USAID | JORDAN
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Energy Sector Capacity Building (ESCB)

PV Plant Grid Impact Study

CYME Training No. 1

Dynamic Studies

5 December 2016

Quasi steady state analysis-Time series analysis

- Why is quasi steady state analysis needed ?
- Need to study coincident PV analysis
- Help identify the time dependent aspects of power flowing in distribution systems
- Captures interaction between changing load and PV output.
- 8760 (hourly analysis) done for this study.

Quasi steady state analysis-Long term dynamics

- Setting up the model/load files
- Defining load and generation curves in the library
- Assigning the curves
- Visualizing results
  - Voltage profile of the feeder
  - Power flow at the substation
  - Power factor at the substation
  - Voltage regulation and status of voltage regulating equipment ?

Quasi steady state analysis-Long term dynamics

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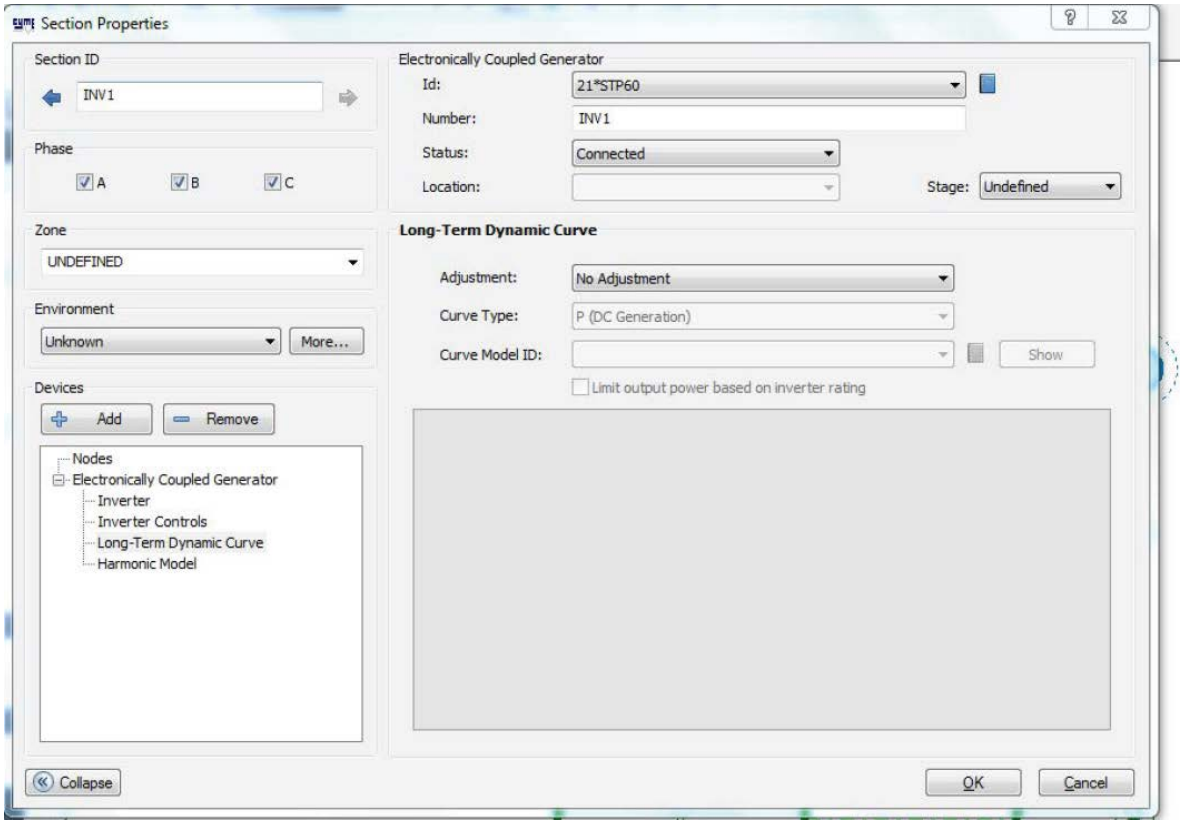
Setting up the Generation File

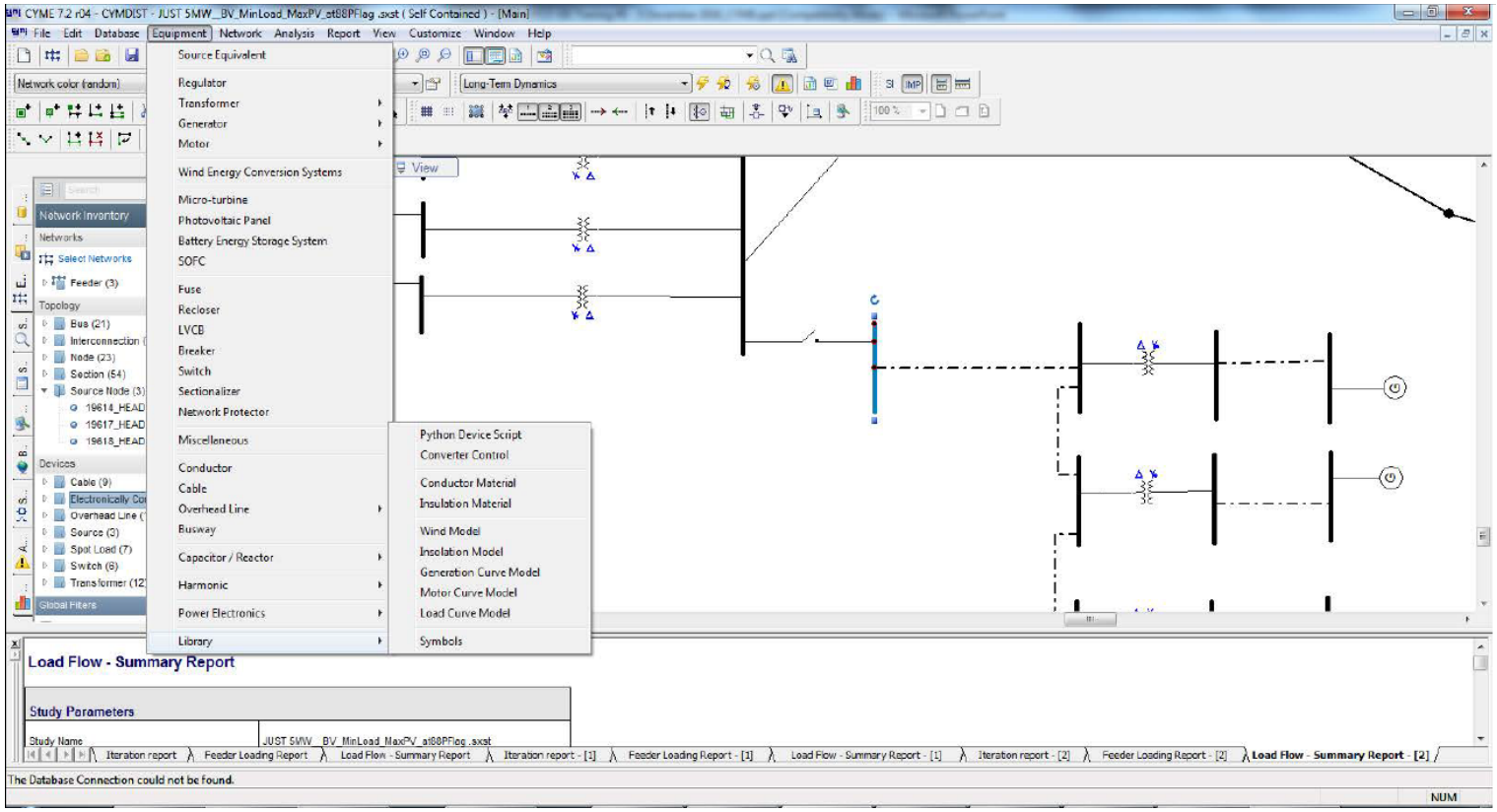
- Start with IDECO ‘Generation Profile INV1.csv’
- Create Excel file 8760 with columns Time, Power, PF. Normalize to Peak Production value.
- Save as a .txt file

Setting up the Load File

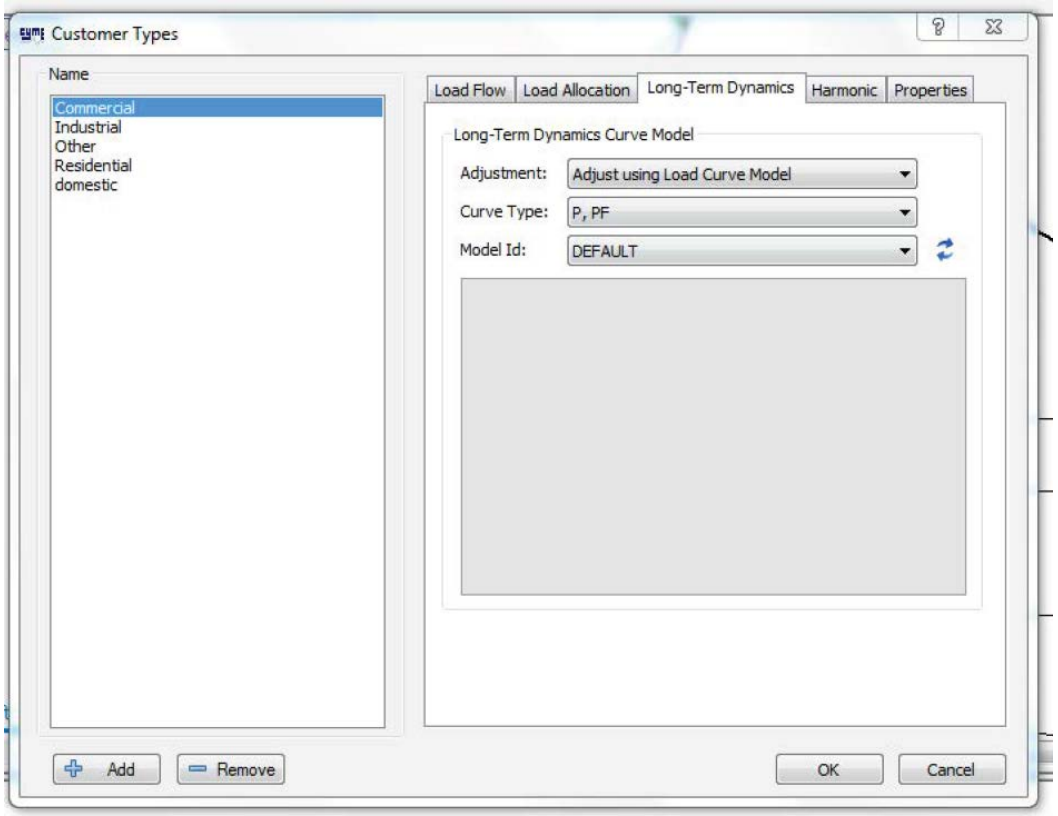
- Start with 8760 Load Profile from Day 1 Training.
- Normalize to Peak Load value
- Save as a .txt file


Section Properties
Section ID
INV1
Phase
A
B
C
Zone
UNDEFINED
Environment
Unknown
More...
Devices
Add
Remove
Nodes
Electronically Coupled Generator
Inverter
Inverter Controls
Long-Term Dynamic Curve
Harmonic Model
Electronically Coupled Generator
Id:
21*STP60
Number:
INV1
Status:
Connected
Location:
Stage:
Undefined
Long-Term Dynamic Curve
Adjustment:
No Adjustment
Curve Type:
P (DC Generation)
Curve Model ID:
Show
Limit output power based on inverter rating
Collapse
OK
Cancel

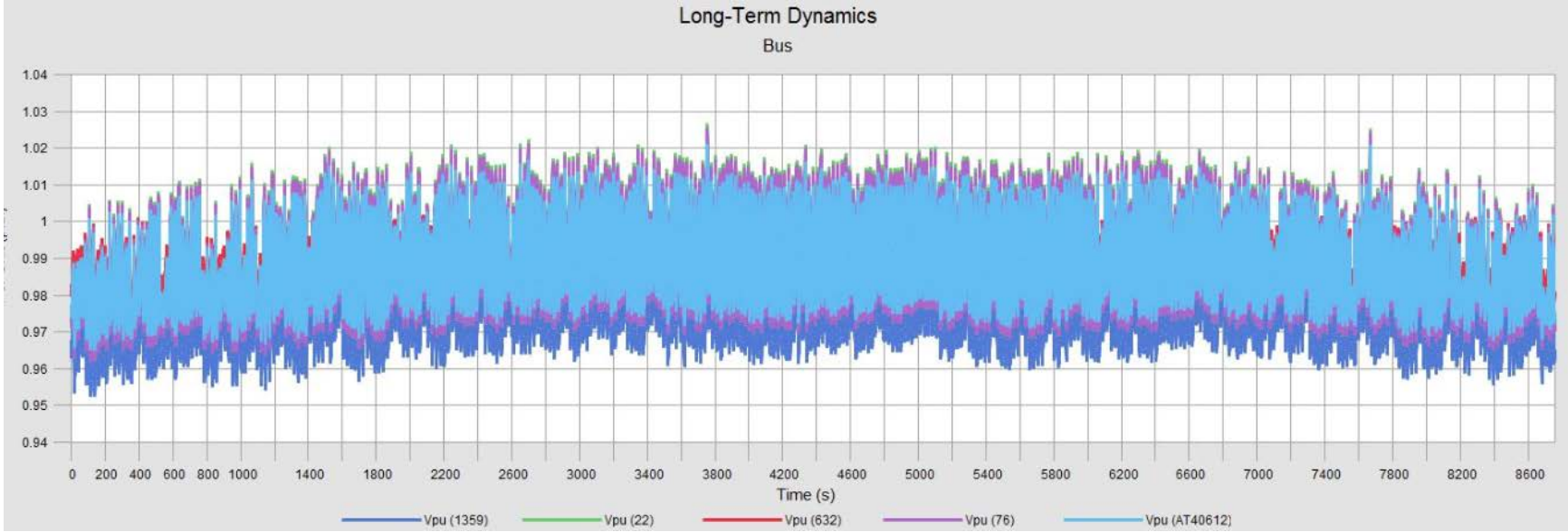
Long term dynamics-Adding curves to the library



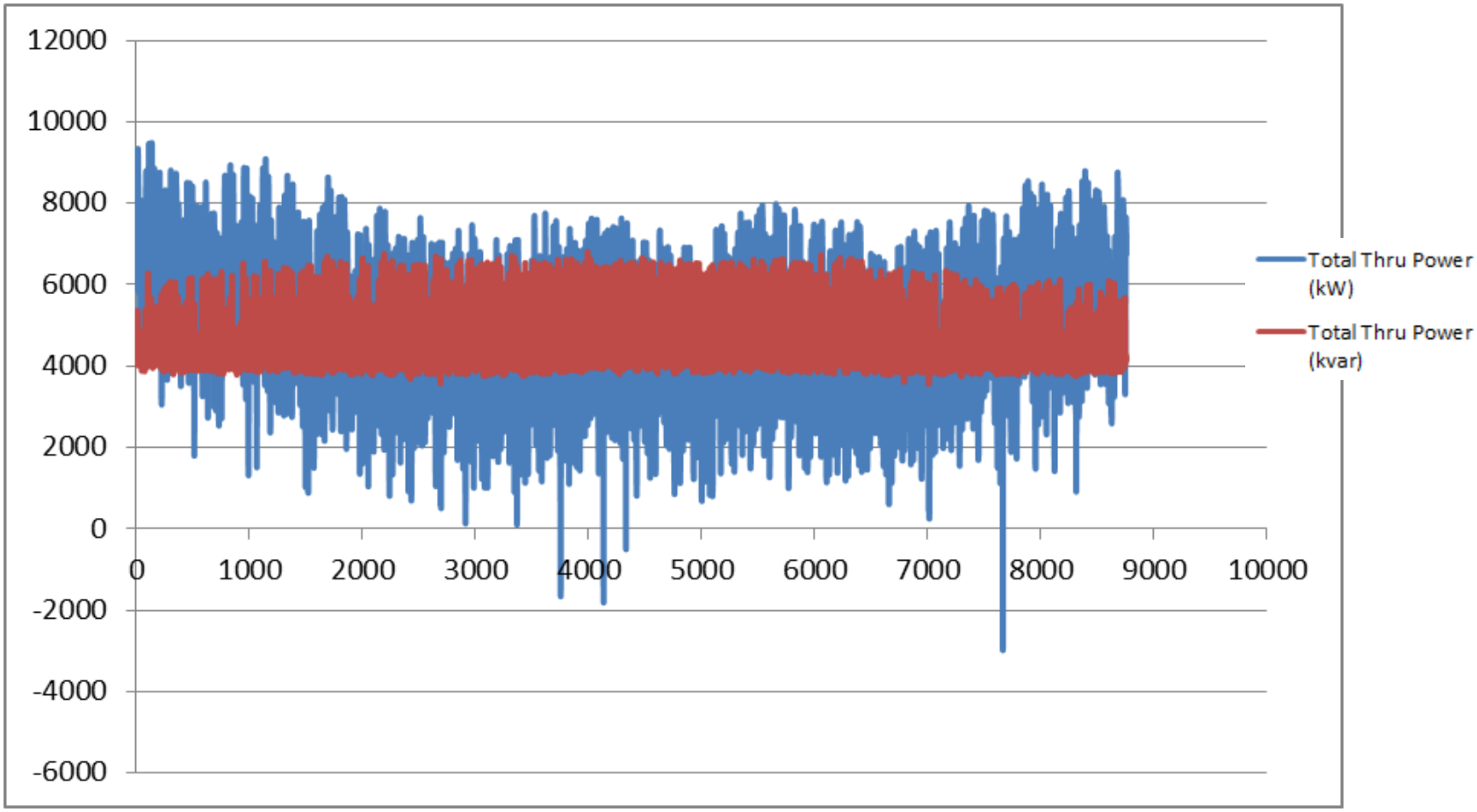
Long term dynamics-Assign curves to loads and generators



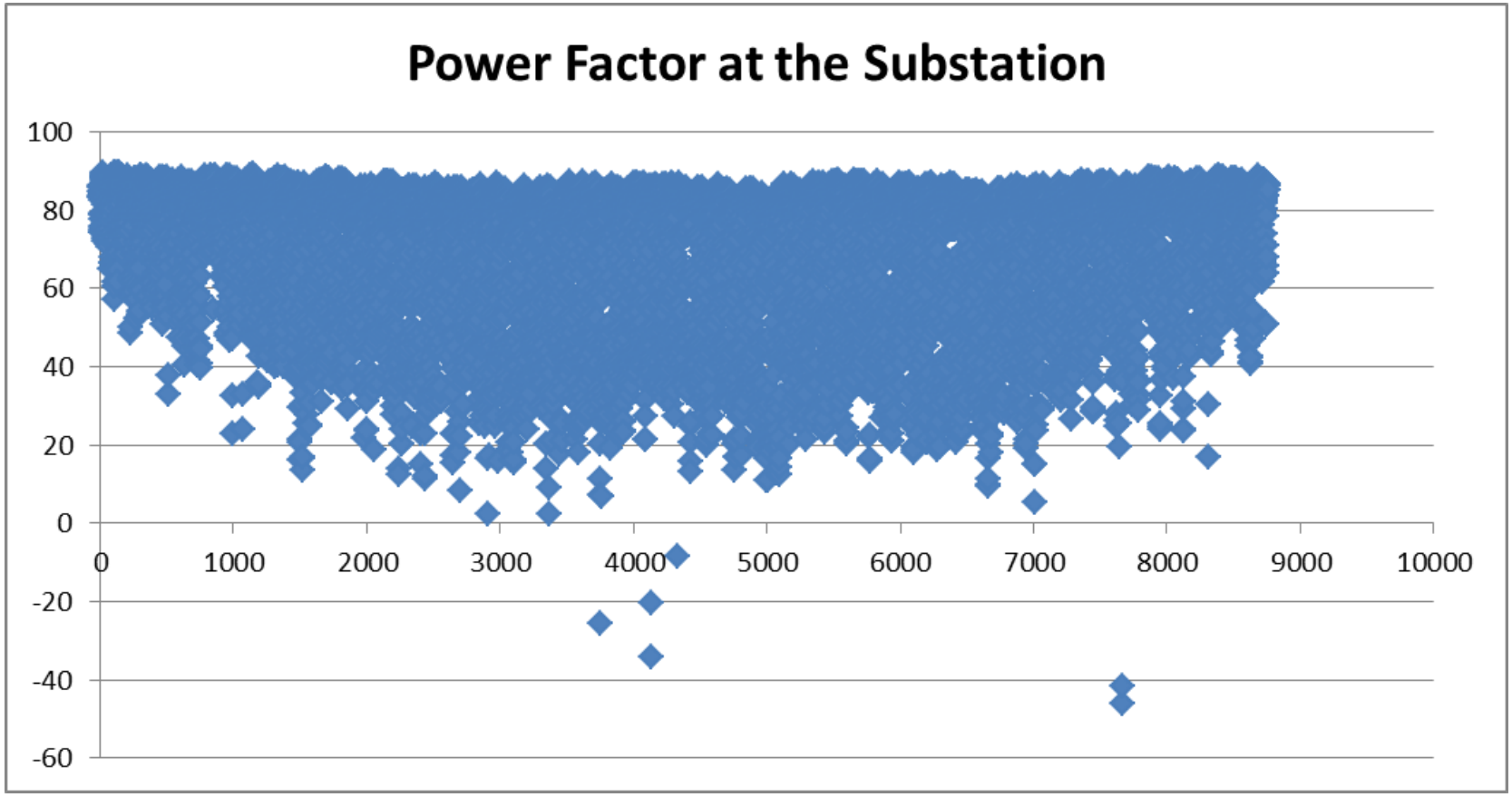
Visualizing results-Voltage Profile - EDCO



Visualizing results-Active power at the substation - EDCO



Visualizing the results – Power Factor at the Substation – EDCO



Work Flow

- Day 1:
  - Setting up the model
  - Substation Transformer Assumptions
  - Exercise 1.1: Calculating substation short circuit levels
  - Exercise 1.2: Populate PV inverter PF table
  - Discussing IRR-DCC-MV 5 Voltage Requirements
  - Load Allocation
  - Steady state snapshot analysis, Grid code compliance
- Day 2:
  - Exercise 1.3: Quasi steady state analysis-Long term dynamics
  - ***Exercise 1.4: Short Circuit Study***
  - Comparing results of shadow study

Short Circuit Study

- Compute fault current contribution from the project
- What is the SC fault contribution of the inverter?
- Analyze fault contribution at all buses before and after the project is added
- What do you see at the PCC?

Short Circuit Study

3 Short-Circuit Contribution for SMA Sunny Tripower Inverters

At an international level, the standard IEC 61400-21 describes testing procedures for wind farms that can be easily applied to PV inverters. In some countries like Germany (TR3, Technische Richtlinien für Erzeugungseinheiten Teil 3, FGW e.V., 2013) and Italy (CEI 0-21 and CEI 0-16) there are specific standard requirements for testing the capability of "riding through" grid voltage dips.

The instantaneous values of AC currents and AC voltages are recorded synchronously with 50 kHz (20 µs). Positive sequence fundamentals based on measurement of instantaneous voltages and currents are calculated according to IEC 61400-21 (2008). All results are measured as half periods RMS values.

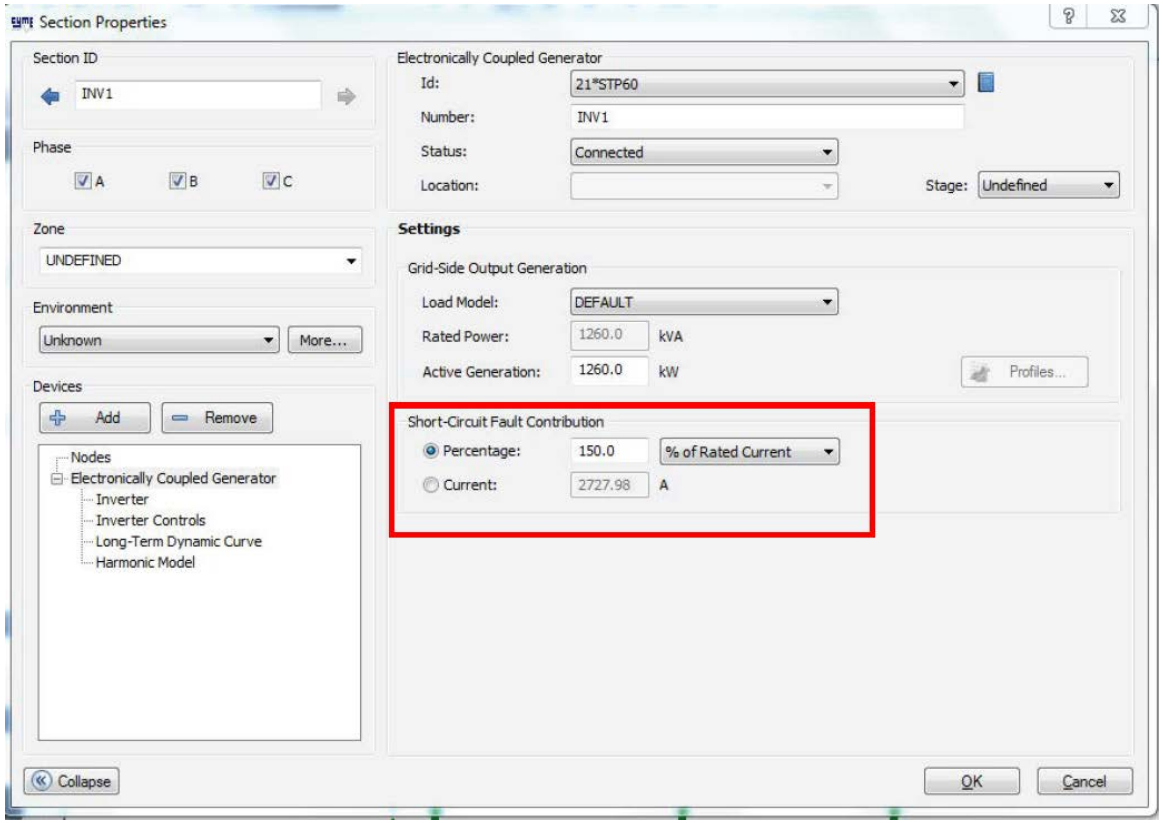
The following table shows the test results for each SMA inverter. Note that the ip values are given as an amplitude, whereas the values for I_k'' and I_k are RMS.

Inverter type	Short-circuit surge current i_p (A)	Initial symmetrical short-circuit current I_k'' (A)	Uninterrupted short-circuit current I_k (A)		Maximal current I_{max} (A)
			Mode 1	Mode 2	
STP 5000TL-20	56.56	9.71	7.3	0	7.3
STP 6000TL-20	59.39	9.79	8.7	0	8.7
STP 7000TL-20	64.76	14.07	10.2	0	10.2
STP 8000TL-20	67.65	14.19	11.6	0	11.6
STP 9000TL-20	71.52	14.40	13.1	0	13.1
STP 10000TL-20	77.65	15.98	14.5	0	14.5
STP 12000TL-20	76.36	19.14	17.4	0	17.4
STP 10000TL-10	72.99	20.60	16.0	0	14.5
STP 12000TL-10	76.03	20.89	19.2	0	17.4
STP 15000TL-10	92.85	26.45	24.0	0	21.7
STP 17000TL-10	98.94	26.88	24.6	0	24.6
STP 15000TLEE-10	94.94	25.85	24.0	0	21.7
STP 20000TLEE-10	106.84	31.14	29	0	29
STP 20000TL-30	98.58	31.07	29	0	29
STP 25000TL-30	116.37	40.06	36.2	0	36.2
STP 12000TL-US-10	81.30	17.27	14.4	0	14.4
STP 15000TL-US-10	89.29	20.57	18	0	18
STP 20000TL-US-10	101.44	26.46	24	0	24
STP 24000TL-US-10	111.92	30.91	29	0	29
STP 30000TL-US-10	181	50.68	36.2	0	36.2
STP 60-10 / STP 60-US-10	201.2	106.6	87	0	87

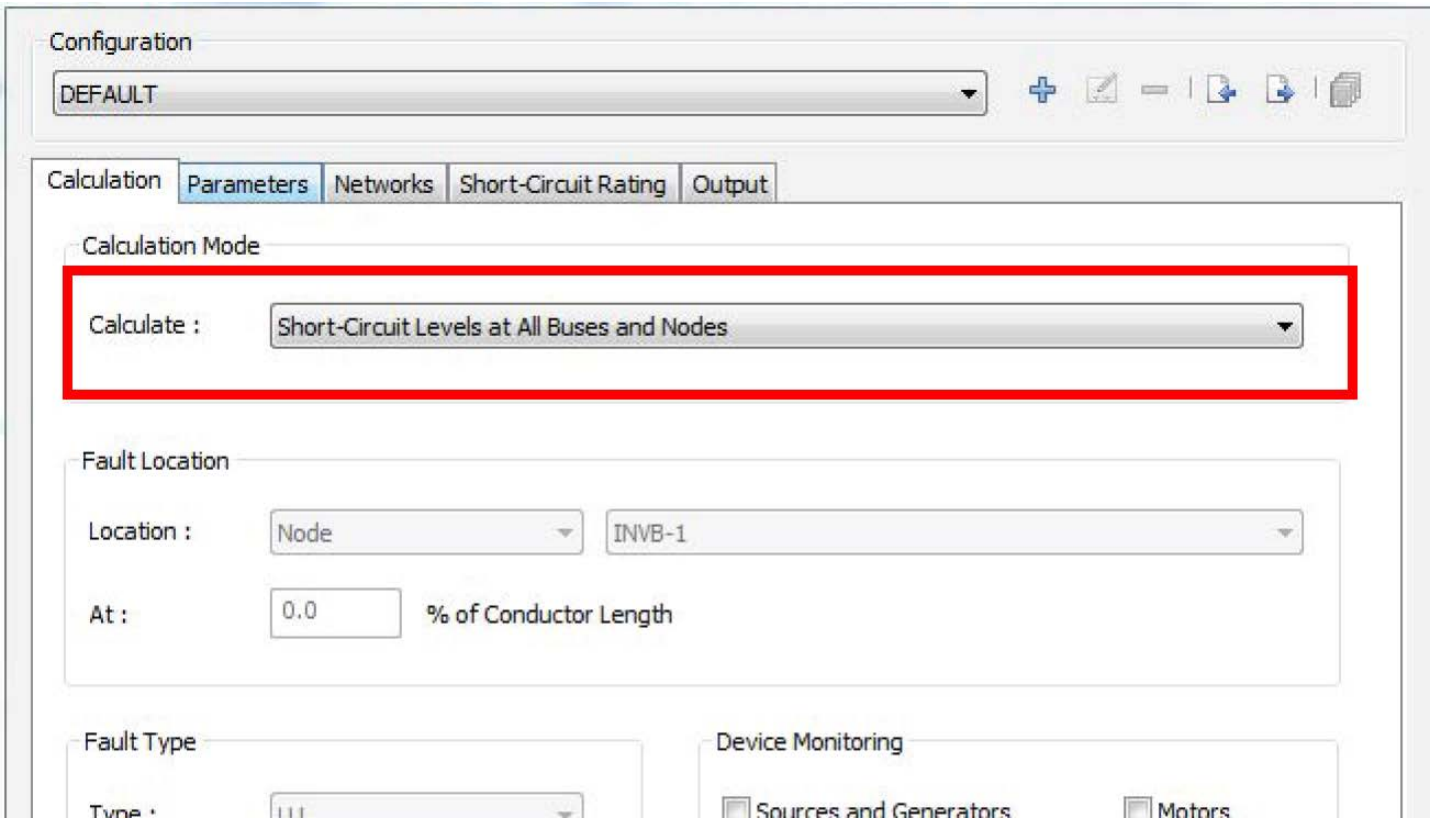
Table 2 Short-circuit contribution for SMA Sunny Tripower.

The values for I_k'' and i_p were measured during the certification process by an accredited test institute (BDEW, CEI 0-16) and are comparable to the characteristic values defined in DIN/EN 60909. These values represent the maximum values of all tests.

Short Circuit Study



Short Circuit Study



Short Circuit Study