WECC Composite Load Flow Model

DIgSILENT PowerFactory 2019

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Dynamic Load Flow Modelling and WECC

Dynamic load models are used to simulate aggregate load responses to disturbances in the grid. The dynamic behaviour of the end-user load has a huge impact on the dynamic behaviour of the interconnected Bulk power system.

Considerable progress has been made in these fields from simple static load modelling to three-phase induction motor plus the ZIP model and then composite load model (CLM).

The WECC CLM guidelines are one of the state-of-art, due to the capability for representing the diversity in the composition and dynamic characteristics of end-use loads and the electrical distance between its end-use and substations.

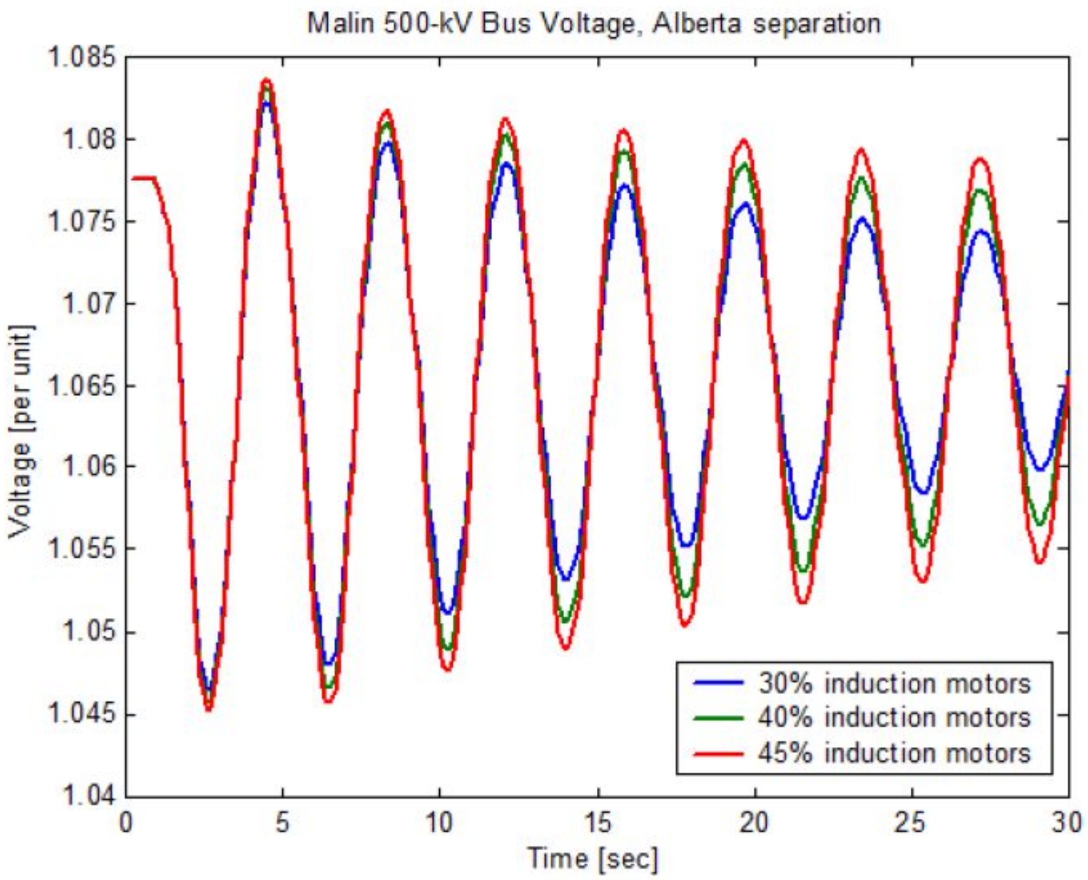


Figure 1.1: System Damping Sensitivity to Motor Load [Source: BPA]

Source NERC

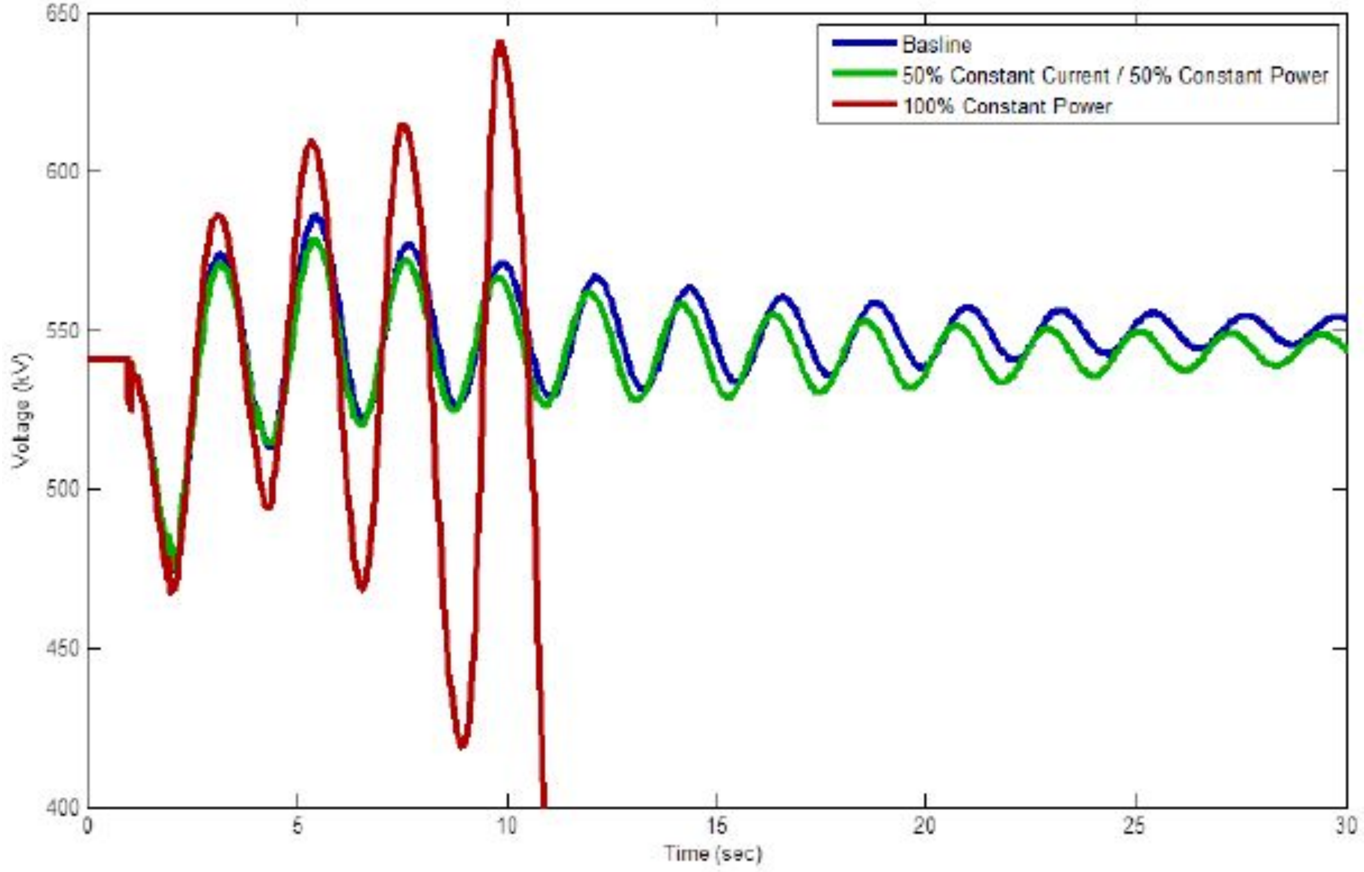


Figure 2.1: Impact of Constant Power Load on Oscillatory Stability [Source: WECC]

Source NERC

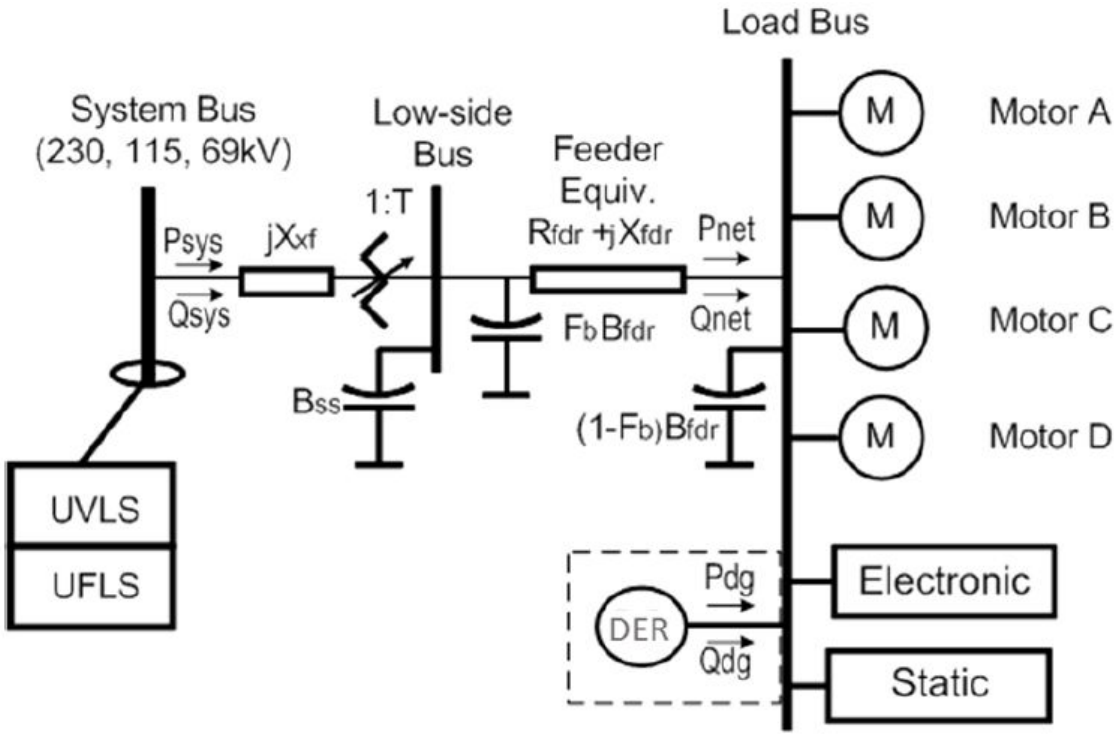
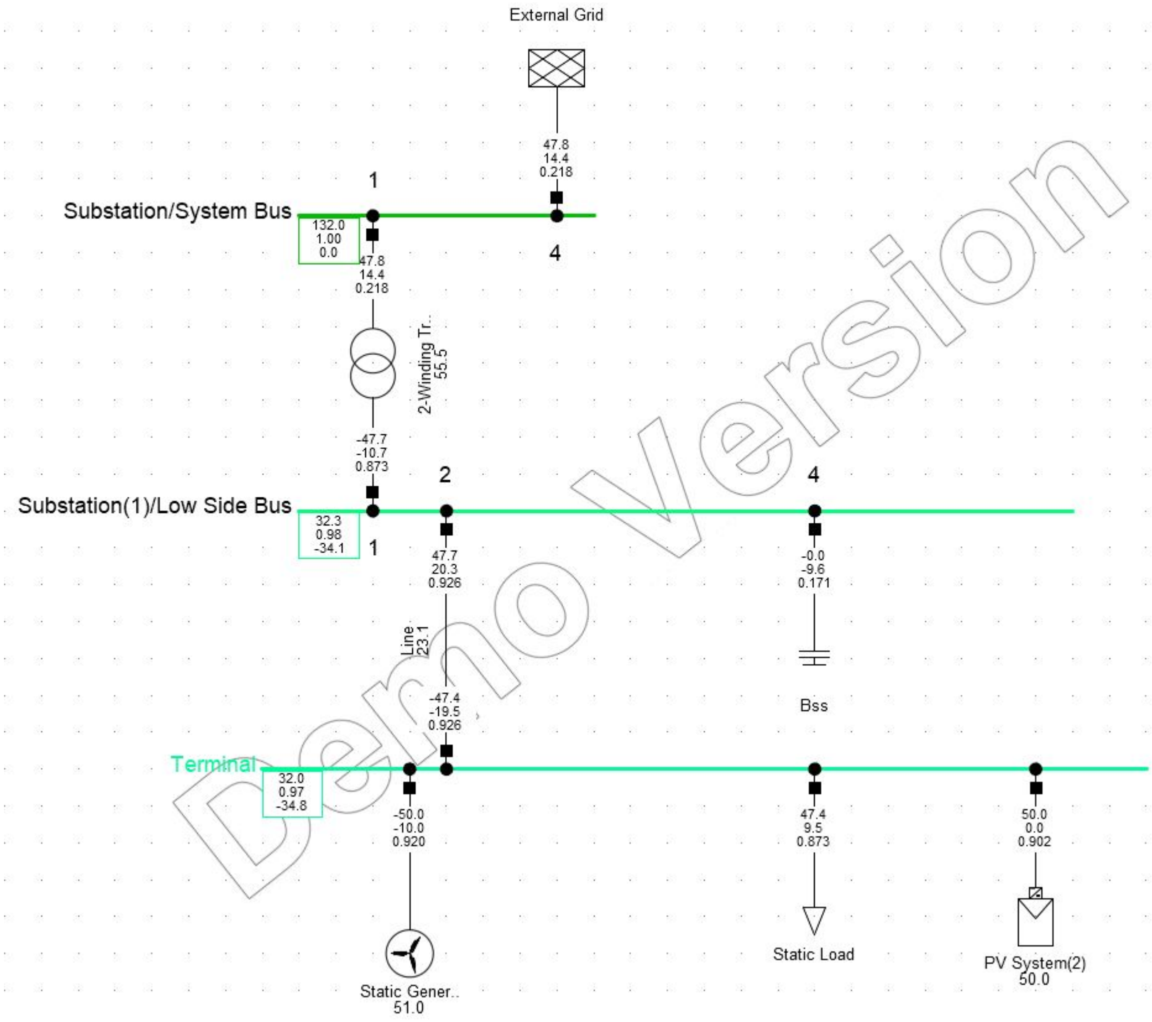


Figure 1.3: Composite Load Model Structure (CMPLDWG)

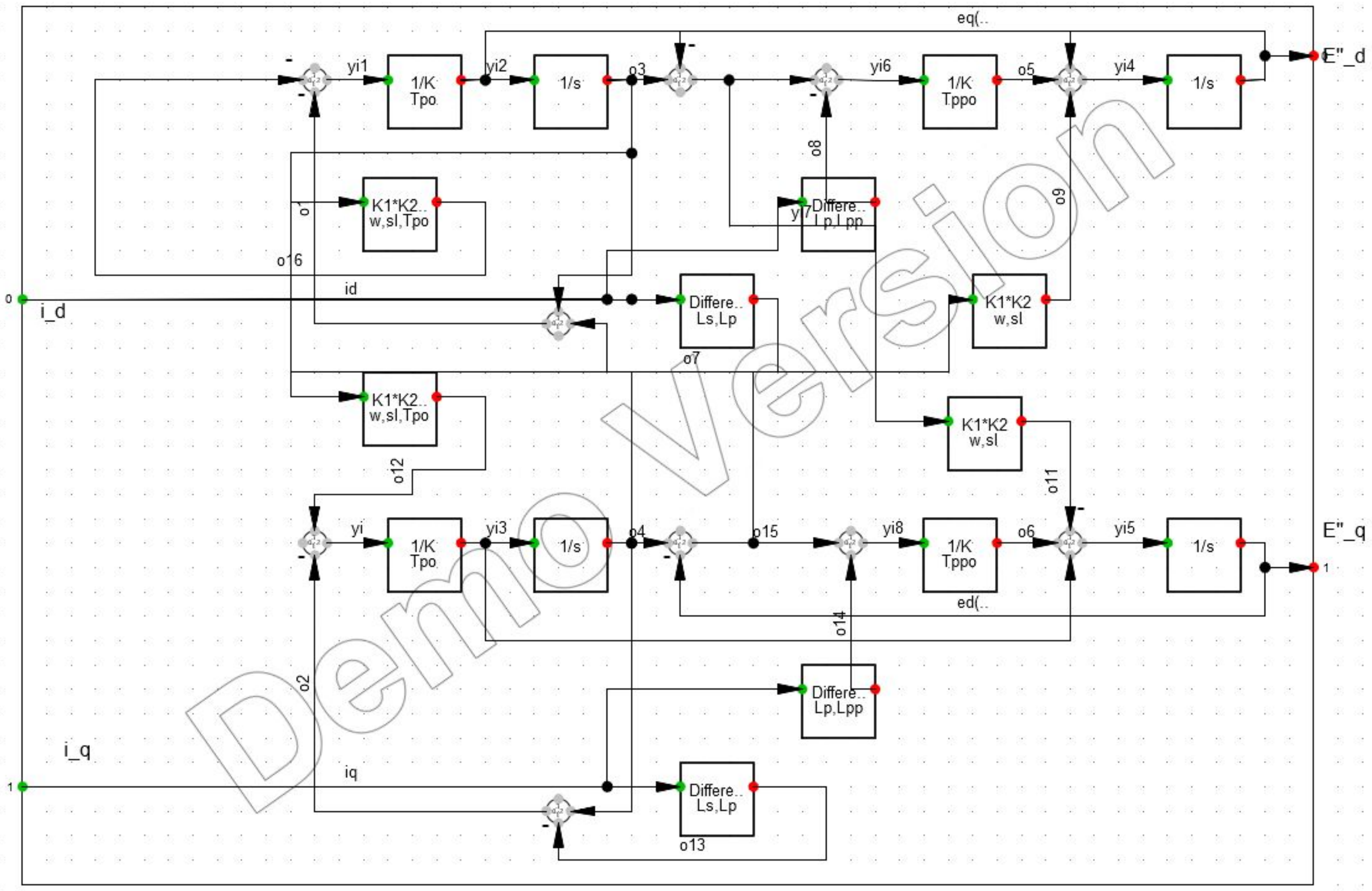
The WECC Composite Load Model

DIgSILENT Model

- Grid with a 132 kV 3-phase busbar system
- Transformer of 132/33 KV, 90 MVA rating. LV side of the transformer is connected to a transmission bus at 33 KV.
- The 33 kV load bus is connected through a transmission line of 1 km length with the resistance of 0.1 ohm and inductance of 1mH. (shunt capacitance is neglected)
- Variable capacitor bank for reactive power compensation.
- The PV system injects 50 MW into the system.
- The WECC modelled motor consumes 50 MW and 10 Mvar of active and reactive power respectively.
- Static load has been modelled as a ZIP-model with 70% constant impedance and 30% constant current load. The nominal power consumption of the load (rated at 33 kV) is 50 MW (active) and 10 Mvar (reactive).



Motor:



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i_q
iq
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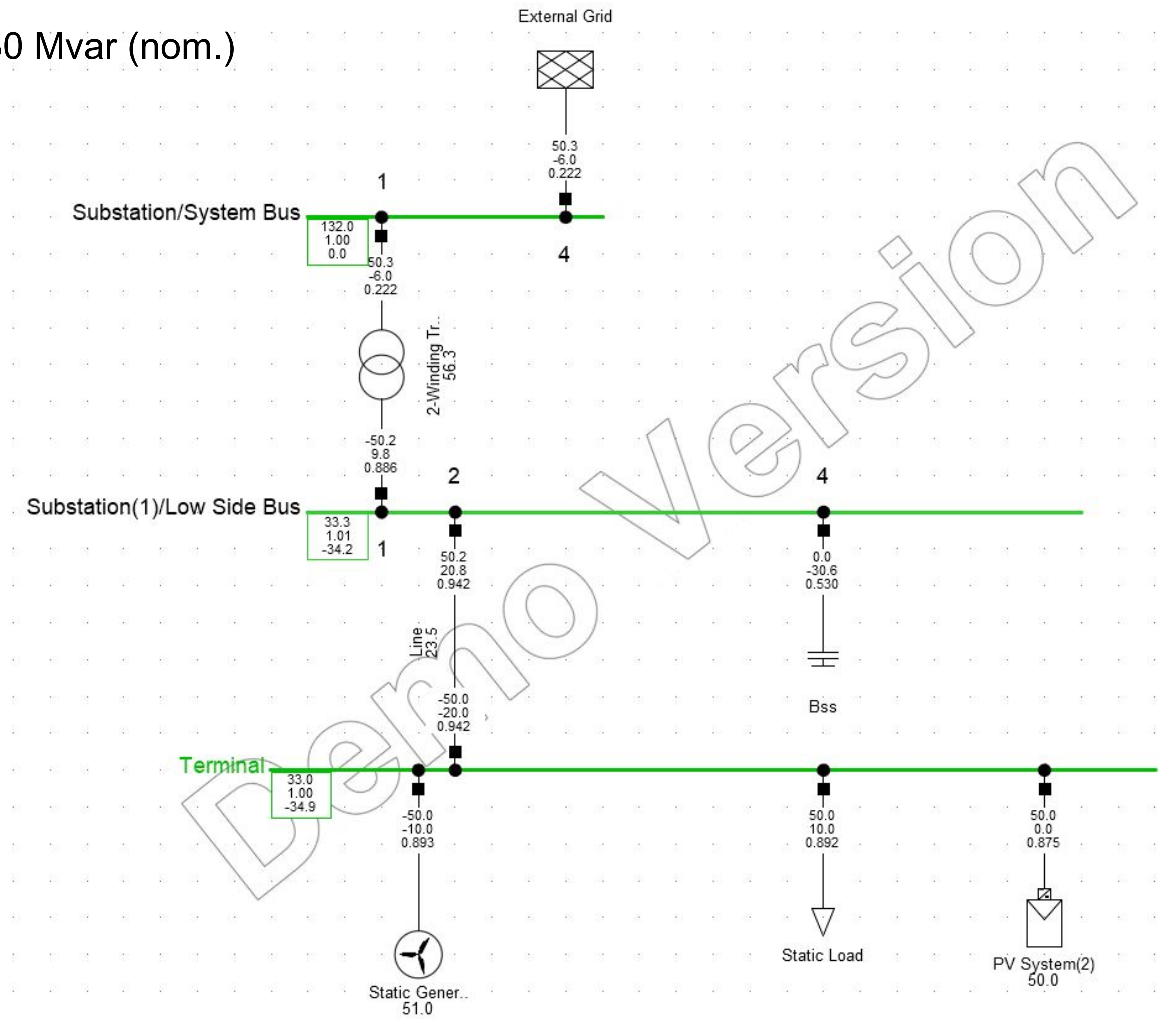
Demo Version

Capacitor Bank : 30 Mvar (nom.)



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| Load Flow Calculation                                                                             Busbars/Terminals |
------------------------------------------------------------------------------------------------------------------------
|    AC Load Flow, balanced, positive sequence                |    Automatic Model Adaptation for Convergence      No    |
|    Automatic tap adjustment of transformers        No       |    Max. Acceptable Load Flow Error for                  |
|    Consider reactive power limits                  No       |      Nodes                                     1.00 kVA |
|                                                             |      Model Equations                           0.10 %   |
------------------------------------------------------------------------------------------------------------------------
------------------------------------------------------------------------------------------------------------------------
| Grid: Grid                 System Stage: Grid            | Study Case: Study Case             | Annex:           / 1  |
------------------------------------------------------------------------------------------------------------------------
|          rated                             Active Reactive Power                 |                                   |
|         Voltage     Bus-voltage             Power    Power   Factor Current Loading|           Additional Data        |
|          [kV]  [p.u.]    [kV]    [deg]     [MW]    [Mvar]    [-]     [kA]    [%]  |                                   |
------------------------------------------------------------------------------------------------------------------------
|Substation(1)                                                                     |                                   |
|  Low Side B.00    1.01   33.33  -34.19                                           |                                   |
|   Cub_1  /Shnt     Bss                      0.00   -30.60   0.00    0.53          |                                   |
|   Cub_1  /Lne      Line                    50.22    20.83   0.92    0.94   23.55 |Pv:    266.13 kW   cLod:  0.00 Mvar L:   1.00 km|
|   Cub_1  /Tr2      2-Winding Transfor     -50.22     9.77  -0.98    0.89   56.33 |Tap:     0.00      Min:     -9     Max:     6  |
|                                                                                  |                                   |
|Substation                                                                        |                                   |
|  System Bus.00    1.00  132.00    0.00                                           |                                   |
|   Cub_1  /Xnet     External Grid           50.34    -5.97   0.99    0.22          |Sk": 10000.00 MVA                  |
|   Cub_1  /Tr2      2-Winding Transfor      50.34    -5.97   0.99    0.22   56.33 |Tap:     0.00      Min:     -9     Max:     6  |
|                                                                                  |                                   |
|Terminal                                                                          |                                   |
|          33.00     1.00   32.98  -34.91                                           |                                   |
|   Cub_10(/Pvsys    PV System(2)            50.00     0.00   1.00    0.88   50.00 |                                   |
|   Cub_6  /Lod      Static Load             49.95     9.99   0.98    0.89          |P10:    50.00 MW   Q10:  10.00 Mvar          |
|   Cub_8  /Genstat  Static Generator       -50.00   -10.00  -0.98    0.89   50.99 |                                   |
|   Cub_9  /Lne      Line                   -49.95   -19.99  -0.93    0.94   23.55 |Pv:    266.13 kW   cLod:  0.00 Mvar L:   1.00 km|
|                                                                                  |                                   |
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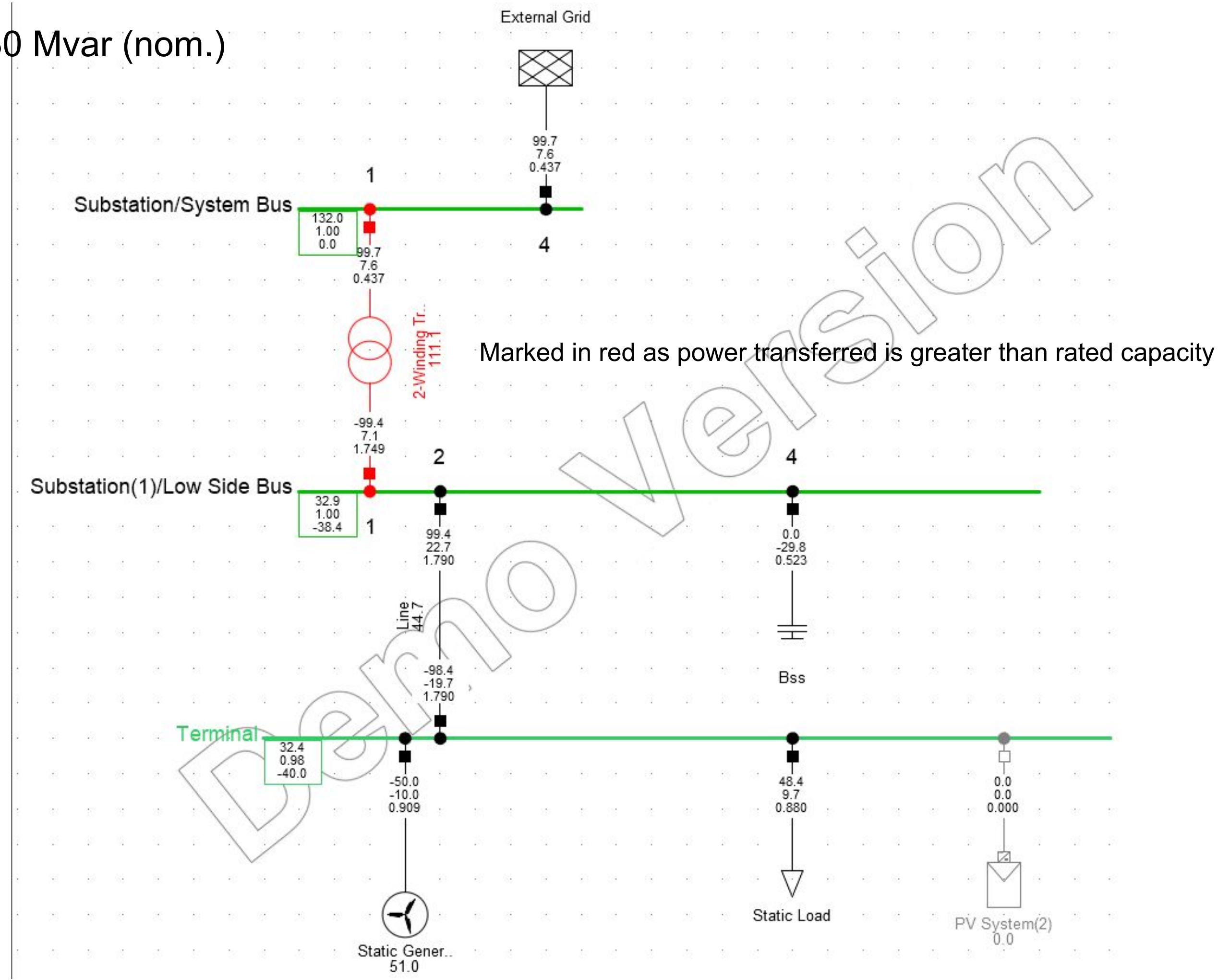
Capacitor Bank : 30 Mvar (nom.)
No PV generation



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|     Consider reactive power limits                   No       |      Nodes                                 1.00 kVA   |
|                                                               |      Model Equations                       0.10 %     |
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| Grid: Grid                System Stage: Grid          | Study Case: Study Case                | Annex:          / 1  |
--------------------------------------------------------------------------------------------------------------------
|          rated                             Active Reactive Power                  |                                    |
|         Voltage     Bus-voltage            Power    Power   Factor Current Loading|          Additional Data           |
|           [kV]   [p.u.]    [kV]    [deg]    [MW]    [Mvar]    [-]    [kA]    [%]  |                                    |
--------------------------------------------------------------------------------------------------------------------
|Substation(1)                                                                      |                                    |
|  Low Side B.00     1.00   32.89  -38.41                                           |                                    |
|   Cub_1  /Shnt      Bss                   0.00   -29.79   0.00    0.52           |                                    |
|   Cub_1  /Lne       Line                 99.37    22.70   0.97    1.79    44.74  |Pv:     960.76 kW   cLod:  0.00 Mvar L:     1.00 km|
|   Cub_1  /Tr2       2-Winding Transfor  -99.37     7.09  -1.00    1.75   111.13  |Tap:      0.00      Min:     -9      Max:      6  |
|                                                                                   |                                    |
|Substation                                                                         |                                    |
|  System Bus.00     1.00  132.00    0.00                                           |                                    |
|   Cub_1  /Xnet      External Grid        99.72     7.59   1.00    0.44           |Sk": 10000.00 MVA                   |
|   Cub_1  /Tr2       2-Winding Transfor   99.72     7.59   1.00    0.44   111.13  |Tap:      0.00      Min:     -9      Max:      6  |
|                                                                                   |                                    |
|Terminal                                                                           |                                    |
|          33.00     0.98   32.38  -39.97                                           |                                    |
|   Cub_10(/Pvsys     PV System(2)           0.00     0.00   1.00    0.00     0.00  |                                    |
|   Cub_6  /Lod       Static Load          48.41     9.68   0.98    0.88           |P10:     50.00 MW   Q10:  10.00 Mvar                |
|   Cub_8  /Genstat   Static Generator    -50.00   -10.00  -0.98    0.91    50.99  |                                    |
|   Cub_9  /Lne       Line                -98.41   -19.68  -0.98    1.79    44.74  |Pv:     960.76 kW   cLod:  0.00 Mvar L:     1.00 km|
|                                                                                   |                                    |
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References

1. Wecc.biz
2. Huang, Qiuhua, et al. "A Reference Implementation of WECC Composite Load Model in Matlab and GridPACK." arXiv preprint arXiv:1708.00939 (2017).
3. WECC Composite Load Model (CMPLDW) Benchmarking Summary
4. WECC Dynamic Composite Load Model (CMPLDW) Specifications
5. Reliability Guideline: Developing Load Model Composition Data

Thank you