Distributed Energy Resource Modeling Capabilities

Improvements to Simulation Tools

NERC System Planning Impacts from DER Working Group
Informational Webinar
October 28, 2021

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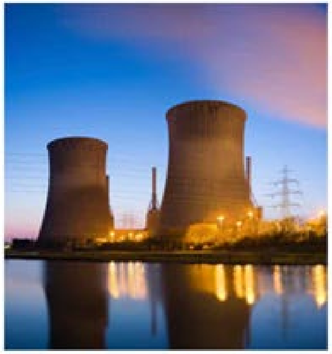
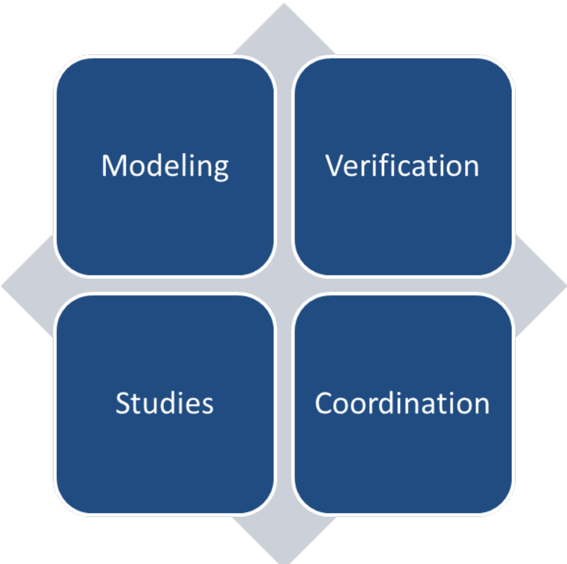
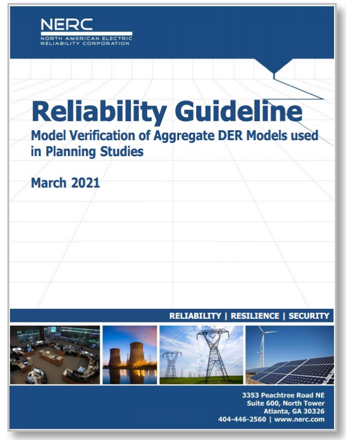
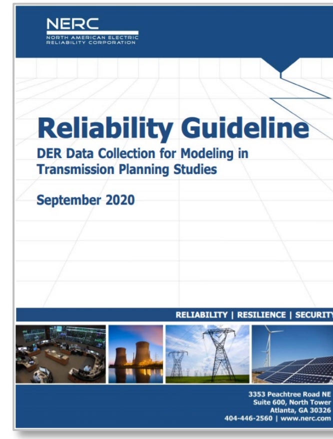
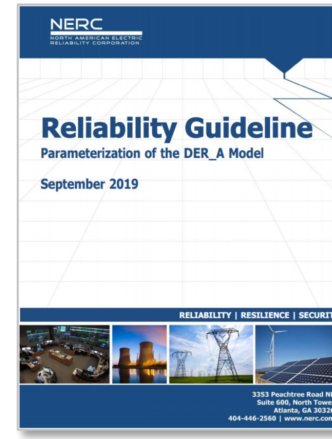


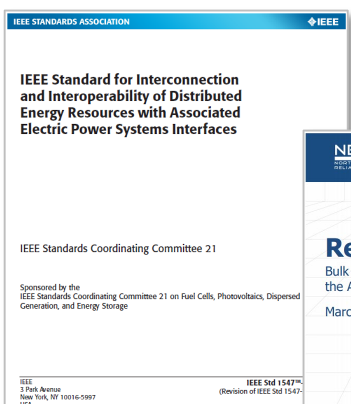
What Has SPIDERWG Been Up To?

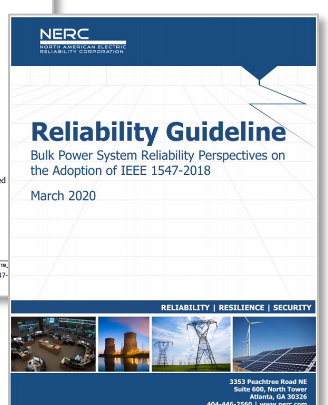


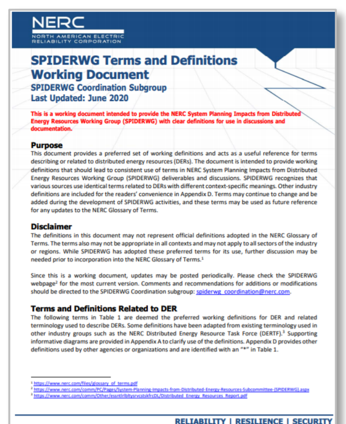


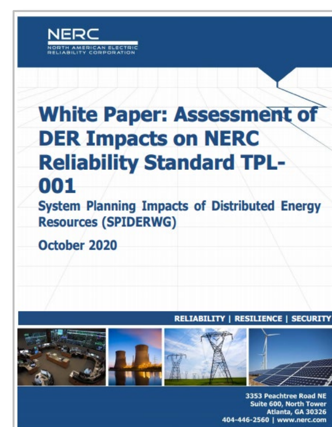


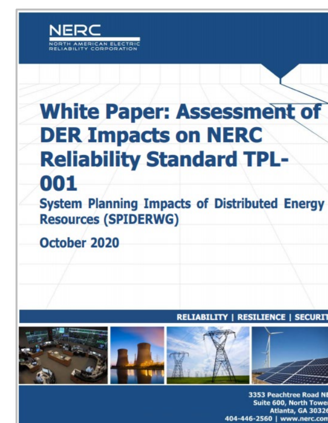












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Webinar Outline

Welcome	Bill Quaintance, SPIDERWG Vice-chair
Overview of Simulation Improvements Whitepaper	Ian Beil, Portland General Electric
Modeling Distributed Energy Resources in PSS®E	Feng Dong, Siemens PTI Jayapalan Senthil, Siemens PTI
PowerWorld Distributed Energy Resource (DER) Modeling	Jamie Weber, PowerWorld Corporation
PowerTech	Pouya Zadkhast, PowerTech Labs
PSLF – Tools and Techniques Related to DER Planning	Shruti, Rao, GE PSLF
EMTP® DER Modeling	Henry Gras, EMTP Alliance
Q&A	JP Skeath, NERC Ryan Quint, NERC

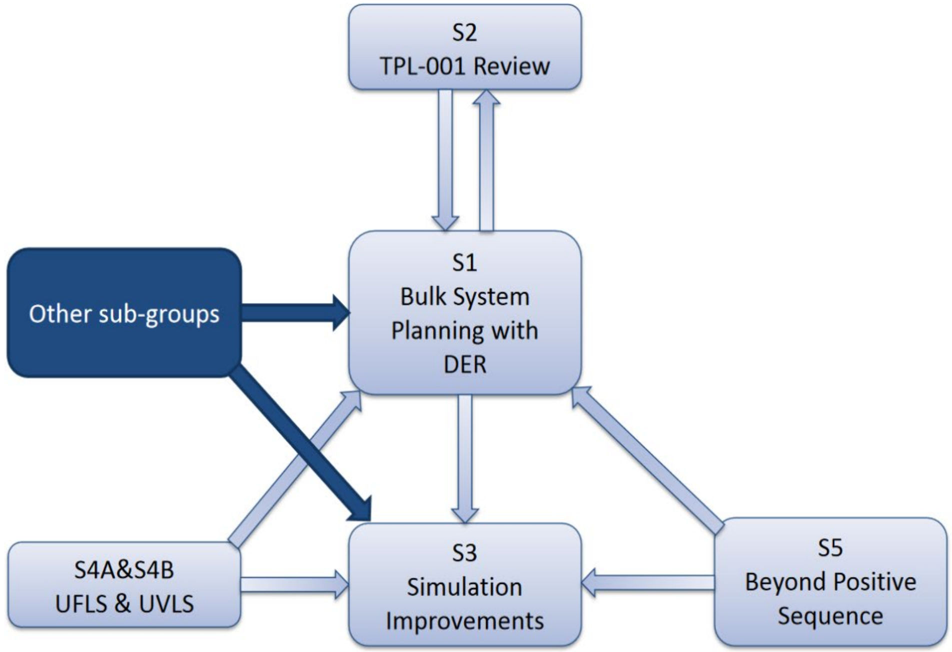
SPIDERWG Welcome Remarks

Bill Quaintance, Duke Energy Progress, SPIDERWG Vice Chair

Overview of White Paper

Ian Beil, Portland General Electric

SPIDER Working Group S3: Simulation Improvements



"Simulation Improvements" document developed by S3 subgroup, with input from related NERC SPIDER working group efforts

Collaborators include members of utilities, ISO/RTOs, academia, NERC, FERC, EPRI, and software vendors. Open and publicly available development of recommendations.

Document is vendor agnostic – recommendations apply to all power system software developers

S3 White Paper and Checklist

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Recommendations for Simulation Improvement and Techniques Related to DER Planning White Paper

NERC System Planning Impacts of Distributed Energy Resources (SPIDERWG)
____ 2021

Disclaimer: This document is intended to be a resource for software vendors to help guide the next generation of software tools and techniques that will aid power system planners as they contend with increased proliferation of distributed energy resources. This document is not intended to be an endorsement of any particular software platform, nor as a critique of the existing capabilities of any software program. Screenshots of various software tools appear in the document only as a means of offering further clarity on the topic at hand.

Purpose

The NERC System Planning Impacts of Distributed Energy Resources (SPIDER) working group has developed a number of guidelines and studies relating to distributed energy resource (DER) integration. Tracking DERs will add significant level of complexity to the planning process, stressing data fidelity, modeling accuracy, and computational limitations. This document provides a distilled version of the NERC SPIDER working group recommendations that may be pertinent to power system software developers, and outlines some of the related literature that may aid in developing further software improvements and techniques.

The white paper is broken down into three sections. **Part I** provides an overview of SPIDER working group efforts to quantify and qualify the manner in which DERs are changing the system planning process. This section also provides a review of related literature from government, industry, academic sources. **Part II** identifies a number of issues related to DERs that may strain the existing capabilities of power system software. **Part III** discusses the seams that exist between typical power system analysis (transmission versus distribution studies, positive-sequence load flow versus electromagnetic transient analysis, etc.), and how DERs may necessitate new software solutions that stitch these seams together.

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Summary of the "Recommendations for Simulation Improvement and Techniques Related to DER Planning" Checklist

NERC System Planning Impacts of Distributed Energy Resources (SPIDERWG)
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Recommended Power System Software Capabilities Related to DER

Organizing DER information in load flow models

- Smaller aggregations of DER dispersed across a feeder (denoted R_DER) should be accounted for using the Distributed Generation MW and MVAR fields in power flow load models, in order to separate these resources from gross load.
- Load values in tables, reports, and GUI's should always be labeled as Net or Gross.
- Information on the total Distributed Generation MW and MVAR for a particular Area, Zone, Owner, etc. should be made available within the power flow software structure.
- Fields for the minimum and maximum real power (Pmin/Pmax) should be provided within Distributed Generation models
- It is recommended that software vendors be aware of the implications of DER-provided reactive power and consider how best to model any reactive power limitations.

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Modeling Distributed Energy Resources in PSS®E

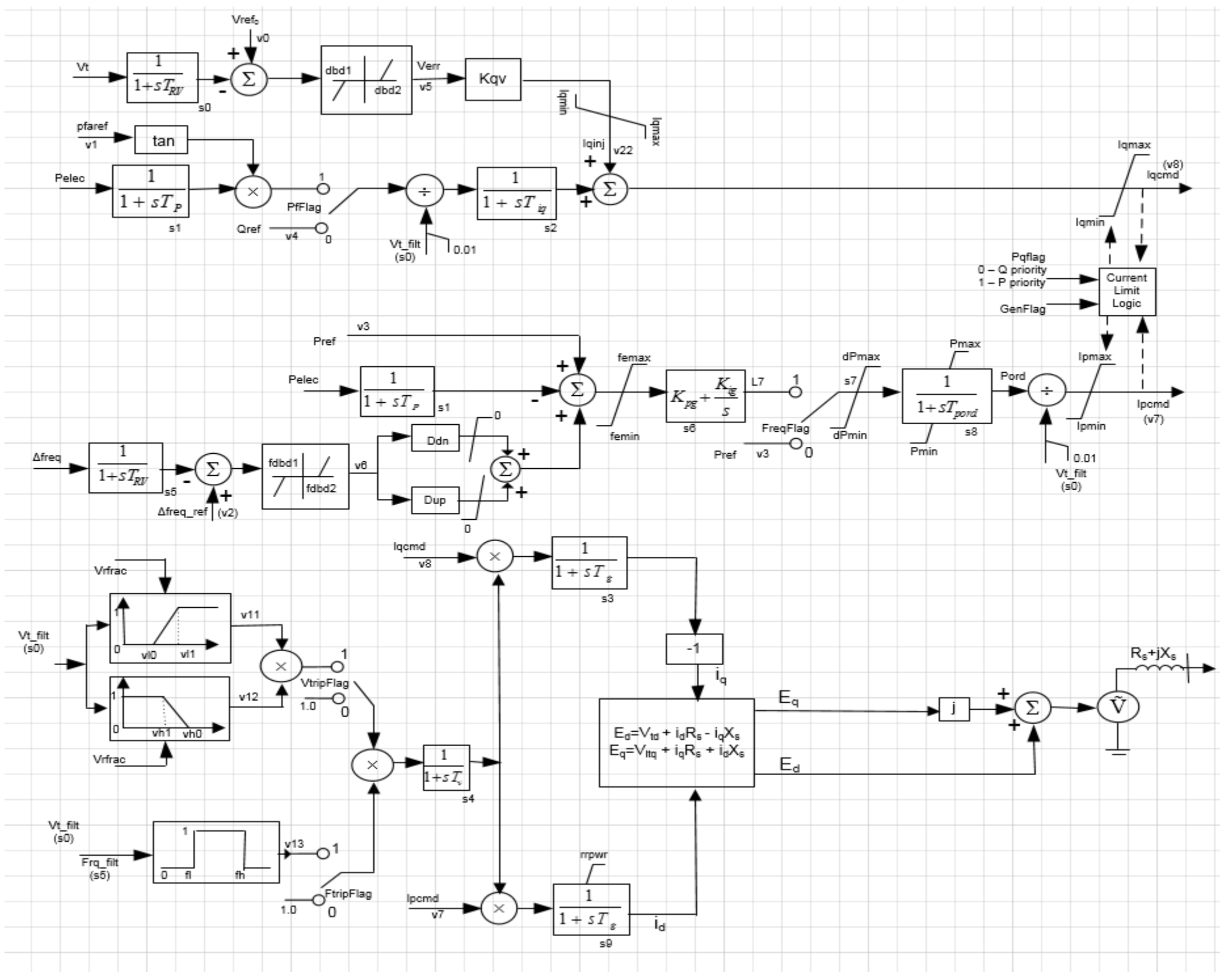
Feng Dong, Senior Engineer, Siemens PTI
Jayapalan Senthil, Senior Engineer, Siemens PTI

PSS®E Power flow Modeling of U-DER

- Modeled as a generator (specifically as a Renewable Machine) in power flow
- Reactive power boundary conditions allowed when modeled as Renewable Machine:
  - *Limits specified by QT and QB (i.e., same as for conventional machines)*
  - *QT and QB limits determined from the machine's active power output and a specified power factor*
  - *Fixed reactive power setting determined from the machine's active power output and a specified power factor*
- Support voltage setpoint control and voltage droop control

PSS®E Stability Modeling of U-DER

- Modeled using DER_A model (called DERA1 in PSS®E)



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PSS®E Power flow Modeling of R-DER

- Modeled as part of load data in power flow
  - DER MW and MVAr can be specified as part of the load record
  - Options are provided to scale net load, gross load as well as DER only.

Bus Number	Bus Name	Code	Pload (MW)	Qload (Mvar)	IPload (MW)	IQload (Mvar)	YPload (MW)	YQload (Mvar)	Distributed Gen (MW)	Distributed Gen (Mvar)
153	MID230 230.00	1	0.0000	0.0000	0.0000	0.0000	183.6681	-91.8341	0.0000	0.0000
154	DOWNTN 230.00	1	0.0000	0.0000	0.0000	0.0000	635.3055	-476.4792	0.0000	0.0000
154	DOWNTN 230.00	1	0.0000	0.0000	0.0000	0.0000	423.5370	-370.5949	0.0000	0.0000
203	EAST230 230.00	1	0.0000	0.0000	0.0000	0.0000	309.1698	-154.5849	0.0000	0.0000
205	SUB230 230.00	1	0.0000	0.0000	0.0000	0.0000	1249.4790	-728.8630	0.0000	0.0000
3005	WEST 230.00	1	0.0000	0.0000	0.0000	0.0000	97.0432	-48.5216	0.0000	0.0000
3007	RURAL 230.00	1	0.0000	0.0000	0.0000	0.0000	204.8823	-76.8309	0.0000	0.0000
3008	CATDOG 230.00	1	0.0000	0.0000	0.0000	0.0000	205.6811	-77.1304	0.0000	0.0000

PSS®E Stability Modeling of R-DER

- Modeled using CMLDxxDGU2 model in PSS®E (xx could be BL, AR, OW, ZN, AL)

9.7. CMLDBLDGU2, CMLDOWU2, CMLDZNDGU2, CMLDARDGU2, CMLDALDGU2

Composite Load Model

CONs	Value	Description
J		Load MVA base[a]
J+1		Substation shunt B (pu on Load MVA base)
J+2		Rfdr, Feeder R (pu on Load MVA base)
J+3		Xfdr, Feeder X (pu on Load MVA base)[b]
J+4		Xxf, Transformer Reactance - pu on load MVA base[c]
J+5		Tfixhs, High side fixed transformer tap
J+6		Tfixls, Low side fixed transformer tap
J+7		LTC flag (1: active during simulation, 0: inactive, -1: active during initialization, but inactive during simulation)

PSS®E-EMTP Co-Simulation

PSS®E

(RMS Type Tool)

EMTP Type Tool

PSS®E (RMS) and EMTP Co-simulation

- *Over 40 years of success studying unbalanced faults with HVDC controls*
- *High IBR penetration studies may require specialized controls that rely on phase and/or sequence voltage and/or currents -> Now available in PSS®E*

- *Involves 3-phase modeling with very detailed controls*
- *Not practical for very large systems*
- *May still be required for some localized studies where the short-circuit ratio (SCR) is very low*

- *Good for studying systems where detailed EMTP type control models are required for some equipment or a portion of network.*
- *Using such detailed models for long range planning type studies may not be feasible or may not be required.*

Accessing Phase and/or Sequence Quantities for use in IBR models

New functions available

To get branch sequence currents:

- *GetBranchSeqCurrents(IB,JB,ICKT,VPMAG,VPANG,VNMAG,VNANG,VZMAG,VZANG)*

To get bus phase voltage:

- *GetPhaseVoltages(IB,VAMAG,VAANG,VBMAG,VBANG,VCMAG,VCANG)*

To get bus sequence voltage:

- *GetPhaseVoltages(IB,VAMAG,VAANG,VBMAG,VBANG,VCMAG,VCANG)*

To get generator sequence currents:

- *GetMachSeqCurrents(MC,VPMAG,VPANG,VNMAG,VNANG,VZMAG,VZANG)*

For details of arguments etc., refer to Model Library Manual, chapter on 'Model Functions' of PSS®E 35.3

PTIs Efforts to Handle the rapid growth of DER

- Participate in various industry working groups (WECC Renewable Modeling Energy Working Group, NERC SPIDERWG) and work closely with Research organizations like EPRI, PNNL, NREL etc., to be aware of industry needs and add modeling capabilities (for power flow, short-circuit, and dynamic simulation) required by utilities and the industry.

http://www.powerworld.com
weber@powerworld.com

PowerWorld Distributed Energy Resource (DER) Modeling

Jamie Weber, Ph.D.
Director of Software Development
PowerWorld Corporation

Steady State Model (Time = minutes – hours)

- PowerWorld DER Modeling is 3-phase balanced modeling
- Fields for a load object: **DistStatus**, **DistMW**, **DistMvar**
  - The **NetMW** is then **LoadMW – DistMW**

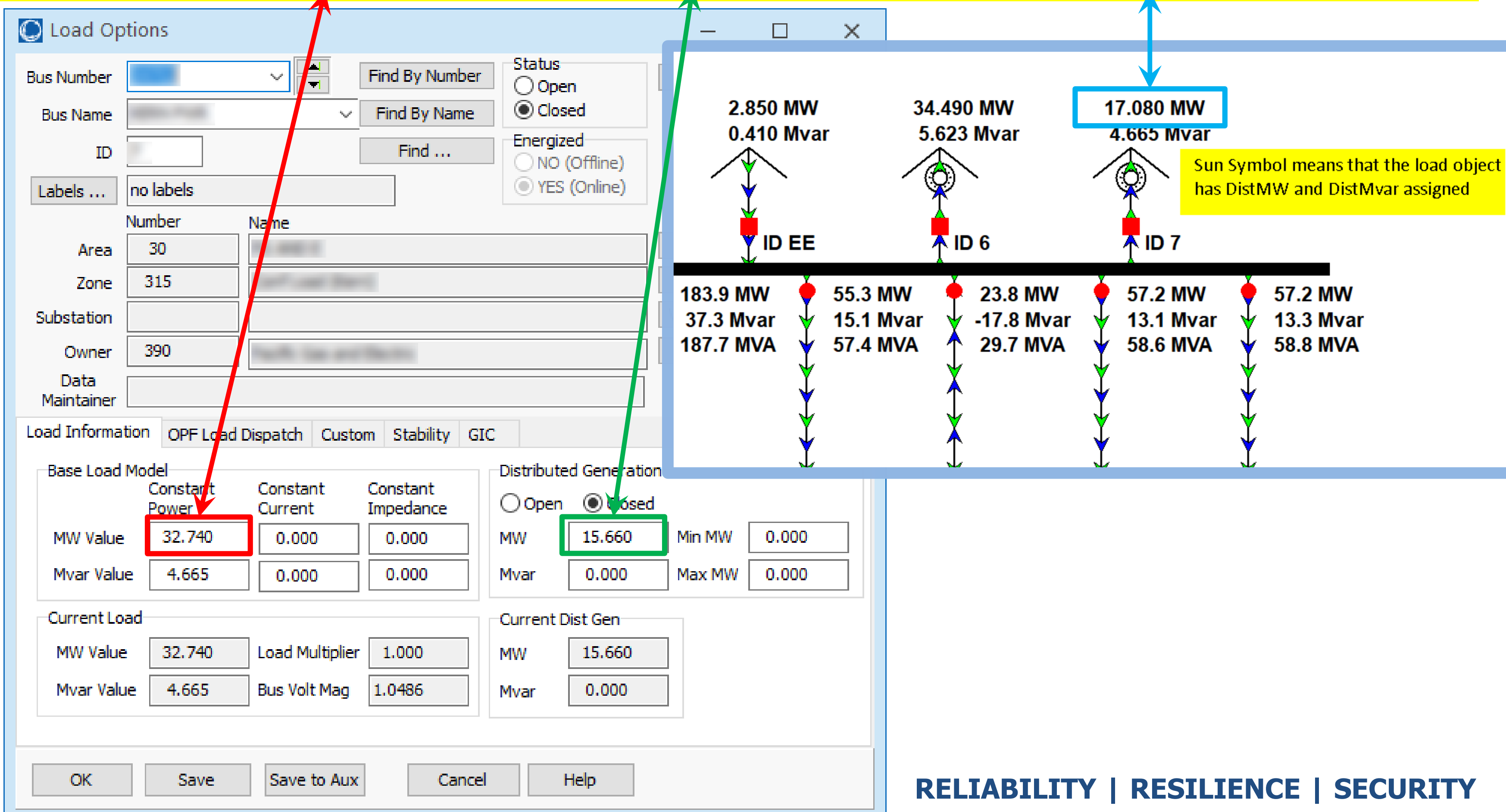
	Number of Bus	Name of Bus	Area Name of Load	Zone Name of Load	ID	Status	MW	Mvar	MVA	S MW	S Mvar	Dist Status	Dist MW Input	Dist Mvar Input	Dist MW	Dist Mvar	Net Mvar	Net MW
1	2	Two	Top	1	1	Closed	80.00	20.00	82.46	80.00	20.00	Closed	40.00	0.00	40.000	0.000	20.000	40.00
2	3	Three	Top	1	1	Closed	220.00	40.00	223.61	220.00	40.00	Open	110.00	0.00	0.000	0.000	40.000	220.00
3	4	Four	Top	1	1	Closed	160.00	30.00	162.79	160.00	30.00	Closed	80.00	0.00	80.000	0.000	30.000	80.00
4	5	Five	Top	1	1	Closed	260.00	40.00	263.06	260.00	40.00	Open	130.00	0.00	0.000	0.000	40.000	260.00
5	6	Six	Left	1	1	Closed	400.00	0.00	400.00	400.00	0.00	Closed	200.00	0.00	200.000	0.000	0.000	200.00
6	7	Seven	Right	1	1	Closed	400.00	0.00	400.00	400.00	0.00	Closed	200.00	0.00	200.000	0.000	0.000	200.00

  - Also include fields for **DistMWMin**, **DistMWMax**, and **DistUnitType**
- Reporting features with aggregations to show the summations of **DistMW**, **DistMvar**, **DistMWMin**, **DistMWMax** across groups
  - Bus
  - Area
  - Zone
  - Substation
  - Owner
  - Substation
  - Super Area (group of Areas)
  - Injection Group (user-specified group of loads and/or gens)
  - Load Model Group
  - Case

Visualization of DER with Load

NetMW = LoadMW – DistMW

NetMW = 32.74 – 15.66 = 17.08 MW



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http://www.powerworld.com
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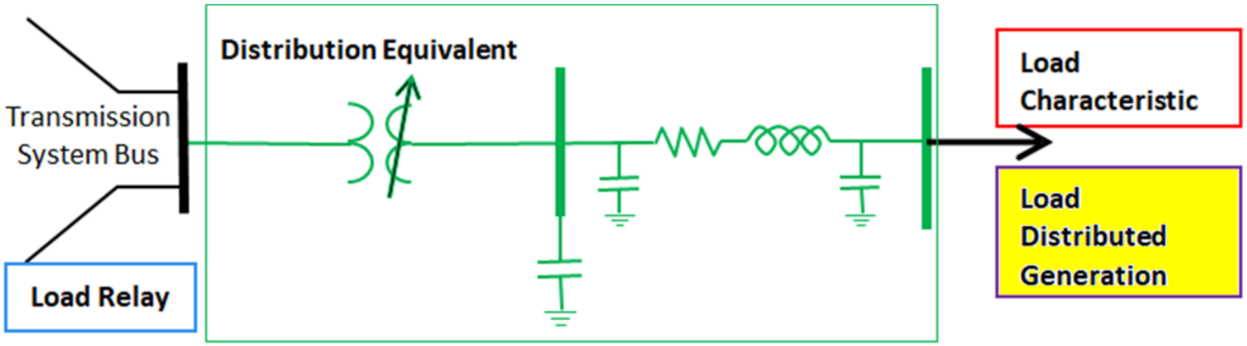
Transient Stability (Time = 10 ms – minutes)

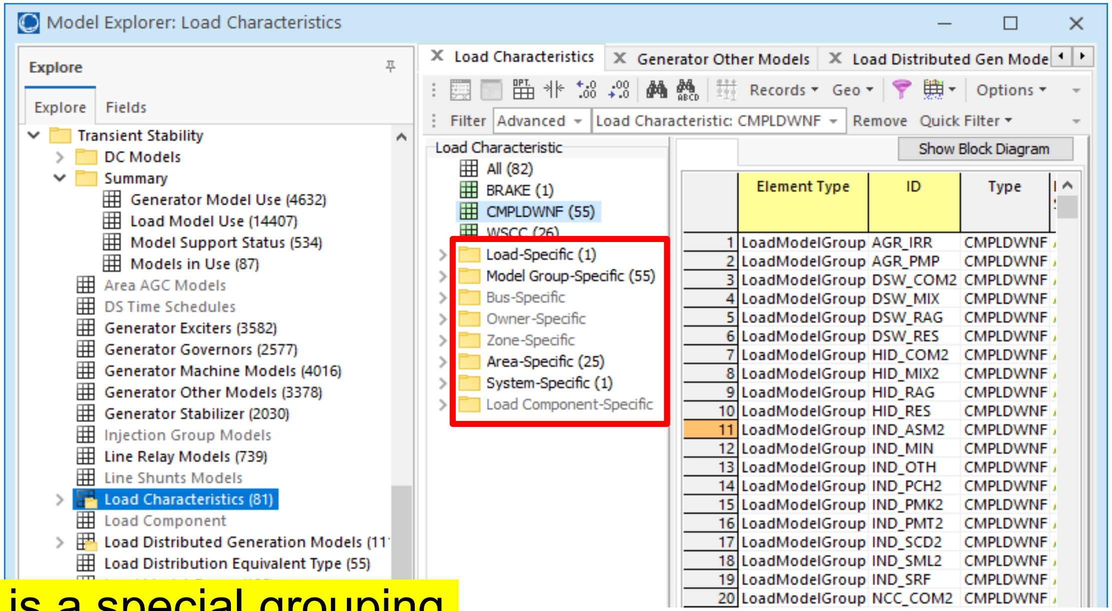
- *Separate* dynamic models assigned to load objects
  - Distributed Generation Model (DGPV and DGDER_A) describes how the **DistMW/DistMvar** behaves
    - https://www.powerworld.com/WebHelp/#MainDocumentation_HTML/Transient_Stability_LoadDistributedGeneration.htm
  - Load Characteristic such as CMPLDW, CMLD, INDMOT1P, etc… describes how the **LoadMW/LoadMvar** behaves
    - https://www.powerworld.com/WebHelp/#MainDocumentation_HTML/Transient_Stability_LoadCharacteristic.htm
  - Distribution Equivalent Model is separate model adds in the green portion below to model distribution system
    - https://www.powerworld.com/WebHelp/#MainDocumentation_HTML/Transient_Stability_Load_Model_Group_Distribution_Feeder_Equivalent.htm
  - Load Relay models are separate models



https://www.powerworld.com/WebHelp/#MainDocumentation_HTML/Transient_Stability_Overview_Loads.htm

Hierarchy of Model Specification

- Specify a model at any level in the hierarchy
- Model Used will be first model from highest precedence found
- Separate choices for: (each individually follows hierarchy)
  - Load Characteristic
  - Distribution Equivalent (Also separate Dist Equiv MVABase choice)
  - Distributed Generation model (Also separate Dist Gen MVABase choice)
- Precedence:
  1. Load
  2. Load Model Group
  3. Bus
  4. Owner
  5. Zone
  6. Area
  7. System



Load Model Group is a special grouping explicitly designed for dynamic models

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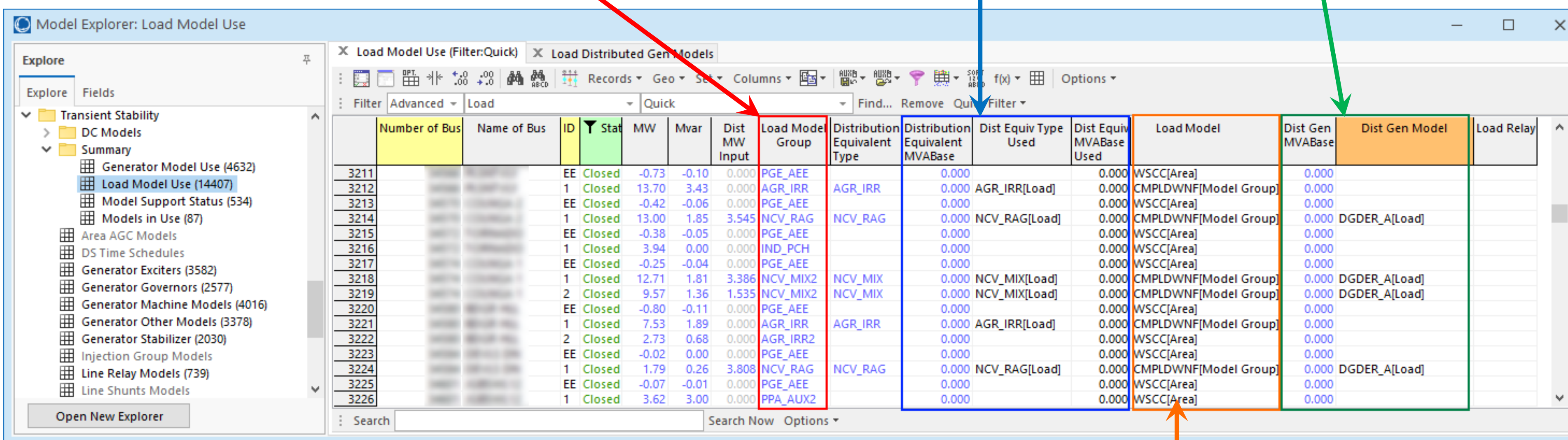
Load Model Use Summary Example

- Summary of which models are being used for each load

Distributed Generation Model and Dist Gen MVABase

Load Model Group Assignment

Distribution Equivalent and Dist Equiv MVABase



	Number of Bus	Name of Bus	ID	Stat	MW	Mvar	Dist MW Input	Load Model Group	Distribution Equivalent Type	Distribution Equivalent MVABase	Dist Equiv Type Used	Dist Equiv MVABase Used	Load Model	Dist Gen MVABase	Dist Gen Model	Load Relay
3211	[illegible]	[illegible]	EE	Closed	-0.73	-0.10	0.000	PGE_AEE		0.000		0.000	WSCC[Area]	0.000		
3212	[illegible]	[illegible]	1	Closed	13.70	3.43	0.000	AGR_IRR	AGR_IRR	0.000	AGR_IRR[Load]	0.000	CMPLDWNF[Model Group]	0.000		
3213	[illegible]	[illegible]	EE	Closed	-0.42	-0.06	0.000	PGE_AEE		0.000		0.000	WSCC[Area]	0.000		
3214	[illegible]	[illegible]	1	Closed	13.00	1.85	3.545	NCV_RAG	NCV_RAG	0.000	NCV_RAG[Load]	0.000	CMPLDWNF[Model Group]	0.000	DGDER_A[Load]	
3215	[illegible]	[illegible]	EE	Closed	-0.38	-0.05	0.000	PGE_AEE		0.000		0.000	WSCC[Area]	0.000		
3216	[illegible]	[illegible]	1	Closed	3.94	0.00	0.000	IND_PCH		0.000		0.000	WSCC[Area]	0.000		
3217	[illegible]	[illegible]	EE	Closed	-0.25	-0.04	0.000	PGE_AEE		0.000		0.000	WSCC[Area]	0.000		
3218	[illegible]	[illegible]	1	Closed	12.71	1.81	3.386	NCV_MIX2	NCV_MIX	0.000	NCV_MIX[Load]	0.000	CMPLDWNF[Model Group]	0.000	DGDER_A[Load]	
3219	[illegible]	[illegible]	2	Closed	9.57	1.36	1.535	NCV_MIX2	NCV_MIX	0.000	NCV_MIX[Load]	0.000	CMPLDWNF[Model Group]	0.000	DGDER_A[Load]	
3220	[illegible]	[illegible]	EE	Closed	-0.80	-0.11	0.000	PGE_AEE		0.000		0.000	WSCC[Area]	0.000		
3221	[illegible]	[illegible]	1	Closed	7.53	1.89	0.000	AGR_IRR	AGR_IRR	0.000	AGR_IRR[Load]	0.000	CMPLDWNF[Model Group]	0.000		
3222	[illegible]	[illegible]	2	Closed	2.73	0.68	0.000	AGR_IRR2		0.000		0.000	WSCC[Area]	0.000		
3223	[illegible]	[illegible]	EE	Closed	-0.02	0.00	0.000	PGE_AEE		0.000		0.000	WSCC[Area]	0.000		
3224	[illegible]	[illegible]	1	Closed	1.79	0.26	3.808	NCV_RAG	NCV_RAG	0.000	NCV_RAG[Load]	0.000	CMPLDWNF[Model Group]	0.000	DGDER_A[Load]	
3225	[illegible]	[illegible]	EE	Closed	-0.07	-0.01	0.000	PGE_AEE		0.000		0.000	WSCC[Area]	0.000		
3226	[illegible]	[illegible]	1	Closed	3.62	3.00	0.000	PPA_AUX2		0.000		0.000	WSCC[Area]	0.000		

Load Characteristic Inherited from ModelGroup and Area

PowerTech

Pouya Zadkhast, Engineering Applications Lead, PowerTech Labs

DER Modeling in DSATools

- Supported in static (PSAT/VSAT) and dynamic analysis (TSAT)
- Part of load records in powerflow and dynamic data
  - Supporting generic PVD1 and DER_A models
  - Can be a separate module in the modular composite load
- Ability to
  - Apply step change, monitor internal states, etc.
  - Monitor MW, Mvar, and other output quantities

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DER Modeling in DSATools

- From software Perspective
  - DER as a new composite load component
  - Requires efficient implementation
  - Increased program dimension
  - Not unusual impact on simulation performance so far
- Future plan
  - Following NERC guidelines and requests from users
  - For example, translating dynamic simulation switching into a powerflow file

PSLF – Tools and Techniques Related to DER Planning

Shruti Rao, GE PSLF

26 October 2021

PSLF

- Current versions allow for DG to be modeled separately from load by entering the STDG, PDGEN, QDGEN entries in the load table.
- Versions 23 and higher will have PDGENMAX, PDGENMIN, DG_TURBTYP (1=PV, 0=Non-PV) as well. PDGENMAX, PDGENMIN limits are for information/warning purposes only. The program will not impose these limits to change the user input Pdgen.
- The *der_a* model can be used for:
  - U-DER (modeled like any other generator in power-flow) with stand-alone *der_a* model
  - R-DER (DG component in load power-flow table) along with a *cmp_der_a* component in the composite load model (*cmpldwg*) representing the load.

Organizing and modifying DER Information

- Summary tables:
  - In version 23, the label in the load table will be clarified as gross.
  - The area/zone/BA etc summary does show both net load and gross load.
  - The total MW/MVAr from R-DER is included in the area/zone/owner summary reports. From v23, the total Pdgenmax and Pdgenmin will also be seen in these reports.
- Can the total DER production in a given area, zone, owner, etc. be adjusted as a ratio to its total available DER active power? In particular when total available DER active power is less that maximum capable.
  - Yes, scaling of R-DER load DG component added for upcoming version 23 as a part of scal() feature.
  - When executing this scaling feature, PSLF will take care about not scaling non-PV DER.

Organizing DER Dynamic Modeling Data

- Can post-contingency information on DER be placed in a tabular format, particularly fraction tripped or restored?
  - Yes, cmpldwg includes an output channel for Pdgen whose initial and final values can be seen in the view table of PLOT.
  - Additionally, the ldtrpmon model can be used that monitors the total DG in a given area/zone/BA/owner. The initial and final values for this can also be seen in the view table.

Monitoring at individual cmpldwg model level:

For Type 2 distributed generation (cmp_der_a):

1	Pdg	DG active power generation, MW
1	Qdg	DG reactive power generation, MVAr
2	ipcm	Active current command (ipcmd), p.u.
2	iqcm	Reactive current command (iqcmd), p.u.
3	vmul	Fraction not tripped by low or high voltage protection (vmult)
3	fmul	Fraction not tripped by low or high frequency protection (fmult)

Monitoring at area/zone/owner/BA level:

Model Name: ldtrpmon

Description Load trip monitor

Prerequisites: None

Inputs: Tripping values from composite load models

Invocation: ldtrpmon [<n>] {<name> <kv>} :

Parameters:

EPCL Variable	*Default Data*	*Description*
flag	none	1=area, 2=zone, 3=owner, 4=balancing area
num	none	Number of area, zone, owner, or balancing area
plotno	0.0	Plot selection number

Record Level	*Name*	*Description*
1	Pld	Total load active power at high side bus, MW
1	xshn	Nominal value of load shed, MW
1	xton	Nominal value of load tripped, MW
1	xtoi	Instantaneous value of load tripped and shed, MW
1	Pdg	Distributed Generation P, MW
1	xdgn	Nominal value of distributed generation tripped, MW
1	xdgi	Inst. value of distributed generation tripped and shed , MW
2	Pst	Static load P, MW
2	Pel	Electronic load P, MW
2	Pma	Motor A P, MW
2	Pmb	Motor B P, MW
2	Pmc	Motor C P, MW
2	Pmd	Motor D P, MW
2	xeln	Nominal electronic load tripped, MW
2	xman	Nominal motor A load tripped, MW
2	xmbn	Nominal motor B load tripped, MW
2	xmcn	Nominal motor C load tripped, MW
2	xmdn	Nominal motor D load tripped, MW
2	xeli	Instantaneous electronic load tripped and shed, MW
2	xmai	Instantaneous motor A load tripped and shed, MW
2	xmb	Instantaneous motor B load tripped and shed, MW
2	xmci	Instantaneous motor C load tripped and shed, MW
2	xmdi	Instantaneous motor D load tripped and shed, MW

Organizing DER Dynamic Modeling Data

- Can DER behavior be presented in plotting tools? If so, can it be presented at individual busses and in aggregate?
  - Yes, cmpldwg includes an output channel for Pdgen that can be plotted.
  - Additionally, ldtrpmon model can be used that monitors the total DG in a given area/zone/BA/owner throughout a simulation
- Can plotting tools show both “Gross” and “Net” load?
  - Yes, gross load added as a channel in addition to pre-existing net load in version 22.0.1

Off-Peak Dispatch of DER - Dynamic

- Can the tool flag out of bounds dynamic parameters? What automations are done to correct “incorrect” parameters?
  - Yes, for each model some data checks are done before initialization. If “fix bad data” flag is set to 1 in the init command, the parameters are modified along with a warning message. If the flag is 0 only warnings are recorded.
  - For the der_a model these are the data checks:
    - Trv → if smaller than the global integration time step i.e. dypar[0].delt, set to dypar[0].delt
    - Tp → if smaller than the global integration time step i.e. dypar[0].delt, set to dypar[0].delt
    - Tiq → if smaller than the global integration time step i.e. dypar[0].delt, set to dypar[0].delt
    - Tpord → if smaller than the global integration time step i.e. dypar[0].delt, set to dypar[0].delt
    - Tg → if smaller than the global integration time step i.e. dypar[0].delt, set to dypar[0].delt

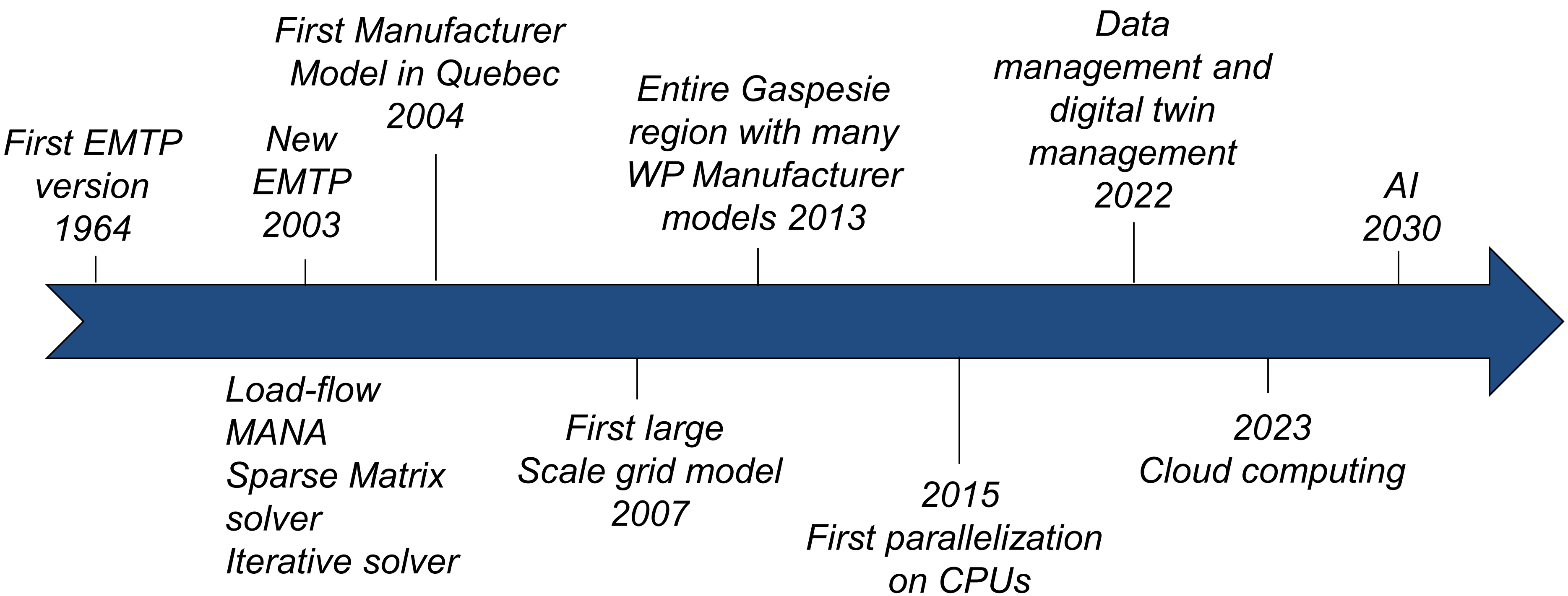
Off-Peak Dispatch of DER - Dynamic

- Can the tool identify standalone U-DER representations and adjust powerflow and dynamic discrepencies?
  - Current version does not check for discrepancy in Pmax/Pmin between power-flow and dynamics data. We will look into adding this capability going forward.
  - Regarding MVAbase discrepancy:
    - For cmpldwg component der_a model – the MVAbase can be entered as a loading factor that is applied to the steady state pdgen value. With this implementation the user does not have to worry about updating the dynamic MVAbase for DER modeled as a load component for different DG penetration levels.
    - For standalone der_a, at the moment the default option is for the dynamic MVAbase to over-ride power-flow MVAbase for all generators. This default option can be changed to reverse it i.e., have the power-flow MVAbase take precedence for all generators. Going forward, we will look into handling the der_a model differently to flag a discrepancy between the two MVAbase values.

EMTP® DER Modeling

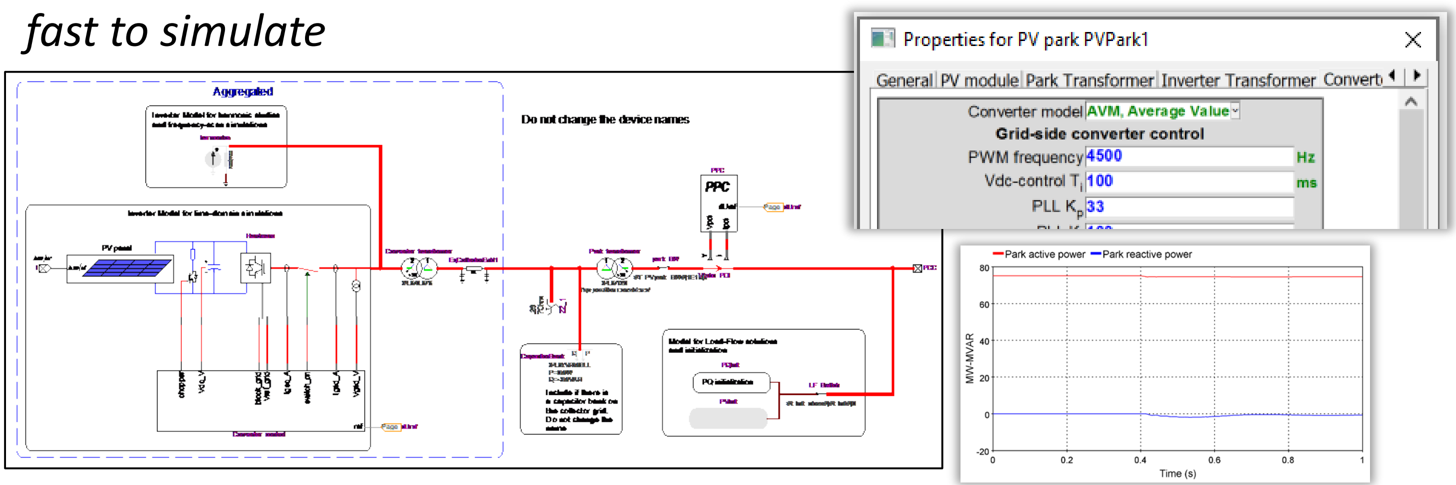
Henry Gras, EMTP Alliance

EMTP® History and future



DER Modeling – our vision

- *Users must:*
  - *be able to access models with maximum precision*
  - *be able to access simpler and faster models*
  - *be able to go from simple to complex model in seamless manner*
- *Models must:*
  - *be consistent between load-flow and time-domain solutions*
  - *be usable, flexible and initialized from load-flow (services must be available for developers)*
  - *fast to simulate*



PV model in EMTP®: In a single click, the user may transition from a simple harmonic current source version, to the average value or detailed version. All models provide the same results in steady-state.

Load-Flow module improvements

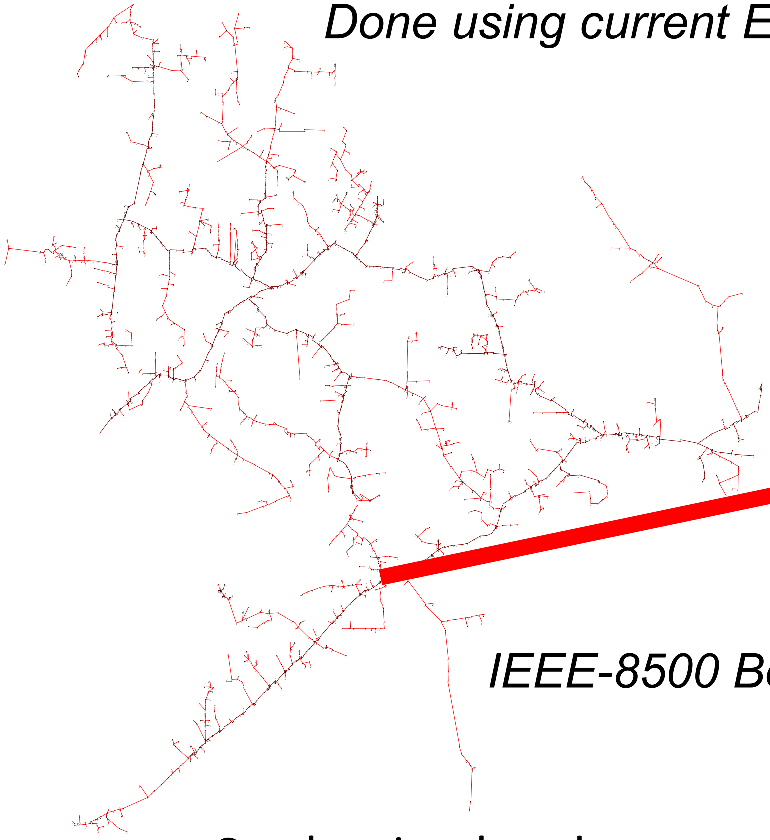
- Limits on Load-Flow constraints
- Automatic tap changer settings
- PQ bus: upper and lower limits for voltage
- PQ diagram for generators: limits on P and Q powers
- Droop functions for DGs
- Capabilities to simulate multiple AC/DC microgrids

$$P_G - P_0 = \alpha_{drp}(\omega_0 - \omega)$$

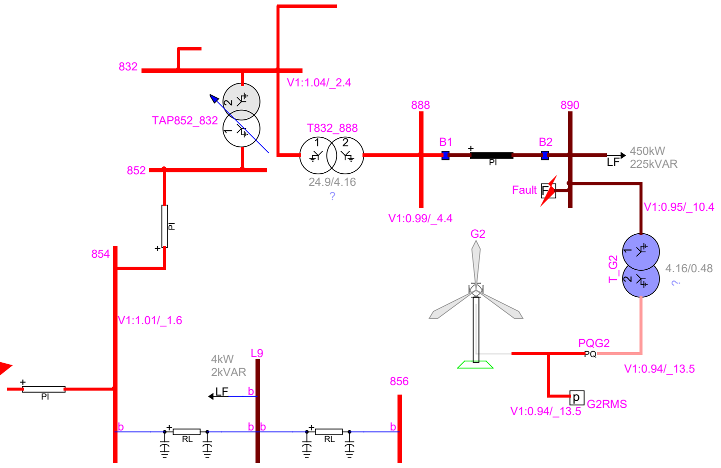
$$Q_G - P_0 = \beta_{drp}(|V_0| - |V_G|)$$

Very large scale EMT simulations

Done using current EMTP® version



IEEE-8500 Benchmark



Zoomed view

Can be simulated on a regular laptop.

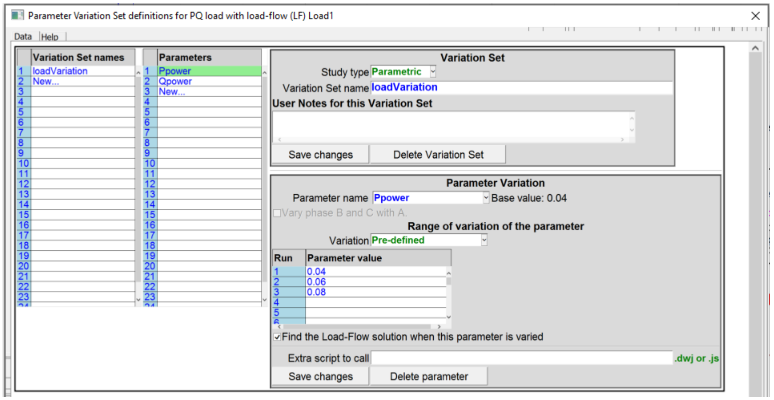
Load-flow: 2 seconds

EMT: 15s (1s of simulation at 100µs)

Continuous improvement in solvers and methods

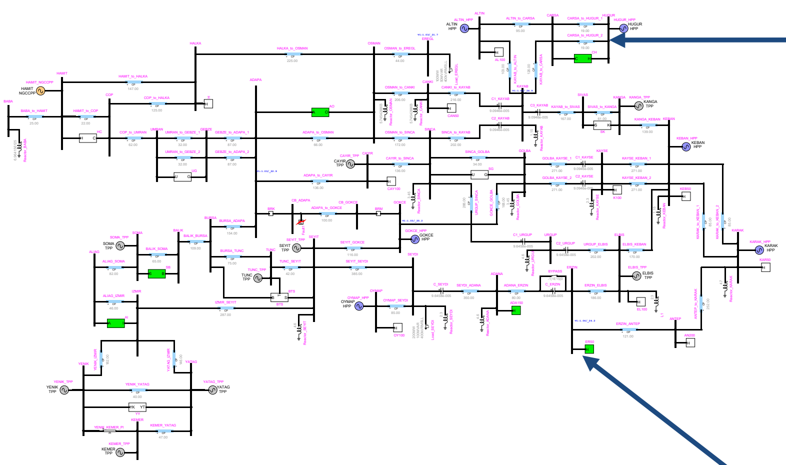
- Reduced-order Jacobian matrix solver for control-block diagrams
- Variable time-step numerical integration
  - Promising if efficiently implemented
- Cloud computing
- Advanced contingency analysis tool
- Automatic reporting (tripping, flags, powers, etc)
- Automatic importation from other formats (PSS/E, CIM, etc)

Accelerate large scale power system simulations on laptops!



Manufacturer model interfacing with actual grid

Actual grid, Operation state established by operator



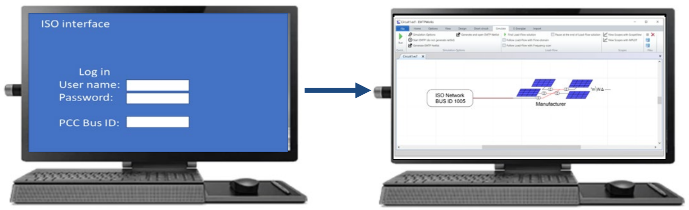
PV manufacturer model
Aggregated or detailed parc

Direct access to grid model at given connection point

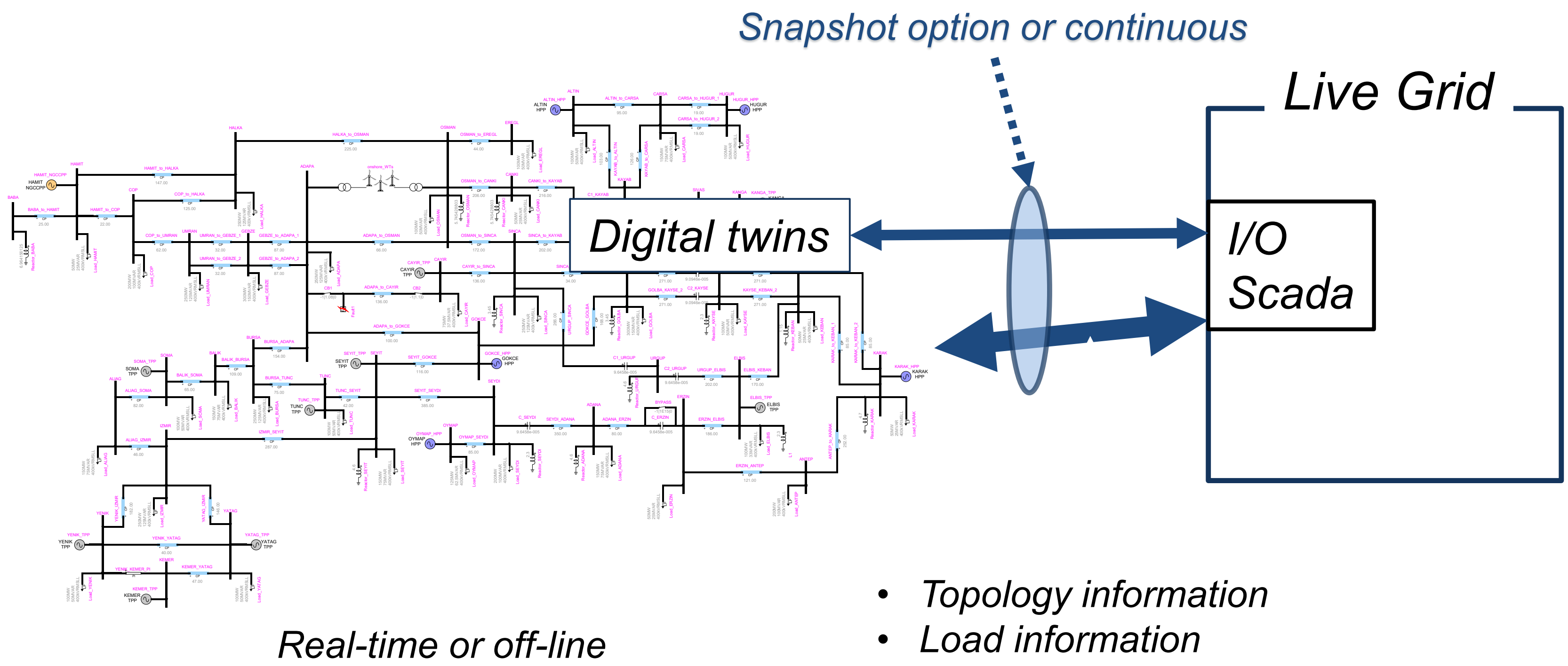
- *Web or locally available*
- *Encryption*
- *Static view option with access to results at any point*
- *Full access to given region with hidden remains*
- *Acces to Actual grid*
- *Acces to Equivalent (FDNE, dynamic)*

Developer interface – software independent

Feasible today



Electronic copy concept



- *Topology information*
- *Load information*
- *Settings of protection systems*
- *Fault conditions*
- *Monitoring…*

Feasible today

Questions and Answers