USAID | JORDAN
FROM THE AMERICAN PEOPLE

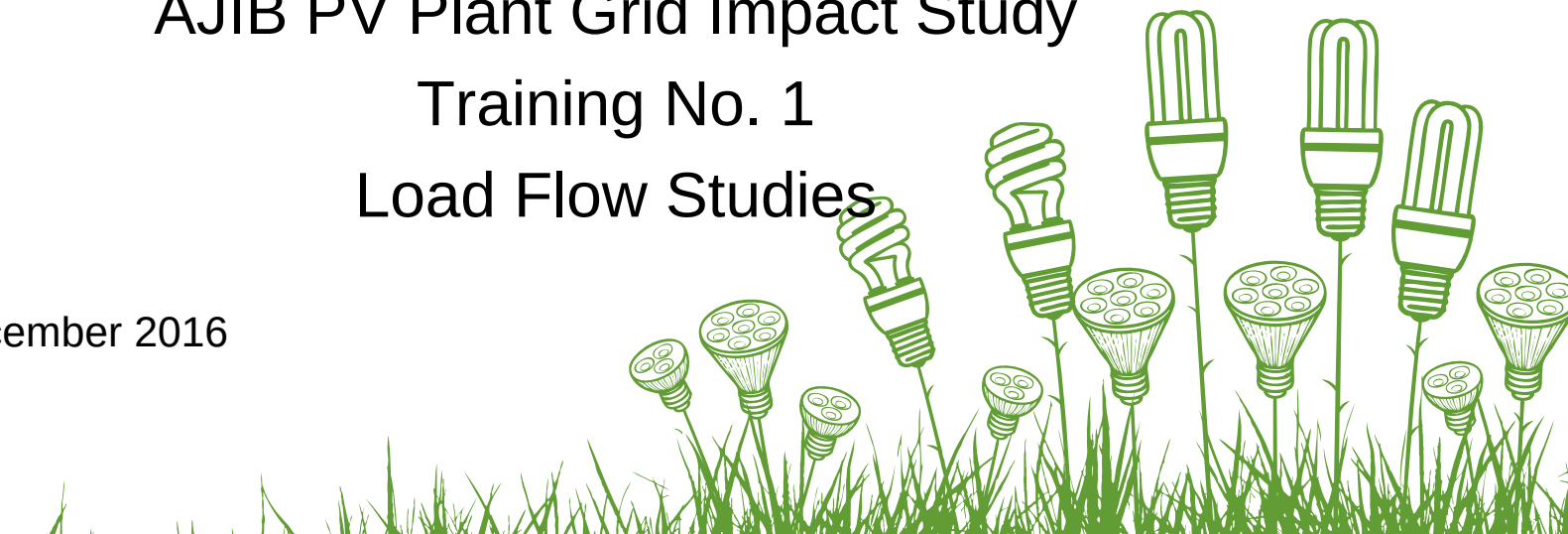
Energy Sector Capacity Building (ESCB)

AJIB PV Plant Grid Impact Study

Training No. 1

Load Flow Studies

6 December 2016



Agenda

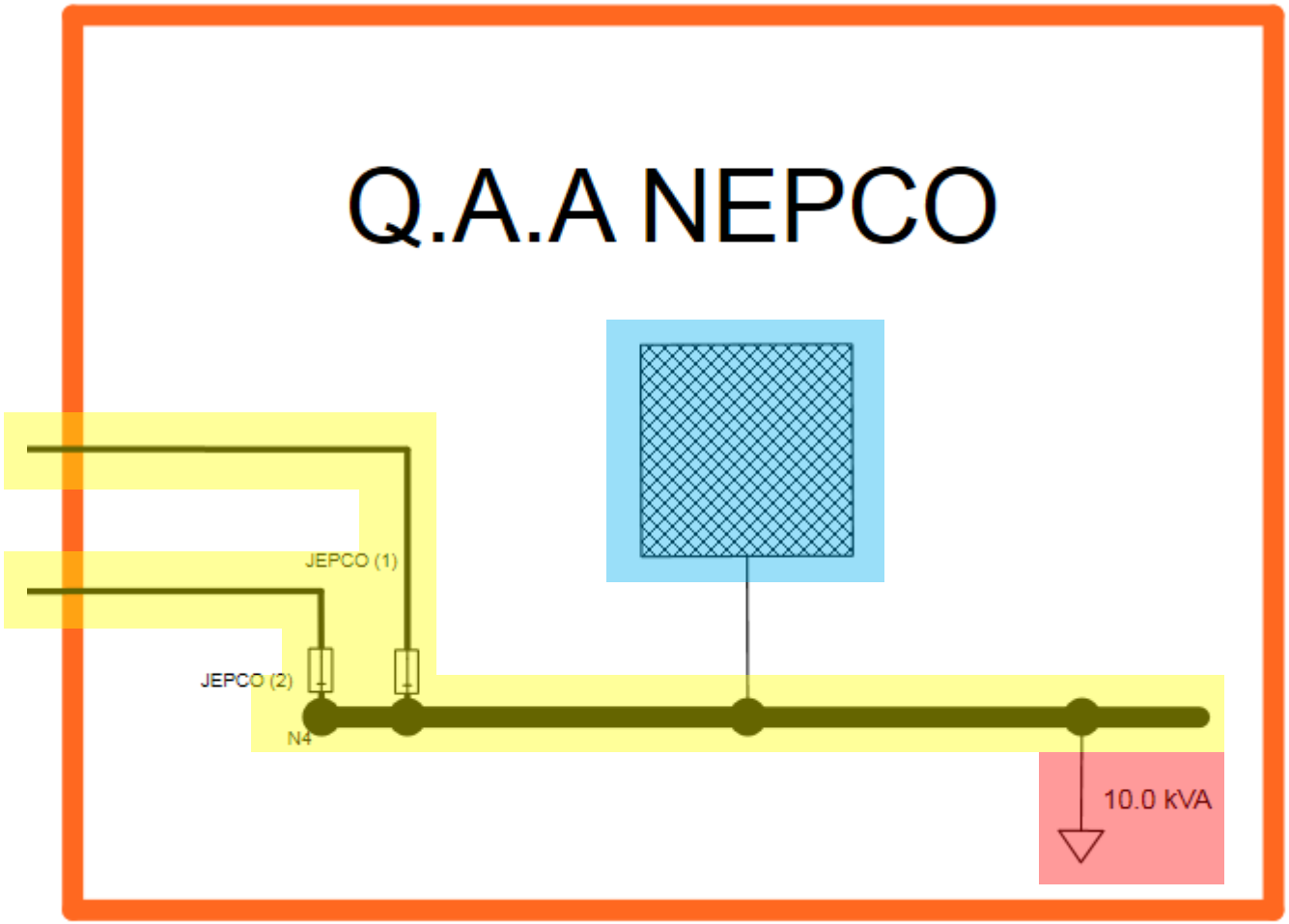
- Introductions
- **Morning Session**
  - 9:15 – 11:00 AM: Load Flow Analysis Part 2
    - Wrap-up Analysis from Part 1
    - Compare JEPCO results with Black & Veatch Results
- **Afternoon Session**
  - 11:00 AM – 1:30 PM: Long-Term Dynamic Analysis
    - Prepare Load and Generation Profile
    - Study Cases
    - Analysis
  - 2:30 – 3:30 PM: Short Circuit Analysis

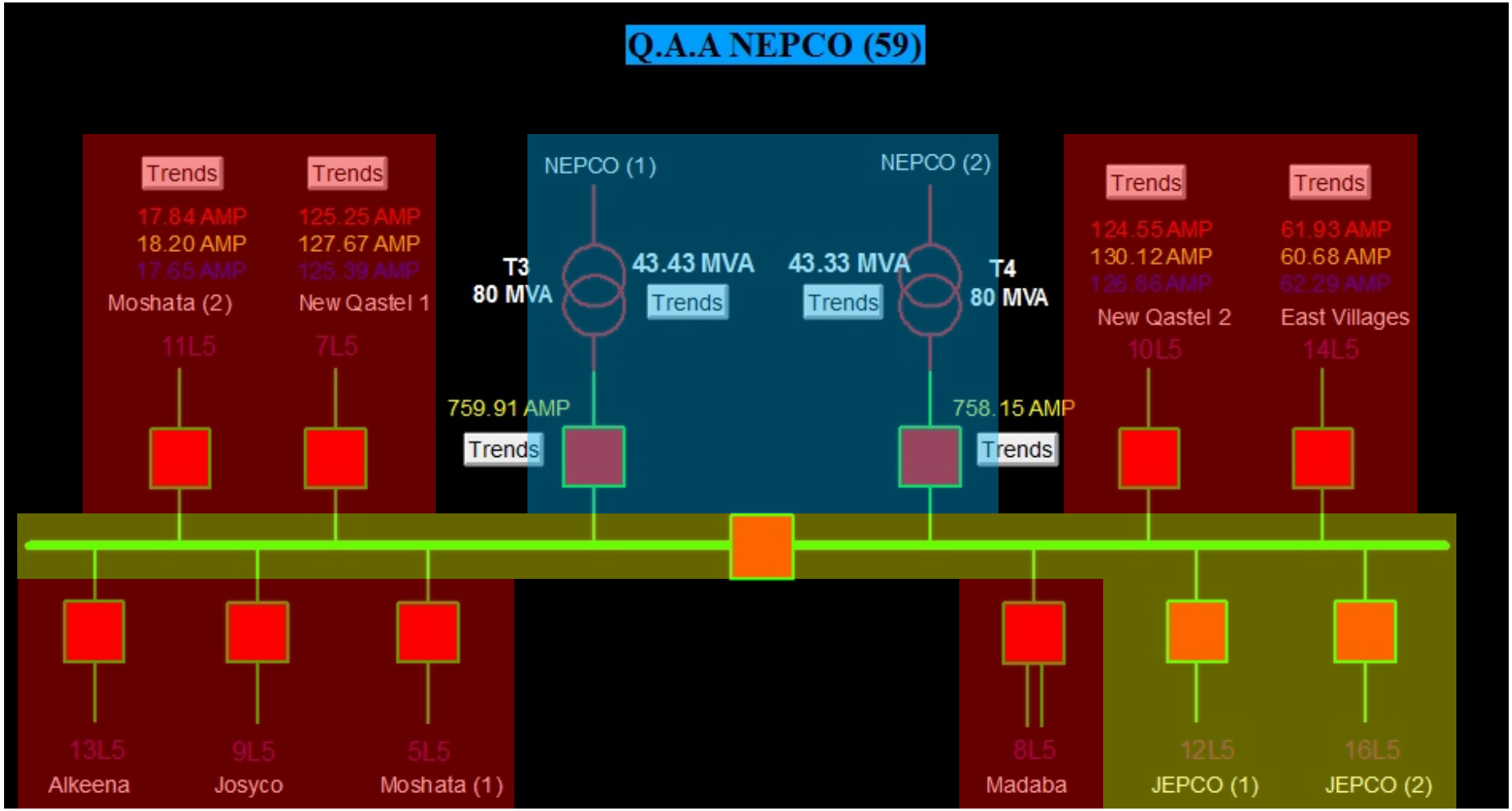
Long-Term Dynamic Analysis

- The Long-Term Dynamic analysis studies the impact of changing load and generation over a period of time
- Requires load and generation profiles to be imported into PSS SINCAL
- The objective of the analysis is dependent on the resolution of the data:
  - Lower resolution data can be used to study voltage profile, reverse power flow, and determining total number of voltage regulator/LTC tap changes
  - Higher resolution data can be used to study power quality impact such as voltage flicker and voltage regulator/LTC tap cycling

Load Profile Setup – Review JEPCO Load Profiles

Q.A.A. NEPCO



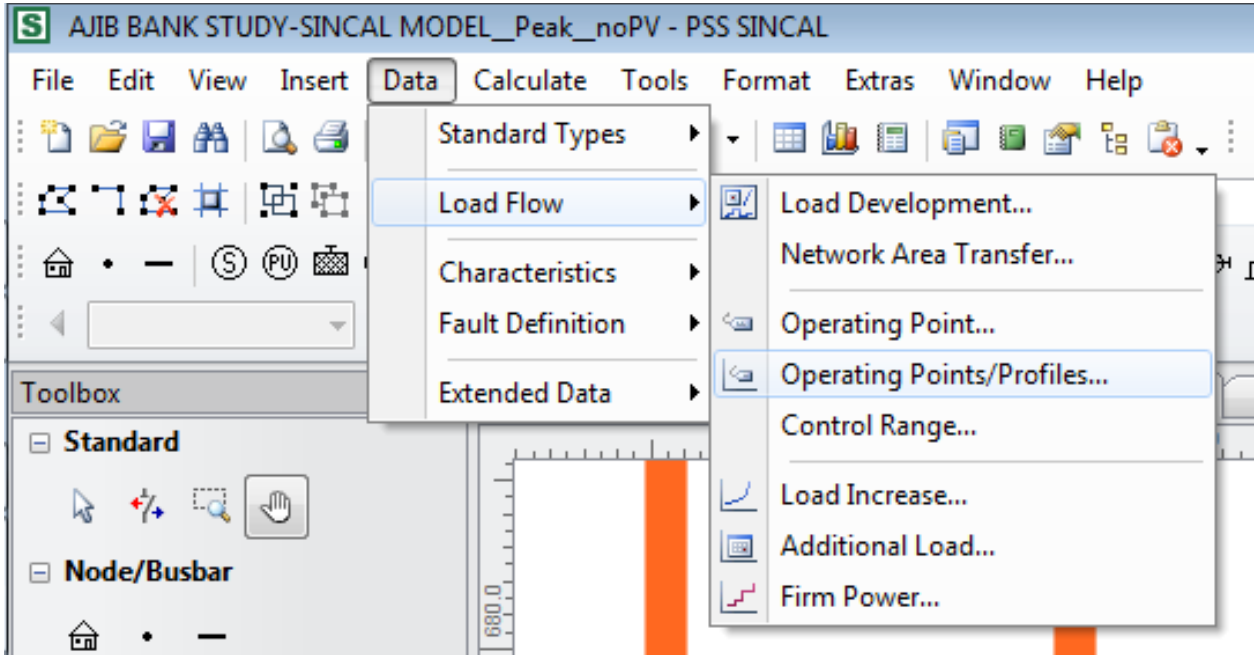

Q.A.A NEPCO (59)
Trends
Trends
17.84 AMP
18.20 AMP
17.65 AMP
Moshata (2)
11L5
125.25 AMP
127.67 AMP
125.39 AMP
New Qastel 1
7L5
NEPCO (1)
NEPCO (2)
T3
80 MVA
43.43 MVA
Trends
43.33 MVA
Trends
T4
80 MVA
759.91 AMP
Trends
758.15 AMP
Trends
Trends
Trends
124.55 AMP
130.12 AMP
126.86 AMP
New Qastel 2
10L5
61.93 AMP
60.68 AMP
62.29 AMP
East Villages
14L5
13L5
Alkeena
9L5
Josyco
5L5
Moshata (1)
8L5
Madaba
12L5
JEPCO (1)
16L5
JEPCO (2)

Creating a Composite Load Profile for Q.A.A. NEPCO

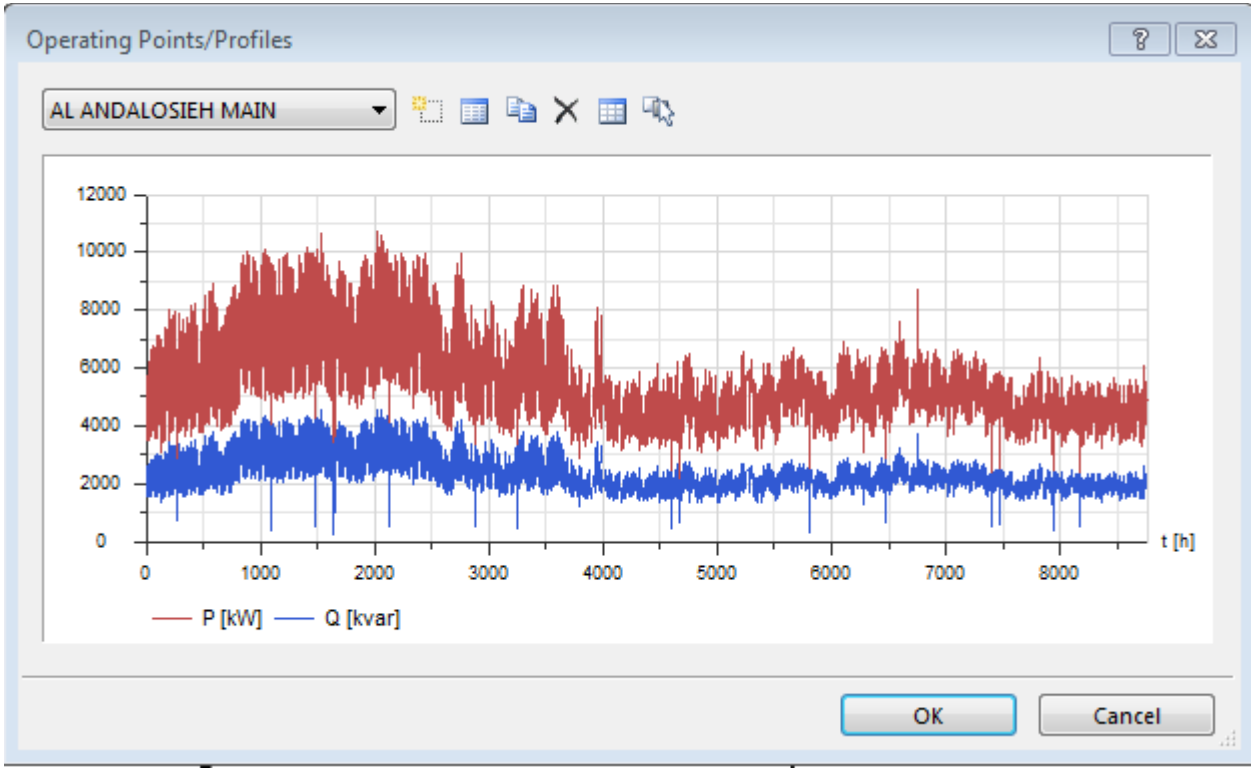
- Open the load spreadsheet for Q.A.A. NEPCO
- Loads are populated for individual circuits
- Assuming the load at the 33 kV Q.A.A. NEPCO bus is a lumped representation of the following circuits:
  - Moshata 1 and 2
  - New Qastel 1 and 2
  - East Villages
  - Josyco
  - Madaba
  - Alkeena
- Need to create a composite load profile to represent the 33 kV load

Importing Load Profiles in PSS SINCAL

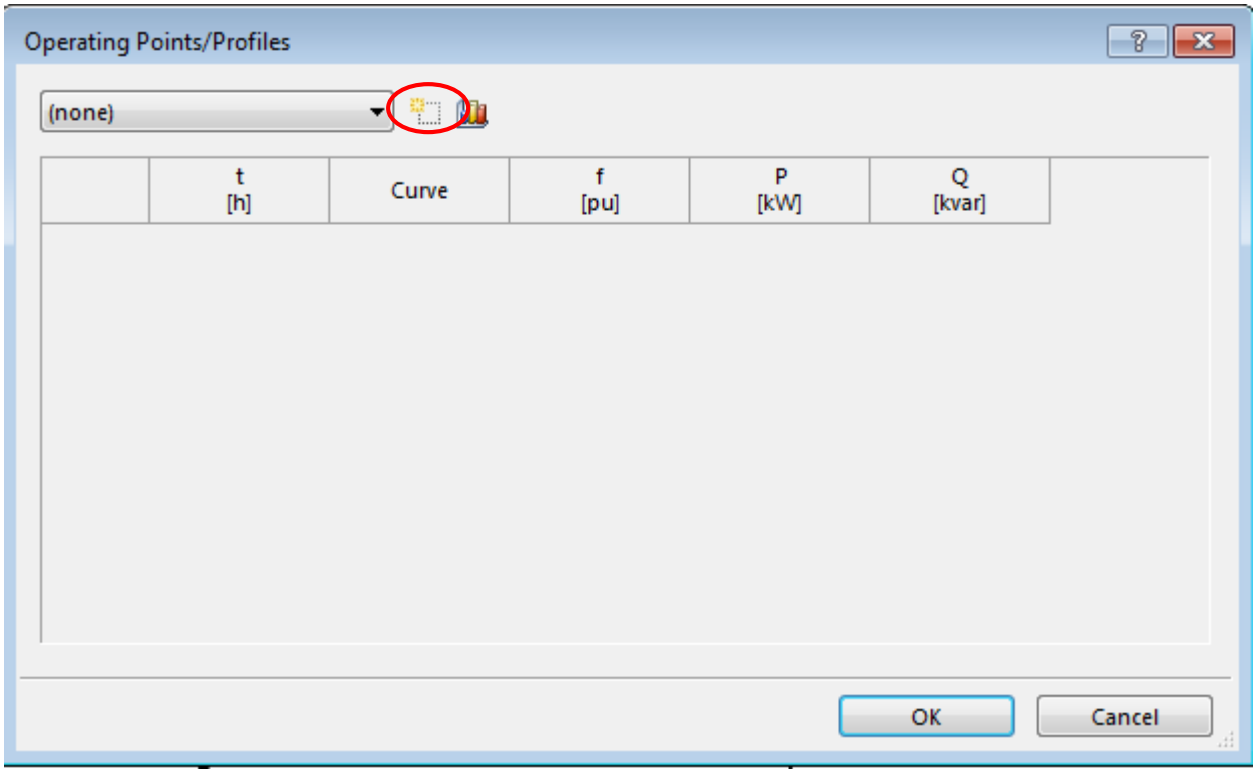
- Review the required format for load and generation profiles



Example Load Profile

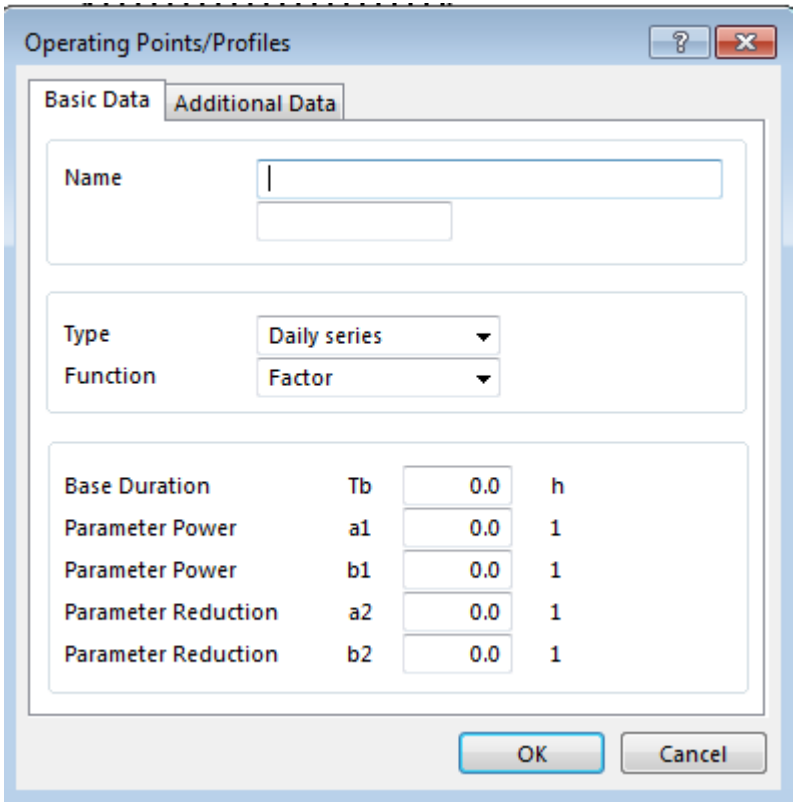


Creating a New Load Profile



Creating New Load Profile

- Several types of series:
  - Daily
  - Weekly
  - Yearly



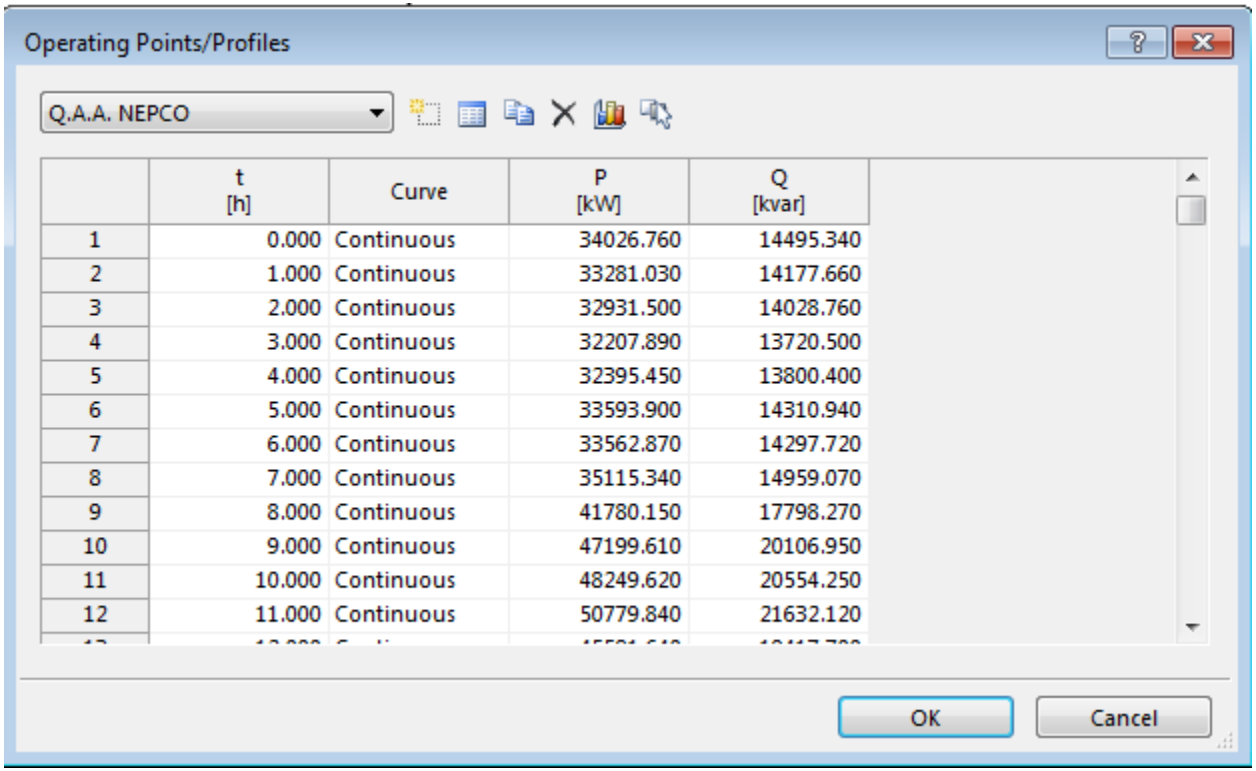
Creating New Load Profiles

- Profile Functions
  - Factor S
  - Factor P and Q
  - Power (kW and kVAR)
  - V and P (kV and kW)
  - Factor V and P

- For 33 kV loads use “Power” due to current flow being specified
- For 0.415 kV loads use “Factor” due to loads being specified as a percentage of S

Create Composite Load Profile for 33 kV Load at Q.A.A. NEPCO

- The format for the composite load:



	t [h]	Curve	P [kW]	Q [kvar]
1	0.000	Continuous	34026.760	14495.340
2	1.000	Continuous	33281.030	14177.660
3	2.000	Continuous	32931.500	14028.760
4	3.000	Continuous	32207.890	13720.500
5	4.000	Continuous	32395.450	13800.400
6	5.000	Continuous	33593.900	14310.940
7	6.000	Continuous	33562.870	14297.720
8	7.000	Continuous	35115.340	14959.070
9	8.000	Continuous	41780.150	17798.270
10	9.000	Continuous	47199.610	20106.950
11	10.000	Continuous	48249.620	20554.250
12	11.000	Continuous	50779.840	21632.120

Create Composite Load Profile for 33 kV Load at Q.A.A. NEPCO

- Modify existing load data spreadsheet as follows:

TIME STAMP	#	HOUR	MONTH	AMPER	kVA	pf	kW	kVAR
01-Nov-15 00:00:00	0	0	11	255.33	14594.07	0.92	14592.19	234.33
01-Nov-15 01:00:00	1	1	11	253.90	14512.44	0.92	14510.57	233.02
01-Nov-15 02:00:00	2	2	11	246.98	14116.81	0.92	14114.99	226.66
01-Nov-15 03:00:00	3	3	11	247.27	14133.56	0.92	14131.74	226.93
01-Nov-15 04:00:00	4	4	11	241.82	13821.97	0.92	13820.18	221.93
01-Nov-15 05:00:00	5	5	11	248.99	14231.94	0.92	14230.11	228.51
01-Nov-15 06:00:00	6	6	11	248.53	14205.63	0.92	14203.80	228.09
01-Nov-15 07:00:00	7	7	11	258.52	14776.19	0.92	14774.28	237.25
01-Nov-15 08:00:00	8	8	11	284.24	16246.34	0.92	16244.24	260.86
01-Nov-15 09:00:00	9	9	11	276.24	15789.31	0.92	15787.28	253.52
01-Nov-15 10:00:00	10	10	11	297.75	17018.46	0.92	17016.27	273.25

- In the future, this can be implemented by macros

Create Composite Load Profile for 33 kV Load at Q.A.A. NEPCO

- Create a new “Summary” tab within the load spreadsheet

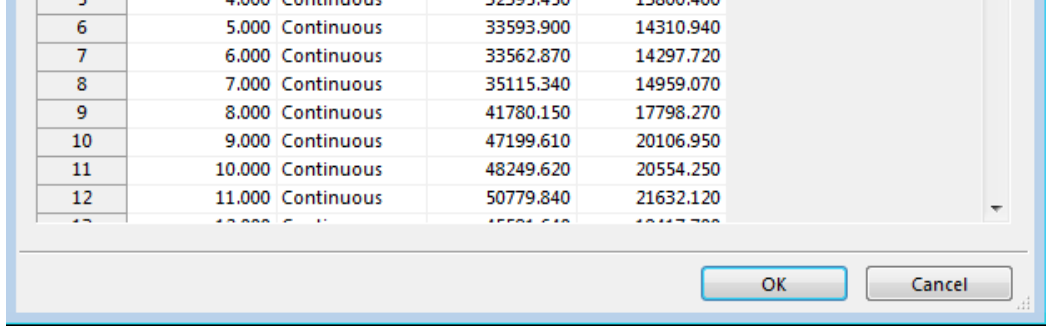
DATE	ALKEENA 33KV FEEDER (kVA)	MADABA 33KV FEEDER (kVA)	MOSHATA (2) 33KV FEEDER (kVA)	JOSYCO 33KV FEEDER (kVA)	NEW QASTEL (1) 33KV FEEDER (kVA)	NEW QASTEL (2) (kVA)	MOSHATA (1) 33KV FEEDER (kVA)	EAST VILLAGES 33KV FEEDER (kVA)	TOTAL	t [h]	Curve	P [kW]	Q [kVAR]
01-Nov-15 00:00:00	14594.07	3099.74	937.77	3688.29	5495.59	5585.46	906.37	2678.30	**36985.61**	0	Continuous	34026.76	14495.34
01-Nov-15 01:00:00	14512.44	3077.76	950.33	3667.36	5277.06	5375.44	909.51	2405.13	**36175.03**	1	Continuous	33281.03	14177.66
01-Nov-15 02:00:00	14116.81	3075.32	943.00	3606.65	5325.20	5505.22	904.28	2318.61	**35795.11**	2	Continuous	32931.50	14028.76
01-Nov-15 03:00:00	14133.56	3055.08	946.14	3462.22	5062.50	5157.22	906.37	2285.47	**35008.58**	3	Continuous	32207.89	13720.50
01-Nov-15 04:00:00	13821.97	3056.48	936.38	3648.52	5187.05	5281.25	901.49	2379.32	**35212.44**	4	Continuous	32395.45	13800.40
01-Nov-15 05:00:00	14231.94	3046.01	932.89	3589.91	5608.84	5700.42	891.72	2513.38	**36515.11**	5	Continuous	33593.90	14310.94
01-Nov-15 06:00:00	14205.63	3039.39	919.63	3528.90	5514.85	5626.21	881.95	2764.82	**36481.38**	6	Continuous	33562.87	14297.72
01-Nov-15 07:00:00	14776.19	3085.44	948.94	3903.89	5842.23	5946.90	911.26	2754.01	**38168.85**	7	Continuous	35115.34	14959.07
01-Nov-15 08:00:00	16246.34	3031.71	938.47	4919.12	8042.23	8341.56	901.49	2992.29	**45413.20**	8	Continuous	41780.15	17798.27
01-Nov-15 09:00:00	15789.31	3018.45	919.63	5530.34	10694.37	10832.52	881.25	3638.05	**51303.93**	9	Continuous	47199.61	20106.95
01-Nov-15 10:00:00	17018.46	3018.10	935.68	5484.29	10702.74	10836.71	896.60	3552.65	**52445.23**	10	Continuous	48249.62	20554.25
01-Nov-15 11:00:00	17038.28	3018.10	933.59	5745.95	11906.35	12048.69	898.70	3605.82	**55195.47**	11	Continuous	50779.84	21632.12

- Sum up the kVA from each of the circuits to be represented by the 33 kV load, create PSS SINCAL inputs

Create Composite Load Profile for 33 kV Load at Q.A.A. NEPCO

- Data can be copied and pasted into PSS SINCAL:

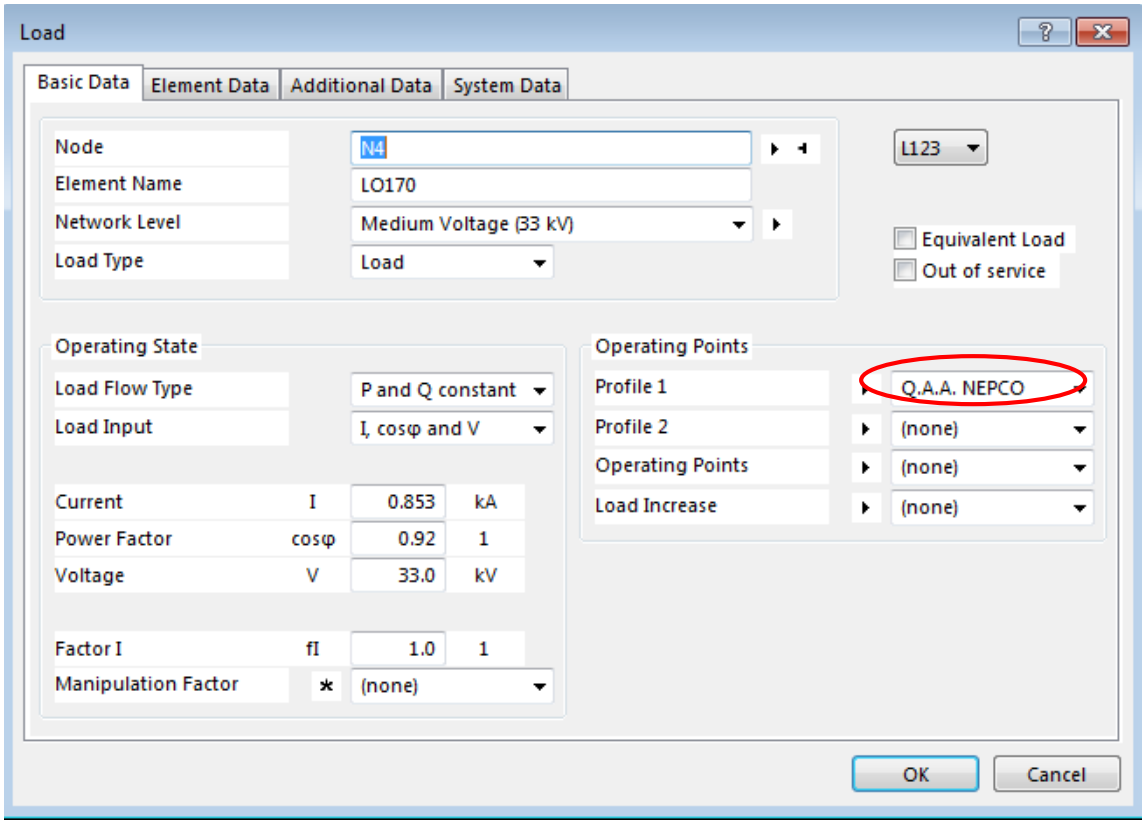
t [h]	Curve	P [kW]	Q [kVAR]
0	Continuous	34026.76	14495.34
1	Continuous	33281.03	14177.66
2	Continuous	32931.50	14028.76
3	Continuous	32207.89	13720.50
4	Continuous	32395.45	13800.40
5	Continuous	33593.90	14310.94
6	Continuous	33562.87	14297.72
7	Continuous	35115.34	14959.07
8	Continuous	41780.15	17798.27
9	Continuous	47199.61	20106.95
10	Continuous	48249.62	20554.25
11	Continuous	50779.84	21632.12



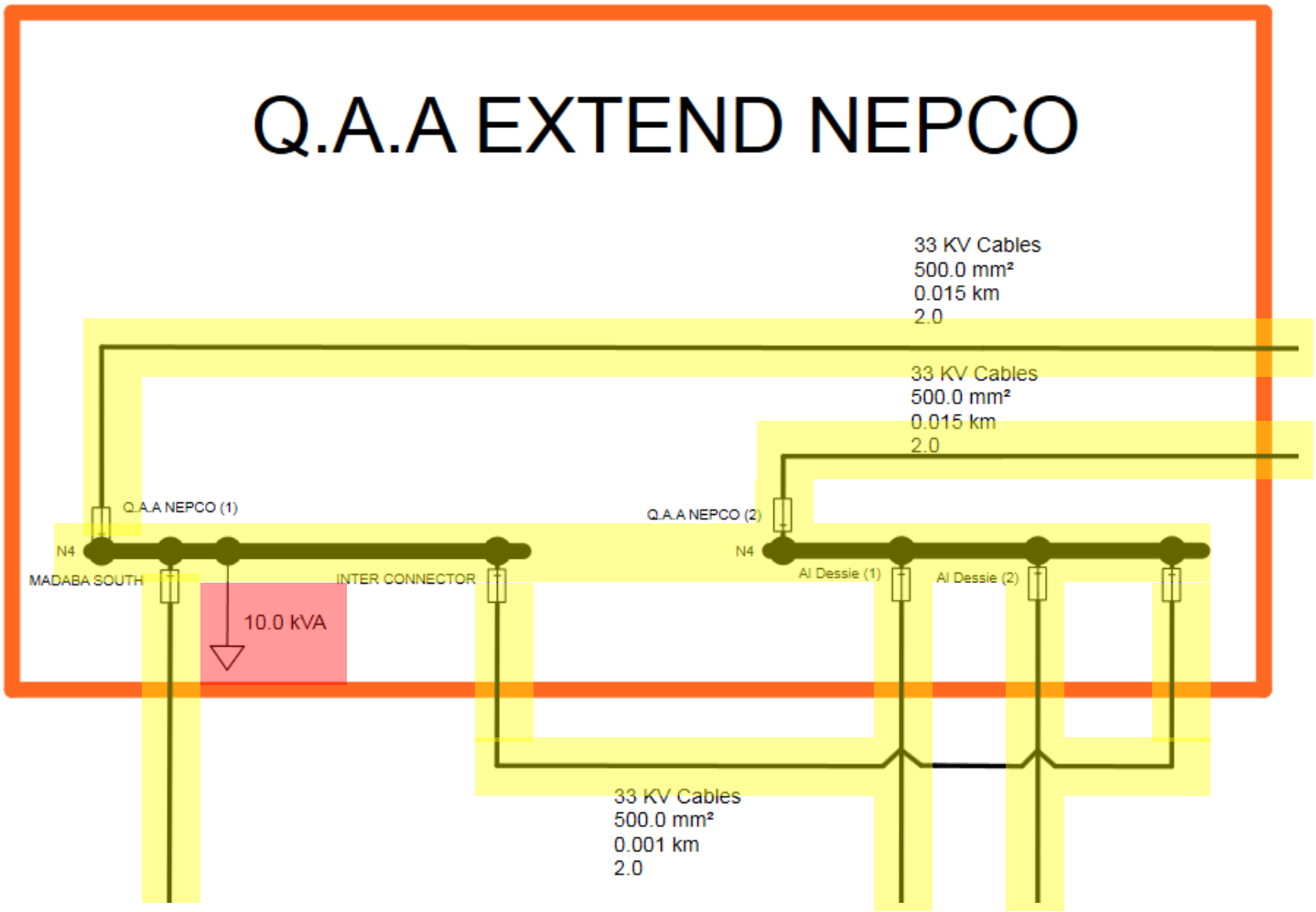
Exercise – Create 24 Hour Load Profile for Q.A.A. NEPCO for 1/11/15

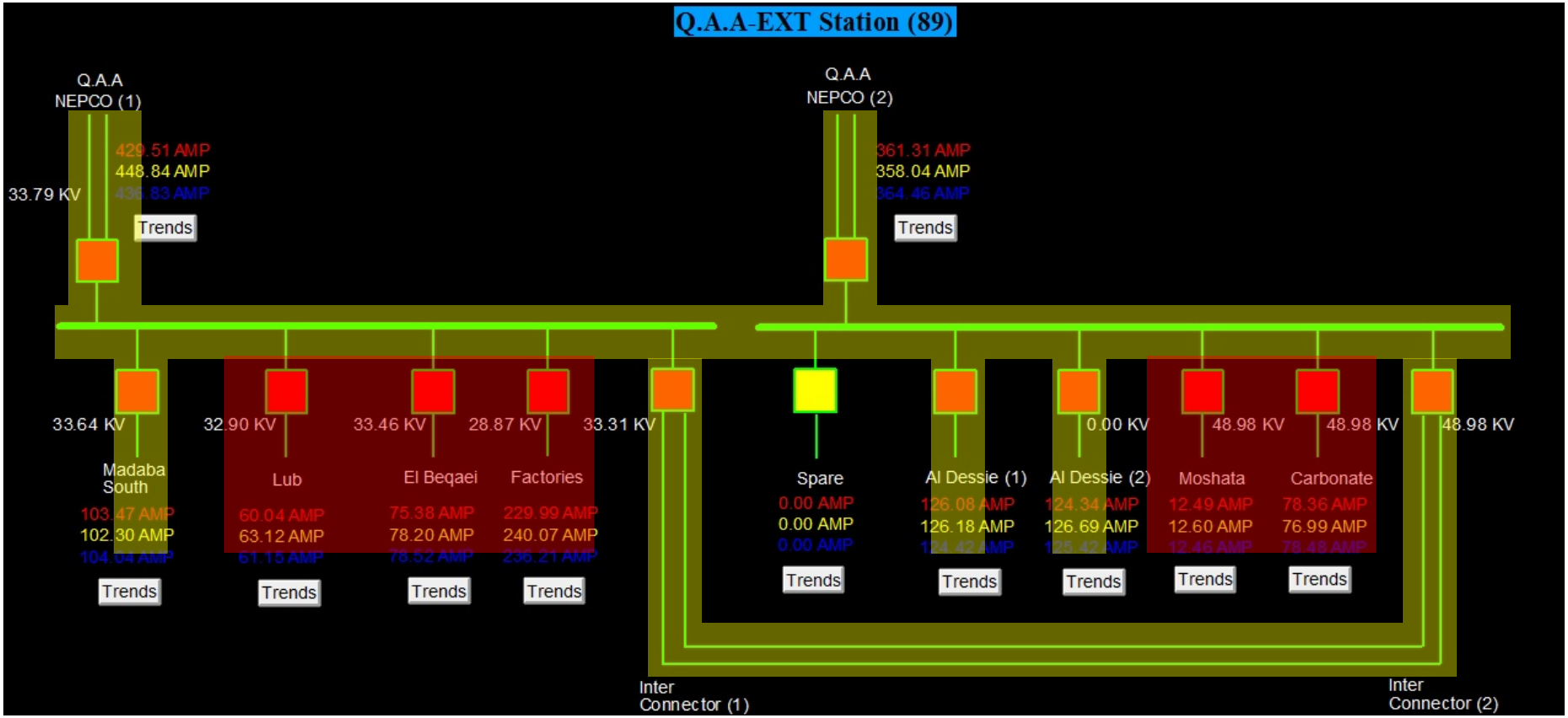
- Open the model:
  - AJIB BANK STUDY-SINCAL MODEL__Min__MaxPV__100
- Make the necessary updates to the load profile spreadsheet for each circuit
- Create the load profile in PSS SINCAL
- Create Summary tab in the load profile spreadsheet, combine the necessary loads together
- Format the data so it is ready to be pasted into PSS SINCAL

Assigning the Load Profile



Q.A.A. Extended NEPCO

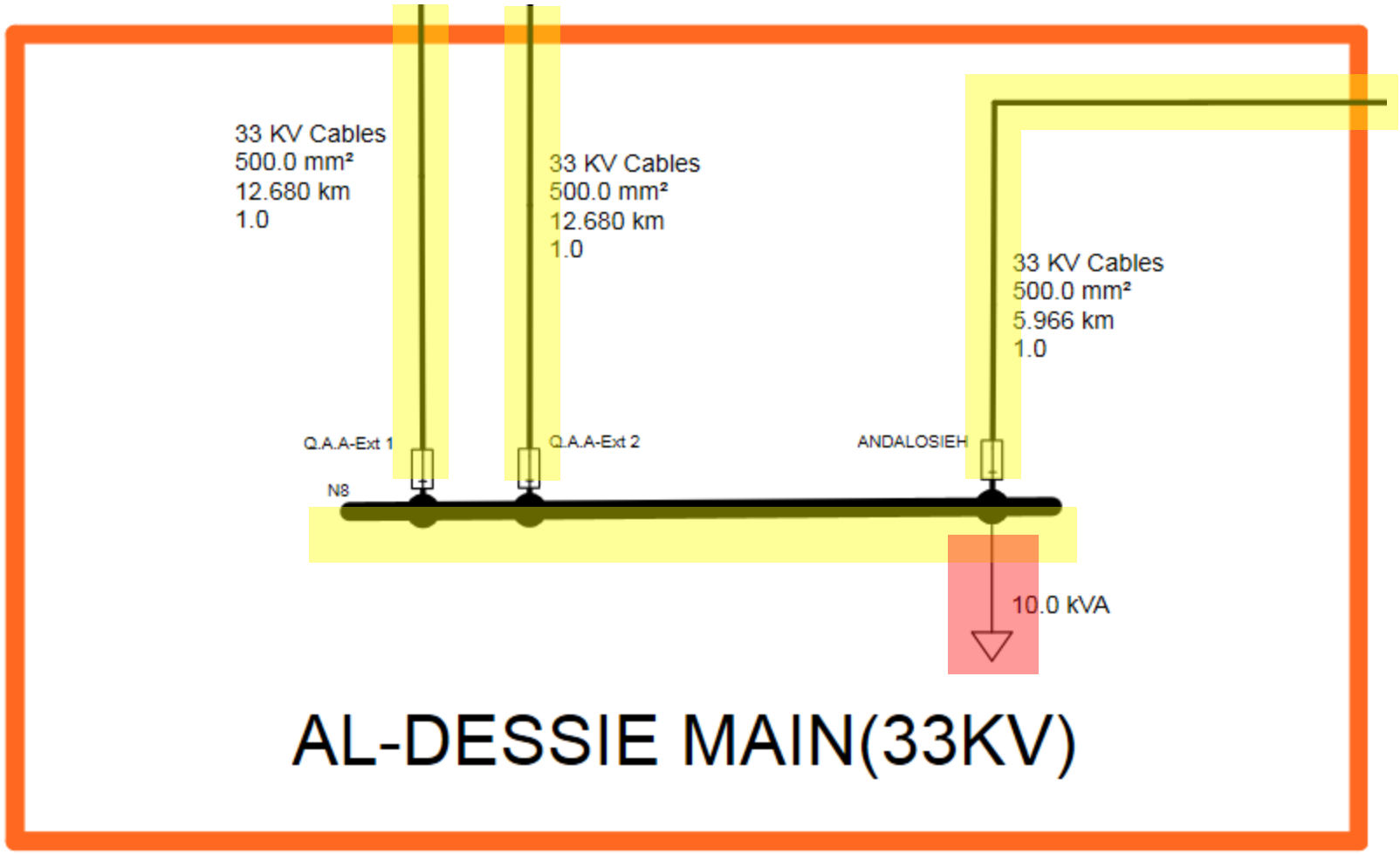


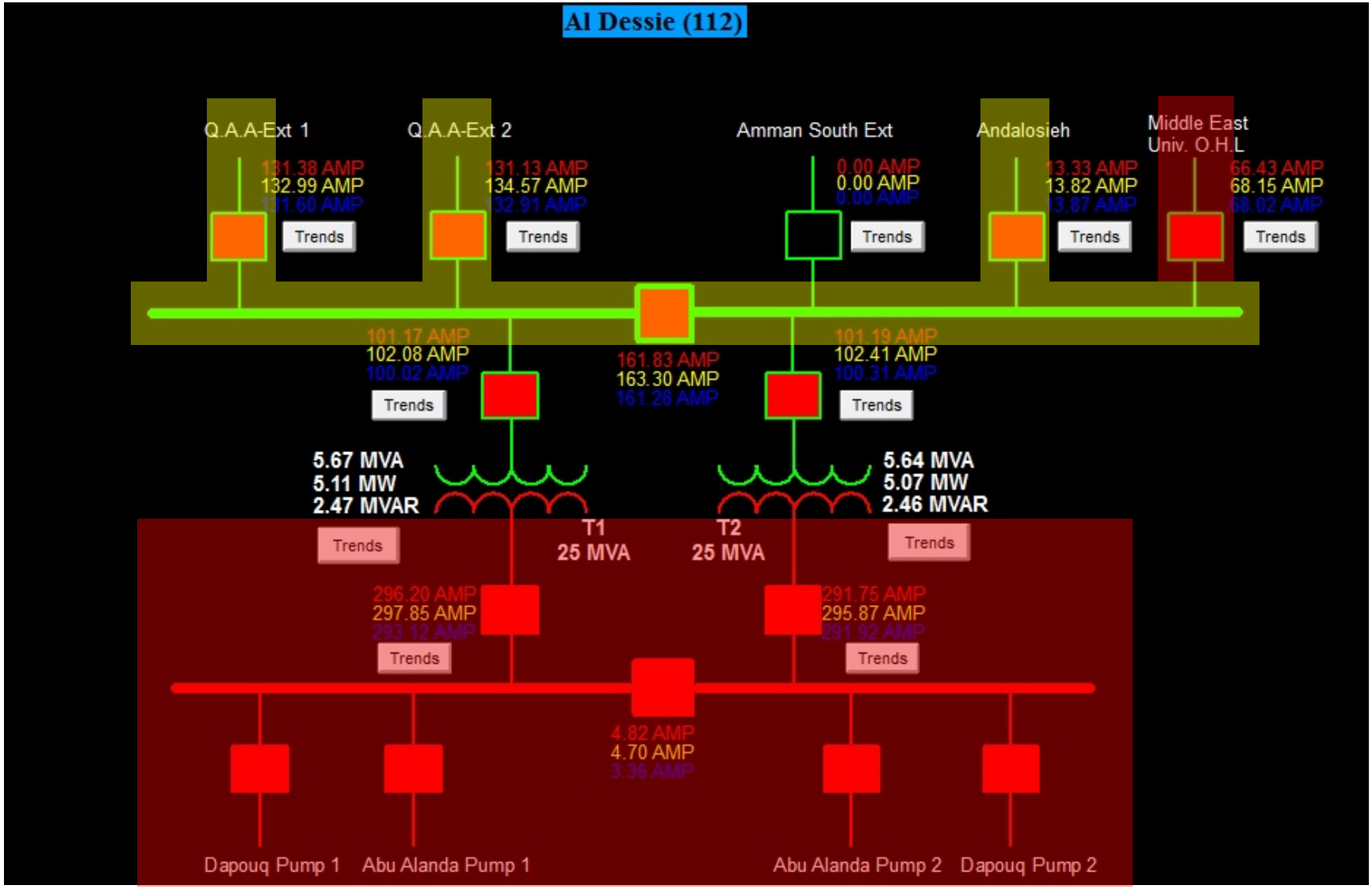

Q.A.A-EXT Station (89)
Q.A.A NEPCO (1)
429.51 AMP
448.84 AMP
436.83 AMP
33.79 KV
Trends
Q.A.A NEPCO (2)
361.31 AMP
358.04 AMP
364.46 AMP
Trends
33.64 KV
Madaba South
103.47 AMP
102.30 AMP
104.04 AMP
Trends
32.90 KV
Lub
60.04 AMP
63.12 AMP
61.15 AMP
Trends
33.46 KV
El Beqaei
75.38 AMP
78.20 AMP
78.52 AMP
Trends
28.87 KV
Factories
229.99 AMP
240.07 AMP
236.21 AMP
Trends
33.31 KV
Inter Connector (1)
Spare
0.00 AMP
0.00 AMP
0.00 AMP
Trends
Al Dessie (1)
126.08 AMP
126.18 AMP
124.42 AMP
Trends
0.00 KV
Al Dessie (2)
124.34 AMP
126.69 AMP
125.42 AMP
Trends
48.98 KV
Moshata
12.49 AMP
12.60 AMP
12.46 AMP
Trends
48.98 KV
Carbonate
78.36 AMP
76.99 AMP
78.48 AMP
Trends
48.98 KV
Inter Connector (2)

Repeat the Process – Create 24 Hour Load Profile for 1/11/15 Q.A.A. Extended NEPCO

- Make the necessary updates to the load profile spreadsheet for each circuit
- Create the load profile in PSS SINCAL
- Create Summary tab in the load profile spreadsheet, combine the necessary loads together
- Format the data so it is ready to be pasted into PSS SINCAL

AL DESSIE MAIN

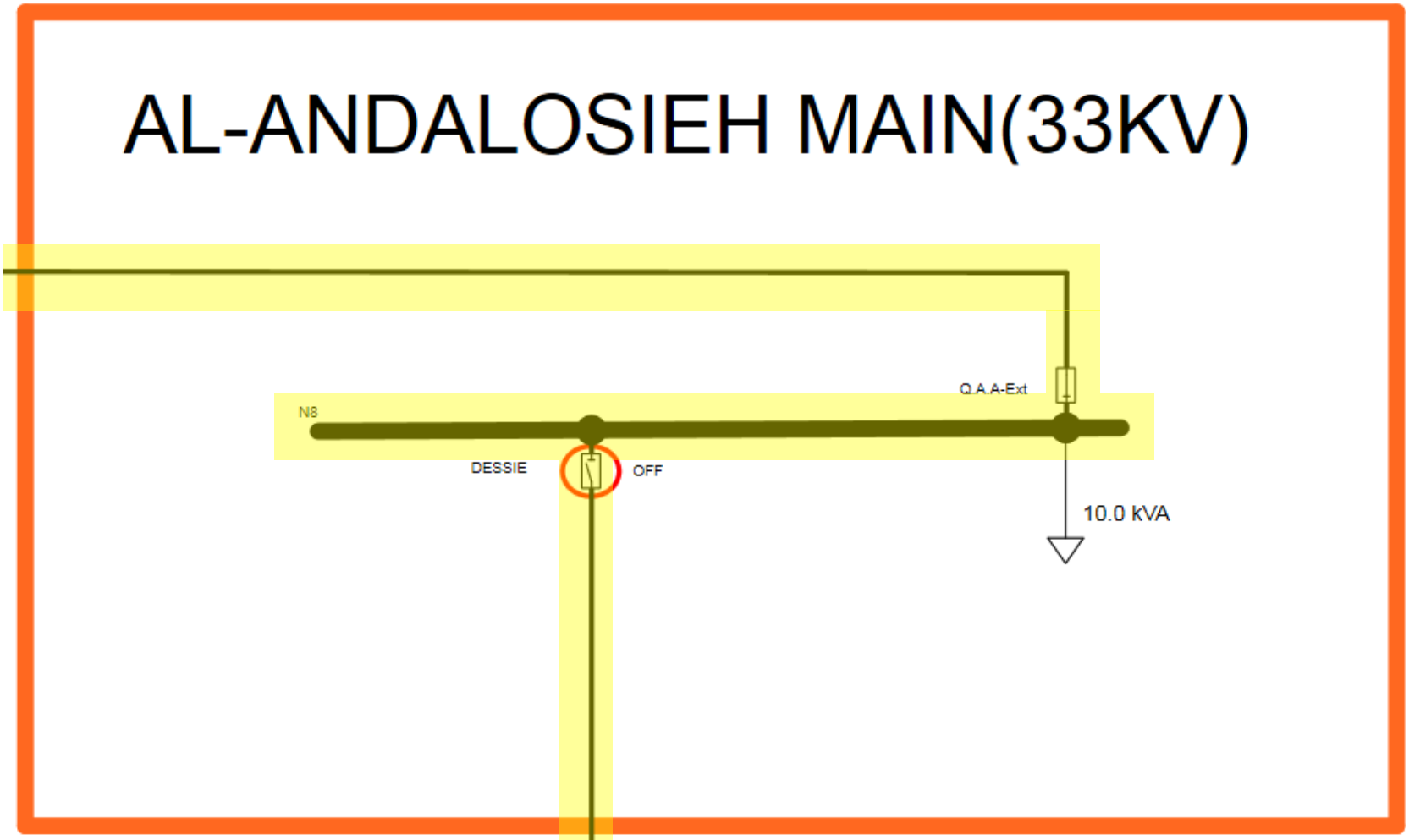


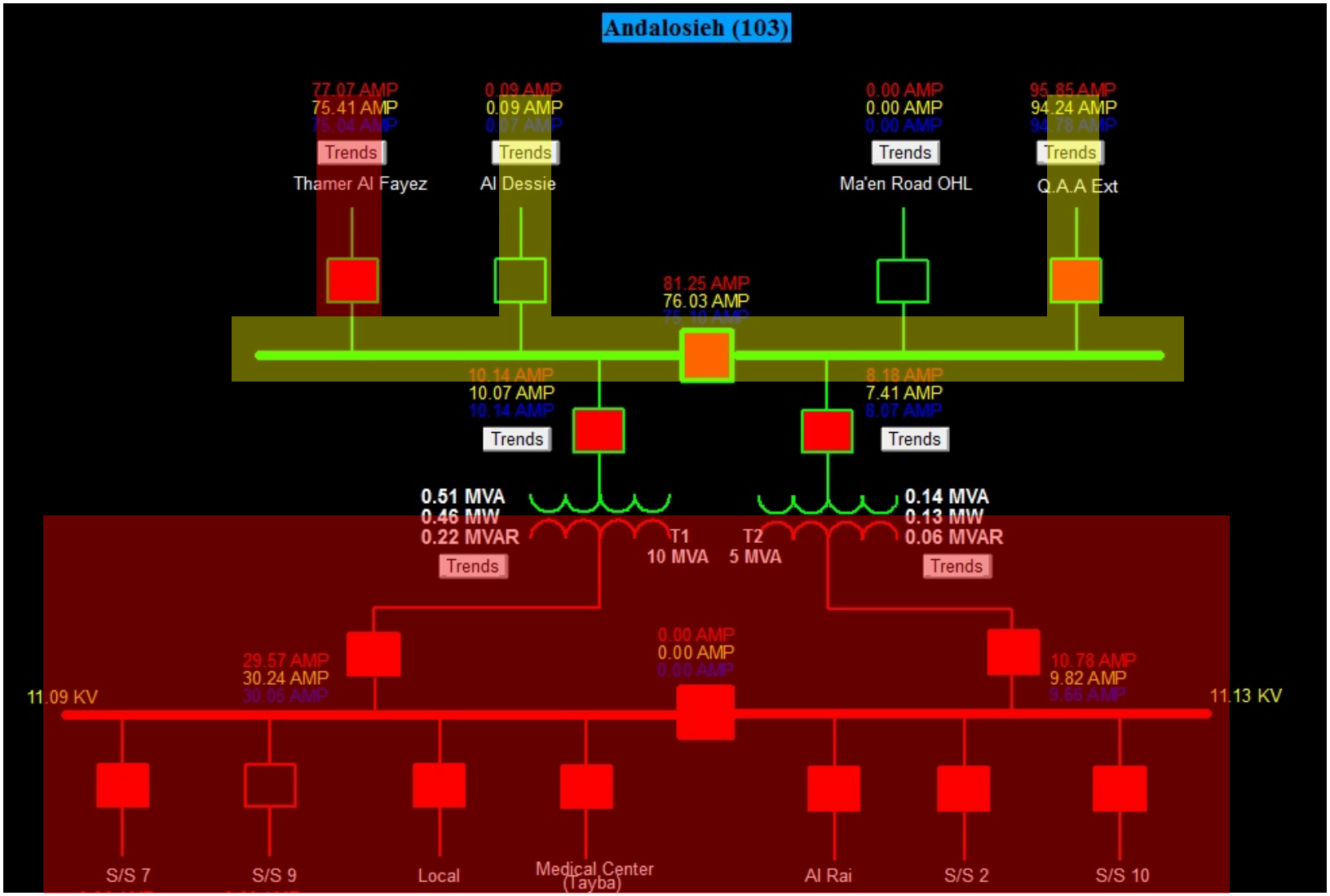

Al Dessie (112)
Q.A.A-Ext 1
131.38 AMP
132.99 AMP
Trends
Q.A.A-Ext 2
131.13 AMP
134.57 AMP
Trends
Amman South Ext
0.00 AMP
0.00 AMP
Trends
Andalosieh
13.33 AMP
13.82 AMP
Trends
Middle East Univ. O.H.L
66.43 AMP
68.15 AMP
Trends
101.17 AMP
102.08 AMP
Trends
161.83 AMP
163.30 AMP
101.19 AMP
102.41 AMP
Trends
5.67 MVA
5.11 MW
2.47 MVAR
Trends
T1
25 MVA
T2
25 MVA
5.64 MVA
5.07 MW
2.46 MVAR
Trends
296.20 AMP
297.85 AMP
Trends
291.75 AMP
295.87 AMP
Trends
4.82 AMP
4.70 AMP
Dapouq Pump 1
Abu Alanda Pump 1
Abu Alanda Pump 2
Dapouq Pump 2

Repeat the Process – Create 24 Hour Load Profile for 1/11/15 AL DESSIE MAIN

- Make the necessary updates to the load profile spreadsheet for each circuit
- Create the load profile in PSS SINCAL
- Create Summary tab in the load profile spreadsheet, combine the necessary loads together
- Format the data so it is ready to be pasted into PSS SINCAL

AL ANDALOSIEH MAIN

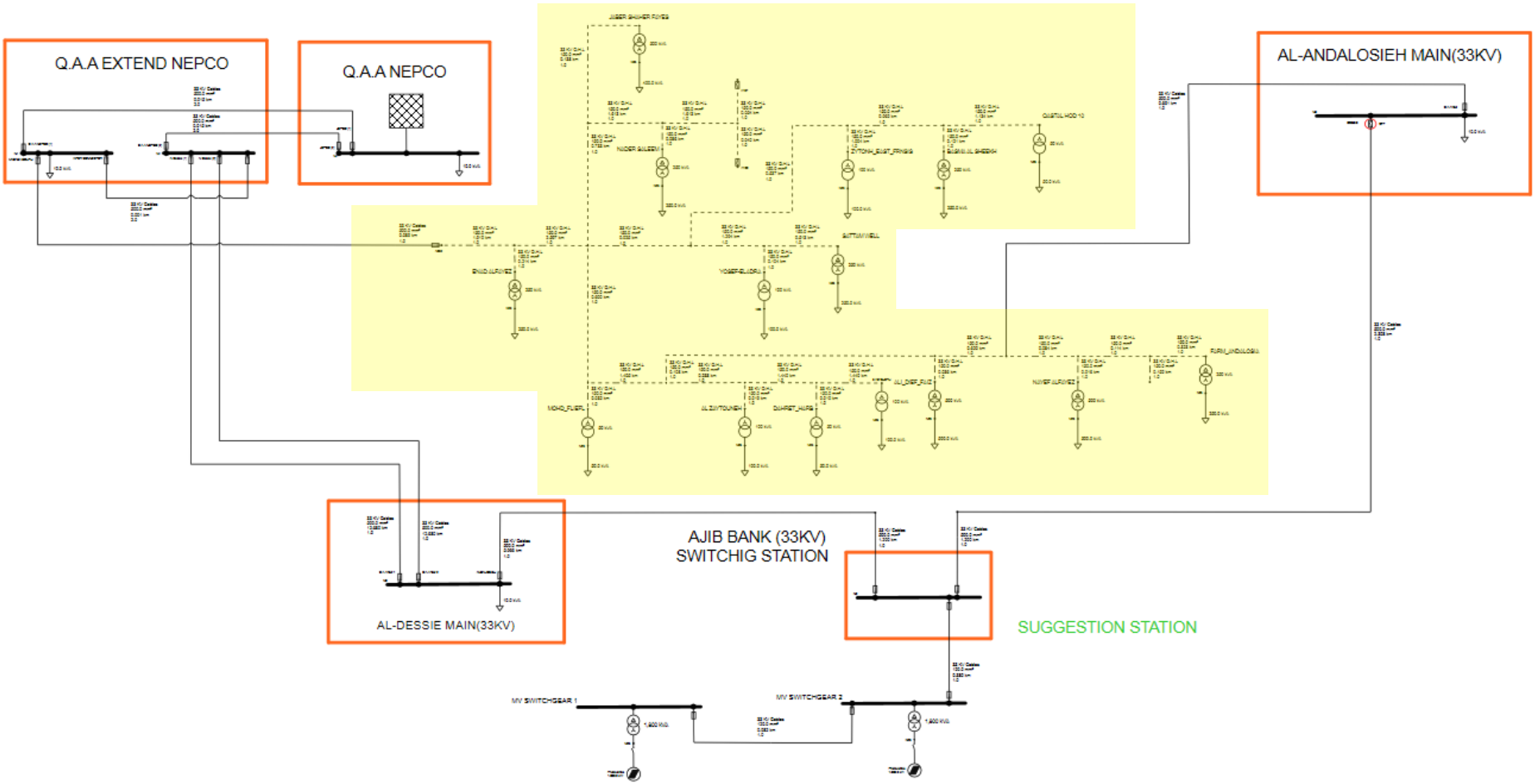



Andalosieh (103)
77.07 AMP
75.41 AMP
Trends
Thamer Al Fayez
0.09 AMP
0.09 AMP
Trends
Al Dessie
0.00 AMP
0.00 AMP
Trends
Ma'en Road OHL
95.85 AMP
94.24 AMP
Trends
Q.A.A Ext
81.25 AMP
76.03 AMP
10.14 AMP
10.07 AMP
Trends
8.18 AMP
7.41 AMP
Trends
0.51 MVA
0.46 MW
0.22 MVAR
Trends
T1
10 MVA
T2
5 MVA
0.14 MVA
0.13 MW
0.06 MVAR
Trends
0.00 AMP
0.00 AMP
29.57 AMP
30.24 AMP
10.78 AMP
9.82 AMP
11.09 KV
11.13 KV
S/S 7
S/S 9
Local
Medical Center (Tayba)
Al Rai
S/S 2
S/S 10

Repeat the Process – Create 24 Hour Load Profile for 1/11/15 AL ANDALOSIEH MAIN

- Make the necessary updates to the load profile spreadsheet for each circuit
- Create the load profile in PSS SINCAL
- Create Summary tab in the load profile spreadsheet, combine the necessary loads together
- Format the data so it is ready to be pasted into PSS SINCAL

MADABA SOUTH



Creating the Madaba South Load Profile

- The Madaba South load profile is based on the difference between the flow from Q.A.A. Extended NEPCO and Al Andalosieh Main 33 kV circuits
- Subtract the two currents to obtain the Madaba South load current.
- Per-unitize the based on the peak value
  - Recall, the 0.415 kV loads are modeled based on a factor of their total apparent power (S)
- Open Q.A.A. Extended NEPCO load profile
- Open Al Andalosieh Main load profile

Creating the Madaba South Load Profile

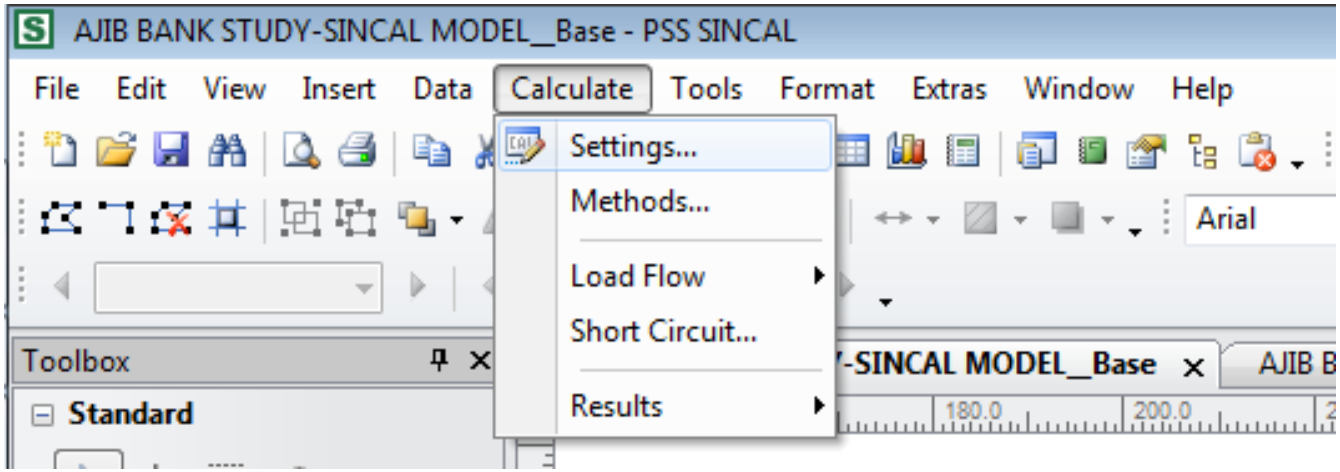
- Let's make these changes:

Seen from Q.A.A. Ext. NEPCO									Seen from ANDALOSIEH 33 kV			1215.48			
TIME STAMP	#	HOUR	MONTH	AMPER	kVA	pf	kW	kVAR	(kVA)	Delta (kVA)	Delta (pu, peak)		t [h]	Curve	f [pu]
01-Nov-15 00:00:00	0	0	11	89.36	5107.51	0.92	5106.85	82.01	4763.52	**343.99**	**0.28**		0	Continuous	0.28
01-Nov-15 01:00:00	1	1	11	85.92	4911.24	0.92	4910.61	78.86	4510.00	**401.24**	**0.33**		1	Continuous	0.33
01-Nov-15 02:00:00	2	2	11	86.98	4971.45	0.92	4970.81	79.82	4308.59	**662.86**	**0.55**		2	Continuous	0.55
01-Nov-15 03:00:00	3	3	11	77.32	4419.43	0.92	4418.86	70.96	4051.12	**368.31**	**0.30**		3	Continuous	0.30
01-Nov-15 04:00:00	4	4	11	73.10	4178.22	0.92	4177.69	67.09	3805.28	**372.95**	**0.31**		4	Continuous	0.31
01-Nov-15 05:00:00	5	5	11	78.92	4510.93	0.92	4510.35	72.43	4113.68	**397.25**	**0.33**		5	Continuous	0.33
01-Nov-15 06:00:00	6	6	11	85.01	4859.11	0.92	4858.48	78.02	4484.65	**374.46**	**0.31**		6	Continuous	0.31
01-Nov-15 07:00:00	7	7	11	96.61	5522.08	0.92	5521.37	88.66	5119.60	**402.48**	**0.33**		7	Continuous	0.33
01-Nov-15 08:00:00	8	8	11	99.05	5661.52	0.92	5660.79	90.90	5327.30	**334.22**	**0.27**		8	Continuous	0.27
01-Nov-15 09:00:00	9	9	11	101.28	5788.68	0.92	5787.94	92.95	5397.54	**391.15**	**0.32**		9	Continuous	0.32
01-Nov-15 10:00:00	10	10	11	100.05	5718.73	0.92	5718.00	91.82	5444.87	**273.87**	**0.23**		10	Continuous	0.23

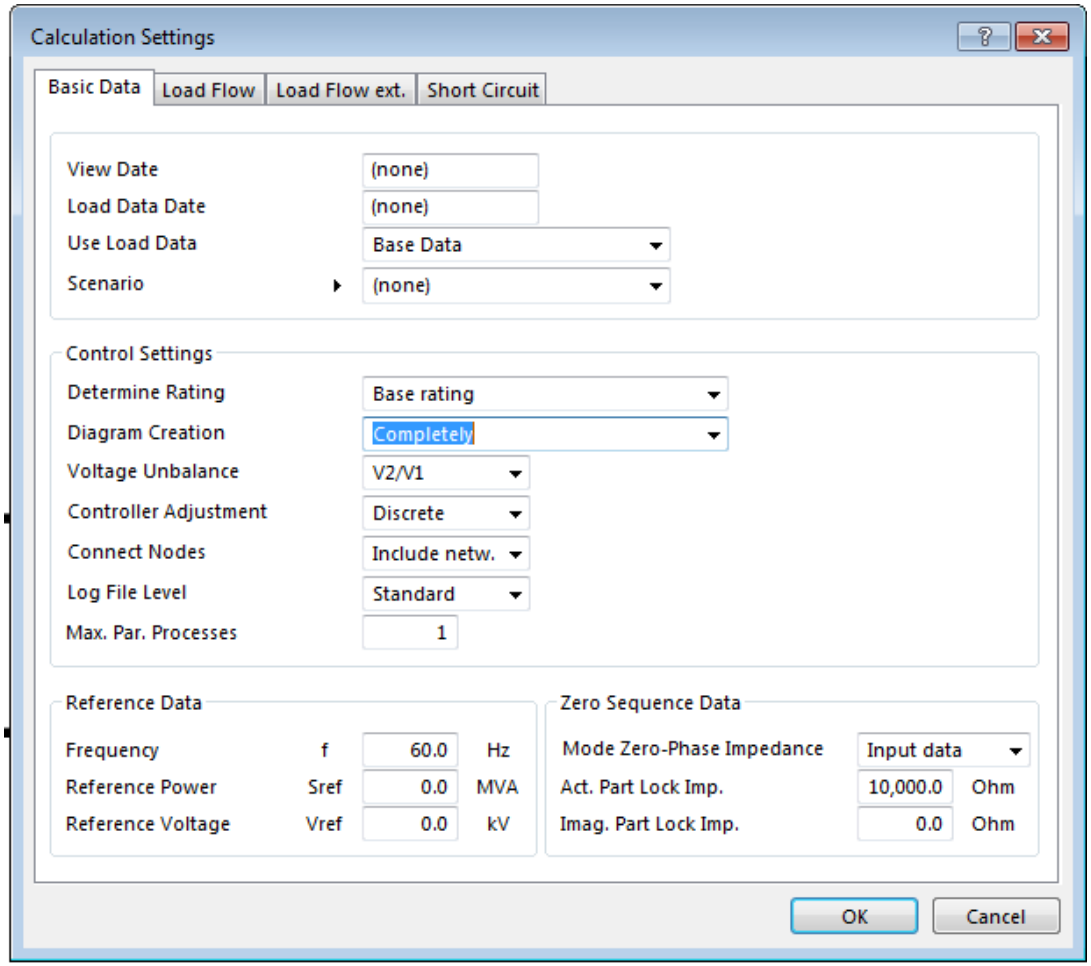
Generator Profile

- Solar data was not available at the time of the study
- Black & Veatch utilized the PV profiles from the IDECO project
- The IDECO profiles were per-unitized so they can be applied to this project
- Generator Profile

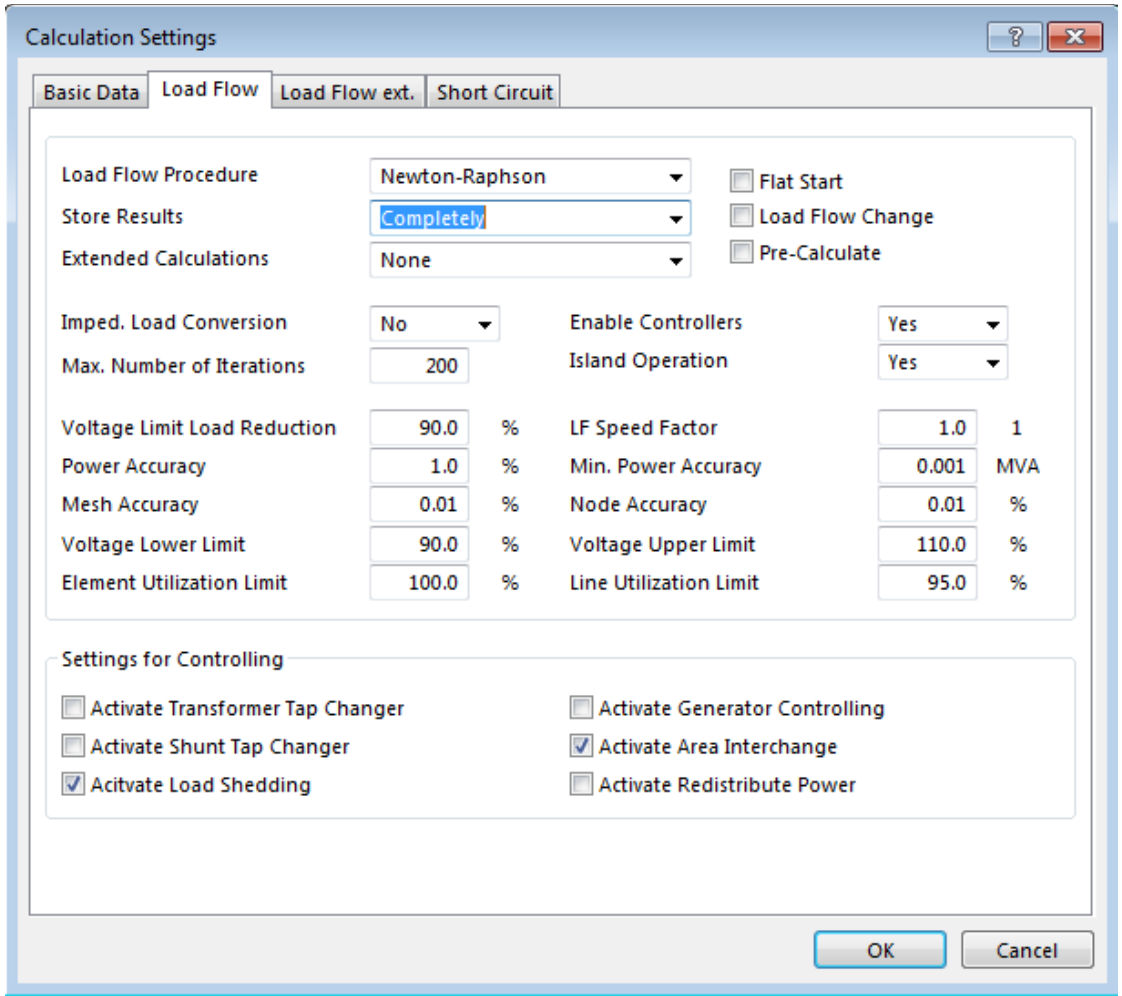
Long-Term Dynamic Analysis Settings



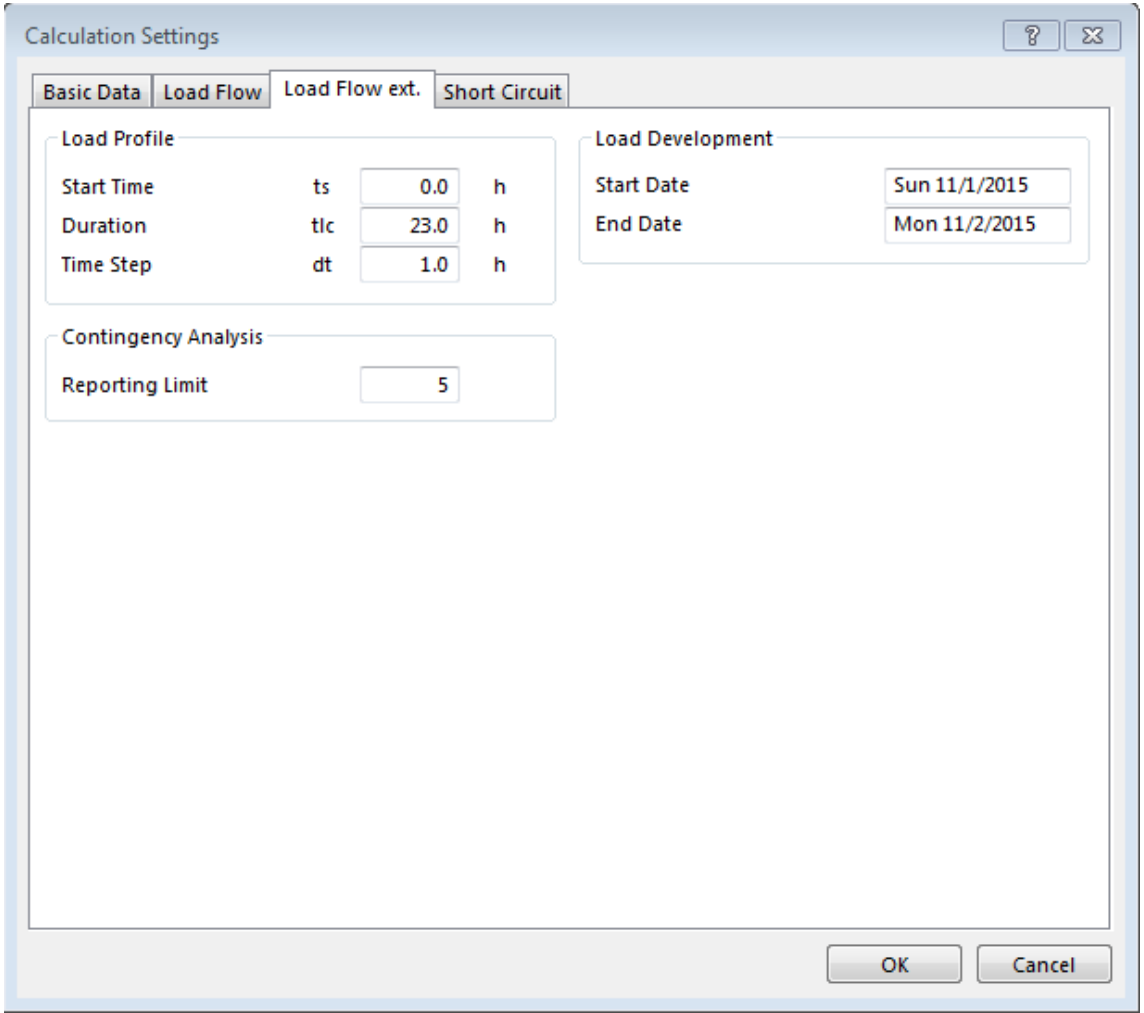
Long-Term Dynamic Analysis Settings



Long-Term Dynamic Analysis Settings (continued)

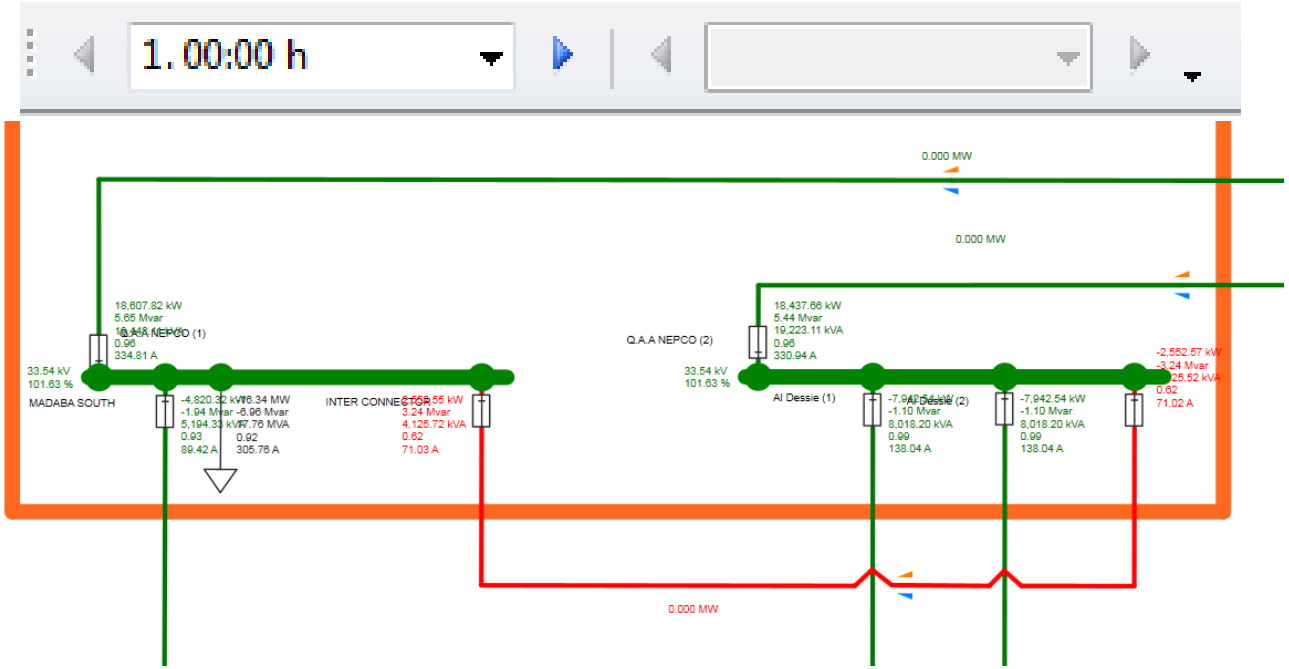


Long-Term Dynamic Analysis Settings (continued)



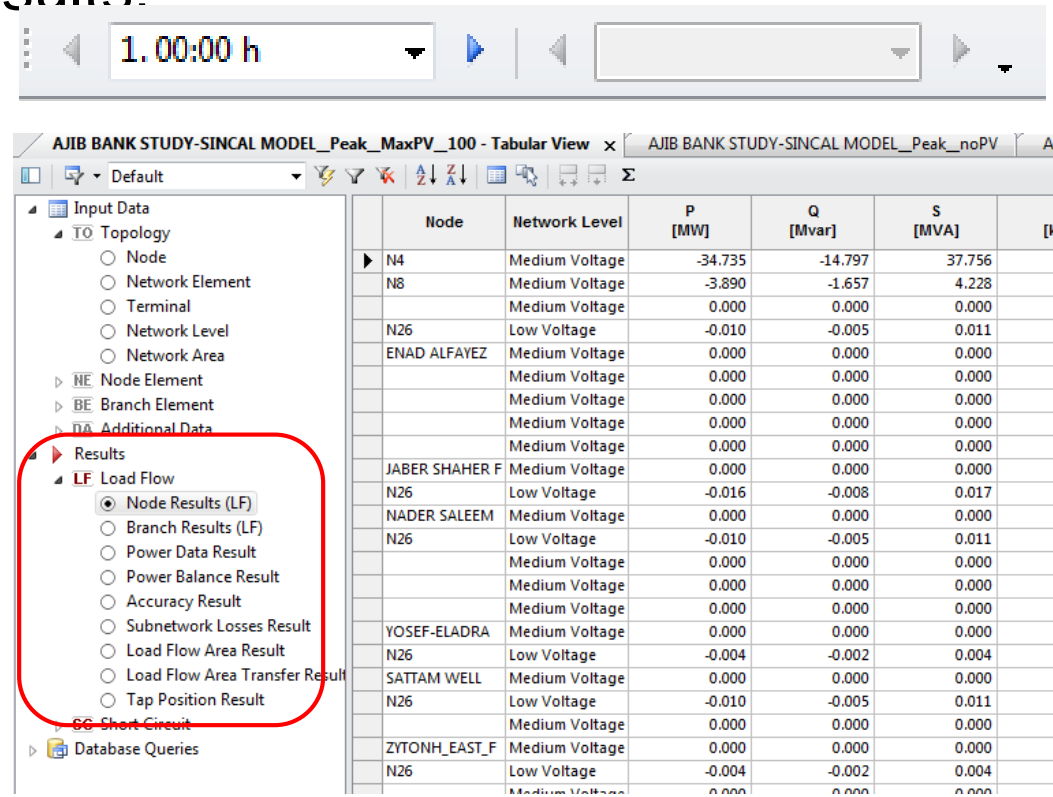
Viewing Results (Graphic View)

- Option 1 – Viewing the results in the Graphic View
- Step through the results using the Results toolbar



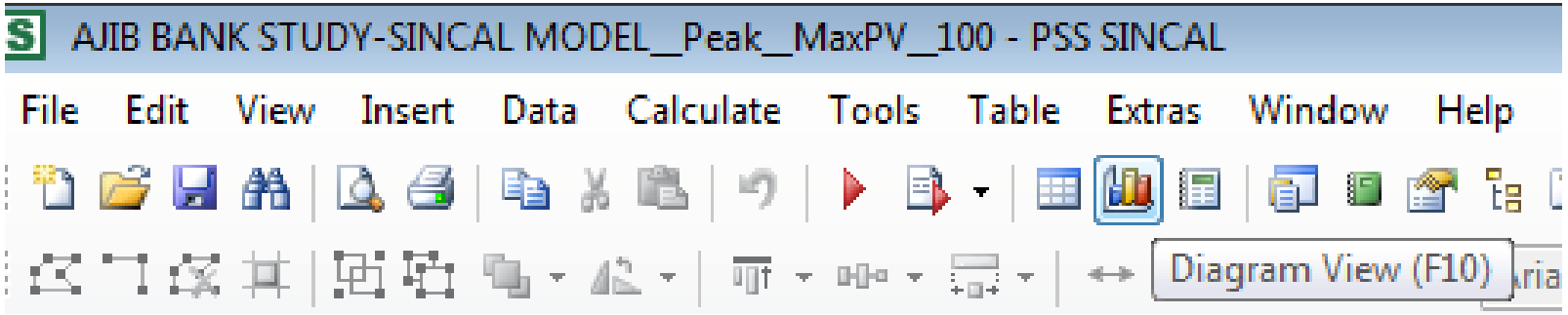
Viewing the Results (Tabular Format)

- Option 2 – Open the Tabular View and step through the results:



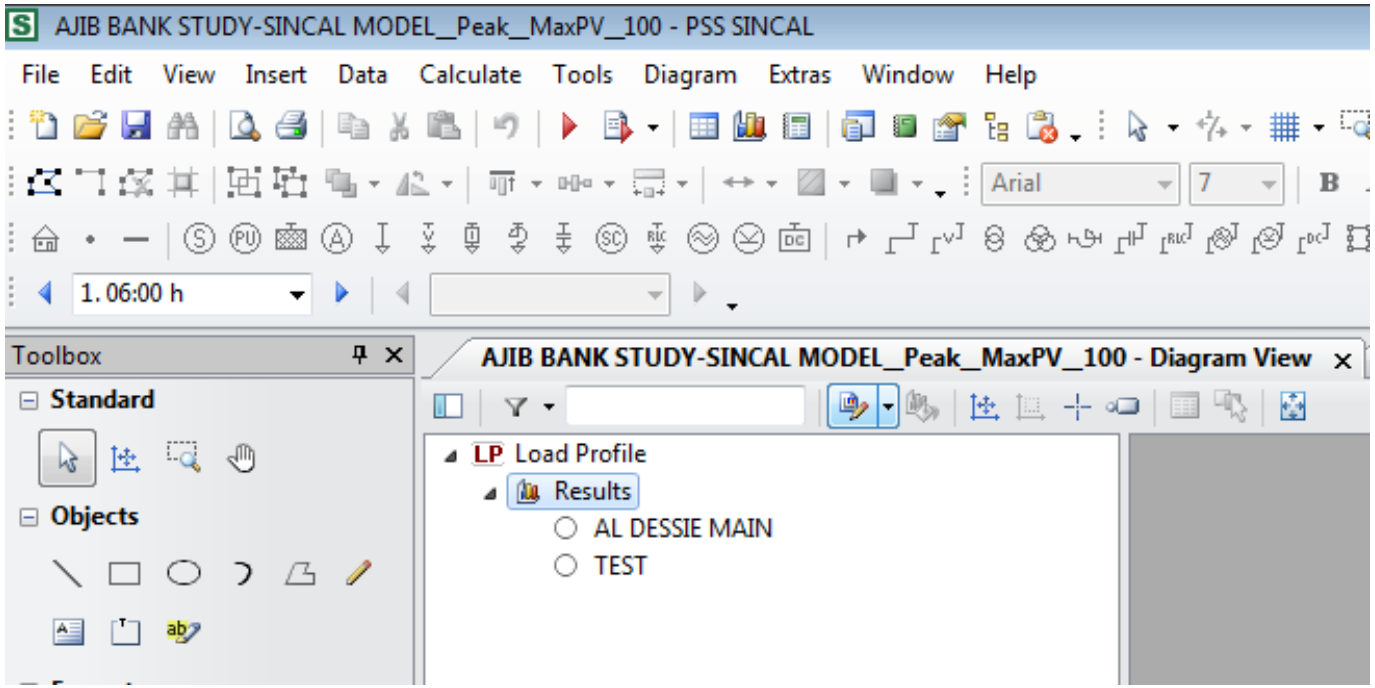
Plotting Results in Graphic View

- Open the Graphic View:

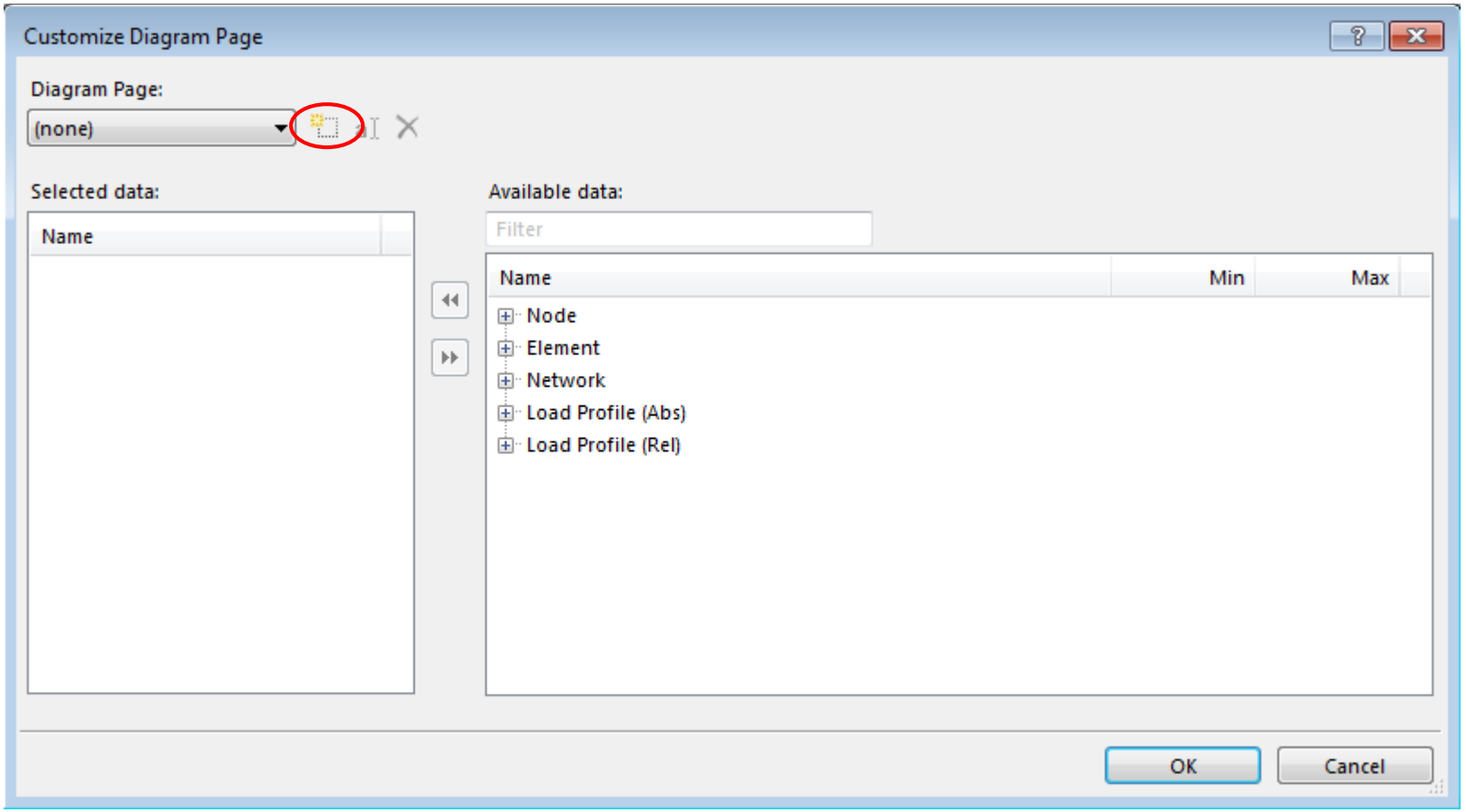


Plotting Results in Graphic View

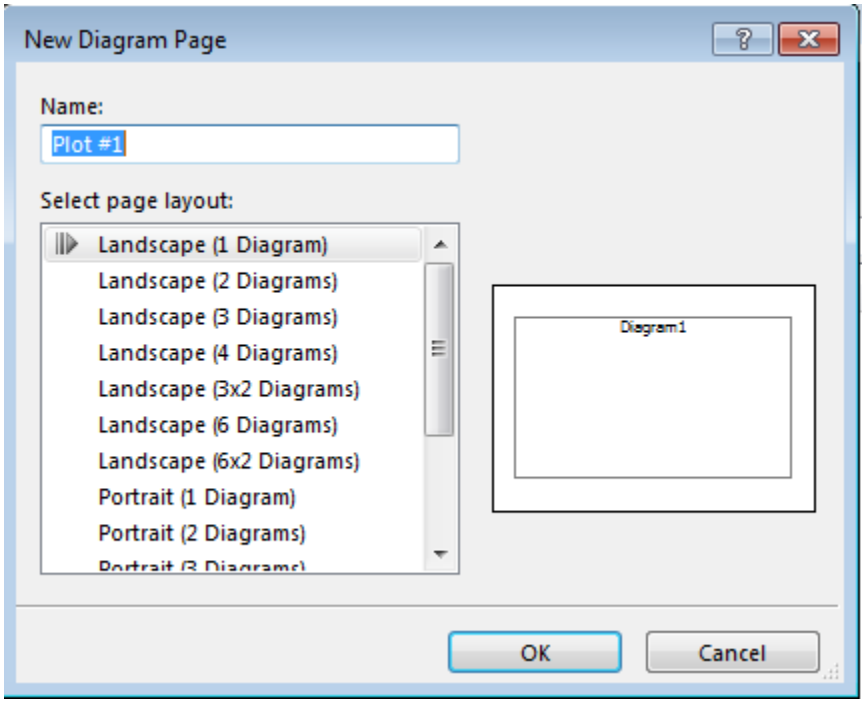
- Create new diagram page:



Plotting Results in Graphic View

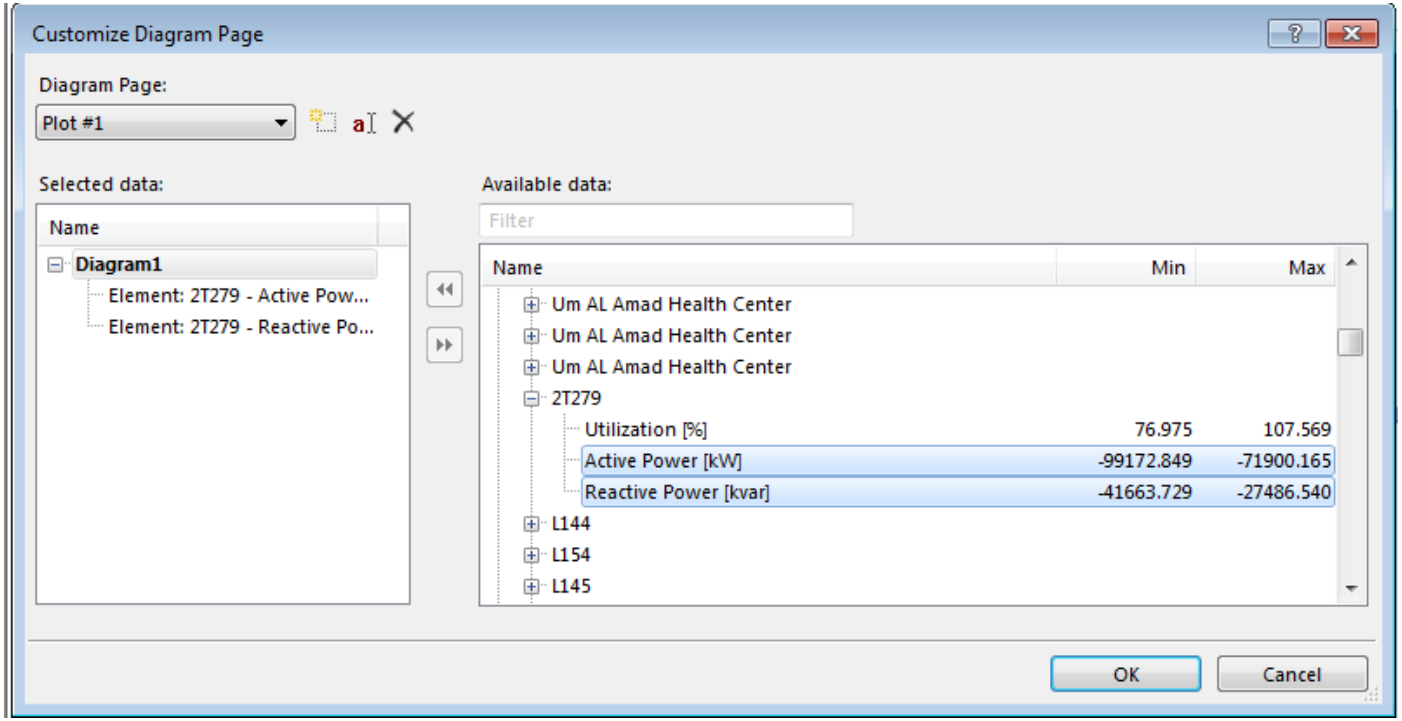


Plotting Results in Graphic View

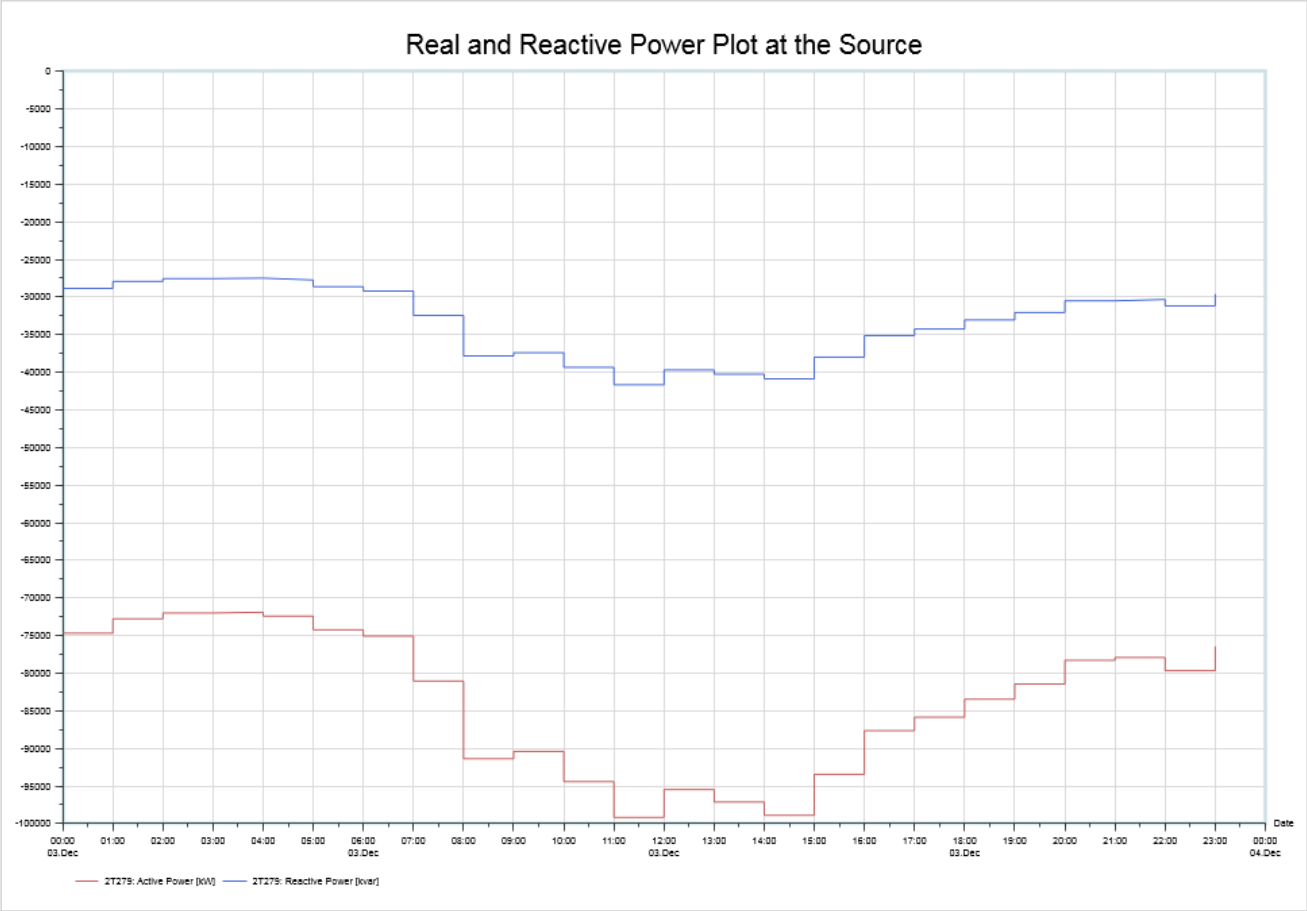


Plotting Results in Graphic View

- Search to the node, element, or other data set you wish to plot, use the left double arrows to add them



Monitoring for Reverse Power Flow at the Distribution Substation



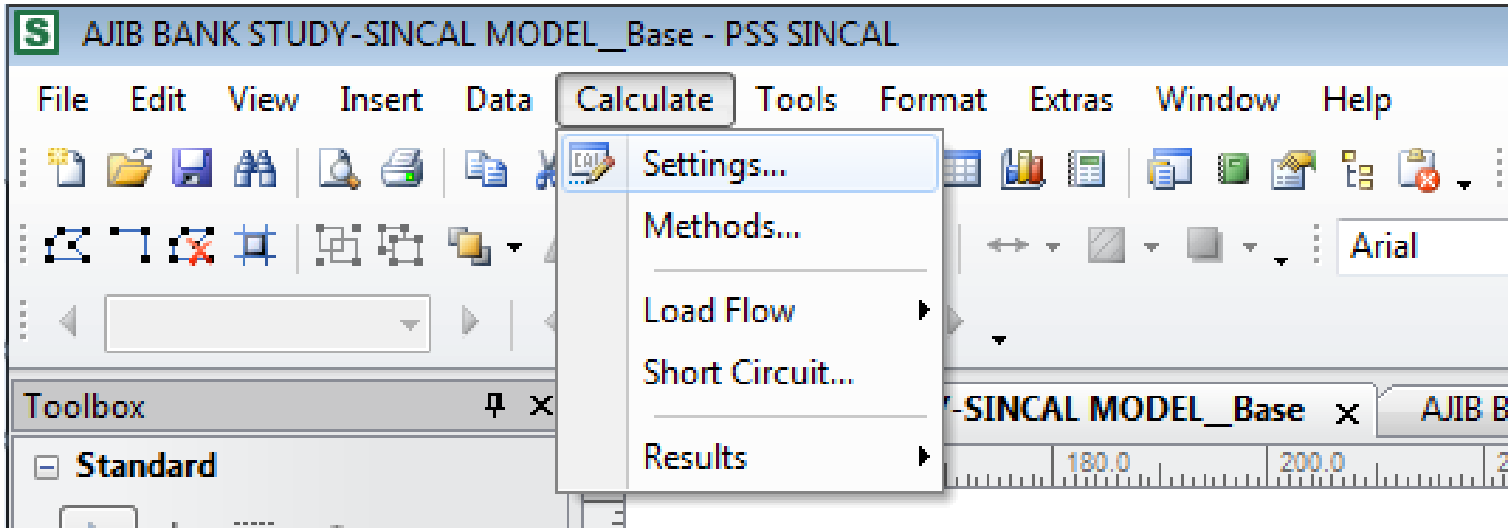
Review Shadow Study Results
Long-Term Dynamics

- Compare JEPCO and Black & Veatch results using the 24 hour profiles we created

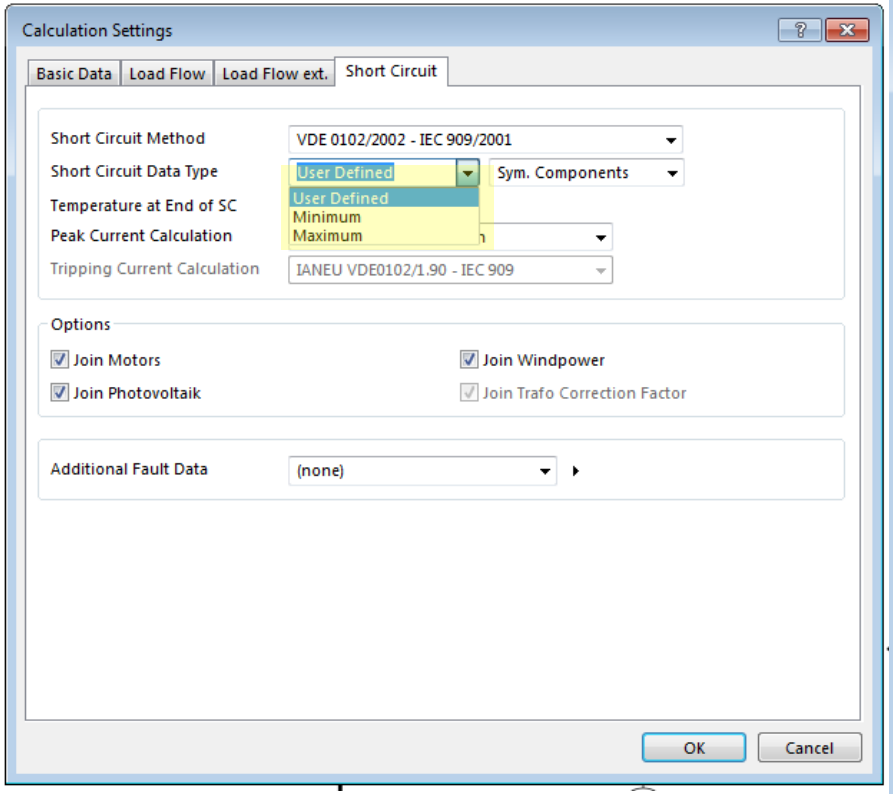
- Are they different?

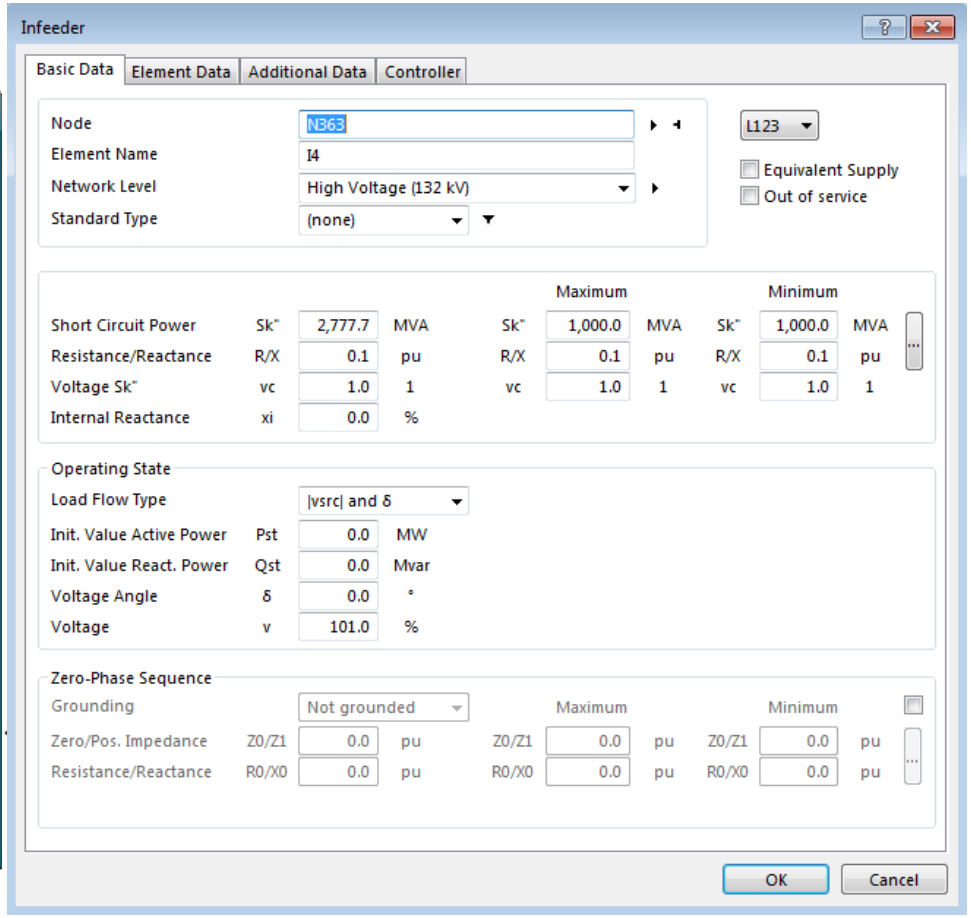
- Discuss why…

Check Short Circuit Calculation Settings



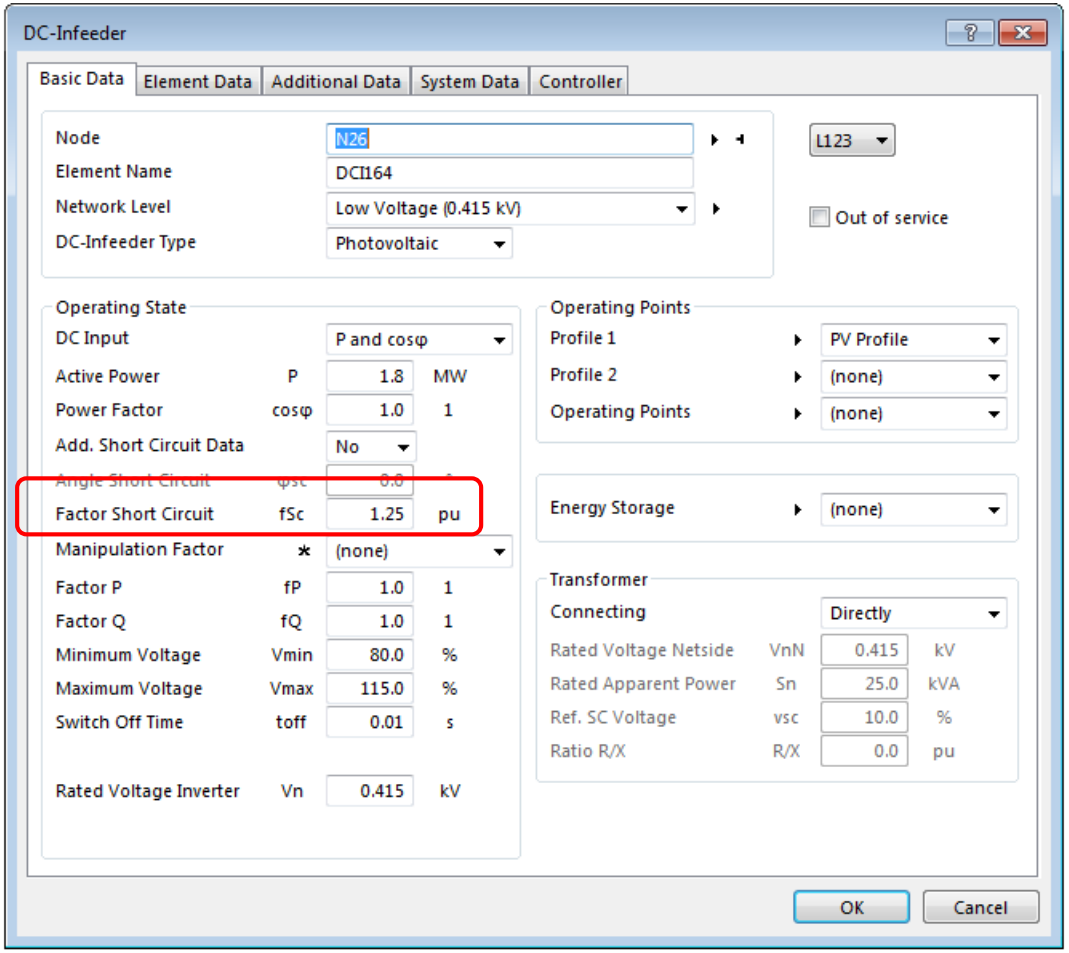
Check Short Circuit Calculation Settings





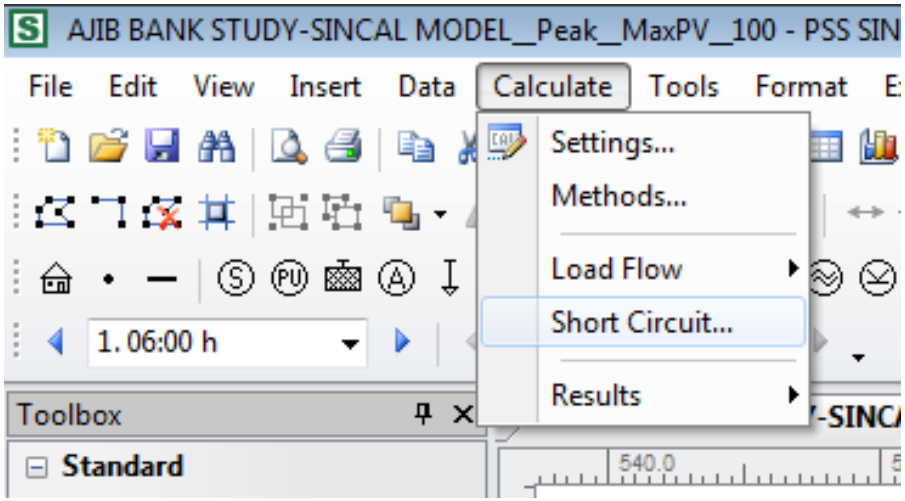
Setting Fault Contribution from PV Inverters

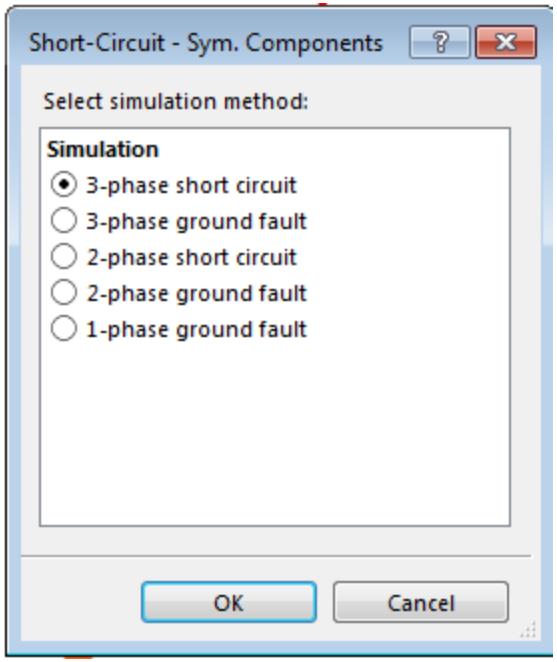
- Review the Inverter SC Data to determine the SC level to specify for the PV inverters



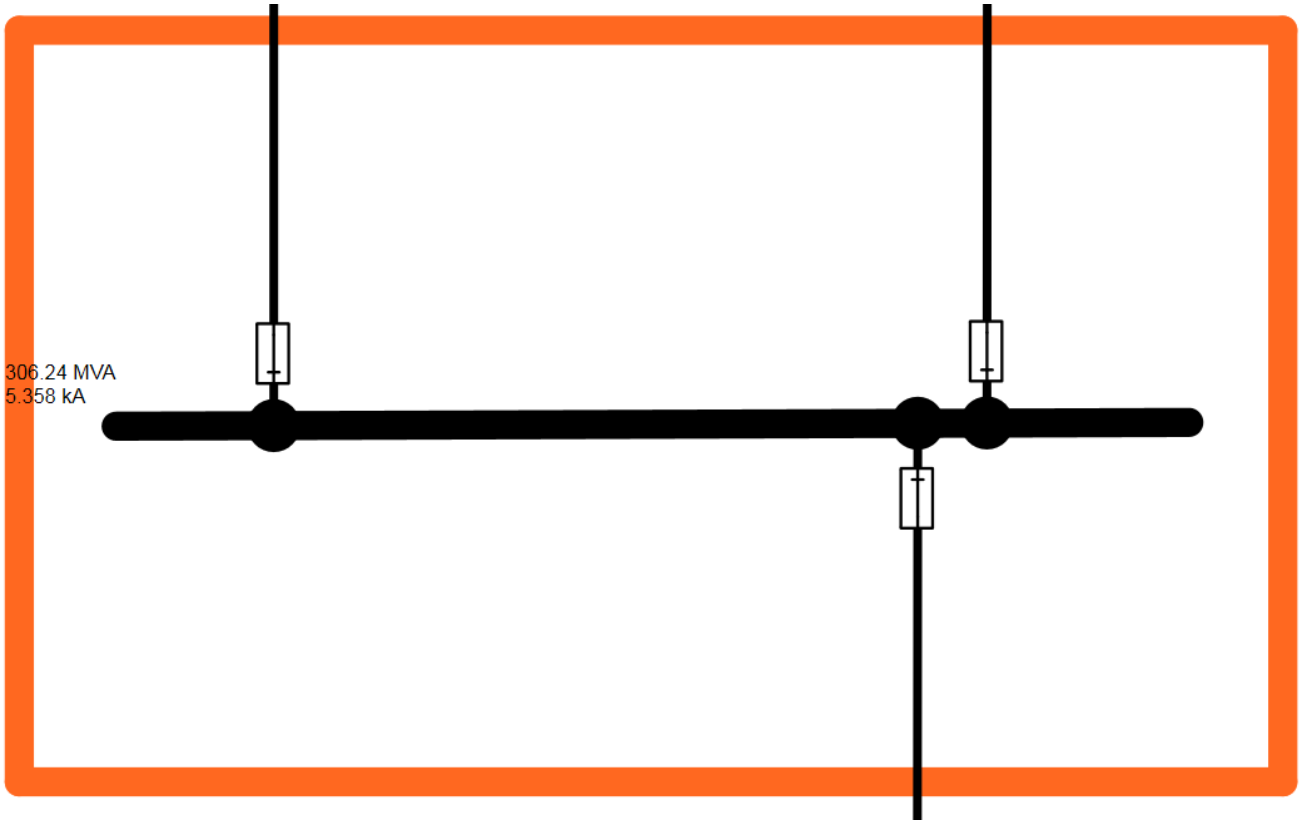
Performing Short Circuit Analysis

- Select the bus you wish to fault, then:

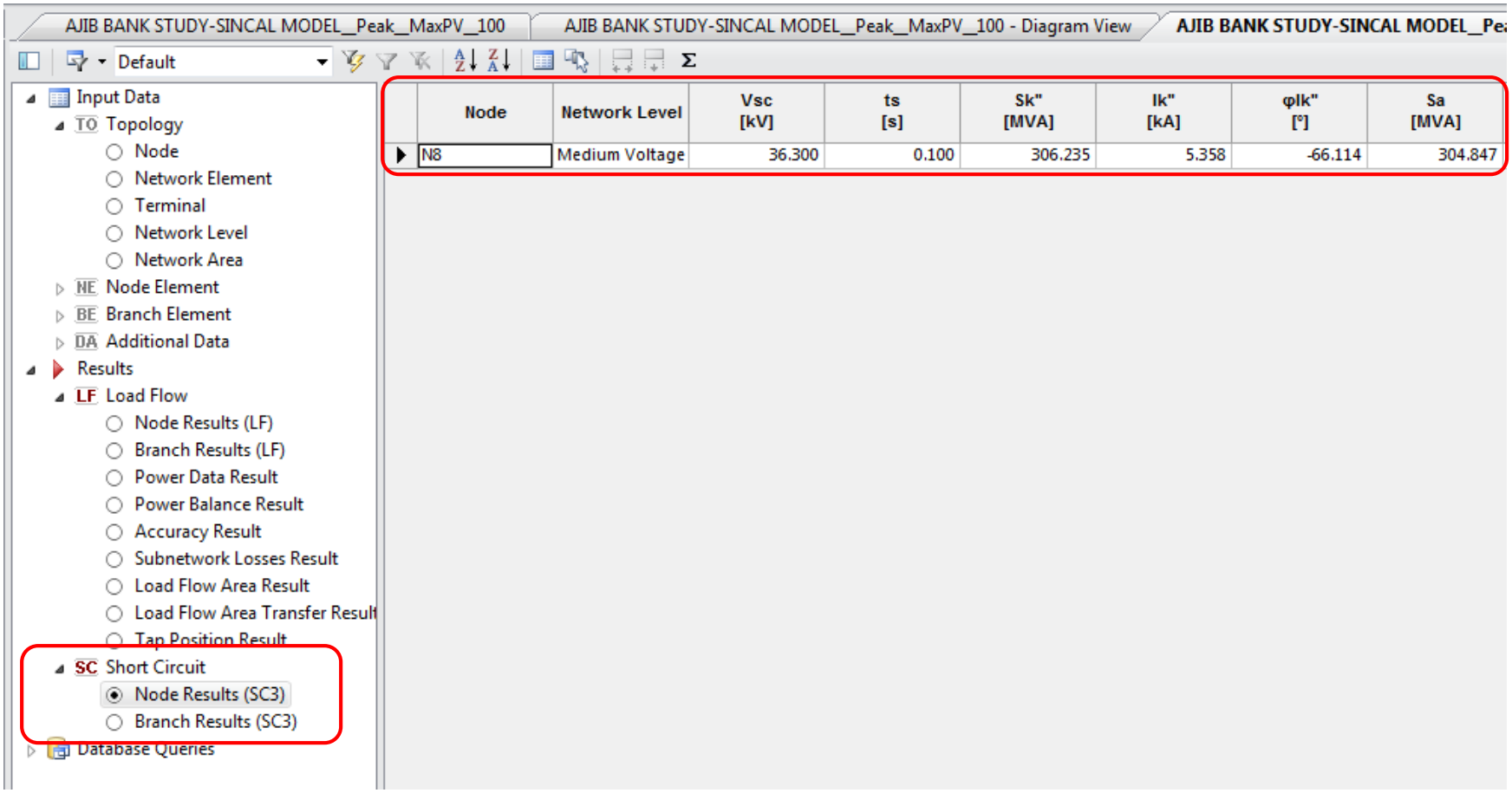




Viewing the results (Graphic View)



Viewing the results (Tabular View)



Compare Fault Contribution with and Without PV

- Apply a 3-Phase fault at the PCC with the PV in-service at full output
- Verify the correct output is being provided by the PV inverters per the Inverter SC Data
- Remove the PV inverters and apply the same fault
- How much does the fault level at the PCC change?
- Are the results correct?