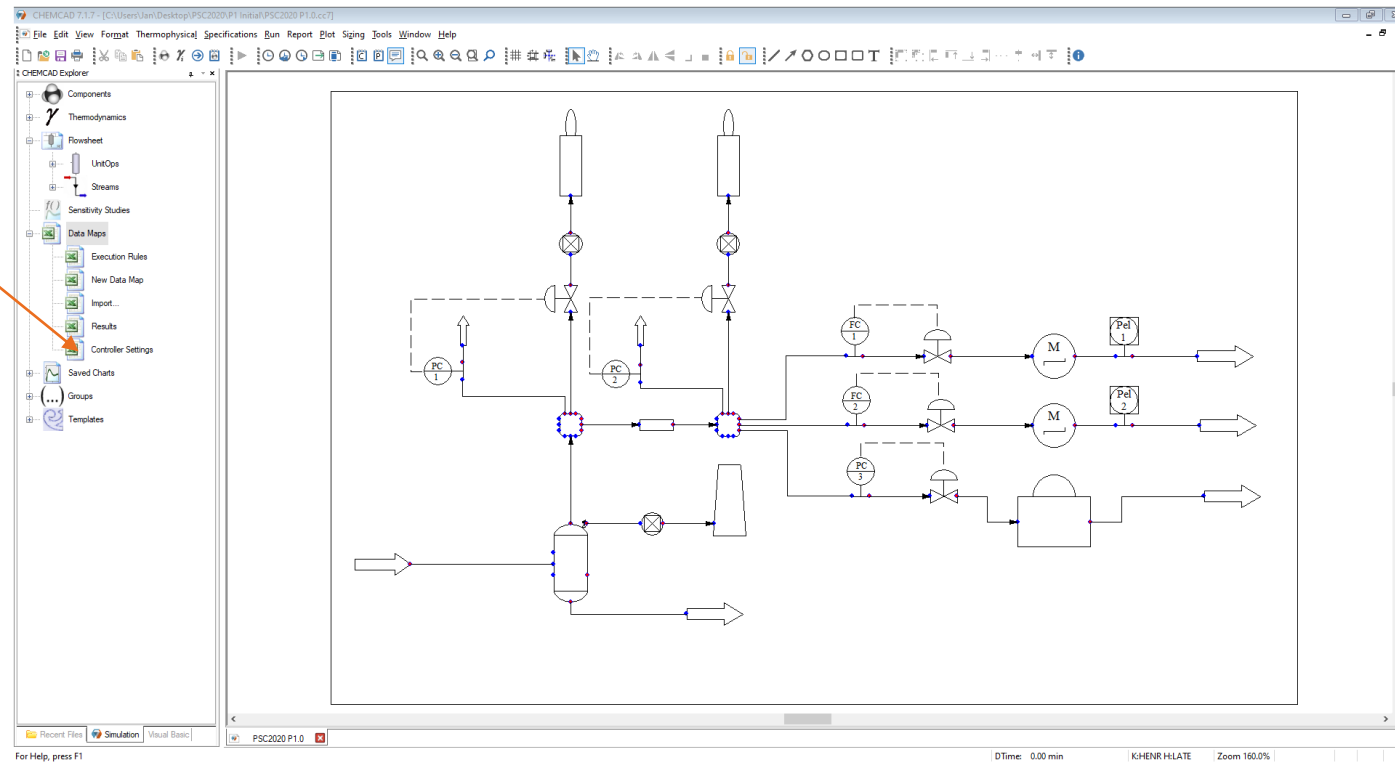
# 4: SEE THE DATA MAPS USED IN PSC2020





# 4: SEE THE DATA MAPS USED IN PSC2020

Click here



# 5: OPEN THE DATA MAP CONTROLLER SETTINGS

The screenshot shows the 'Controller Settings' dialog box in ChemCAD Explorer. The dialog is titled 'Controller Settings' and contains a table of map rules. The table has columns for Map Rule, CC Obj Type, CC Obj ID, Par ID, Component, WkShHt Cell..., Weight, and Comment. The table lists 30 map rules, each with a weight of 1.00000. The dialog also includes fields for 'Excel Workbook Path' (PSC2020.XLS) and 'Excel Worksheet Name' (Controller Settings).

Map Rule	CC Obj Type	CC Obj ID	Par ID	Component	WkShHt Cell...	Weight	Comment
11	To CC Only	UnitOp	5	PB, Proportio...	<None> C3	1.00000	
12	To CC Only	UnitOp	9	PB, Proportio...	<None> C4	1.00000	
13	To CC Only	UnitOp	15	PB, Proportio...	<None> C5	1.00000	
14	To CC Only	UnitOp	11	PB, Proportio...	<None> C6	1.00000	
15	To CC Only	UnitOp	13	PB, Proportio...	<None> C7	1.00000	
16	To CC Only	UnitOp	5	Ti, Integral (m...	<None> D3	1.00000	
17	To CC Only	UnitOp	9	Ti, Integral (m...	<None> D4	1.00000	
18	To CC Only	UnitOp	15	Ti, Integral (m...	<None> D5	1.00000	
19	To CC Only	UnitOp	11	Ti, Integral (m...	<None> D6	1.00000	
20	To CC Only	UnitOp	13	Ti, Integral (m...	<None> D7	1.00000	
21	To CC Only	UnitOp	5	Td, Derivative...	<None> E3	1.00000	
22	To CC Only	UnitOp	9	Td, Derivative...	<None> E4	1.00000	
23	To CC Only	UnitOp	15	Td, Derivative...	<None> E5	1.00000	
24	To CC Only	UnitOp	11	Td, Derivative...	<None> E6	1.00000	
25	To CC Only	UnitOp	13	Td, Derivative...	<None> E7	1.00000	
26	To CC Only	UnitOp	27	PB, Proportio...	<None> C8	1.00000	
27	To CC Only	UnitOp	28	PB, Proportio...	<None> C9	1.00000	
28	To CC Only	UnitOp	27	Ti, Integral (m...	<None> D8	1.00000	
29	To CC Only	UnitOp	28	Ti, Integral (m...	<None> D9	1.00000	
30	To CC Only	UnitOp	27	Td, Derivative...	<None> E8	1.00000	
31	To CC Only	UnitOp	28	Td, Derivative...	<None> E9	1.00000	
32	To CC Only	UnitOp	111	Option	<None> I2	1.00000	
33	To CC Only	UnitOp	201	Option	<None> I3	1.00000	
34	To CC Only	UnitOp	312	Option	<None> I4	1.00000	
35	To CC Only	UnitOp	427	0	I5	1.00000	
36	To CC Only	UnitOp	428	0	K5	1.00000	
37	To CC Only	UnitOp	527	0	I6	1.00000	
38	To CC Only	UnitOp	528	0	K6	1.00000	
39	To CC Only	UnitOp	27	State	<None> M2	1.00000	
40	To CC Only	UnitOp	28	State	<None> M3	1.00000	

# 5: OPEN THE DATA MAP CONTROLLER SETTINGS

Click here

The screenshot shows the ChemCAD 7.1.2.2 interface with the 'Controller Settings' window open. The left sidebar contains a tree view with 'Controller Settings' highlighted. An orange arrow points from the 'Click here' text to this button. Another orange arrow points from the 'Controller Settings' button to the 'Excel Worksheet Name' field in the main window, which is set to 'Controller Settings'. The main window displays a table of map rules.

Map Rule	CC Obj Type	CC Obj ID	Par ID	Component	WkShHt Cell...	Weight	Comment
11	To CC Only	UnitOp	7	PB, Proportio...	<None>	C3	1.00000
12	To CC Only	UnitOp	9	PB, Proportio...	<None>	C4	1.00000
13	To CC Only	UnitOp	15	PB, Proportio...	<None>	C5	1.00000
14	To CC Only	UnitOp	11	PB, Proportio...	<None>	C6	1.00000
15	To CC Only	UnitOp	13	PB, Proportio...	<None>	C7	1.00000
16	To CC Only	UnitOp	5	Ti, Integral (m...	<None>	D3	1.00000
17	To CC Only	UnitOp	9	Ti, Integral (m...	<None>	D4	1.00000
18	To CC Only	UnitOp	15	Ti, Integral (m...	<None>	D5	1.00000
19	To CC Only	UnitOp	11	Ti, Integral (m...	<None>	D6	1.00000
20	To CC Only	UnitOp	13	Ti, Integral (m...	<None>	D7	1.00000
21	To CC Only	UnitOp	5	Td, Derivative...	<None>	E3	1.00000
22	To CC Only	UnitOp	9	Td, Derivative...	<None>	E4	1.00000
23	To CC Only	UnitOp	15	Td, Derivative...	<None>	E5	1.00000
24	To CC Only	UnitOp	11	Td, Derivative...	<None>	E6	1.00000
25	To CC Only	UnitOp	13	Td, Derivative...	<None>	E7	1.00000
26	To CC Only	UnitOp	27	PB, Proportio...	<None>	C8	1.00000
27	To CC Only	UnitOp	28	PB, Proportio...	<None>	C9	1.00000
28	To CC Only	UnitOp	27	Ti, Integral (m...	<None>	D8	1.00000
29	To CC Only	UnitOp	28	Ti, Integral (m...	<None>	D9	1.00000
30	To CC Only	UnitOp	27	Td, Derivative...	<None>	E8	1.00000
31	To CC Only	UnitOp	28	Td, Derivative...	<None>	E9	1.00000
32	To CC Only	UnitOp	111	Option	<None>	I2	1.00000
33	To CC Only	UnitOp	201	Option	<None>	I3	1.00000
34	To CC Only	UnitOp	312	Option	<None>	I4	1.00000
35	To CC Only	UnitOp	427	0		I5	1.00000
36	To CC Only	UnitOp	428	0		K5	1.00000
37	To CC Only	UnitOp	527	0		I6	1.00000
38	To CC Only	UnitOp	528	0		K6	1.00000
39	To CC Only	UnitOp	27	State	<None>	M2	1.00000
40	To CC Only	UnitOp	28	State	<None>	M3	1.00000

# 6: OPEN THE EXCEL FILE OF THE DATA MAP CONTROLLER SETTINGS

The screenshot shows an Excel spreadsheet with the following data:

Controller Settings				
		PB [%]	Ti [min]	Td [min]
	PC1	100	1	0
	PC2	100	1	0
	PC3	100	1	0
	FC1	100	1	0
	FC2	100	1	0
	Pel1	100	1	0
	Pel2	100	1	0
Scenario Selection				1

# 7: CHANGE CONTROLLER SETTINGS

	A	B	C	D	E	F	G	H	I
1		<b>Controller Settings</b>							
2			PB [%]	Ti [min]	Td [min]				
3		PC1	100	1	0				
4		PC2	100	1	0				
5		PC3	100	1	0				
6		FC1	100	1	0				
7		FC2	100	1	0				
8		Pel1	100	1	0				
9		Pel2	100	1	0				
10									
11									
12		<b>Scenario Selection</b>			<b>1</b>				
13									
14									
15									

# 8: CHANGE CONTROLLER SETTINGS

The editable parameters of phase 1 are maked yellow!

Controller Settings			
	PB [%]	Ti [min]	Td [min]
PC1	100	1	0
PC2	100	1	0
PC3	100	1	0
FC1	100	1	0
FC2	100	1	0
Pel1	100	1	0
Pel2	100	1	0
Scenario Selection			1

# 9: SELECT SCENARIO 1

Type "1"  
in cell E12

The screenshot shows an Excel spreadsheet with the following data:

Controller Settings				
		PB [%]	Ti [min]	Td [min]
	PC1	100	1	0
	PC2	100	1	0
	PC3	100	1	0
	FC1	100	1	0
	FC2	100	1	0
	Pe1	100	1	0
	Pe2	100	1	0

Scenario Selection	
	1

# 10: SAVE THE EXCEL TABLE

Click here

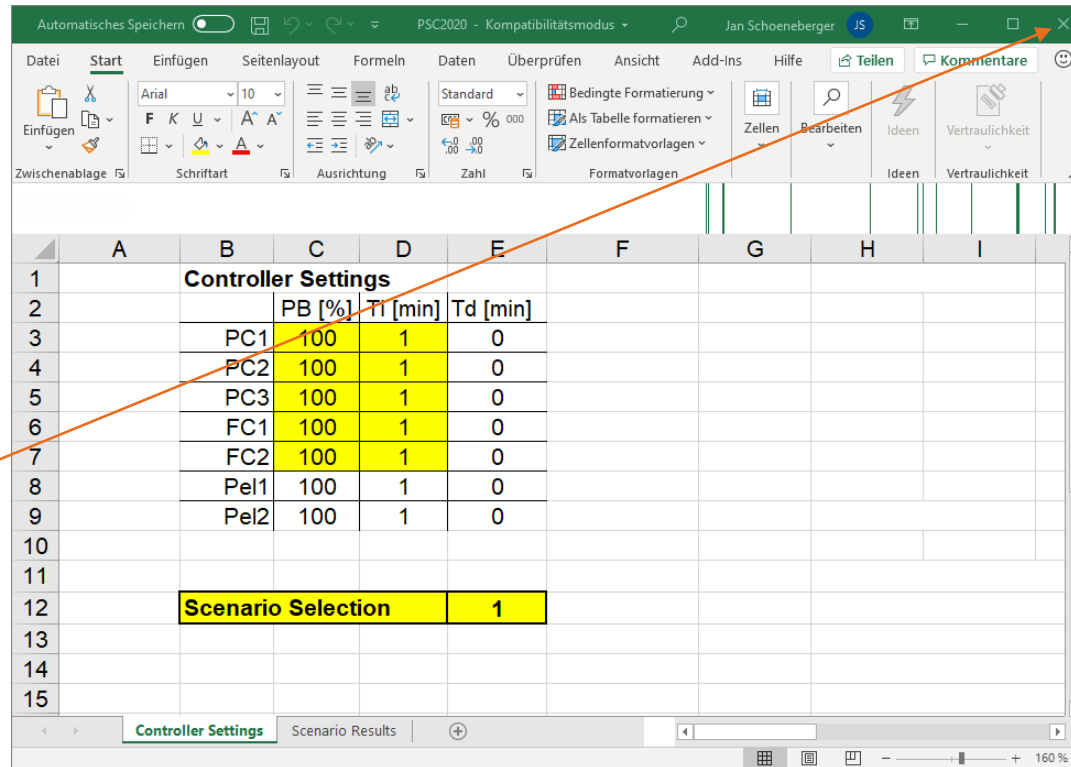
The screenshot shows an Excel spreadsheet with the following data:

Controller Settings				
		PB [%]	Ti [min]	Td [min]
3	PC1	100	1	0
4	PC2	100	1	0
5	PC3	100	1	0
6	FC1	100	1	0
7	FC2	100	1	0
8	Pel1	100	1	0
9	Pel2	100	1	0
Scenario Selection				1



# 11: CLOSE THE EXCEL TABLE

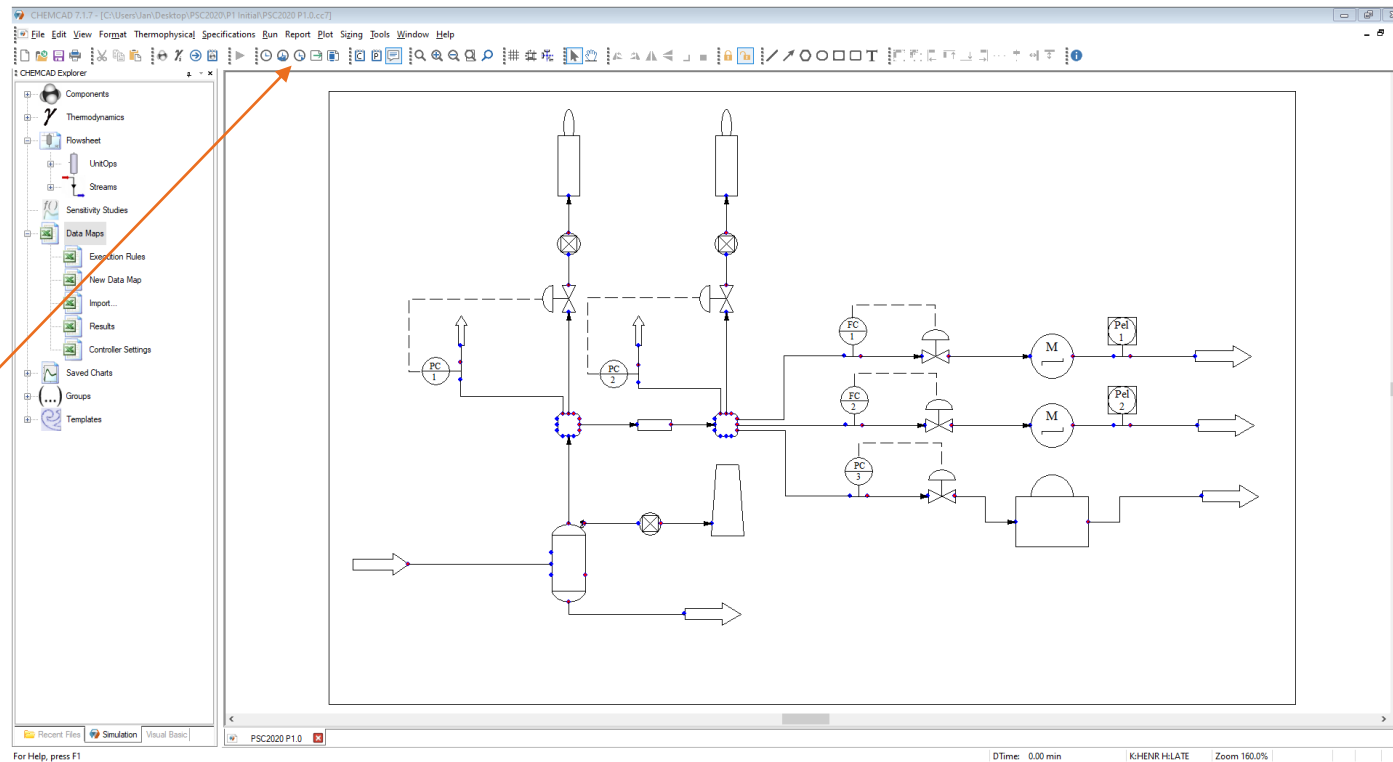
Click here



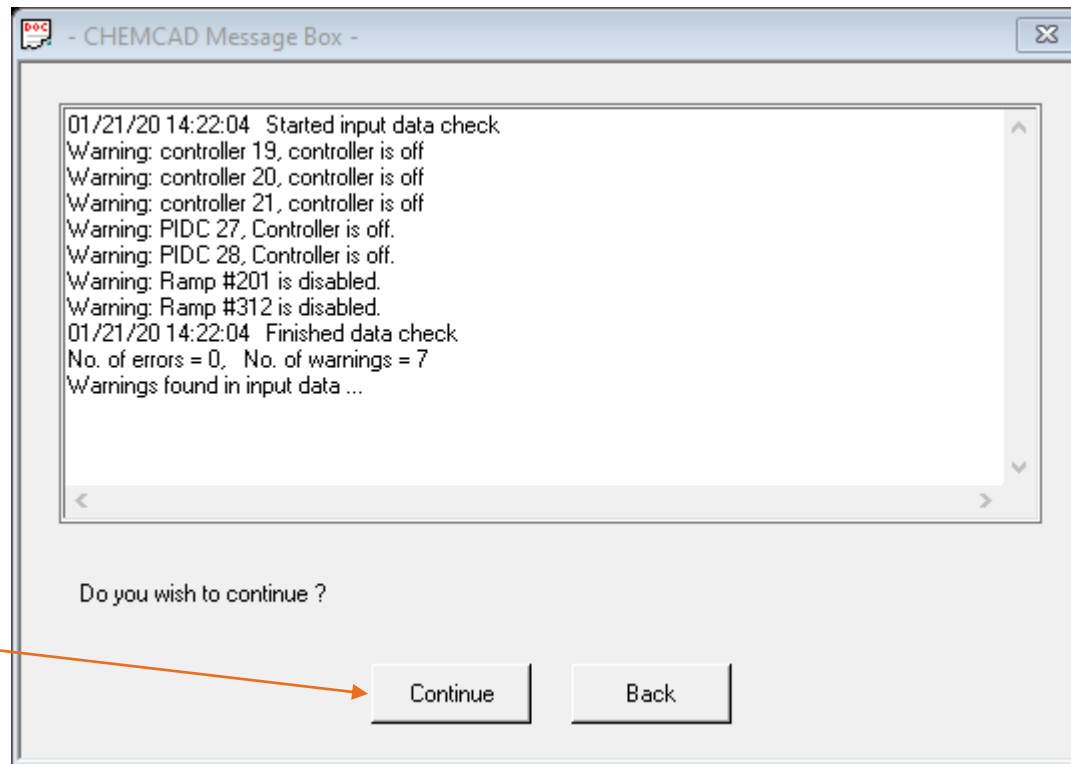
Controller Settings				
	PB [%]	Ti [min]	Td [min]	
PC1	100	1	0	
PC2	100	1	0	
PC3	100	1	0	
FC1	100	1	0	
FC2	100	1	0	
Pel1	100	1	0	
Pel2	100	1	0	
Scenario Selection			1	

# 12: INITIATE DYNAMIC RUN

Click here

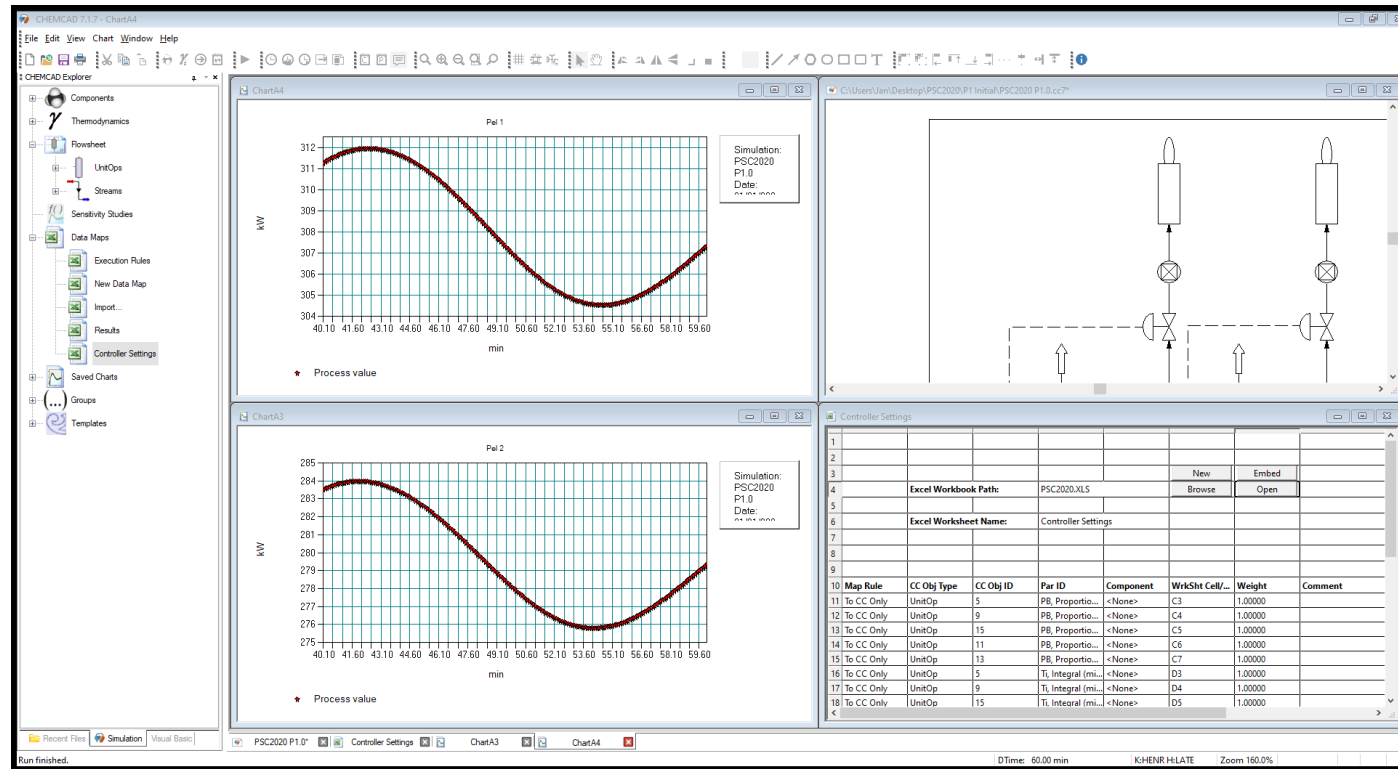


# 13: SKIP THE WARNINGS



Click here

# 14: OBSERVE THE POWER GENERATION (PRESET PLOTS)



# 15: OPEN THE EXCEL FILE OF THE DATA MAP CONTROLLER SETTINGS

The screenshot displays the ChemCAD software interface. On the left is the 'CHEMCAD Explorer' tree view. The main workspace is divided into four panes: two charts (ChartA3 and ChartA4) showing process value (kW) vs. time (min) for 'Pal 2' and 'Pal 1' respectively; a process flow diagram; and a 'Controller Settings' table. An orange box with the text 'Click here' has an arrow pointing to the 'Browse' button in the 'Controller Settings' pane.

Map Rule	CC Obj Type	CC Obj ID	Par ID	Component	WrkSht Cell...	Weight	Comment
11 To CC Only	UnitOp	5	P8, Proportio...	<None>	C3	1.00000	
12 To CC Only	UnitOp	9	P8, Proportio...	<None>	C4	1.00000	
13 To CC Only	UnitOp	15	P8, Proportio...	<None>	C5	1.00000	
14 To CC Only	UnitOp	11	P8, Proportio...	<None>	C6	1.00000	
15 To CC Only	UnitOp	13	P8, Proportio...	<None>	C7	1.00000	
16 To CC Only	UnitOp	5	Ti, Integral (mi...	<None>	D3	1.00000	
17 To CC Only	UnitOp	9	Ti, Integral (mi...	<None>	D4	1.00000	
18 To CC Only	UnitOp	15	Ti, Integral (mi...	<None>	D5	1.00000	

# 16: SWITCH TO THE SCENARIO RESULTS TAB

Click here

The screenshot shows an Excel spreadsheet with the following data:

Controller Settings				
	PB [%]	Ti [min]	Td [min]	
PC1	100	1	0	
PC2	100	1	0	
PC3	100	1	0	
FC1	100	1	0	
FC2	100	1	0	
Pe11	100	1	0	
Pe12	100	1	0	

Scenario Selection	
	1

The bottom navigation bar shows two tabs: 'Controller Settings' (active) and 'Scenario Results'. An orange arrow points from the 'Click here' text to the 'Scenario Results' tab.

# 17: CHECK YOUR PROFIT FOR SCENARIO 1

The screenshot shows an Excel spreadsheet titled 'PSC2020 - Kom...' with the following data:

	A	B	C	D	E	F	G
1	<b>Scenario Results</b>						
2							
3	Emissions Safety Valve	0.00 kg					
4	Emissions Flare 1	0.00 kg					
5	Emissions Flare 2	0.00 kg					
6							
7	ISA FC1	6.35					
8	ISA FC2	2.95					
9							
10	ISA Pel1	0					
11	ISA Pel2	0					
12							
13	Benefit	56.00 €					
14	Penalty for Safety Valve Emissions	0.00 €					
15	Penalty for Flare 1 Emissions	0.00 €					
16	Penalty for Flare 2 Emissions	0.00 €					
17	Penalty for Controller Error FC 1	63.51 €					
18	Penalty for Controller Error FC 2	29.51 €					
19	Penalty for Controller Error Pel 1	0.00 €					
20	Penalty for Controller Error Pel 2	0.00 €					
21							
22	<b>Profit</b>	<b>-37.03 €</b>					

# 18: SWITCH TO THE CONTROLLER SETTINGS TAB

Click here

	A	B	C	D	E	F	G
1	<b>Scenario Results</b>						
2							
3	Emissions Safety Valve	0.00 kg					
4	Emissions Flare 1	0.00 kg					
5	Emissions Flare 2	0.00 kg					
6							
7	ISA FC1	6.35					
8	ISA FC2	2.95					
9							
10	ISA Pel1	0					
11	ISA Pel2	0					
12							
13	Benefit	56.00 €					
14	Penalty for Safety Valve Emissions	0.00 €					
15	Penalty for Flare 1 Emissions	0.00 €					
16	Penalty for Flare 2 Emissions	0.00 €					
17	Penalty for Controller Error FC 1	63.51 €					
18	Penalty for Controller Error FC 2	29.51 €					
19	Penalty for Controller Error Pel 1	0.00 €					
20	Penalty for Controller Error Pel 2	0.00 €					
21							
22	<b>Profit</b>	<b>-37.03 €</b>					



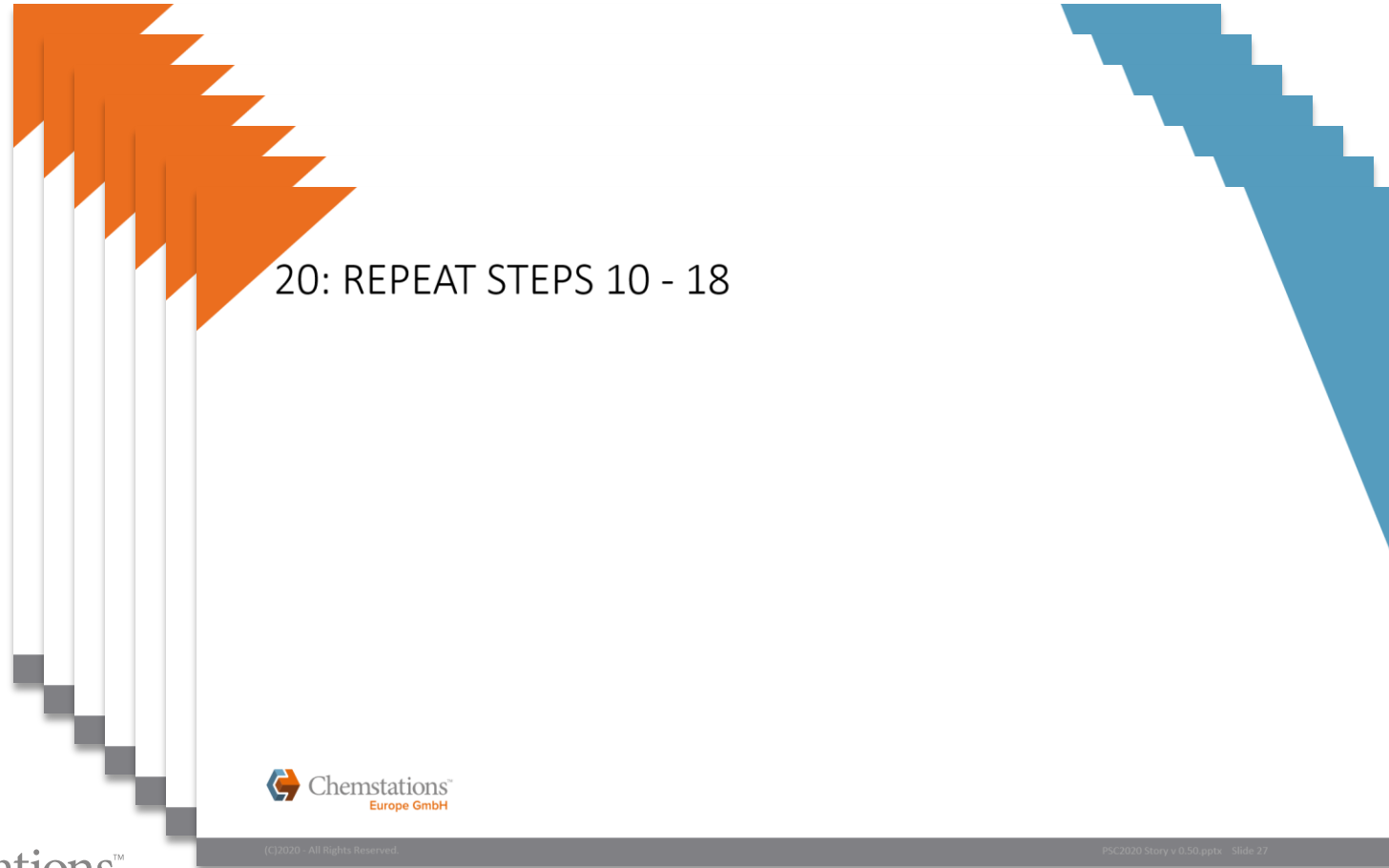
# 19: SELECT SCENARIO 2

The screenshot shows an Excel spreadsheet with the following data:

Controller Settings				
		PB [%]	Ti [min]	Td [min]
	PC1	100	1	0
	PC2	100	1	0
	PC3	100	1	0
	FC1	100	1	0
	FC2	100	1	0
	Pel1	100	1	0
	Pel2	100	1	0
	Scenario Selection			1

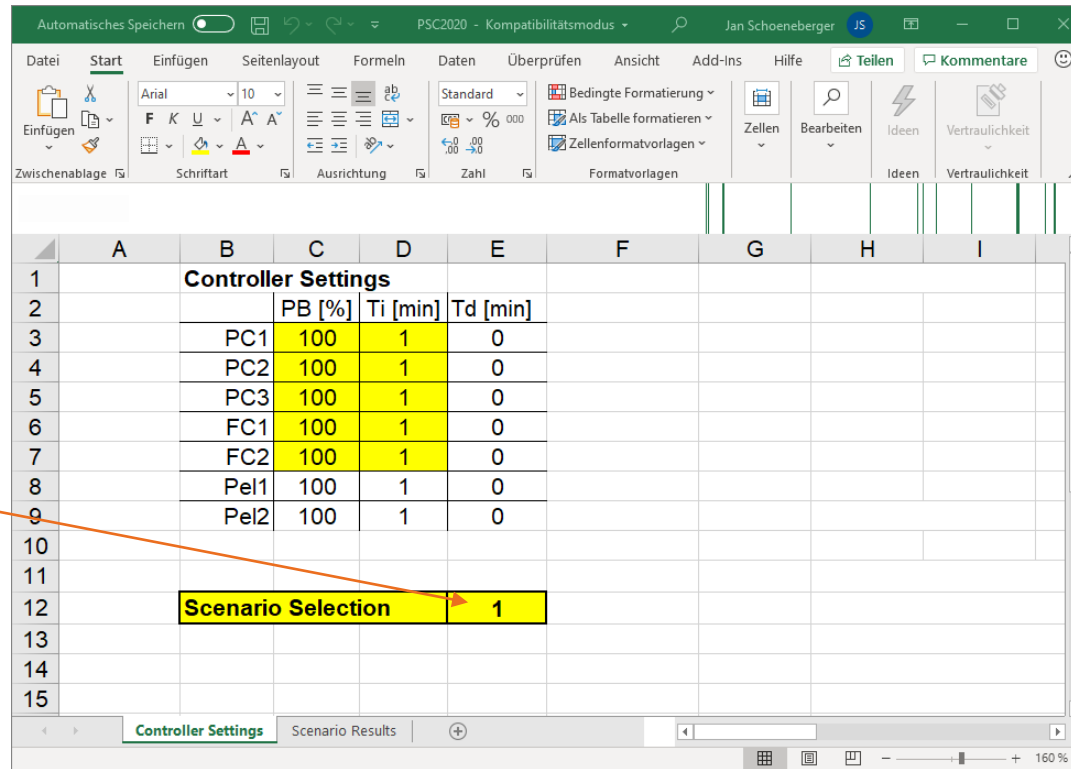
Type "2"  
in cell E12

# 20: REPEAT STEPS 10 - 18



# 21: SELECT SCENARIO 3

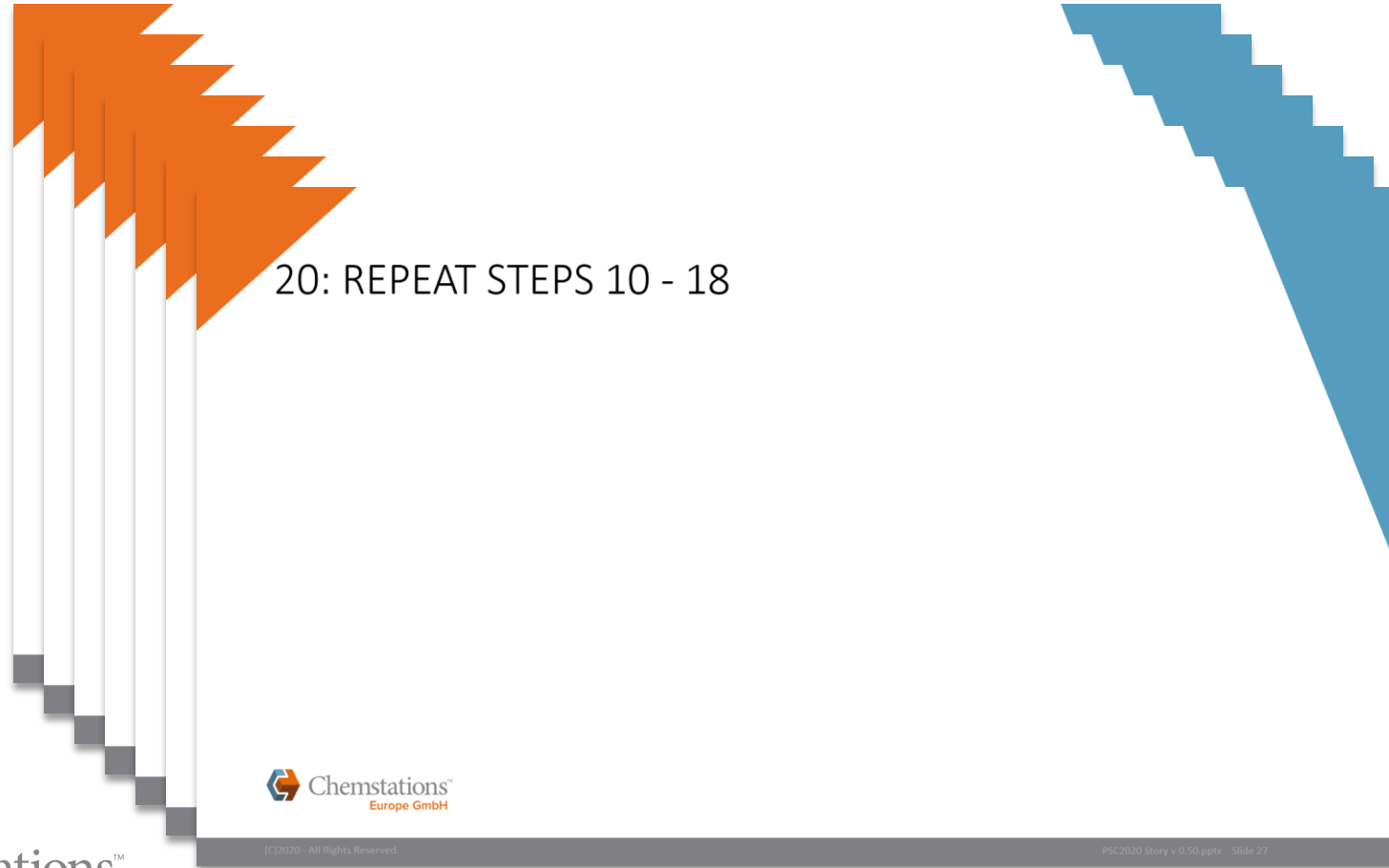
Type "3"  
in cell E12



The screenshot shows an Excel spreadsheet with the following data:

	A	B	C	D	E	F	G	H	I
1		<b>Controller Settings</b>							
2			PB [%]	Ti [min]	Td [min]				
3		PC1	100	1	0				
4		PC2	100	1	0				
5		PC3	100	1	0				
6		FC1	100	1	0				
7		FC2	100	1	0				
8		Pel1	100	1	0				
9		Pel2	100	1	0				
10									
11									
12		<b>Scenario Selection</b>			1				
13									
14									
15									

# 22: REPEAT STEPS 10 - 18



# 23: SUM-UP THE SCENARIO PROFITS TO CALCULATE THE OVERALL PROFIT

Scenario 1 Profit	- 37.03 €
Scenario 2 Profit	- 21.41 €
Scenario 3 Profit	<u>42.37 €</u>
Phase 1 Profit	<u><u>- 16.07 €</u></u>

## Result

	Scenario 1	Scenario 2	Scenario 3
Benefit [€]	56.00	56.00	56.00
Penalty for Safety Valve Emissions [€]	0.00	0.00	0.00
Penalty for Flare 1 Emissions [€]	0.00	37.98	2.24
Penalty for Flare 2 Emissions [€]	0.00	0.02	0.29
Penalty for Controller Error FC 1 [€]	63.51	17.26	0.00
Penalty for Controller Error FC 2 [€]	29.51	22.15	11.10
Penalty for Controller Error Pel 1 [€]	0.00	0.00	0.00
Penalty for Controller Error Pel 2 [€]	0.00	0.00	0.00
Profit [€]	-37.03	-21.41	42.37

**Total profit: -16.07€**

# 23: SUM-UP THE SCENARIO PROFITS TO CALCULATE THE OVERALL PROFIT

Scenario 1 Profit	- 37.03 €
Scenario 2 Profit	- 21.41 €
Scenario 3 Profit	<u>42.37 €</u>
Phase 1 Profit	<u>- 16.07 €</u>

## Result

	Scenario 1	Scenario 2	Scenario 3
Benefit [€]	56.00	56.00	56.00
Penalty for Safety Valve Emissions [€]	0.00	0.00	0.00
Penalty for Flare 1 Emissions [€]	0.00	37.98	2.24
Penalty for Flare 2 Emissions [€]	0.00	0.02	0.29
Penalty for Controller Error FC 1 [€]	63.51	17.26	0.00
Penalty for Controller Error FC 2 [€]	29.51	22.15	11.10
Penalty for Controller Error Pel 1 [€]	0.00	0.00	0.00
Penalty for Controller Error Pel 2 [€]	0.00	0.00	0.00
Profit [€]	-37.03	-21.41	42.37

Total profit: -16.07€

Now it's up to you to find better controller settings!

# THANK YOU!

JS@CHEMSTATIONS.EU