

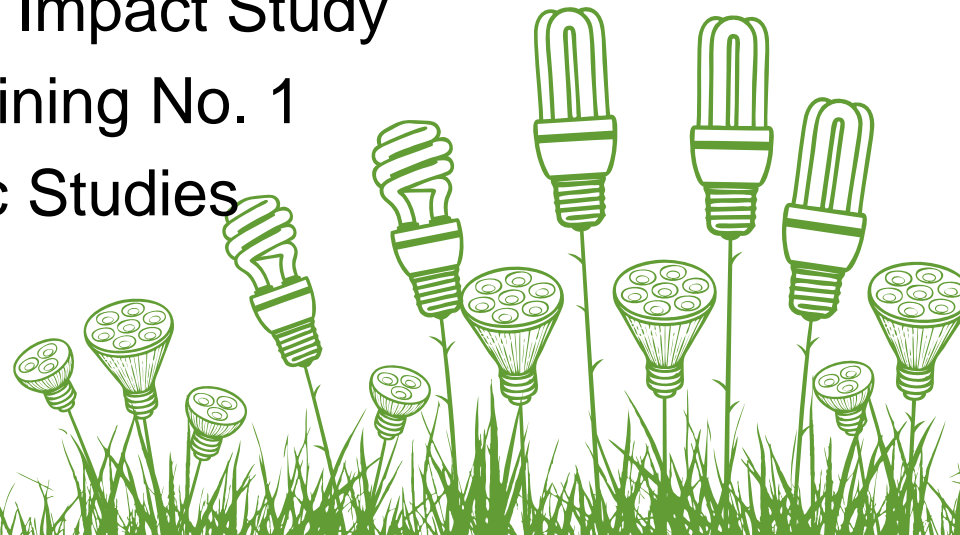


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# Energy Sector Capacity Building (ESCB)

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

- ***Setting up the model/load files***
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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



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**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

[OK](#) [Cancel](#)



## Long term dynamics-Adding curves to the library

The screenshot displays the CYME 7.2 software interface. The main window shows a power system diagram with buses, lines, and equipment. A menu is open, showing the 'Library' option. The 'Library' menu is expanded, showing a list of components including: Regulator, Transformer, Generator, Motor, Wind Energy Conversion Systems, Micro-turbine, Photovoltaic Panel, Battery Energy Storage System, SOFC, Fuse, Recloser, LVCB, Breaker, Switch, Sectionalizer, Network Protector, Miscellaneous, Conductor, Cable, Overhead Line, Busway, Capacitor / Reactor, Harmonic, Power Electronics, and Library. The 'Library' option is highlighted, and a sub-menu is visible with the following items: Python Device Script, Converter Control, Conductor Material, Insulation Material, Wind Model, Insulation Model, Generation Curve Model, Motor Curve Model, Load Curve Model, and Symbols.

The bottom of the screen shows a 'Load Flow - Summary Report' window. The 'Study Parameters' section is visible, showing the 'Study Name' as 'JUST 5MW\_BV\_MinLoad\_MaxPV\_at60PFlog\_axst'. The report window also displays a list of reports: Iteration report, Feeder Loading Report, Load Flow - Summary Report, Iteration report - [2], Feeder Loading Report - [2], Load Flow - Summary Report - [2], Iteration report - [3], Feeder Loading Report - [3], Load Flow - Summary Report - [3], Iteration report - [4], Feeder Loading Report - [4], Load Flow - Summary Report - [4], Iteration report - [5], Feeder Loading Report - [5], Load Flow - Summary Report - [5], Iteration report - [6], Feeder Loading Report - [6], Load Flow - Summary Report - [6], Iteration report - [7], Feeder Loading Report - [7], Load Flow - Summary Report - [7], Iteration report - [8], Feeder Loading Report - [8], Load Flow - Summary Report - [8], Iteration report - [9], Feeder Loading Report - [9], Load Flow - Summary Report - [9], Iteration report - [10], Feeder Loading Report - [10], Load Flow - Summary Report - [10], Iteration report - [11], Feeder Loading Report - [11], Load Flow - Summary Report - [11], Iteration report - [12], Feeder Loading Report - [12], Load Flow - Summary Report - [12].

The status bar at the bottom indicates 'The Database Connection could not be found.' and 'NUM'.



## Long term dynamics-Assign curves to loads and generators

Customer Types

Name

- Commercial
- Industrial
- Other
- Residential
- domestic

Load Flow Load Allocation Long-Term Dynamics Harmonic Properties

Long-Term Dynamics Curve Model

Adjustment: Adjust using Load Curve Model

Curve Type: P, PF

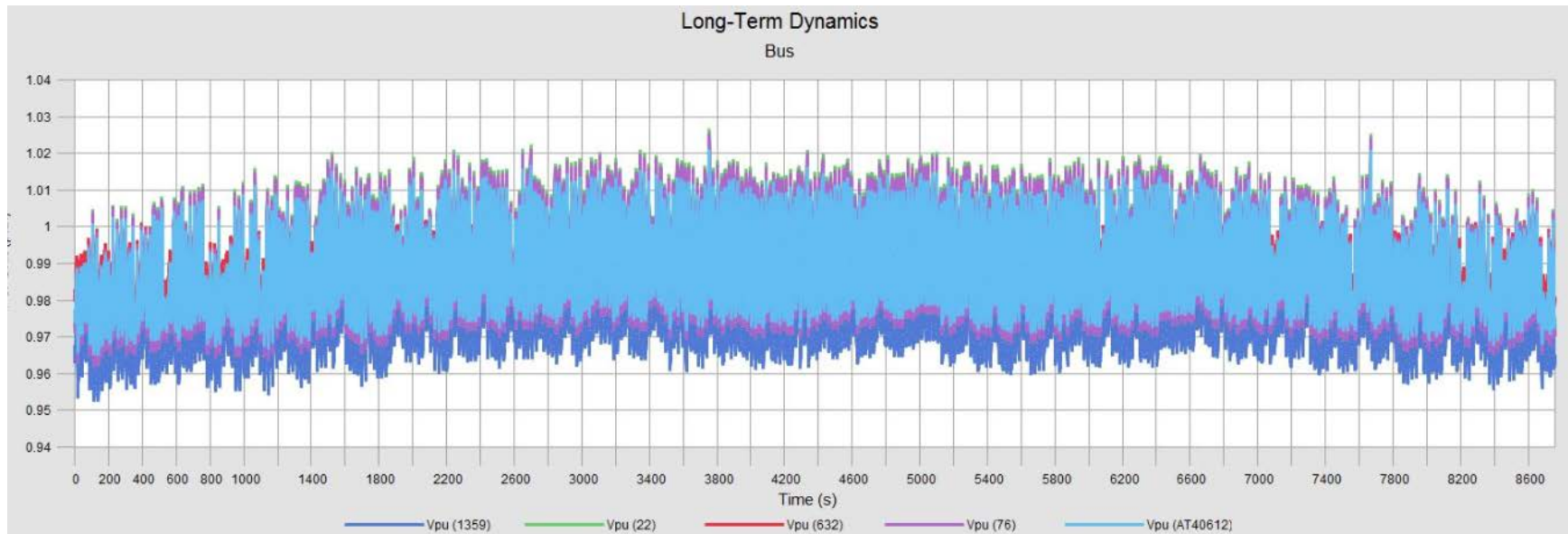
Model Id: DEFAULT

+ Add - Remove

OK Cancel

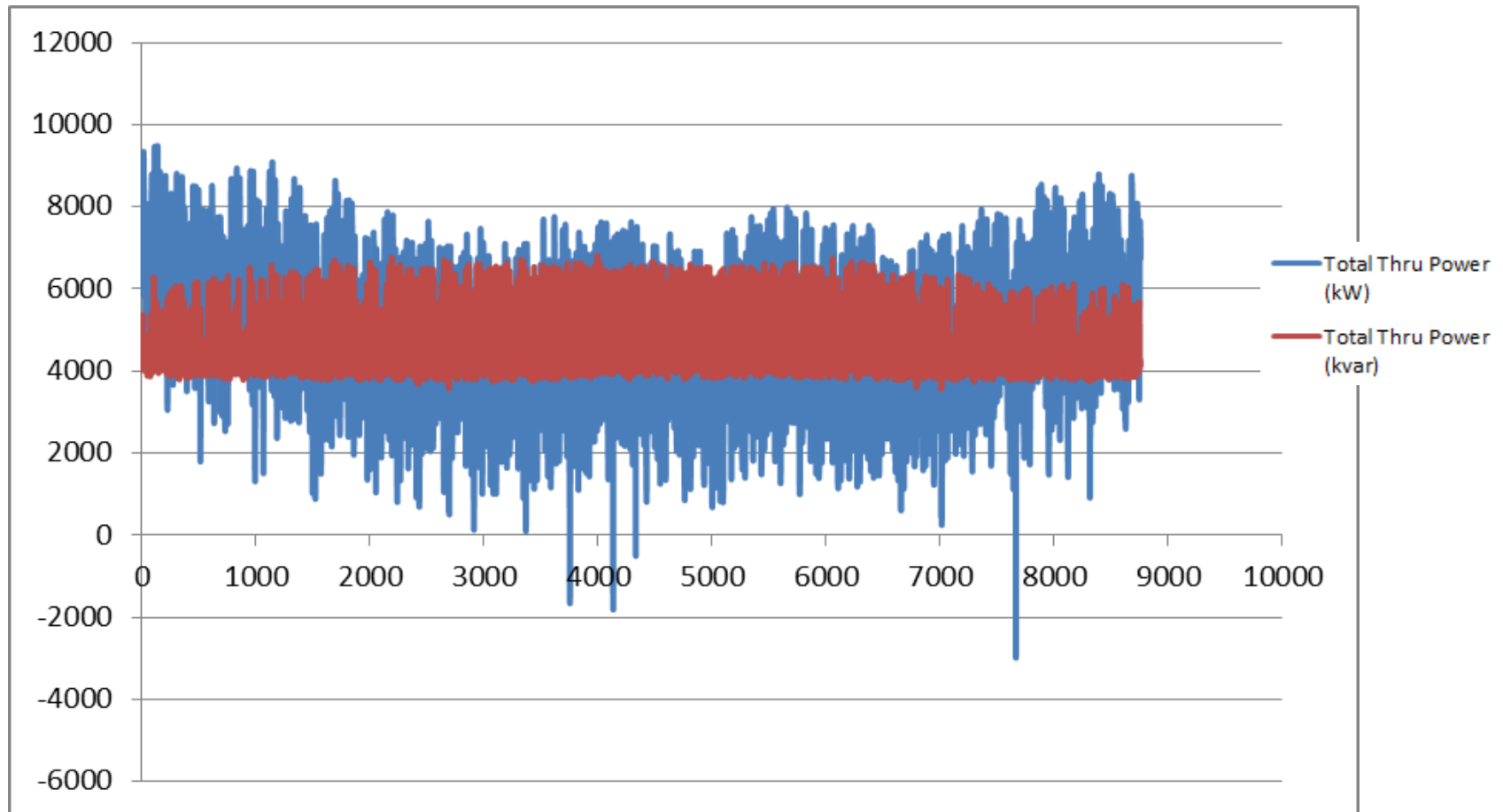


## Visualizing results-Voltage Profile - EDCO



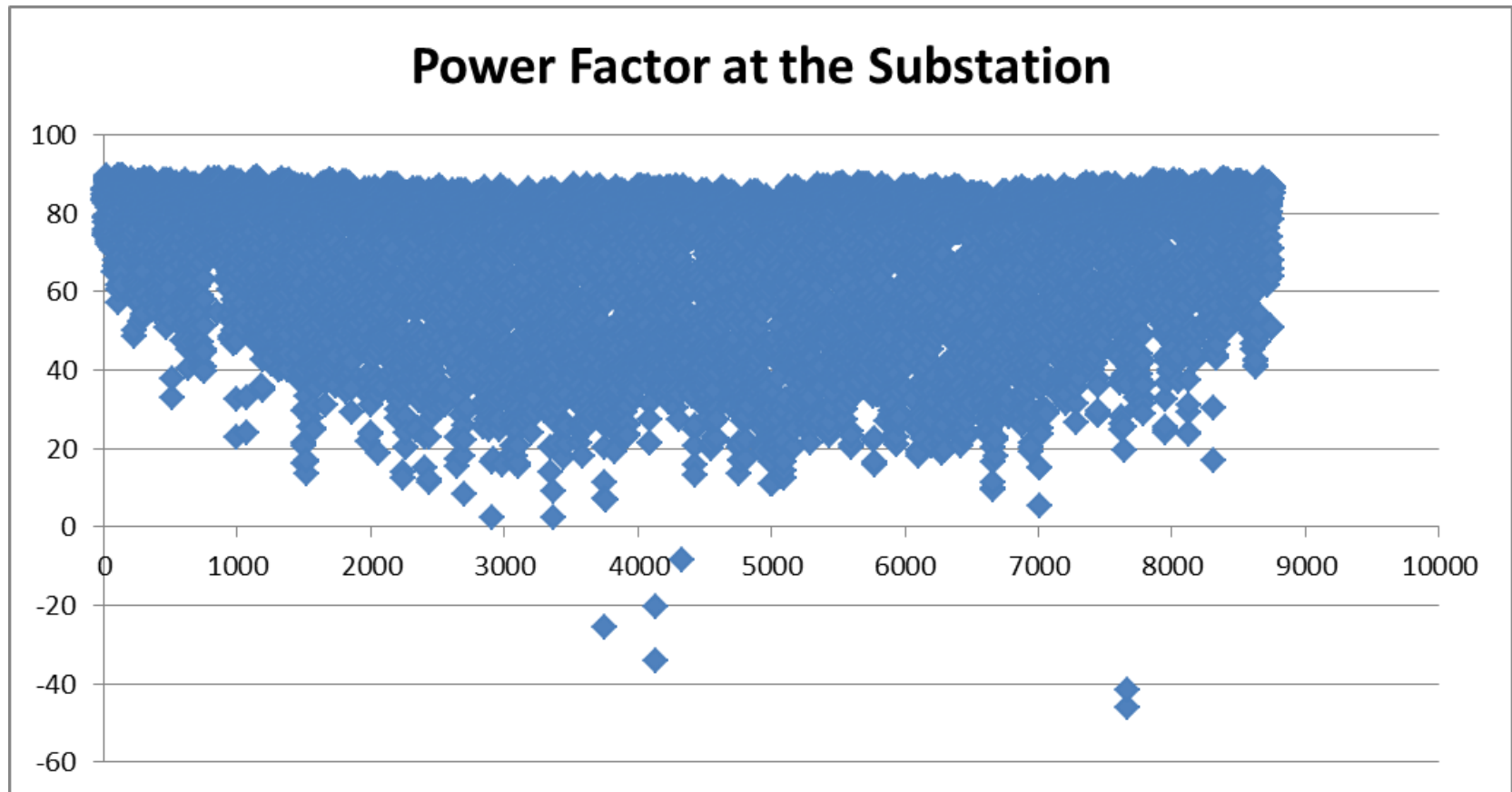


## Visualizing results-Active power at the substation - EDCO





## 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

SMA Solar Technology AG

3 Short-Circuit Contribution for SMA Sunny Tripower Inverters

### 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  $I_p$  values are given as an amplitude, whereas the values for  $I_{sc}''$  and  $I_{sc}$  are RMS.

Inverter type	Short-circuit surge current $I_p$ (A)	Initial symmetrical short-circuit current $I_{sc}''$ (A)	Uninterrupted short-circuit current $I_{sc}$ (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 /	201.2	106.6	87	0	87
STP 60US-10					

Table 3 Short circuit contribution for SMA Sunny Tripower

The values for  $I_{sc}''$  and  $I_{sc}$  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

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

Settings

Grid-Side Output Generation

Load Model: DEFAULT

Rated Power: 1260.0 kVA

Active Generation: 1260.0 kW

[Profiles...](#)

Short-Circuit Fault Contribution

☒ Percentage: 150.0 % of Rated Current

☐ Current: 2727.98 A

[Collapse](#) [OK](#) [Cancel](#)



## Short Circuit Study

Configuration

DEFAULT

Calculation Parameters Networks Short-Circuit Rating Output

Calculation Mode

Calculate : Short-Circuit Levels at All Buses and Nodes

Fault Location

Location : Node INVB-1

At : 0.0 % of Conductor Length

Fault Type

Type : III

Device Monitoring

☐ Sources and Generators ☐ Motors



## Short Circuit Study

The screenshot shows the 'Short-Circuit' software window with the 'Configuration' tab selected. The 'DEFAULT' configuration is chosen. The 'Calculation' tab is active, showing the following settings:

- Pre-Fault Voltage:** Nominal Voltage (dropdown), ☐ Transformers at Nominal Tap
- Security Factors:** Kmax: 1.0 p.u., Kmin: 1.0 p.u.
- Fault Impedances:** Zf: 0.0 R, 0.0 X (ohms), Zg: 0.0 R, 0.0 X (p.u.)
- Impedance Adjustments:** ☐ Adjust Impedances, Edit...
- Inverter Based DG Model:** Voltage Source Behind Impedance (dropdown)
- Machine Impedances:** Steady State (dropdown)
- Include Contributions from:**
  - ☒ Synchronous Generators
  - ☐ Induction Motors
  - ☐ Induction Generators
  - ☒ Electronically Coupled Generators (highlighted with a red box)
  - ☒ WECS
  - ☒ SOFC
  - ☒ Micro Turbine
  - ☒ Photovoltaic
  - ☐ Synchronous Motors
  - ☐ BESS
  - ☐ Zero Sequence Line Susceptance

Buttons at the bottom: Save, Restore, Run, OK, Cancel.