

Dynamic Load Models in PowerWorld Simulator



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Modular Structure of Generator Dynamic Models



- Generators have included a modular structure for several decades (1970s and onward)
- Synchronous generators had up to 8 separate modules with coordinated initialization
 - Machine
 - Exciter
 - Governor
 - Stabilizer
 - Under Excitation Limiter
 - Over Excitation Limiter
 - Compensator Model
 - Relay Model
- Even more have been added recently
 - Aerodynamic Model (Type 3 Wind)
 - Pref Controller (Type 3 wind and LCFB1)
 - Plant Controller (renewable models)
 - AGC Controller (Implemented in Version 19 of PowerWorld Simulator)

Load Models have not kept up



- Load Models have been stuck with only two modules
 - Load characteristic
 - Load relay
- The MOTORW model introduced in PSLF in the 1990s was a step in the right direction
 - MOTORW included a parameter indicating what percentage of the load was a motor
 - This meant we now had 3 modules
 - Dynamic Model
 - Algebraic Model
 - Relay Model
 - No longer required you to split the power flow load record to permit a load model split

Initial Implementation of Distribution Equivalent



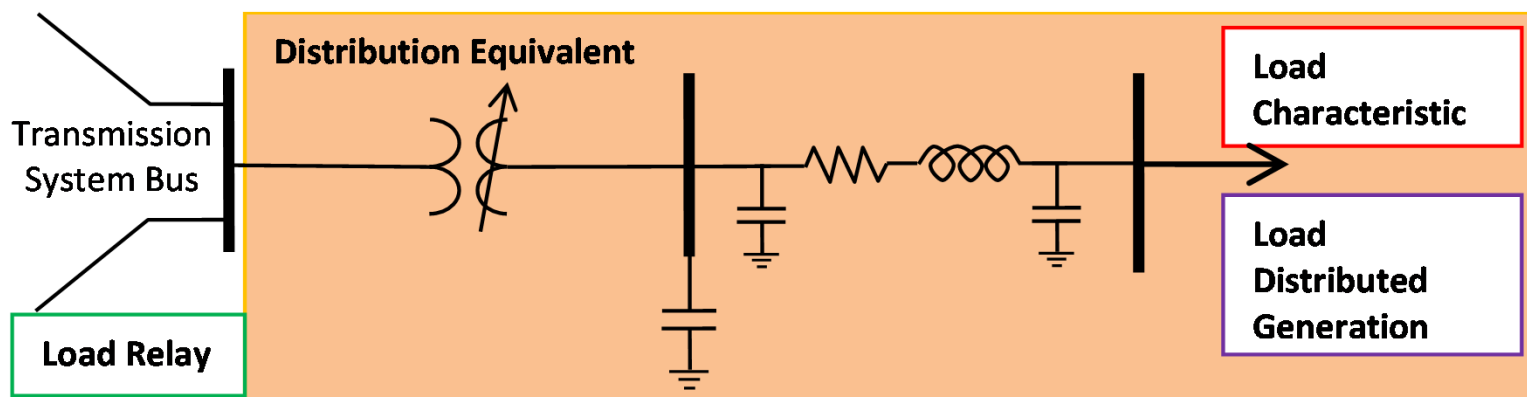
- Composite load model (CMPLDW) was designed within the WECC LMTF in the mid 2000s
 - The distribution equivalent is stuck inside the load characteristic
 - Has meant that new load models in WECC are gravitating toward being smashed into the CMPLDW framework
- Load Distributed Generation (Roof-top Solar for example)
 - This also needs to be at the end of Distribution Equivalent

It is Time to Modularize: Just like Generators



- Natural for a load record to have 4 modules associated with transient stability
 - Load Characteristic
 - Ability to generically split up into any combination of components will be available in PowerWorld Simulator Version 20 in Summer 2017
 - Relay Model
 - Distribution Equivalent
 - Added in PowerWorld Simulator Version 17 in January 2013
 - Load Distributed Generation Model
 - Added in PowerWorld Simulator Version 19 in November 2015

Attributes of a load are not always related to one another and thus independent dynamic models should be available



Load Record: Distributed Generation



- Discussed in WECC LMTF for a few years and decision was made in 2014 to model with three new user input fields with each Load Record
 - Dist MW Input:** the user entered MWs of distributed generation at the load
 - Dist Mvar Input:** the user entered Mvars of distributed generation at the load
 - Dist Status:** The status of the distributed generation (**Open** or **Closed**)
- Available in PowerWorld Simulator 19 in year 2015

	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	40.000
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	220.000
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	80.000
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	260.000
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	200.000
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	200.000

Other Load Record Fields



- **Dist MW, Dist Mvar:** this is the actual MWs being seen by the power flow solution
 - This will be 0.0 if **DistStatus** = **Open**
 - This will be reduced if the voltage falls below the minimum voltage for constant power load
- **Net MW:** this is equal to the subtraction of the fields **MW – Dist MW**
- **Net Mvar:** this is equal to the subtraction of the fields **Mvar – Dist Mvar**

	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	40.000
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	220.000
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	80.000
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	260.000
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	200.000
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	200.000

Treatment of Distributed Generation in Power Flow

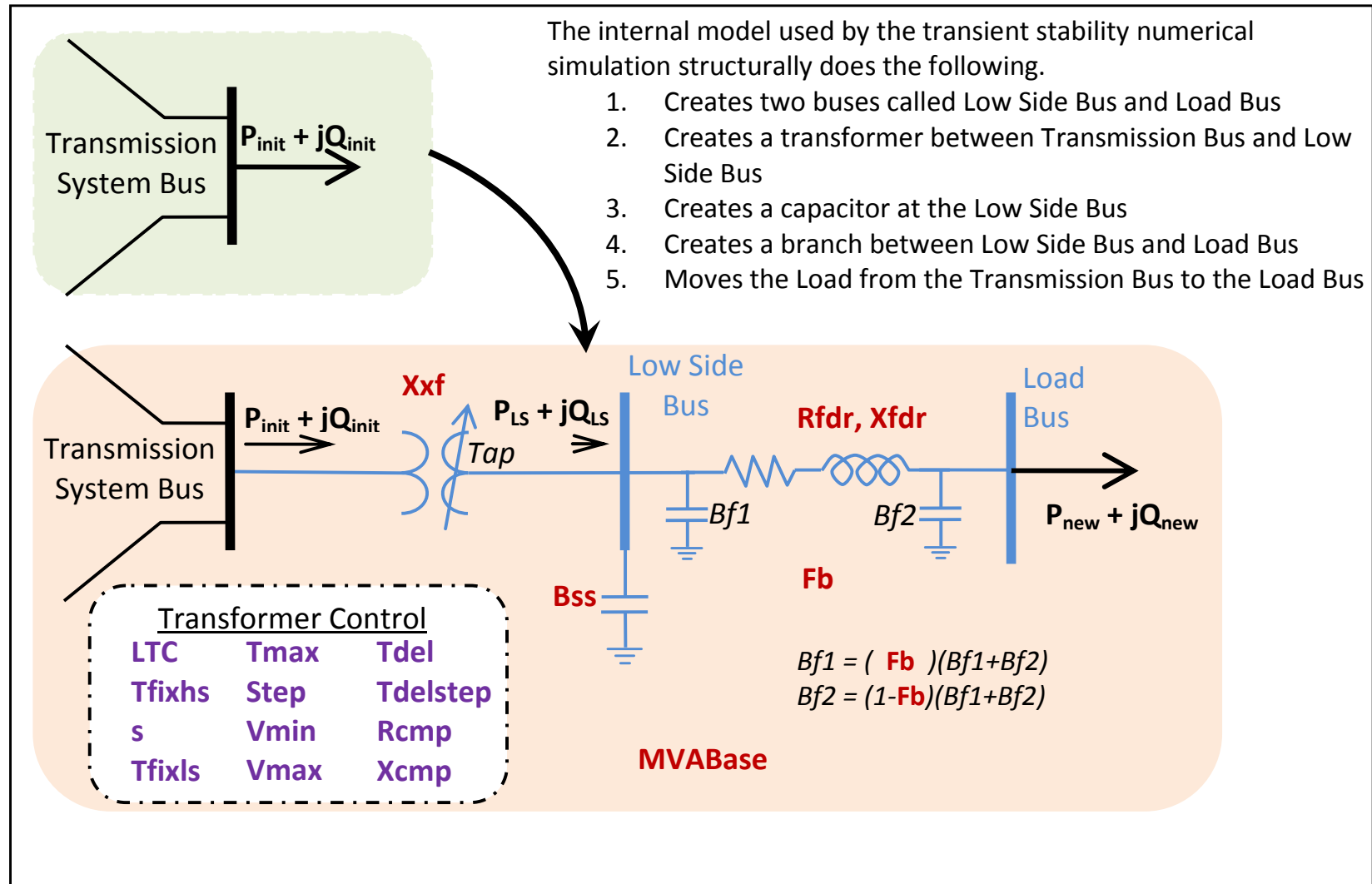


- Summary Information with Areas, Zones, Substations, etc...
 - Dist MW is separate summation from Load MW

	Area Num	Area Name	AGC Status	Gen MW	Load MW	Dist MW	Shunt MW	Tot Sched MW	Int MW	ACE MW	Lambda	Loss MW
1	1	Top	ED	367.42	720.00	120.000		0.00	-359.54	-359.54	0.00	6.96
2	2	Left	ED	199.52	400.00	200.000		0.00	-200.82	-200.82	0.00	0.34
3	3	Right	ED	400.99	400.00	200.000		0.00	0.36	0.36	0.00	0.64

- Injection Group Treatment
 - Injected MW = Gen MW – Load MW – Dist Gen MW
- Contingency Actions
 - “Set, Change, Move” actions only act on Load portion
 - Open and Close actions also open the distributed gen

Load Distribution Equivalent



Load Model Features for Data Management



- Dynamic model structure for loads: 4 model types
 - Load **Characteristic**
 - Describes load behavior (CMPLDW, WSCC, MOTORW, CIM5, CIM6, etc)
 - Can be assigned in hierarchy levels (Load Model Group, Bus, Owner, Zone, Area, System)
 - Load **Distribution Equivalent**
 - Assigned to the load record
 - Not part of load characteristic, so can be used in combination with any load characteristic
 - Load **Distributed Generation**
 - Describes the behavior of the distributed generation
 - Load **Relay**
- Load **Model Group**
 - Special named object that contains Characteristics, Distributed Generation or Relay models. Load object may then refer to the Model Group
- Load **Component**
 - Special named object that contains a Characteristic
 - Then used inside the CompLoad characteristic
- Special Load Characteristic: **CompLoad**
 - New type of load characteristic model (like CIM5, IEEL, MOTORW, LDELEC, etc.)
 - This gives a combination of other load characteristics

Load Characteristic Models



- Load models apply to either a load, Load model group, bus, owner, zone, area, or the entire case

Precedence:

1. Load-specific
2. Load Model Group-specific
3. Bus-specific
4. Owner-specific
5. Zone-specific
6. Area-specific
7. System-specific
8. Default load modeling option with transient stability options

Transient Stability Data - Load Characteristic

Filter: Advanced Load Characteristic: General Find... Remove Quick Filter...

Load Characteristic

- All (478)
- CIM5
- CIM6
- CIMW
- CLOD
- CMPLDW
- CMPLDWNF (23)
- DLIGHT
- EXTL
- IEEL
- LDIPAC
- LDFR
- LDRANDOM
- MOTORW (4)
- WSCC (451)
- Load-Specific
- Model Group-Specific
- Bus-Specific (430)
- Owner-Specific
- Zone-Specific
- Area-Specific (21)
- System-Specific

Show Models Supported By

☒ PW Only ☒ PTI

☐ BPA ☒ GE

Save Load

	Fully Supported	Element Type	Number	Name_Nominal kv	ID	Name	MW
1	YES	Bus	13402	BLACKWTR_345.00		BLACKWTR	-50
2	YES	Bus	24007	ALMITOSW_66.00		ALMITOSW	90.45
3	YES	Bus	24017	BLYTHESC_161.00		BLYTHESC	30.94
4	YES	Bus	24024	CHINO_66.00		CHINO	408.99
5	YES	Bus	24028	DELAMO_66.00		DELAMO	252.58
6	YES	Bus	24039	EL NIDO_66.00		EL NIDO	214.02
7	YES	Bus	24055	ETIWANDA_66.00		ETIWANDA	367.48
8	YES	Bus	24057	GOLETA_66.00		GOLETA	149.55
9	YES	Bus	24064	HINSON_66.00		HINSON	243.51
10	YES	Bus	24073	LA FRESA_66.00		LA FRESA	355.68
11	YES	Bus	24075	LAGUBELL_66.00		LAGUBELL	291.93
12	YES	Bus	24083	LITEHIPE_66.00		LITEHIPE	237.4
13	YES	Bus	24098	MOORPARK_66.00		MOORPARK	377.03
14	YES	Bus	24111	PADUA_66.00		PADUA	325.65
15	YES	Bus	24127	S.CLARA_66.00		S.CLARA	273.66
16	YES	Bus	24133	SANTIAGO_66.00		SANTIAGO	310.42
17	YES	Bus	24135	SAUGUS_66.00		SAUGUS	444.39
18	YES	Bus	24152	VESTAL_66.00		VESTAL	75.77
19	YES	Bus	24157	WALNUT_66.00		WALNUT	320.89
20	YES	Bus	24160	VALLEYSC_115.00		VALLEYSC	366.08
21	YES	Bus	24197	ELLIS_66.00		ELLIS	369.54
22	YES	Bus	24199	CHEVMAIN_66.00		CHEVMAIN	172.38
23	YES	Bus	24201	BARRE_66.00		BARRE	344.17
24	YES	Bus	24202	CAMINO_66.00		CAMINO	2.04
25	YES	Bus	24203	CENTER_66.00		CENTER	239.72
26	YES	Bus	24204	EAGLEMTN_66.00		EAGLEMTN	1.05
27	YES	Bus	24205	EAGLOCK_66.00		EAGLOCK	115.85

Search Search Now Options

Load Model Group

Load Distribution Equivalent Type



Model Explorer: Load Model Use

Explore

- Recent
- Network
- Aggregations
- Solution Details
- Case Information and Auxiliary
- Contingency Analysis
- Fault Analysis
- Optimal Power Flow
- Transient Stability
 - DC Models
 - Summary
 - Generator Model Use (36/1)
 - Load Model Use (8645)**
 - Model Support Status (322)
 - Models in Use (96)
- Generator Exciters (2825)
- Generator Governors (2267)
- Generator Machine Models (3381)
- Generator Other Models (611)
- Generator Stabilizer (1493)
- Line Relay Models (147)
- Load Characteristics (80)
- Load Distribution Equivalent Type (386)
- Load Model Group (58)
- Load Relays (2551)

Open New Explorer

Load Model Summary

	Number of Bus	Name of Bus	ID	Status	MW	Mvar	Load Model Group	Distribution Equivalent Type
1	10005	ALCAZAR	1	Closed	18.13	-0.81	HID4	RES 43
2	10008	ALLISON	1	Closed	9.64	3.17	HID	COM31
3	10013	ANDERSON	1	Closed	8.98	-0.97	HID4	RES 11
4	10015	ARNO_1	1	Closed	3.61	0.04		
5	10017	ARRIBA	1	Closed	3.74	-0.32		
6	10020	ASPEN	1	Closed	19.25	3.91	HID4	RES 55
7	10022	AVILA	1	Closed	8.48	2.43	HID4	RES 90
8	10027	BACA	1	Closed	3.86	-0.64		
9	10029	BALL_PRK	1	Closed	1.72	-0.20		
10	10032	BECKNER	1	Closed	13.11	1.78	HID	COM22
11	10034	BEL_AIR	1	Closed	12.90	-0.23	HID4	RES 43
12	10036	ARNO_2	1	Closed	9.21	-0.77	HID4	RES 11
13	10037	FIRST_ST	1	Closed	12.75	4.63	HID4	RES 62
14	10040	BEV_WOOD	1	Closed	7.15	1.26	HID4	RES 35
15	10041	BISTI	1	Closed	7.50	4.28	HID3	RAG47
16	10043	BLCKRA	1	Closed	18.50	4.32	HID4	RES 35
17	10046	BOSQUE_F	1	Closed	4.81	-0.06		
18	10049	BROADWAY	1	Open	0.00	0.00		
19	10050	BUCKMAN	1	Closed	7.54	-1.78	HID	COM32
20	10057	BURNHAM	1	Closed	1.50	0.50		

Fields

Find Field... Add ->

Available Fields

- Sensitivity of Bus
- Substation
- Super Area
- Time Step
- Transient Stability
 - Results
 - Save
 - Load Characteristic Name (Motor)
 - Load Characteristic Name (Static)
 - Load Distribution Equivalent Type**
 - Load Model Group
 - Load Relay Name
- Voltage
- Zone
- Key Fields
- Required Fields
- Secondary Key Fields

Expand Collapse

Frozen Columns 1

Reset to Factory Defaults

Load Model Group



- Identified by unique name
- List of Load Characteristic Models assigned to it
 - CIM5, CIM6, MOTORW, WSCC, CMPLDWNF, etc.
- Allows flexibility in grouping load characteristic models with the same parameters
 - Useful when existing aggregations (such as area, zone, etc) don't capture this
 - *Climate-based* grouping such as “High Desert”
 - *Economic-based* grouping such as “Server Farm” or “Mining Operation”

Load Characteristic Aggregate Models



- Load Characteristic used will be the model available at the lowest point in the precedence hierarchy as follows
 1. Load-specific
 2. Load Model Group-specific
 3. Bus-specific
 4. Owner-specific
 5. Zone-specific
 6. Area-specific
 7. System-specific
 8. Default load modeling option with transient stability options

Load Characteristic Models



Load Model Hierarchy

The screenshot displays the 'Model Explorer: Load Characteristics' window. The left pane shows a tree structure of load models. The 'Load-Specific' folder is expanded, and the 'CMPLDWNF (56)' model group is highlighted. The right pane shows a table of model data for the 'CMPLDWNF' group.

Element Type	ID	Name	Type	Device Status	FmA	FmB	FmC	FmD	Fel	PFel	Vd1	Vd2	fr
LoadModelGroup	AGR	AGR	CMPLDWNF	Active	1	0	0	0	0	1	0.75	0.6	0
LoadModelGroup	DSW	Desert Southwest	CMPLDWNF	Active	0.31	0.122	0.052	0.129	0.157	1	0.7	0.5	0
LoadModelGroup	DSW2	Desert Southwest	CMPLDWNF	Active	0.169	0.153	0.108	0.284	0.107	1	0.7	0.5	0
LoadModelGroup	DSW3	Desert Southwest	CMPLDWNF	Active	0.096	0.168	0.027	0.484	0.088	1	0.7	0.5	0
LoadModelGroup	DSW4	Desert Southwest	CMPLDWNF	Active	0.206	0.141	0.04	0.29	0.141	1	0.7	0.5	0
LoadModelGroup	HID	High Desert	CMPLDWNF	Active	0.257	0.122	0.049	0.113	0.172	1	0.7	0.5	0
LoadModelGroup	HID2	High Desert	CMPLDWNF	Active	0.171	0.133	0.041	0.254	0.158	1	0.7	0.5	0
LoadModelGroup	HID3	High Desert	CMPLDWNF	Active	0.153	0.144	0.11	0.249	0.12	1	0.7	0.5	0
LoadModelGroup	HID4	High Desert	CMPLDWNF	Active	0.079	0.151	0.032	0.424	0.109	1	0.7	0.5	0
LoadModelGroup	IND	IND	CMPLDWNF	Active	0.05	0.55	0.25	0	0.12	1	0.75	0.6	0
LoadModelGroup	IND2	IND	CMPLDWNF	Active	0.1	0.35	0.1	0	0.4	1	0.75	0.6	0
LoadModelGroup	IND3	IND	CMPLDWNF	Active	0.2	0.35	0.35	0	0.05	1	0.75	0.6	0
LoadModelGroup	IND4	IND	CMPLDWNF	Active	0.15	0.25	0.4	0	0.15	1	0.75	0.6	0
LoadModelGroup	IND5	IND	CMPLDWNF	Active	0.25	0.1	0.05	0	0.65	1	0.75	0.6	0
LoadModelGroup	IND6	IND	CMPLDWNF	Active	0.2	0.25	0.3	0	0.2	1	0.75	0.6	0
LoadModelGroup	IND7	IND	CMPLDWNF	Active	0.1	0.25	0.4	0	0.2	1	0.75	0.6	0
LoadModelGroup	NCC	Northern California Coast	CMPLDWNF	Active	0.236	0.115	0.05	0.063	0.208	1	0.7	0.5	0
LoadModelGroup	NCC2	Northern California Coast	CMPLDWNF	Active	0.151	0.116	0.122	0.144	0.156	1	0.7	0.5	0
LoadModelGroup	NCC3	Northern California Coast	CMPLDWNF	Active	0.161	0.108	0.05	0.146	0.204	1	0.7	0.5	0
LoadModelGroup	NCC4	Northern California Coast	CMPLDWNF	Active	0.076	0.103	0.052	0.25	0.166	1	0.7	0.5	0
LoadModelGroup	NCI	Northern California Inland	CMPLDWNF	Active	0.089	0.135	0.038	0.361	0.133	1	0.7	0.5	0
LoadModelGroup	NCI2	Northern California Inland	CMPLDWNF	Active	0.163	0.134	0.114	0.206	0.137	1	0.7	0.5	0
LoadModelGroup	NCI3	Northern California Inland	CMPLDWNF	Active	0.186	0.123	0.041	0.208	0.184	1	0.7	0.5	0
LoadModelGroup	NCI4	Northern California Inland	CMPLDWNF	Active	0.271	0.118	0.044	0.09	0.199	1	0.7	0.5	0
LoadModelGroup	NCV	Northern California Valley	CMPLDWNF	Active	0.112	0.15	0.032	0.422	0.109	1	0.7	0.5	0
LoadModelGroup	NCV2	Northern California Valley	CMPLDWNF	Active	0.184	0.141	0.111	0.242	0.121	1	0.7	0.5	0
LoadModelGroup	NCV3	Northern California Valley	CMPLDWNF	Active	0.231	0.126	0.04	0.244	0.161	1	0.7	0.5	0
LoadModelGroup	NCV4	Northern California Valley	CMPLDWNF	Active	0.337	0.111	0.048	0.105	0.176	1	0.7	0.5	0
LoadModelGroup	NWC	Northwest Coast	CMPLDWNF	Active	0.137	0.094	0.047	0.089	0.206	1	0.7	0.5	0
LoadModelGroup	NWC2	Northwest Coast	CMPLDWNF	Active	0.139	0.102	0.12	0.088	0.155	1	0.7	0.5	0
LoadModelGroup	NWC3	Northwest Coast	CMPLDWNF	Active	0.201	0.112	0.046	0.039	0.216	1	0.7	0.5	0

Model CMPLDWNF



- Identical to CMPLDW except that parameters for Load Distribution Equivalent have been removed (first 17 parameters and MVABase)

Load Characteristic Information

LoadModelGroup DSW

Load Characteristics

Insert Delete Show Block Diagram

Type Active - CMPLDWNF ☒ Active (Only One Active, Except for Supplementary Models)

Parameters

FmA	0.0960	P2e	1.0000	LFma	0.7500	Vtr	
FmB	0.1680	P2c	0.4526	Rsa_CompPFa	0.0400	Ttr	
FmC	0.0270	Pfrq	0.0000	Lsa_Vstalla	1.8000	Ftr2a_Vc1o	
FmD	0.4840	Q1e	2.0000	Lpa_Rstalla	0.1200	Vrc1a_Vc2o	
Fel	0.0880	Q1c	-0.5000	Lppa_Xstalla	0.1040	Trc1a_Vc1c	
PFel	1.0000	Q2e	1.0000	Tpoa_Tstalla	0.0950	Vrc2a_Vc2c	
Vd1	0.7000	Q2c	1.5000	Tppoa_Frsta	0.0021	Trc2a_Tt	
Vd2	0.5000	Qfrq	-1.0000	Ha_Vrsta	0.0500	Th	
frcl	0.7000	Mtypa	3.0000	Etrqa_Trsta	0.0000	Th	
PFs	-0.9973	Mtypb	3.0000	Ftr1a_Fuvra	0.7000	T	
P1e	2.0000	Mtypc	3.0000	Vtr1a	0.0200	LF	
P1c	0.5474	Mtypd	1.0000	Ttr1a	0.2000	Rsb_CompF	

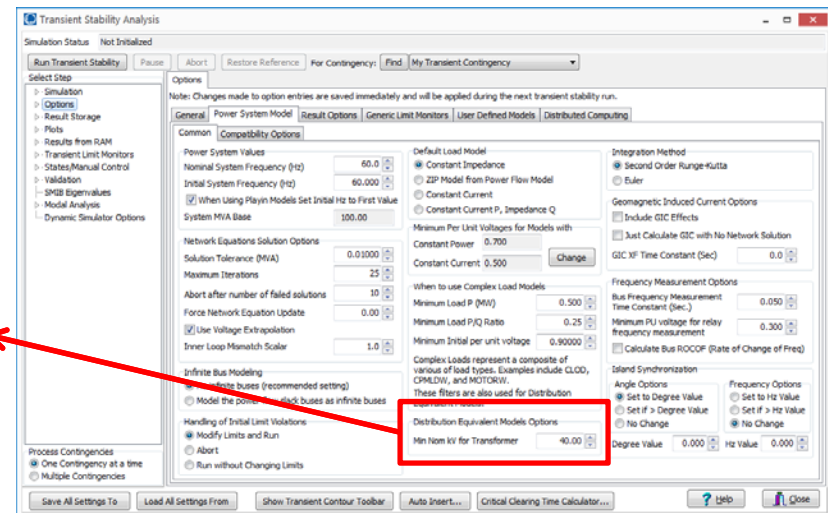
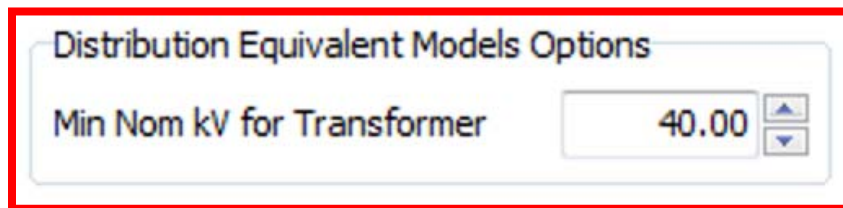
Show Torque Speed Dialog

OK Save Cancel

New Option in Version 20



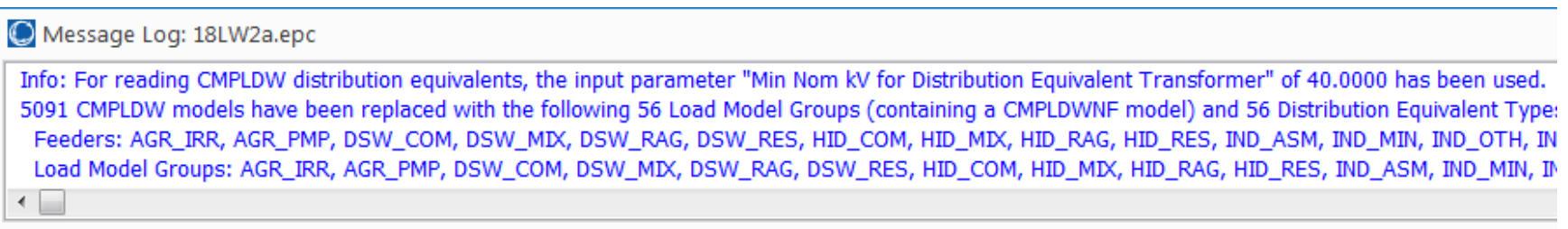
- Distribution Equivalent Models Options
 - Min Nom kV for Transformer: 40 kV is default
 - Any load connected to a bus with a nominal voltage below this will ignore the transformer impedance (Xxf) specified with the distribution



What Happens When you open EPC and DYD files



- Example: 18LW2a.epc and 18LW21.dyd
- Simulator groups together all CMPLDW records with same parameters
- **Distribution Equivalents** are created using first 17 parameters (and MVABase) to create.
 - Each unique combination of these parameters
 - Try to use names from the load “long id” field
 - Also uses the new option in version 20 regarding the minimum Nom kV for Transformer
- **LoadModelGroups** are created using remaining values with each unique combination of these parameters
 - Try to use names from the load “long id” field



56 Load Model Groups



Model Explorer: Load Model Group

Explore Fields

- Contingency Analysis
- Optimal Power Flow
- Tools and Add Ons
- Transient Stability
 - DC Models
 - Summary
 - Area AGC Models
 - DS Time Schedules
 - Generator Exciters (3493)
 - Generator Governors (2583)
 - Generator Machine Models (3952)
 - Generator Other Models (1791)
 - Generator Stabilizer (1899)
 - Line Relay Models (618)
 - Line Shunts Models
 - Load Characteristics (78)
 - Load Component
 - Load Distributed Generation Models
 - Load Distribution Equivalent Type (56)
 - Load Model Group (56)**
 - Load Relays (3097)
 - Measurement Objects Models
 - PlayIn Configuration
 - Switched Shunt Models (19)
 - User-Defined

Open New Explorer

Load Model Group Buses

Filter Advanced Model Group Find... Remove

	Name	Long Name	Load Static Model	Load Motor Model
24	NCI_COM	Northern California Inland / Commercial	CMPLDWNF	CMPLDWNF
25	NCI_MIX	Northern California Inland / Mix	CMPLDWNF	CMPLDWNF
26	NCI_RAG	Northern California Inland / Rural	CMPLDWNF	CMPLDWNF
27	NCI_RES	Northern California Inland / Residential	CMPLDWNF	CMPLDWNF
28	NCV_COM	Northern California Valley / Commercial	CMPLDWNF	CMPLDWNF
29	NCV_MIX	Northern California Valley / Mix	CMPLDWNF	CMPLDWNF
30	NCV_RAG	Northern California Valley / Rural	CMPLDWNF	CMPLDWNF
31	NCV_RES	Northern California Valley / Residential	CMPLDWNF	CMPLDWNF
32	NWC_COM	Northwest Coast / Commercial	CMPLDWNF	CMPLDWNF
33	NWC_MIX	Northwest Coast / Mix	CMPLDWNF	CMPLDWNF
34	NWC_RAG	Northwest Coast / Rural	CMPLDWNF	CMPLDWNF
35	NWC_RES	Northwest Coast / Residential	CMPLDWNF	CMPLDWNF
36	NWI_COM	Northwest Inland / Commercial	CMPLDWNF	CMPLDWNF
37	NWI_MIX	Northwest Inland / Mix	CMPLDWNF	CMPLDWNF
38	NWI_RAG	Northwest Inland / Rural	CMPLDWNF	CMPLDWNF
39	NWI_RES	Northwest Inland / Residential	CMPLDWNF	CMPLDWNF
40	NWV_COM	Northwest Valley / Commercial	CMPLDWNF	CMPLDWNF
41	NWV_MIX	Northwest Valley / Mix	CMPLDWNF	CMPLDWNF
42	NWV_RAG	Northwest Valley / Rural	CMPLDWNF	CMPLDWNF
43	NWV_RES	Northwest Valley / Residential	CMPLDWNF	CMPLDWNF
44	PPA_AUX	Power Plant / Auxiliary	CMPLDWNF	CMPLDWNF
45	RMN_COM	Rocky Mountain North / Commercial	CMPLDWNF	CMPLDWNF
46	RMN_MIX	Rocky Mountain North / Mix	CMPLDWNF	CMPLDWNF
47	RMN_RAG	Rocky Mountain North / Rural	CMPLDWNF	CMPLDWNF
48	RMN_RES	Rocky Mountain North / Residential	CMPLDWNF	CMPLDWNF

Search Search Now Options

56 CMPLDWNF created (one for each LoadModelGroup)



Model Explorer: Load Characteristics

Explore Fields

- Tools and Add Ons
 - Transient Stability
 - DC Models
 - Summary
 - Area AGC Models
 - DS Time Schedules
 - Generator Exciters (3493)
 - Generator Governors (2583)
 - Generator Machine Models
 - Generator Other Models (1)
 - Generator Stabilizer (1899)
 - Line Relay Models (618)
 - Line Shunts Models
 - Load Characteristics (78)**
 - Load Component
 - Load Distributed Generators

Load Characteristics

Filter: Advanced Load Characteristic: CMPLDWNF

Load Characteristic

- CIMW
- CLOD
- CMLD
- CMPLDW
- CMPLDWNF (56)**
- DLIGHT

Show Models Supported By

☒ PW Only ☒ PTI

☐ BPA ☒ GE

☐ Only Show Used Models

Save Load

CMPLDWNF

	Element Type	Nk	ID	Name	Type	Device Status	S	FmA	FmB	FmC	FmD	Fel	PFel	Vd1	Vd2	frcl
25	LoadModelGroup	NCI_MIX	Northern California Inland	CMPLDWNF	Active			0.082	0.173	0.036	0.128	0.11	1	0.7	0.5	1
26	LoadModelGroup	NCI_RAG	Northern California Inland	CMPLDWNF	Active			0.076	0.129	0.259	0.098	0.076	1	0.7	0.5	1
27	LoadModelGroup	NCI_RES	Northern California Inland	CMPLDWNF	Active			0.027	0.165	0.011	0.183	0.067	1	0.7	0.5	1
28	LoadModelGroup	NCV_COM	Northern California Valley	CMPLDWNF	Active			0.13	0.153	0.008	0.111	0.133	1	0.7	0.5	1
29	LoadModelGroup	NCV_MIX	Northern California Valley	CMPLDWNF	Active			0.097	0.17	0.039	0.126	0.096	1	0.7	0.5	1
30	LoadModelGroup	NCV_RAG	Northern California Valley	CMPLDWNF	Active			0.083	0.124	0.275	0.092	0.072	1	0.7	0.5	1
31	LoadModelGroup	NCV_RES	Northern California Valley	CMPLDWNF	Active			0.033	0.159	0.012	0.181	0.063	1	0.7	0.5	1
32	LoadModelGroup	NWC_COM	Northwest Coast / Commer	CMPLDWNF	Active			0.102	0.123	0.008	0.125	0.126	1	0.7	0.5	1-0
33	LoadModelGroup	NWC_MIX	Northwest Coast / Mix	CMPLDWNF	Active			0.078	0.137	0.032	0.145	0.086	1	0.7	0.5	1
34	LoadModelGroup	NWC_RAG	Northwest Coast / Rural	CMPLDWNF	Active			0.072	0.107	0.236	0.115	0.062	1	0.7	0.5	1

Search Search Now Options

56 Load Distribution Equivalents



- Note: All Xxf > 0 in example. This is because the option for 40 kV threshold handles ignoring Xxf when required

Model Explorer: Load Distribution Equivalent Type

Explore

- Contingency Analysis
- Optimal Power Flow
- Tools and Add Ons
- Transient Stability
 - DC Models
 - Summary
 - Area AGC Models
 - DS Time Schedules
 - Generator Exciters (3493)
 - Generator Governors (2583)
 - Generator Machine Models (3952)
 - Generator Other Models (1791)
 - Generator Stabilizer (1899)
 - Line Relay Models (618)
 - Line Shunts Models
 - Load Characteristics (78)
 - Load Component
 - Load Distributed Generation Models
 - Load Distribution Equivalent Type (56)**
 - Load Model Group (56)**
 - Load Relays (3097)
 - Measurement Objects Models
 - PlayIn Configuration
 - Switched Shunt Models (19)
 - User-Defined

Open New Explorer

Load Distribution Equivalent Type

Records Set Columns

Filter Find... Remove Quick Filter...

	Name	Long Name	Mbase	Bss	Rfdr	Xfdr	Fb	Xxf	fixhs	Tfixhs	LTC	Tmin	Tmax	step	Vmin	Vmax	Tdel	Tdelstep	Rcmp	Xcmp
23	NCC_RES	Northern California Coast / Residential	-1	0	0.04	0.04	0.75	0.08	1	1	0	0.9	1.1	0.00625	1.025	1.04	30	5	0	0
24	NCL_COM	Northern California Inland / Commercial	-1.1	0	0.04	0.04	0.75	0.08	1	1	0	0.9	1.1	0.00625	1.025	1.04	30	5	0	0
25	NCL_MIX	Northern California Inland / Mix	-1.1	0	0.04	0.04	0.75	0.08	1	1	0	0.9	1.1	0.00625	1.025	1.04	30	5	0	0
26	NCL_RAG	Northern California Inland / Rural	-1	0	0.04	0.04	0.75	0.08	1	1	0	0.9	1.1	0.00625	1.025	1.04	30	5	0	0
27	NCL_RES	Northern California Inland / Residential	-1.1	0	0.04	0.04	0.75	0.08	1	1	0	0.9	1.1	0.00625	1.025	1.04	30	5	0	0
28	NCV_COM	Northern California Valley / Commercial	-1.1	0	0.04	0.04	0.75	0.08	1	1	0	0.9	1.1	0.00625	1.025	1.04	30	5	0	0
29	NCV_MIX	Northern California Valley / Mix	-1.1	0	0.04	0.04	0.75	0.08	1	1	0	0.9	1.1	0.00625	1.025	1.04	30	5	0	0
30	NCV_RAG	Northern California Valley / Rural	-1	0	0.04	0.04	0.75	0.08	1	1	0	0.9	1.1	0.00625	1.025	1.04	30	5	0	0
31	NCV_RES	Northern California Valley / Residential	-1.1	0	0.04	0.04	0.75	0.08	1	1	0	0.9	1.1	0.00625	1.025	1.04	30	5	0	0
32	NWC_COM	Northwest Coast / Commercial	-1	0	0.04	0.04	0.75	0.08	1	1	1	0.9	1.1	0.00625	1.025	1.04	30	5	0	0
33	NWC_MIX	Northwest Coast / Mix	-1	0	0.04	0.04	0.75	0.08	1	1	1	0.9	1.1	0.00625	1.025	1.04	30	5	0	0
34	NWC_RAG	Northwest Coast / Rural	-1	0	0.04	0.04	0.75	0.08	1	1	1	0.9	1.1	0.00625	1.025	1.04	30	5	0	0
35	NWC_RES	Northwest Coast / Residential	-1	0	0.04	0.04	0.75	0.08	1	1	1	0.9	1.1	0.00625	1.025	1.04	30	5	0	0
36	NWI_COM	Northwest Inland / Commercial	-1	0	0.04	0.04	0.75	0.08	1	1	1	0.9	1.1	0.00625	1.025	1.04	30	5	0	0
37	NWI_MIX	Northwest Inland / Mix	-1	0	0.04	0.04	0.75	0.08	1	1	1	0.9	1.1	0.00625	1.025	1.04	30	5	0	0
38	NWI_RAG	Northwest Inland / Rural	-1	0	0.04	0.04	0.75	0.08	1	1	1	0.9	1.1	0.00625	1.025	1.04	30	5	0	0
39	NWI_RES	Northwest Inland / Residential	-1	0	0.04	0.04	0.75	0.08	1	1	1	0.9	1.1	0.00625	1.025	1.04	30	5	0	0
40	NWV_COM	Northwest Valley / Commercial	-1	0	0.04	0.04	0.75	0.08	1	1	1	0.9	1.1	0.00625	1.025	1.04	30	5	0	0
41	NWV_MIX	Northwest Valley / Mix	-1	0	0.04	0.04	0.75	0.08	1	1	1	0.9	1.1	0.00625	1.025	1.04	30	5	0	0
42	NWV_RAG	Northwest Valley / Rural	-1	0	0.04	0.04	0.75	0.08	1	1	1	0.9	1.1	0.00625	1.025	1.04	30	5	0	0
43	NWV_RES	Northwest Valley / Residential	-1	0	0.04	0.04	0.75	0.08	1	1	1	0.9	1.1	0.00625	1.025	1.04	30	5	0	0
44	PPA_AUX	Power Plant / Auxiliary	-1	0	0	0.01	1	0.08	1	1	0	0.9	1.1	0.00625	1.025	1.04	0	0	0	0
45	RMN_COM	Rocky Mountain North / Commercial	-1	0	0.04	0.04	0.75	0.08	1	1	1	0.9	1.1	0.00625	1.025	1.04	30	5	0	0
46	RMN_MIX	Rocky Mountain North / Mix	-1	0	0.04	0.04	0.75	0.08	1	1	1	0.9	1.1	0.00625	1.025	1.04	30	5	0	0
47	RMN_RAG	Rocky Mountain North / Rural	-1	0	0.04	0.04	0.75	0.08	1	1	1	0.9	1.1	0.00625	1.025	1.04	30	5	0	0
48	RMN_RFS	Rocky Mountain North / Residential	-1	0	0.04	0.04	0.75	0.08	1	1	1	0.9	1.1	0.00625	1.025	1.04	30	5	0	0

Search Search Now Options

Existing summary



- For data in existing cases, we think that managing 56 load characteristics and 56 distribution equivalents is manageable.
- Thus, CMPLDW works OK, but...
 - Model components are fixed
 - Always 4 motors (usually 3 induction motors and 1 single phase air conditioner)
 - 1 electronic load
 - 1 static load
 - This makes adding new pieces to the structure very cumbersome

New in Version 20 of Simulator

Available Summer 2017



- Ability to make any combination of load characteristics
 - A new **LoadComponent** object
 - Name to identify it
 - Load characteristic assigned to it
 - Make a new type of load characteristic called **CompLoad**
 - Allow it to reference up to 10 **LoadComponent** objects along with assigning a fractions of each of those 10
- Most existing load characteristics can then be assigned to the **LoadComponent**
 - Benefit: As new stand-alone load characteristics are added to software, they are immediately available in the CompLoad structure

New Object Record: LoadComponent



Model Explorer: Load Component

Explore

- Recent
- Network
- Aggregations
- Solution Details
- Case Information and Auxilia
- Contingency Analysis
- Optimal Power Flow
- Tools and Add Ons
- Transient Stability
 - DC Models
 - Summary
 - Area AGC Models
 - DS Time Schedules
 - Generator Exciters
 - Generator Governors
 - Generator Machine Models
 - Generator Other Models
 - Generator Stabilizer
 - Line Relay Models
 - Line Shunts Models
 - Load Characteristics (8)
 - Load Component (6)**
 - Load Distributed General
 - Load Distribution Equiva
 - Load Model Group
 - Load Relays
 - Measurement Objects Mo
 - PlayIn Configuration
 - Switched Shunt Models
 - User-Defined

Open New Explorer

Load Component

Filter: Advanced Load Characteristic: MOTOR_CMP

	Name	Long Name	Load Model
1	Air Conditioner	Air Conditioner	LD1PAC
2	Big Motor	Big Motor	MOTOR_CMP
3	Electronic	Electronic	LDELEC
4	Pump Fan	Pump Fan	MOTOR_CMP
5	Small Motor	Small Motor	MOTOR_CMP
6	Static	Static	WSCC

Name to identify it

Load Characteristic

- DLIGHT
- EXTL
- IEEL
- LD1PAC (1)
- LDELEC (1)
- LDFR
- LDRANDOM
- LoadTimeSchedule
- MOTORW
- MOTORX
- MOTOR_CMP (3)
- WSCC (1)

Show Models Supported By

☒ PW Only ☒ PTI

☐ BPA ☒ GE

☐ Only Show Used Models

Save Load

Load Component MOTOR_CMP

Show Block Diagram

	Element Type	Number	Name_Nominal kV	ID	Name	MW	Mvar	Type	Default Data Set	Criteria
1	LoadComponent			Big Motor	Big Motor			MOTOR_CMP	Default	
2	LoadComponent			Pump Fan	Pump Fan			MOTOR_CMP	Default	
3	LoadComponent			Small Motor	Small Motor			MOTOR_CMP	Default	

Assign a load characteristic to it

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New Load Characteristic: CompLoad



- CompLoad is a new type of load model
 - Just like other load characteristics (WSCC, MOTORW, CIM5, etc.)
 - Assign to a Load, LoadModelGroup, Bus, Area, Zone, Owner, or System

Model Explorer: Load Characteristics

Explore Fields

Tools and Add Ons

Transient Stability

DC Models

Summary

Area AGC Models

DS Time Schedules

Generator Exciters

Generator Governors

Generator Machine Models

Generator Other Models

Generator Stabilizer

Line Relay Models

Line Shunts Models

Load Characteristics (8)

Load Component (6)

Load Distributed Generation M

Load Distribution Equivalent Ty

Load Model Group

Load Relays

Open New Explorer

Load Characteristics

Load Component

Buses

Filter Advanced Load Characteristic: CompLoad Find... Remove Quick Filter...

Load Characteristic

CompLoad (2)

CompLoad

Show Block Diagram

	Fully Supported	Element Type	Number	Name_Nominal kV	ID	Name	MW	Mvar	Type	Default Data Set	Criteria	Device S
1	NO	Load	7	Seven_138.0	1	Seven	200	0	CompLoad			Active
2	NO	Area	1	Top		Top	360	130	CompLoad			Active

Show Models Supported By

☒ PW Only ☒ PTI

☐ BPA ☒ GE

☐ Only Show Used Models

Save Load

Search Search Now Options

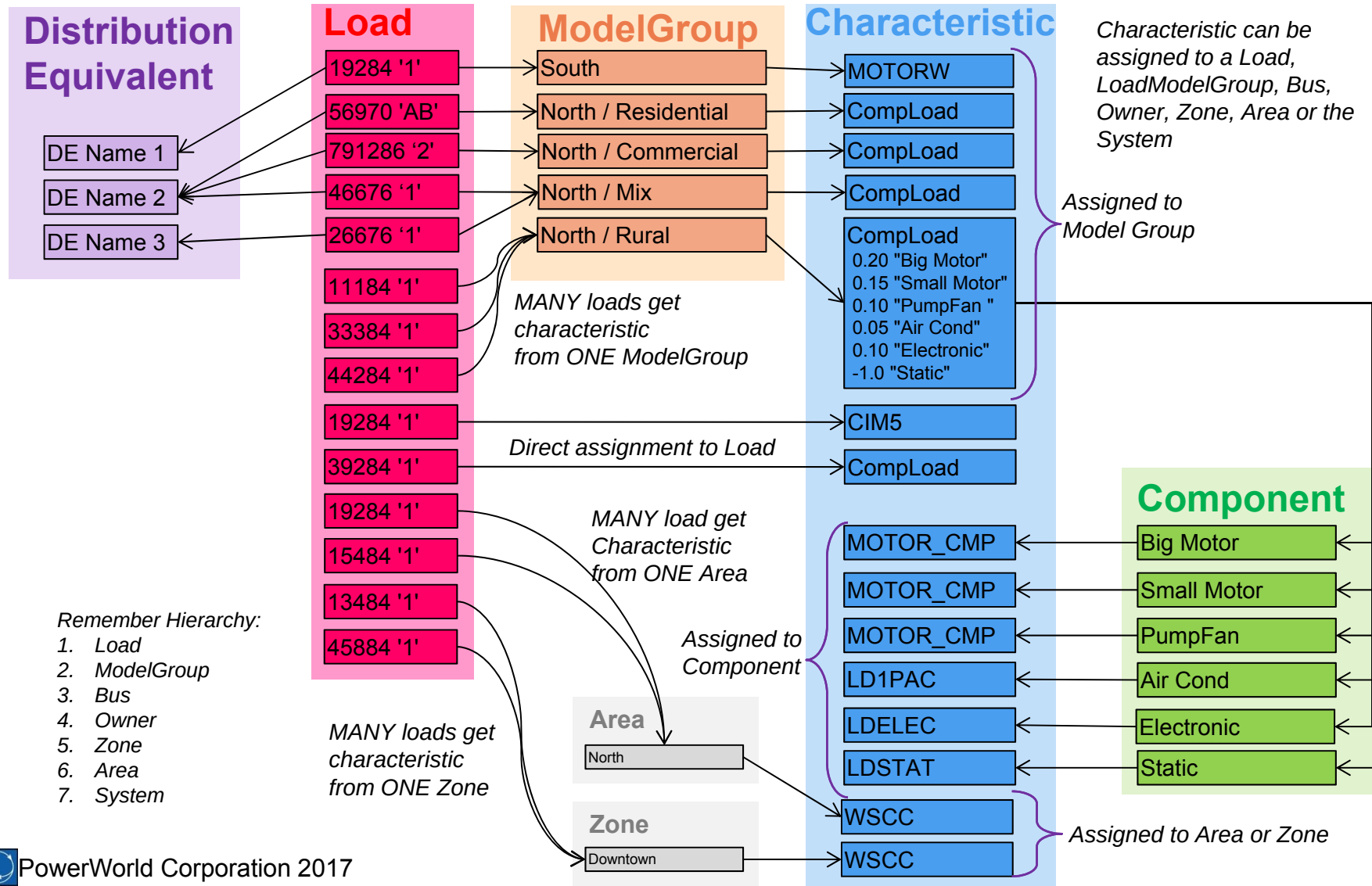
Nomenclature Review



- Dynamic model structure for loads: 4 model types
 - Load **Characteristic**
 - Can be assigned in hierarchy levels (Load Model Group, Bus, Owner, Zone, Area, System)
 - Load **Distribution Equivalent**
 - Load object can be assigned to one
- Load **Model Group**
 - Load object can be assigned to one
- Load **Component**
 - Special named object that contains a Characteristic
 - Then used inside the CompLoad characteristic
- New Load Characteristic: **CompLoad**
 - New type of load characteristic model that gives a combination of other load characteristics

Object References Picture

Shaded Regions represents data tables
Darker boxes inside tables represent one record of that table



Restriction of Load Characteristics that can be assigned to a LoadComponent



- CompLoad only assigns one percentage to each LoadComponent it uses
 - This percentage applies to the total MW
 - What about Mvar?
- Restriction for Load Characteristic: must automatically assign its Mvar based on the MW.
 - Induction Motor models already do this as does LD1PAC
 - Stand-alone model LDELEC has a new parameter (pfel)
 - Stand-alone model IEEL has a new parameter (Pfs)
 - (basically this is an issue for the algebraic load models!)
- Each component of the CompLoad will thus automatically determine its own Mvar value based on its own MW
 - Similar to existing motor models, the CompLoad will then include a capacitance to match the initial conditions for Mvar.

What would happen with existing WECC data?



- New LoadComponent records would be created
 - 46 IEEL models that represent various combinations of ZIP models
 - 6 LD1PAC_CMP models. Only difference is different V_{stall} values
 - 9 MOTOR_CMP models representing different combinations of three-phase motors
 - 3 LDELEC models represents slightly different V_{d1}/V_{d2} values
- The 56 CMPLDWNF records assigned to LoadModelGroups would be replaced by 56 CompLoad records instead

Summary



- Modularize!
 - Following attributes of a load are not always related to one another.
 - Independent dynamic models should be used
 - Characteristic
 - Distributed Generation
 - Distribution Equivalent
 - Relays
- Aggregation Level Models
 - Load Model Group, Bus, Owner, Zone, Area, Case
- Named Load Components
 - CompLoad Characteristic represents a combination of other load model types