European Network of
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entsoe

Micro Grid Test Configuration

Version 2

CGMES 2.4.15

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Contents

1. Introduction

The document is providing an overview of the Micro Grid Test Configuration applicable for the ENTSO-E Common Grid Model Exchange Standard (CGMES) Conformity Assessment Framework hereafter referred as “the Framework”.

Versioning of the document is following the rules specified in the Chapter 5.1 of the CGMES.

Disclaimer

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2. Usage and content of the test configuration

Micro grid type of cases represent the smallest possible data set for focusing on the syntax, connectivity, file management (MAS, zip). It also allows testing different concepts of CGMES with a model which is small enough to debug.
The Micro Grid Base Case (MGBC) is created on the basis of the current ENTSO-E 16 nodes model used in the ENTSO-E IOP July 2013. This model is contains three Model Authority Sets (MAS) – 2 MAS representing TSO type of model and 1 Boundary MAS. The Boundary MAS contains equipment (EQ) and topology (TP) instance files. Each TSO kind of MAS contains EQ, TP, SSH, SV (state variables), DL (diagram layout), GL (geographical location) and DY (dynamics) instance files.

The EQ, TP and SSH files can be used without SV. In this case if calculation is performed on EQ+TP+SSH the same results as in SV should be achieved. In case of the node breaker variant it is also no necessary to use TP files. For each configuration, a final (complete) model is provided, but also Difference files to move from one model to another are included.

Since only one boundary file is used for all Micro Grid Configurations, it is plausible to combine different types of models. Consequently, since in same cases not all of the nodes from Boundary are used it is plausible to receive some warnings concerning the boundary nodes during the import.

The folder structure for Micro Grid test configuration is the following:

- Documentation folder which contains:
  - The doc file which explains MicroGrid test configuration including base case and all the types
  - Xls file which contain all the information (results) the base case and for the four types.
- BaseCase_BC which contains:
  - CGMES_v2.4.15_MicroGridTestConfiguration_BC_BE_v2.zip (Base Case Belgium)
  - CGMES_v2.4.15_MicroGridTestConfiguration_BC_NL_v2.zip (Base Case Ned.)
  - CGMES_v2.4.15_MicroGridTestConfiguration_BD_v2.zip (BC Boundary)
  - CGMES_v2.4.15_MicroGridTestConfiguration_BC_Assembled_v2.zip (BL+NL+BD)
  - CGMES_v2.4.15_MicroGridTestConfiguration_BC_Assembled_CA_v2.zip (BL+NL+BD with Area Control)
- Type1_T1 which contains
  - CGMES_v2.4.15_MicroGridTestConfiguration_T1_BE_Complete_v2.zip

- CGMES_v2.4.15_MicroGridTestConfiguration_T1_NL_Complete_v2.zip
- CGMES_v2.4.15_MicroGridTestConfiguration_T1_Assembled_Complete_v2.zip
- CGMES_v2.4.15_MicroGridTestConfiguration_BD_v2.zip
- T1_BE_Difference_v2 which contains
  - MicroGridTestConfiguration_T1_BE_EQ_Diff1_v2.xml
  - MicroGridTestConfiguration_T1_BE_EQ_Diff2_v2.xml
  - MicroGridTestConfiguration_T1_BE_EQ_Diff3_v2.xml
  - MicroGridTestConfiguration_T1_BE_EQ_Diff4_v2.xml
  - MicroGridTestConfiguration_T1_BE_EQ_Diff5_v2.xml
  - MicroGridTestConfiguration_T1_BE_TP_Diff1_v2.xml
  - MicroGridTestConfiguration_T1_BE_TP_Diff4_v2.xml
  - MicroGridTestConfiguration_T1_BE_SSH_V2_FOR_DIFF1.xml
  - MicroGridTestConfiguration_T1_BE_SSH_V2_FOR_DIFF4.xml
- T1_NL_Difference_v2 which contains
  - MicroGridTestConfiguration_T1_NL_EQ_Diff1_v2.xml
  - MicroGridTestConfiguration_T1_NL_EQ_Diff2_v2.xml
  - MicroGridTestConfiguration_T1_NL_EQ_Diff3_v2.xml
  - MicroGridTestConfiguration_T1_NL_EQ_Diff4_v2.xml
  - MicroGridTestConfiguration_T1_NL_TP_Diff1_v2.xml
  - MicroGridTestConfiguration_T1_NL_SSH_V2_FOR_DIFF1.xml

- Type2_T2 which contains
  - CGMES_v2.4.15_MicroGridTestConfiguration_T2_BE_Complete_v2.zip
  - CGMES_v2.4.15_MicroGridTestConfiguration_T2_NL_Complete_v2.zip
  - CGMES_v2.4.15_MicroGridTestConfiguration_T2_Assembled_Complete_v2.zip
  - CGMES_v2.4.15_MicroGridTestConfiguration_BD_v2.zip
  - T2_BE_Difference_v2 which contains
    - MicroGridTestConfiguration_BC_BE_EQ_DIFF_V2.xml
    - MicroGridTestConfiguration_BC_BE_TP_DIFF_V2.xml
    - MicroGridTestConfiguration_T2_BE_DL_V2.xml
    - MicroGridTestConfiguration_T2_BE_SSH_V2.xml
  - T2_NL_Difference_v2 which contains
    - MicroGridTestConfiguration_BC_NL_EQ_DIFF_V2.xml
    - MicroGridTestConfiguration_BC_NL_TP_DIFF_V2.xml
    - MicroGridTestConfiguration_T2_HVDC_DL_V2.xml
    - MicroGridTestConfiguration_T2_HVDC_DY_V2.xml
    - MicroGridTestConfiguration_T2_HVDC_EQ_V2.xml
    - MicroGridTestConfiguration_T2_HVDC_GL_V2.xml
    - MicroGridTestConfiguration_T2_HVDC_SSH_V2.xml
    - MicroGridTestConfiguration_T2_HVDC_SV_V2.xml
    - MicroGridTestConfiguration_T2_HVDC_TP_V2.xml
    - MicroGridTestConfiguration_T2_NL_DL_V2.xml
    - MicroGridTestConfiguration_T2_NL_SSH_V2.xml
- Type3_T3 which contains
  - CGMES_v2.4.15_MicroGridTestConfiguration_T3_BE_Complete_v2.zip

- CGMES_v2.4.15_MicroGridTestConfiguration_T3_NL_Complete_v2.zip
- CGMES_v2.4.15_MicroGridTestConfiguration_T3_Assembled_Complete_v2.zip
- CGMES_v2.4.15_MicroGridTestConfiguration_BD_v2.zip
- T3_BE_Difference_v2 which contains
  - MicroGridTestConfiguration_T3_BE_DL_V2.xml
  - MicroGridTestConfiguration_T3_BE_EQ_DIFF_V2.xml
  - MicroGridTestConfiguration_T3_BE_SSH_V2.xml
  - MicroGridTestConfiguration_T3_BE_TP_DIFF_V2.xml
- T3_NL_Difference_v2 which contains
  - MicroGridTestConfiguration_T3_NL_DL_V2.xml
  - MicroGridTestConfiguration_T3_NL_EQ_DIFF_V2.xml
  - MicroGridTestConfiguration_T3_NL_SSH_V2.xml
  - MicroGridTestConfiguration_T3_NL_TP_DIFF_V2.xml

- Type4_T4 which contains
  - CGMES_v2.4.15_MicroGridTestConfiguration_BD_v2.zip
  - CGMES_v2.4.15_MicroGridTestConfiguration_T4_Assembled_BB_Complete_v2.zip
  - CGMES_v2.4.15_MicroGridTestConfiguration_T4_Assembled_NB_Complete_v2.zip
  - CGMES_v2.4.15_MicroGridTestConfiguration_T4_BE_BB_Complete_v2.zip
  - CGMES_v2.4.15_MicroGridTestConfiguration_T4_BE_NB_Complete_v2.zip
  - CGMES_v2.4.15_MicroGridTestConfiguration_T4_NL_BB_Complete_v2.zip
  - CGMES_v2.4.15_MicroGridTestConfiguration_T4_NL_NB_Complete_v2.zip
  - T4_BE_BB_Difference_v2 which contains
    - MicroGridTestConfiguration_T4_BE_DL_V2.xml
    - MicroGridTestConfiguration_T4_BE_EQ_DIFF_V2.xml
    - MicroGridTestConfiguration_T4_BE_SSH_V2.xml
    - MicroGridTestConfiguration_T4_BE_TP_DIFF_V2.xml
  - T4_NL_BB_Difference_v2 which contains
    - MicroGridTestConfiguration_T4_NL_DL_V2.xml
    - MicroGridTestConfiguration_T4_NL_EQ_DIFF_V2.xml
    - MicroGridTestConfiguration_T4_NL_SSH_V2.xml
    - MicroGridTestConfiguration_T4_NL_TP_DIFF_V2.xml
  - T4_BE_NB_Difference_v2 which contains
    - MicroGridTestConfiguration_T4_BE_DL_V2.xml
    - MicroGridTestConfiguration_T4_BE_EQ_DIFF_V2.xml
    - MicroGridTestConfiguration_T4_BE_SSH_V2.xml
    - MicroGridTestConfiguration_T4_BE_TP_DIFF_V2.xml
  - T4_NL_NB_Difference_v2 which contains
    - MicroGridTestConfiguration_T4_NL_DL_V2.xml
    - MicroGridTestConfiguration_T4_NL_EQ_DIFF_V2.xml
    - MicroGridTestConfiguration_T4_NL_SSH_V2.xml
    - MicroGridTestConfiguration_T4_NL_TP_DIFF_V2.xml

For all Micro Grid configurations, the same Boundary file is used.

Example of applying difference files for switching from one model to another is illustrated in Figure 1. Similar reasoning is valid for all other models.

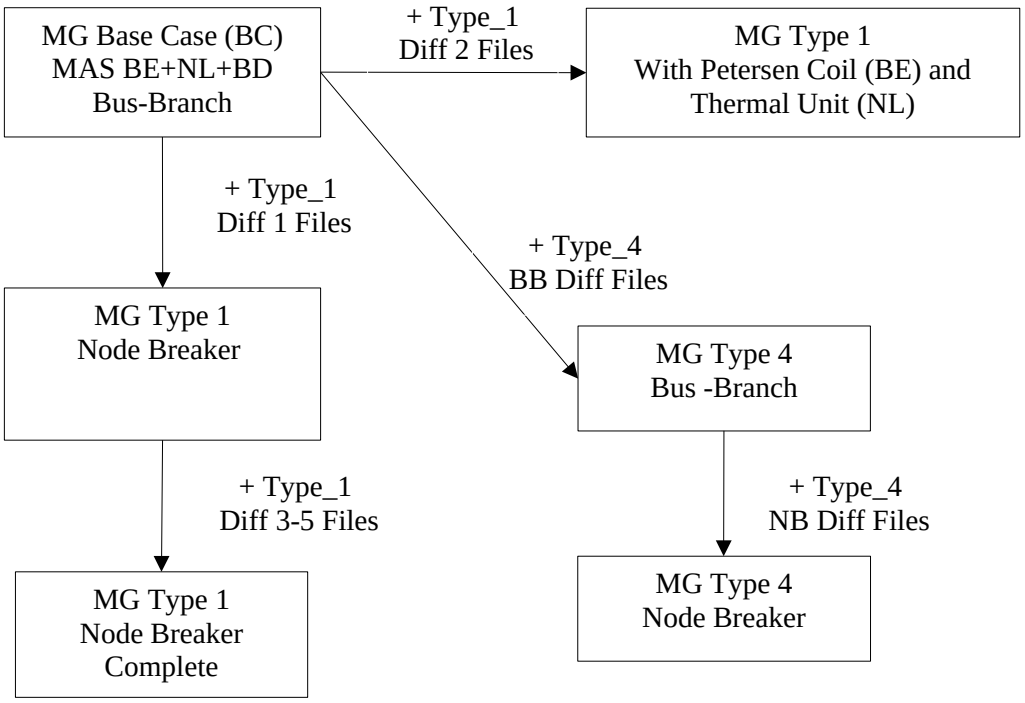

Figure 1Bus Branch to Node Breaker

3. Micro Grid Base Case

3.1. General information

The Base Case model consists of 3 MAS regions, BE, NL and BD (boundary). The separate models are available for each of the MAS-s and also an assembled model is included. This model is Bus-Branch model. All generators are intentionally represented by GeneratingUnits.

In order to test Area Control capability, a separate BC configuration is included in CGMES_v2.4.15_MicroGridTestConfiguration_BC_Assembled_CA_v2.zip. This way, vendors can test their Area Control function, while this will not influence the rest of the configurations (Area Control can be problematic in cases with HVDCs and Phase Shifting transformers in such a small network as Micro Grid).

3.2. Network topology and data

The number and types of the elements in the Micro Grid Base Case model is indicated in Table 1.

Table 1

Class	# of Objects
ACLineSegment	12
BaseVoltage	8

Class	# of Objects
Breaker	1
BusbarSection	13
ConnectivityNode	6
CoordinateSystem	2
CurrentLimit	168
CurveData	3
Diagram	3
DiagramObject	207
DiagramObjectPoint	346
EnergyConsumer	6
EquivalentInjection	10
ExcIEEEAC1A	1
ExcIEEEAC4A	2
ExcIEEEST1A	2
GeneratingUnit	5
GeographicalRegion	3
GovHydro1	2
GovHydro2	1
GovSteam0	1
GovSteam1	1
Junction	1
Line	18
LinearShuntCompensator	3
LoadAggregate	6
LoadResponseCharacteristic	2
LoadStatic	6
Location	15
OperationalLimitSet	39
OperationalLimitType	14
PhaseTapChangerAsymmetrical	1
PositionPoint	49
PowerTransformer	7
PowerTransformerEnd	15
Pss2B	5
RatioTapChanger	6
ReactiveCapabilityCurve	1
RegulatingControl	8
SubGeographicalRegion	4
Substation	3
SvPowerFlow	24
SvShuntCompensatorSections	3
SvTapStep	7
SvVoltage	16
SynchronousMachine	5
SynchronousMachineTimeConstantReactance	5
TapChangerControl	7
Terminal	79
TopologicalIsland	1
TopologicalNode	17
VComplEEEType1	5
VoltageLevel	10
EnergySchedulingType	6

The number and types of the elements in the Micro Grid Base Case: MAS BE model is indicated in Table 2.

Table 2

Class	# of Objects
ACLineSegment	7
BaseVoltage	7
BusbarSection	9
ConnectivityNode	6
CoordinateSystem	1
CurrentLimit	100
CurveData	3
Diagram	2
DiagramObject	108
DiagramObjectPoint	183
EnergyConsumer	3
EquivalentInjection	5
ExcIEEEAC4A	2
GeneratingUnit	2
GeographicalRegion	2
GovSteam0	1
GovSteam1	1
Junction	1
Line	13
LinearShuntCompensator	2
LoadAggregate	3
LoadResponseCharacteristic	1
LoadStatic	3
Location	9
OperationalLimitSet	23
OperationalLimitType	8
PhaseTapChangerAsymmetrical	1
PositionPoint	29
PowerTransformer	4
PowerTransformerEnd	9
Pss2B	2
RatioTapChanger	3
ReactiveCapabilityCurve	1
RegulatingControl	4
SubGeographicalRegion	3
Substation	2
SvPowerFlow	12
SvShuntCompensatorSections	2
SvTapStep	4
SvVoltage	11
SynchronousMachine	2
SynchronousMachineTimeConstantReactance	2
TapChangerControl	4
Terminal	45
TopologicalNode	12
VCompIEEEType1	2
VoltageLevel	6
EnergySchedulingType	6

The number and types of the elements in the Micro Grid Base Case: MAS NL model is indicated in Table 3.

Table 3

Class	# of Objects
ACLineSegment	5
BaseVoltage	5
Breaker	1
BusbarSection	4
ConnectivityNode	6
CoordinateSystem	1
CurrentLimit	68
Diagram	2
DiagramObject	104
DiagramObjectPoint	173
EnergyConsumer	3
EquivalentInjection	5
ExcIEEEAC1A	1
ExcIEEEST1A	2
GeneratingUnit	3
GeographicalRegion	2
GovHydro1	2
GovHydro2	1
Junction	1
Line	11
LinearShuntCompensator	1
LoadAggregate	3
LoadResponseCharacteristic	1
LoadStatic	3
Location	6
OperationalLimitSet	16
OperationalLimitType	6
PositionPoint	20
PowerTransformer	3
PowerTransformerEnd	6
Pss2B	3
RatioTapChanger	3
RegulatingControl	4
SubGeographicalRegion	2
Substation	1
SvPowerFlow	12
SvShuntCompensatorSections	1
SvTapStep	3
SvVoltage	10
SynchronousMachine	3
SynchronousMachineTimeConstantReactance	3
TapChangerControl	3
Terminal	35
TopologicalIsland	1
TopologicalNode	11
VCompIEEEType1	3
VoltageLevel	4
EnergySchedulingType	6

3.3. Load flow and short-circuit calculation information

The single line diagrams for the Micro Grid Base Case is illustrated in Figure 2. The load flow results are included in a file MicroGrid.xls. (Tabs BC_NO_AREA_CONTROL and BC_AREA_CONTROL_ON).

For the purpose of calculation, the Extended Full Newton Raphson method has been used. The maximum number of iterations has been set to 50 while required accuracy is 0.0001. Reactive power limits have not been considered. All shunt control has been disabled. For the slack, NL-G1 generator has been used with voltage angle of 0 degrees and voltage of 16.5kV.

Additionally, phase to ground short circuit has been simulated on Busbar_NL_4, obtained results are illustrated in Figure 4.

3.4. CIMdesk validation report for BE MAS

CIMdesk validation report (validation against Base profiles) on the assembled mode BE MAS and boundary MAS is the following:

Type	Class	Recurrence	Description
Warning	SubGeographicalRegion	1/3	No Substations are associated with SubGeographicalRegion via Association Substation.Region, expecting at least 1.
Warning	TopologicalNode	1/12	No Terminals are associated with TopologicalNode via Association Terminal.TopologicalNode, expecting at least 2.
Warning	ACLineSegment	5/7	The BaseVoltages of the two connected nodes are not the same.
Warning	TopologicalNode	1/12	The TopologicalNode is an island without Terminals connected or with all of the associated Terminals disconnected.
Warning	PowerTransformerEnd	2/9	The rated voltage doesn't match the nominal voltage of the connected node.

The above errors and warnings should be ignored as:

- SubGeographicalRegion warning is related to the CGMES requirement that there are no substations defined in the boundary.
- ACLineSegment is allowed to connect nodes with different BaseVoltages
- PowerTransformerEnd is data issue which is highlighted by CIMdesk to make users check for potential error. In this case that data is fine.

3.5. CIMdesk validation report for NL MAS

CIMdesk validation report (validation against Base profiles) on the assembled mode NL MAS and boundary MAS is the following:

Type	Class	Recurrence	Description
Warning	BaseVoltage	2/5	The BaseVoltage doesn't contain any child instances (or is not referenced by other instances).
Warning	SubGeographicalRegion	1/2	No Substations are associated with SubGeographicalRegion via Association Substation.Region, expecting at least 1.
Warning	TopologicalNode	1/11	No Terminals are associated with TopologicalNode via Association Terminal.TopologicalNode, expecting at least 2.
Warning	ACLineSegment	1/5	Attribute ACLineSegment.r0 is less than Attribute ACLineSegment.r.
Warning	TopologicalNode	1/11	The TopologicalNode is an island without Terminals connected or with all of the associated Terminals

Type	Class	Recurrence	Description
			disconnected.

The above errors and warnings should be ignored as:

- SubGeographicalRegion warning is related to the CGMES requirement that there are no substations defined in the boundary.
- BaseVoltage - it is data issue as there is unused element in the instance file, which is allowed
- ACLineSegment is data issue which is highlighted by CIMdesk to make users check for potential error. In this case that data is fine.

3.6. CIMdesk validation report for BD MAS

CIMdesk validation report (validation against Base profiles) on the boundary EQ and TP instance file does not return errors or warnings.

3.7. CIMdesk validation report for Assembled model

CIMdesk validation report (validation against Base profiles) on the assembled mode NL MAS, BE MAS and boundary MAS is the following:

Type	Class	Recurrence	Description
Warning	SubGeographicalRegion	1/4	No Substations are associated with SubGeographicalRegion via Association Substation.Region, expecting at least 1.
Warning	TopologicalNode	1/17	No Terminals are associated with TopologicalNode via Association Terminal.TopologicalNode, expecting at least 2.
Warning	ACLineSegment	1/12	Attribute ACLineSegment.r0 is less than Attribute ACLineSegment.r.
Warning	ACLineSegment	5/12	The BaseVoltages of the two connected nodes are not the same.
Warning	TopologicalNode	1/17	The TopologicalNode is an island without Terminals connected or with all of the associated Terminals disconnected.
Warning	PowerTransformerEnd	2/15	The rated voltage doesn't match the nominal voltage of the connected node.

The above errors and warnings should be ignored as:

- SubGeographicalRegion warning is related to the CGMES requirement that there are no substations defined in the boundary.
- ACLineSegment is allowed to connect nodes with different BaseVoltages
- PowerTransformerEnd, ACLineSegmant are data issue which is highlighted by CIMdesk to make users check for potential error. In this case that data is fine.

4. Micro Grid Type 1

4.1. General information

The Type 1 model is used for testing interoperability to ensure that tools can handle:

- node-breaker configuration;
- asymmetrical data - positive, negative, zero sequence impedances;
- difference files.

This model is built on top of the MGBC. The following modifications are available:

- Difference files of EQ, TP, GL, DY, files (bus-branch configuration). Node-breaker configuration of the model is available in two variants – separate full EQ, TP, SSH, SV, DI, DY and difference files of EQ, TP, GL and DY to transform bus-branch to node-breaker model.
- Difference files for addition PetersenCoil and other grounding classes/attributes on top of bus-branch variant and node-breaker variant
- Difference files that include additional details on limits for both bus-branch and node-breaker variants
- Difference files to place a boundary point in a substation, i.e. in cases where the boundary point is a ConnectivityNode
- Difference files to change types of generation i.e. a GeneratingUnit becomes ThermalGeneratingUnit.
- Difference files to introduce or replace GeneratingUnit by EnergySource.
- Difference files to introduce changes or replace ReactiveCapabilityCurve.
- Difference files to introduce conform and non-conform loads.

4.2. Network topology and data

Micro Grid Type 1 uses the same starting topology as Base Case, by applying difference models, above mentioned changes can be performed on the model.

The number and types of the elements in the assembled model is indicated in Table 4.

Table 4

Class	# of Objects
ACLineSegment	12
BaseVoltage	8
Breaker	26
BusbarSection	13
ConnectivityNode	41
CoordinateSystem	2
CurrentLimit	170
CurveData	3
Diagram	3
DiagramObject	401
DiagramObjectPoint	692
EnergyConsumer	6
EnergySource	1
EquivalentInjection	10
ExcIEEEAC1A	1
ExcIEEEAC4A	1
ExcIEEEST1A	2
FossilFuel	1
GeneratingUnit	3
GeographicalRegion	3
GovHydro1	2
GovHydro2	1
GovSteam1	1
Junction	1
Line	18
LinearShuntCompensator	3
LoadAggregate	6
LoadResponseCharacteristic	2
LoadStatic	6
Location	15

Class	# of Objects
OperationalLimitSet	39
OperationalLimitType	15
PetersenCoil	1
PhaseTapChangerAsymmetrical	1
PositionPoint	49
PowerTransformer	7
PowerTransformerEnd	15
Pss2B	4
RatioTapChanger	6
ReactiveCapabilityCurve	1
RegulatingControl	7
SubGeographicalRegion	4
Substation	3
SvPowerFlow	24
SvShuntCompensatorSections	3
SvTapStep	7
SvVoltage	16
SynchronousMachine	4
SynchronousMachineTimeConstantReactance	4
TapChangerControl	7
Terminal	130
ThermalGeneratingUnit	1
TopologicalIsland	1
TopologicalNode	17
VCompIEEEType1	4
VoltageLevel	10
EnergySchedulingType	6

NOTE: EnergySource model used in load flow slightly differs from the official CGMES. The EnergySource is modelled using the VoltageAngle and VoltageMagnitude as the values at the terminals of the energy source and not as the open circuit values as suggested in the CGMES. This might be discussed how should be solved in the future. CGMES issue is recorded on this.

4.3. Load flow and short-circuit calculation information

The single line diagrams for the Micro Grid Type is illustrated in Figure 5. The load flow results for complete configuration are included in a file MicroGrid.xls, tab Type_1.

For the purpose of calculation, the Extended Full Newton Raphson method has been used. The maximum number of iterations has been set to 50 while required accuracy is 0.0001. Reactive power limits have not been considered. All shunt control has been disabled. For the slack, NL-G1 generator has been used with voltage angle of 0 degrees and voltage of 16.5kV.

4.4. CIMdesk validation report for Assembled model

CIMdesk validation report (validation against Base profiles) on the assembled mode NL MAS, BE MAS and boundary MAS is the following:

Type	Class	Recurrence	Description
Warning	SubGeographicalRegion	1/4	No Substations are associated with SubGeographicalRegion via Association Substation.Region, expecting at least 1.
Warning	TopologicalNode	1/17	No Terminals are associated with TopologicalNode via Association Terminal.TopologicalNode, expecting at

Type	Class	Recurrence	Description
			least 2.
Warning	ACLineSegment	1/12	Attribute ACLineSegment.r0 is less than Attribute ACLineSegment.r.
Warning	ACLineSegment	5/12	The BaseVoltages of the two connected nodes are not the same.
Warning	TopologicalNode	1/17	The TopologicalNode is an island without Terminals connected or with all of the associated Terminals disconnected.
Warning	PowerTransformerEnd	2/15	The rated voltage doesn't match the nominal voltage of the connected node.

The above errors and warnings should be ignored as:

- SubGeographicalRegion warning is related to the CGMES requirement that there are no substations defined in the boundary.
- ACLineSegment is allowed to connect nodes with different BaseVoltages
- PowerTransformerEnd, ACLineSegment are data issue which is highlighted by CIMdesk to make users check for potential error. In this case that data is fine.

5. Micro Grid Type 2

5.1. General information

Included are:

- Difference files to replace one of the tie-lines as HVDC line for bus-branch configuration. The HVDC should be type VSC (MAS BE)
- Difference files to replace one of the tie-lines as HVDC line for node-breaker configuration. The HVDC should be type VSC (MAS NL)
- Assembled complete model in NB configuration

The difference models are applied on Base Case model. For MAS BE (Bus-Branch), the difference files can be applied directly on BC model, while for MAS NL (Node Breaker) first Difference (Diff 1) models from Type 1 configuration must be applied in order to transform MAS NL to Node-Breaker configuration.

5.2. Network topology and data

Micro Grid Type 2 is based on Base Case configuration. Two HVDC Systems are introduced in the network. One HVDC system is integrated part of MAS BE, while the other is modelled and exported as a separate MAS.

The number and types of the elements in the assembled model is indicated in Table 5.

Table 5

Class	# of Objects
ACDCConverterDCTerminal	8
ACLineSegment	16
BaseVoltage	10
Breaker	26
BusbarSection	13
ConnectivityNode	49
CoordinateSystem	3
CurrentLimit	506
CurveData	3
DCConverterUnit	4
DCGround	4

Class	# of Objects
DCLine	2
DCLineSegment	2
DCNode	9
DCSeriesDevice	1
DCTerminal	10
DCTopologicalNode	9
Diagram	3
DiagramObject	578
DiagramObjectPoint	1012
EnergyConsumer	6
EquivalentInjection	12
ExcIEEEAC1A	1
ExcIEEEAC4A	2
ExcIEEEST1A	2
GeneratingUnit	5
GeographicalRegion	4
GovHydro1	2
GovHydro2	1
GovSteam0	1
GovSteam1	1
Junction	1
Line	22
LinearShuntCompensator	3
LoadAggregate	6
LoadResponseCharacteristic	2
LoadStatic	6
Location	18
OperationalLimitSet	55
OperationalLimitType	15
PhaseTapChangerAsymmetrical	1
PositionPoint	50
PowerTransformer	11
PowerTransformerEnd	23
Pss2B	5
RatioTapChanger	10
ReactiveCapabilityCurve	1
RegulatingControl	8
SubGeographicalRegion	5
Substation	7
SvPowerFlow	26
SvShuntCompensatorSections	3
SvTapStep	11
SvVoltage	25
SynchronousMachine	5
SynchronousMachineTimeConstantReactance	5
TapChangerControl	11
Terminal	151
TopologicalIsland	1
TopologicalNode	25
VComplEEEType1	5
VoltageLevel	18
VsConverter	4
EnergySchedulingType	6

5.3. Load flow and short-circuit calculation information

The single line diagrams for the Micro Grid Type 2 is illustrated in Figure 6. The load flow results are included in a file MicroGrid.xls, tab Type_2.

For the purpose of calculation, the Extended Full Newton Raphson method has been used. The maximum number of iterations has been set to 50 while required accuracy is 0.0001. Reactive power limits have not been considered. All shunt control has been disabled. For the slack, NL-G1 generator has been used with voltage angle of 0 degrees and voltage of 16.5kV.

5.4. CIMdesk validation report for Assembled model

CIMdesk validation report (validation against Base profiles) on the assembled mode NL MAS, BE MAS and boundary MAS is the following:

Type	Class	Recurrence	Description
Warning	OperationalLimitType	3/15	The OperationalLimitType doesn't contain any child instances (or is not referenced by other instances).
Warning	SubGeographicalRegion	1/5	No Substations are associated with SubGeographicalRegion via Association Substation.Region, expecting at least 1.
Warning	ACLineSegment	1/16	Attribute ACLineSegment.r0 is less than Attribute ACLineSegment.r.
Warning	ACLineSegment	5/16	The BaseVoltages of the two connected nodes are not the same.
Warning	PowerTransformerEnd	2/23	The rated voltage doesn't match the nominal voltage of the connected node.
Warning	ACLineSegment	5/16	No Locations are associated with ACLineSegment.
Warning	DCLineSegment	2/2	No Locations are associated with DCLineSegment.

The above errors and warnings should be ignored as:

- SubGeographicalRegion warning is related to the CGMES requirement that there are no substations defined in the boundary.
- ACLineSegment is allowed to connect nodes with different BaseVoltages
- PowerTransformerEnd, ACLineSegment, OperationalLimitType are data issue which is highlighted by CIMdesk to make users check for potential error. In this case that data is fine.
- The last 2 warnings inform that there are no GL coordinates assigned for these elements.

6. Micro Grid Type 3

6.1. General information

Included are:

- Difference files to replace one of the internal AC lines by HVDC Classic (CSC) line for bus-branch configuration.
- Difference files to replace one of the internal AC lines by HVDC Classic (CSC) line for node-breaker configuration.
- Assembled complete model in NB configuration

6.2. Network topology and data

The number and types of the elements in the model is indicated in Table 6.
Table 6

Class	# of Objects
ACDCConverterDCTerminal	8
ACLineSegment	16
BaseVoltage	10
Breaker	26
BusbarSection	13
ConnectivityNode	49
CoordinateSystem	2
CsConverter	4
CurrentLimit	358
CurveData	3
DCConverterUnit	4
DCGround	4
DCLine	2
DCLineSegment	2
DCNode	8
DCTerminal	8
DCTopologicalNode	8
Diagram	3
DiagramObject	557
DiagramObjectPoint	976
EnergyConsumer	6
EquivalentInjection	10
ExcIEEEAC1A	1
ExcIEEEAC4A	2
ExcIEEEST1A	2
GeneratingUnit	5
GeographicalRegion	3
GovHydro1	2
GovHydro2	1
GovSteam0	1
GovSteam1	1
Junction	1
Line	22
LinearShuntCompensator	7
LoadAggregate	6
LoadResponseCharacteristic	2
LoadStatic	6
Location	16
OperationalLimitSet	55
OperationalLimitType	10
PhaseTapChangerAsymmetrical	1
PositionPoint	52
PowerTransformer	11
PowerTransformerEnd	23
Pss2B	5
RatioTapChanger	10
ReactiveCapabilityCurve	1
RegulatingControl	12
SubGeographicalRegion	4
Substation	7
SvPowerFlow	28
SvShuntCompensatorSections	7
SvTapStep	11
SvVoltage	24
SynchronousMachine	5
SynchronousMachineTimeConstantReactance	5

Class	# of Objects
TapChangerControl	11
Terminal	153
TopologicalIsland	1
TopologicalNode	25
VCompIEEEType1	5
VoltageLevel	18
EnergySchedulingType	6

6.3. Load flow and short-circuit calculation information

The single line diagram of the base case Micro Grid 2 network is illustrated in Figure 7 while the load flow results are included in a file MicroGrid.xls, Tab Type_3.

6.4. CIMdesk validation report for Assembled model

CIMdesk validation report (validation against Base profiles) on the assembled mode NL MAS, BE MAS and boundary MAS is the following:

Type	Class	Recurrence	Description
Warning	OperationalLimitType	2/10	The OperationalLimitType doesn't contain any child instances (or is not referenced by other instances).
Warning	SubGeographicalRegion	1/4	No Substations are associated with SubGeographicalRegion via Association Substation.Region, expecting at least 1.
Warning	TopologicalNode	1/25	No Terminals are associated with TopologicalNode via Association Terminal.TopologicalNode, expecting at least 2.
Warning	ACLineSegment	1/16	Attribute ACLineSegment.r0 is less than Attribute ACLineSegment.r.
Warning	ACLineSegment	5/16	The BaseVoltages of the two connected nodes are not the same.
Warning	TopologicalNode	1/25	The TopologicalNode is an island without Terminals connected or with all of the associated Terminals disconnected.
Warning	PowerTransformerEnd	2/23	The rated voltage doesn't match the nominal voltage of the connected node.
Warning	ACLineSegment	3/16	No Locations are associated with ACLineSegment.
Warning	DCLineSegment	2/2	No Locations are associated with DCLineSegment.
Warning	Substation	4/7	No Locations are associated with Substation.

The above errors and warnings should be ignored as:

- SubGeographicalRegion warning is related to the CGMES requirement that there are no substations defined in the boundary.
- ACLineSegment is allowed to connect nodes with different BaseVoltages
- PowerTransformerEnd, ACLineSegment are data issue which is highlighted by CIMdesk to make users check for potential error. In this case that data is fine.
- The last 3 warnings inform that there are no GL coordinates assigned for these elements.

7. Micro Grid Type 4

7.1. General information

This model is used to test interoperability of transformers and shunt/series compensators.

This model is built on top of the MGBC. The following modifications are available as difference files and complete (full) instance files:

- Model transformers that use the following classes should be added: RatioTapChanger, RatioTapChangerTable, RatioTapChangerTablePoint, TapChangerTablePoint, PhaseTapChangerTablePoint, PhaseTapChangerTabular, PhaseTapChangerTable, PhaseTapChangerSymmertical, PhaseTapChangerAsymmetrical, PhaseTapChangerLinear.
- Model shunt compensators that LinearShuntCompensator, NonlinearShuntCompensator, NonlinearShuntCompensatorPoint.
- Model StaticVarCompensator.
- Model SeriesCompensator.

Difference and complete instance files are available for bus-branch and node-breaker type of models.

It should be noted that based on the parameters and setpoints of the Static Var Compensator (SVC), the SVC will run into the reactive power limit (10Mvar). This has been done intentionally to make it easier to achieve same results between tools since otherwise tools could have different results depending on which control they chose to follow (VoltageSetPoint or RegulatingControl). Additionally, obtaining the correct reactive limit shows that parameters of the SVC are correctly interpreted.

7.2. Network topology and data

Micro Grid Type 4 configuration is based on MG Base Case model. Various TapChangers have been added to the transformer models, also, Series Compensator SVC are included. The number and types of the elements in the bus-branch model is indicated in Table 7; for node-breaker version – Table 8.

Table 7

Class	# of Objects
ACLineSegment	12
BaseVoltage	8
Breaker	1
BusbarSection	13
ConnectivityNode	6
CoordinateSystem	2
CurrentLimit	278
CurveData	3
Diagram	3
DiagramObject	213
DiagramObjectPoint	356
EnergyConsumer	6
EquivalentInjection	10
ExcIEEEAC1A	1
ExcIEEEAC4A	2
ExcIEEEST1A	2
GeneratingUnit	5
GeographicalRegion	3
GovHydro1	2
GovHydro2	1
GovSteam0	1
GovSteam1	1
Junction	1

Class	# of Objects
Line	18
LinearShuntCompensator	2
LoadAggregate	6
LoadResponseCharacteristic	2
LoadStatic	6
Location	15
NonlinearShuntCompensator	1
NonlinearShuntCompensatorPoint	5
OperationalLimitSet	39
OperationalLimitType	12
PhaseTapChangerAsymmetrical	1
PhaseTapChangerLinear	1
PhaseTapChangerSymmetrical	1
PhaseTapChangerTable	1
PhaseTapChangerTablePoint	34
PhaseTapChangerTabular	1
PositionPoint	49
PowerTransformer	7
PowerTransformerEnd	15
Pss2B	5
RatioTapChanger	3
RatioTapChangerTable	1
RatioTapChangerTablePoint	31
ReactiveCapabilityCurve	1
RegulatingControl	9
SeriesCompensator	1
StaticVarCompensator	1
SubGeographicalRegion	4
Substation	3
SvPowerFlow	25
SvShuntCompensatorSections	3
SvTapStep	7
SvVoltage	17
SynchronousMachine	5
SynchronousMachineTimeConstantReactance	5
TapChangerControl	7
Terminal	82
TopologicalIsland	1
TopologicalNode	18
VCompIEEEType1	5
VoltageLevel	11
EnergySchedulingType	6

Table 8

Class	# of Objects
ACLineSegment	12
BaseVoltage	8
Breaker	26
BusbarSection	13
ConnectivityNode	42
CoordinateSystem	2
CurrentLimit	278
CurveData	3

Class	# of Objects
Diagram	3
DiagramObject	411
DiagramObjectPoint	706
EnergyConsumer	6
EquivalentInjection	10
ExcIEEEAC1A	1
ExcIEEEAC4A	2
ExcIEEEST1A	2
GeneratingUnit	5
GeographicalRegion	3
GovHydro1	2
GovHydro2	1
GovSteam0	1
GovSteam1	1
Junction	1
Line	18
LinearShuntCompensator	2
LoadAggregate	6
LoadResponseCharacteristic	2
LoadStatic	6
Location	15
NonlinearShuntCompensator	1
NonlinearShuntCompensatorPoint	5
OperationalLimitSet	39
OperationalLimitType	12
PhaseTapChangerAsymmetrical	1
PhaseTapChangerLinear	1
PhaseTapChangerSymmetrical	1
PhaseTapChangerTable	1
PhaseTapChangerTablePoint	34
PhaseTapChangerTabular	1
PositionPoint	49
PowerTransformer	7
PowerTransformerEnd	15
Pss2B	5
RatioTapChanger	3
RatioTapChangerTable	1
RatioTapChangerTablePoint	31
ReactiveCapabilityCurve	1
RegulatingControl	9
SeriesCompensator	1
StaticVarCompensator	1
SubGeographicalRegion	4
Substation	3
SvPowerFlow	25
SvShuntCompensatorSections	3
SvTapStep	7
SvVoltage	17
SynchronousMachine	5
SynchronousMachineTimeConstantReactance	5
TapChangerControl	7
Terminal	132
TopologicalIsland	1
TopologicalNode	18
VCompIEEEType1	5
VoltageLevel	11

Class	# of Objects
EnergySchedulingType	6

7.3. Load flow and short-circuit calculation information

The single line diagram of the base case Micro Grid 4 network is illustrated in Figure 8 while the load flow results are included in a file MicroGrid.xls, Tab Type_4.

For the purpose of calculation, the Extended Newton Raphson method has been used. The maximum number of iterations has been set to 50 while required accuracy is 0.0001. Reactive power limits have not been considered. All shunt control has been disabled. For the slack, NL-G1 generator has been used with voltage angle of 0 degrees and voltage of 16.5kV.

7.4. CIMdesk validation report for Assembled model

CIMdesk validation report (validation against Base profiles) on the assembled model (bus-branch variant): NL MAS, BE MAS and boundary MAS is the following:

Type	Class	Recurrence	Description
Warning	SubGeographicalRegion	1/4	No Substations are associated with SubGeographicalRegion via Association Substation.Region, expecting at least 1.
Warning	TopologicalNode	2/18	No Terminals are associated with TopologicalNode via Association Terminal.TopologicalNode, expecting at least 2.
Warning	ACLineSegment	1/12	Attribute ACLineSegment.r0 is less than Attribute ACLineSegment.r.
Warning	SeriesCompensator	1/1	Attribute SeriesCompensator.r0 is less than or equal to Attribute SeriesCompensator.r.
Warning	ACLineSegment	5/12	The BaseVoltages of the two connected nodes are not the same.
Warning	TopologicalNode	1/18	The TopologicalNode is an island without Terminals connected or with all of the associated Terminals disconnected.
Warning	PowerTransformerEnd	2/15	The rated voltage doesn't match the nominal voltage of the connected node.

The above errors and warnings should be ignored as:

- SubGeographicalRegion warning is related to the CGMES requirement that there are no substations defined in the boundary.
- ACLineSegment is allowed to connect nodes with different BaseVoltages
- PowerTransformerEnd, SeriesCompensator, ACLineSegment are data issue which is highlighted by CIMdesk to make users check for potential error. In this case that data is fine.

CIMdesk validation report (validation against Operation profiles) on the assembled model (node-breaker variant): NL MAS, BE MAS and boundary MAS is the following:

Type	Class	Recurrence	Description
Warning	ConnectivityNode	2/42	No Terminals are associated with ConnectivityNode via Association Terminal.ConnectivityNode, expecting at least 2.
Warning	SubGeographicalRegion	1/4	No Substations are associated with SubGeographicalRegion via Association Substation.Region, expecting at least 1.

Type	Class	Recurrence	Description
Warning	TopologicalNode	2/18	No Terminals are associated with TopologicalNode via Association Terminal.TopologicalNode, expecting at least 2.
Warning	ACLineSegment	1/12	Attribute ACLineSegment.r0 is less than Attribute ACLineSegment.r.
Warning	SeriesCompensator	1/1	Attribute SeriesCompensator.r0 is less than or equal to Attribute SeriesCompensator.r.
Warning	ACLineSegment	5/12	The BaseVoltages of the two connected nodes are not the same.
Warning	TopologicalNode	1/18	The TopologicalNode is an island without Terminals connected or with all of the associated Terminals disconnected.
Warning	PowerTransformerEnd	2/15	The rated voltage doesn't match the nominal voltage of the connected node.

8. Single line diagrams

On the following pages, single line diagrams of all the models are illustrated. All diagrams contain valid load flow or short circuit calculation results.

Micro Grid Base Case

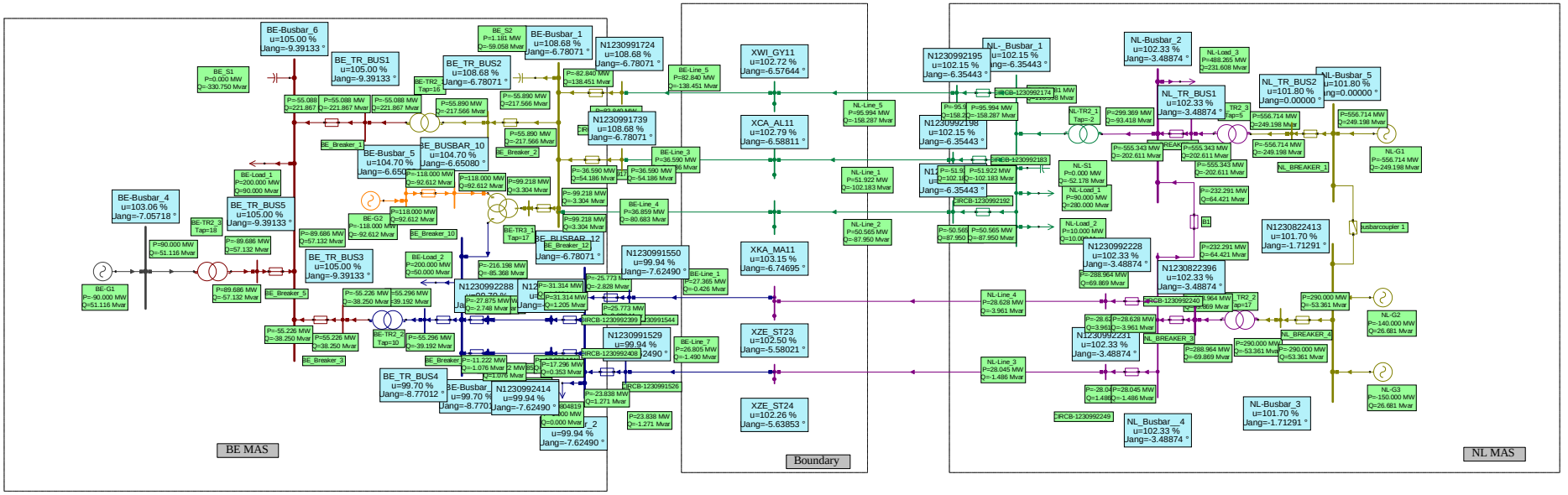

Figure 2 Base case – assembled NO AREA CONTROL

Micro Grid Base Case

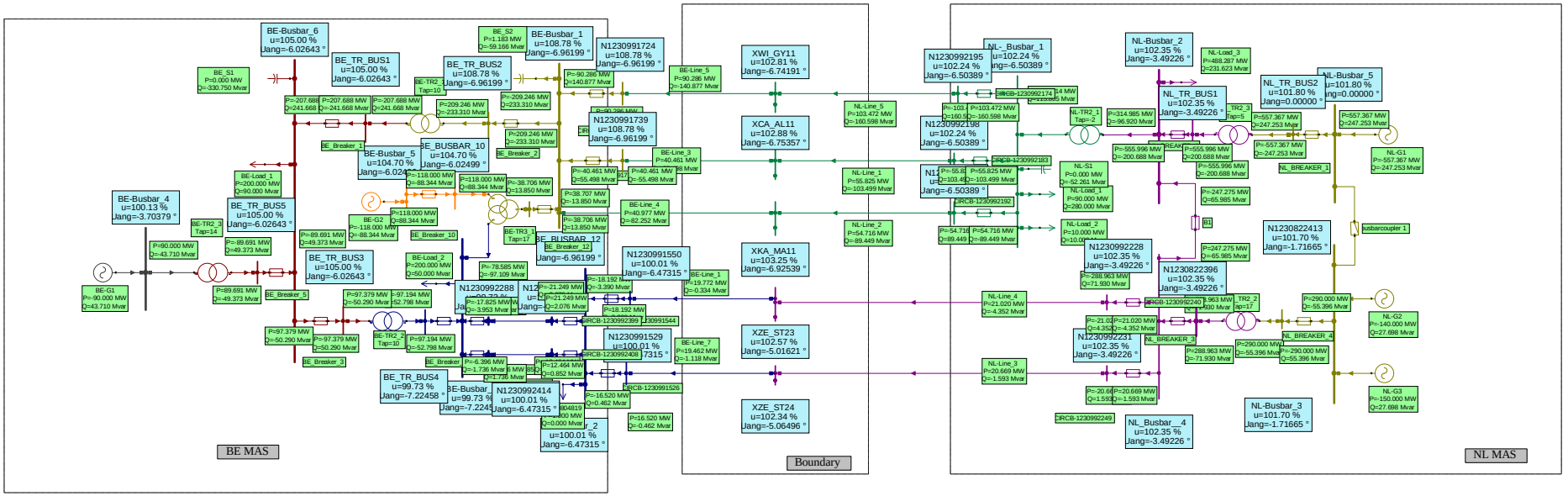

Figure 3Base case – assembled NO AREA CONTROL, NO TRAFO REGULATION

Micro Grid Base Case

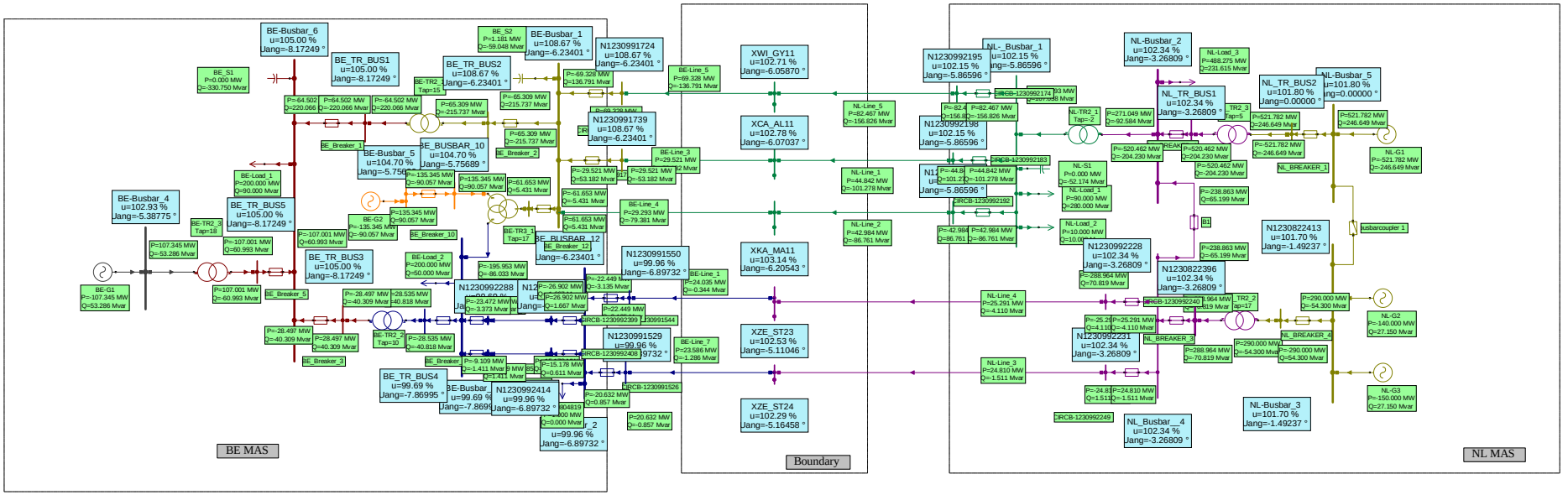

Figure 4 Base case – assembled AREA CONTROL ON

Micro Grid Base Case

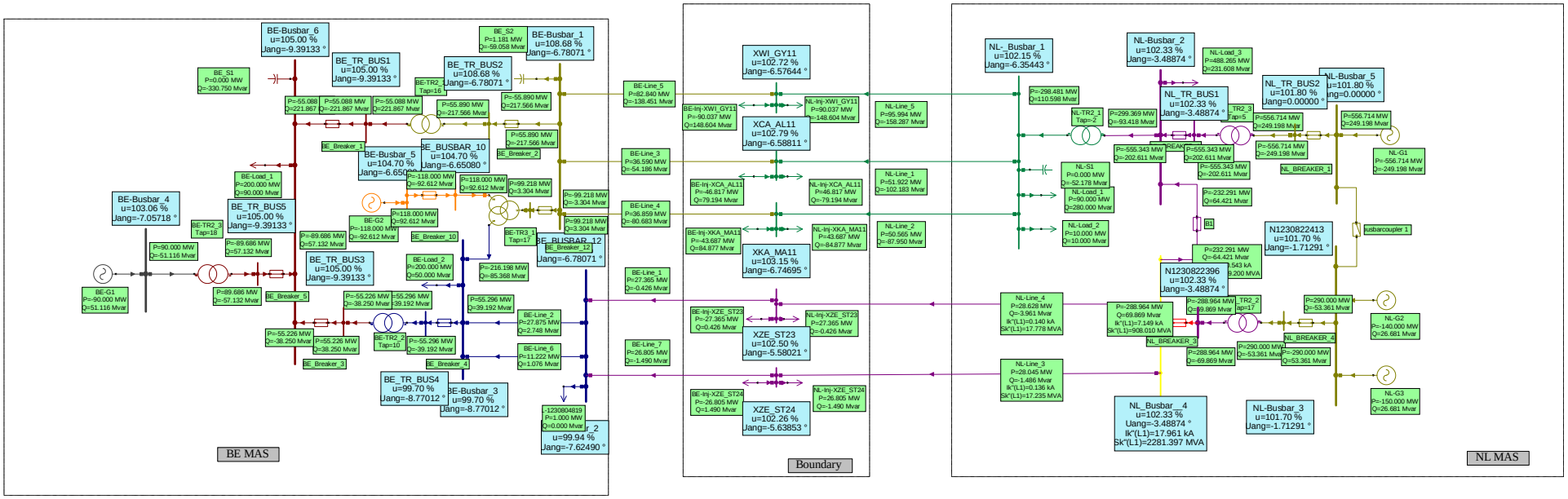

Figure 5BC Short Circuit (NL_Busbar_4)

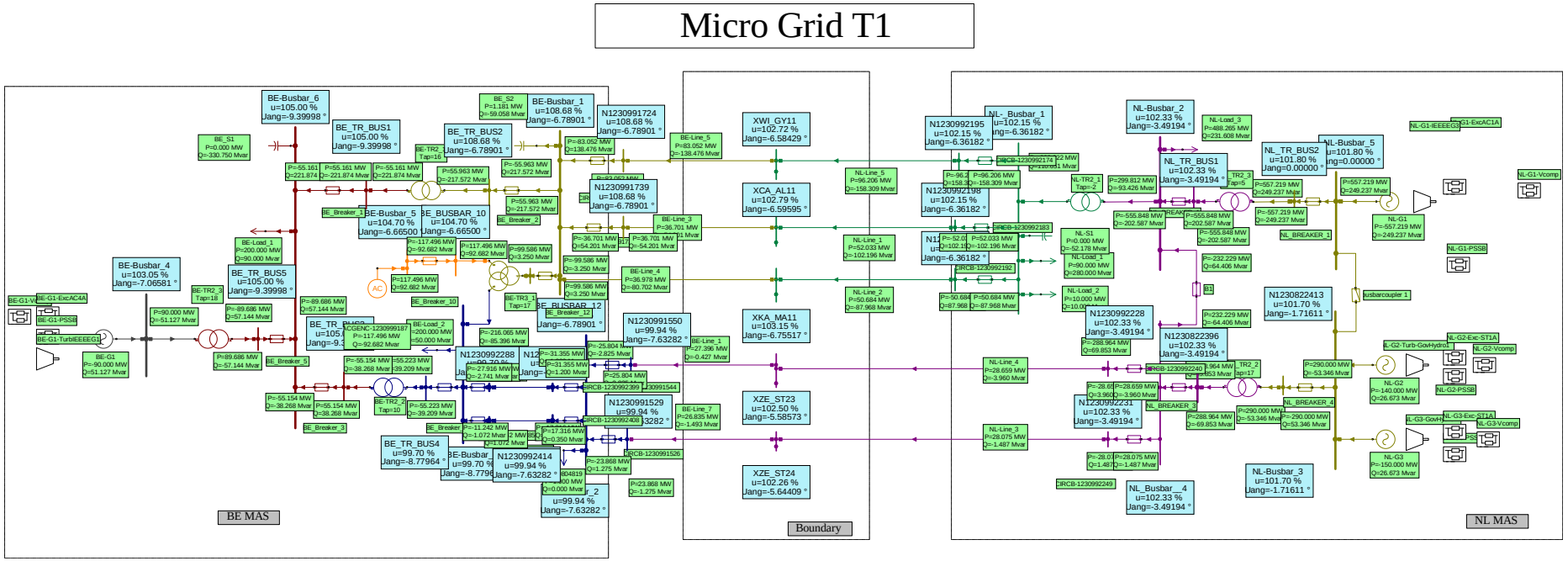

Figure 6 Type 1 – assembled complete

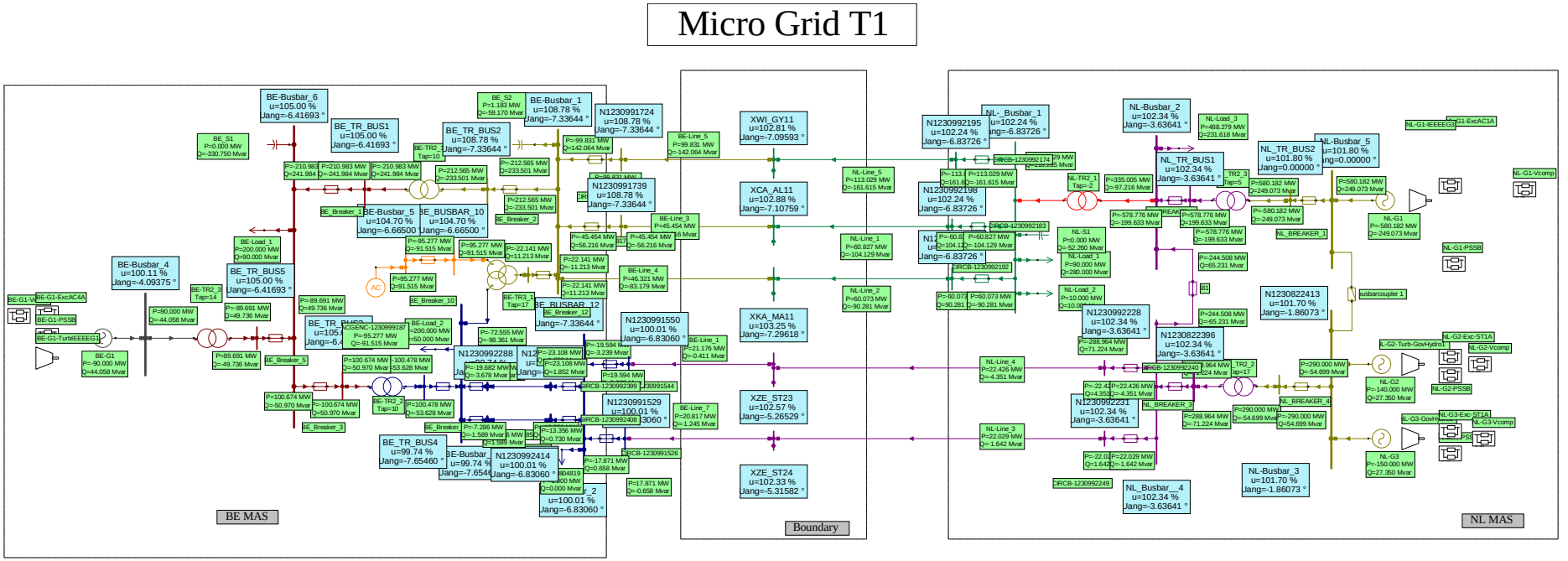

Figure 7 Type 1 – assembled complete NoTrafo Regulation

Micro Grid Type 2

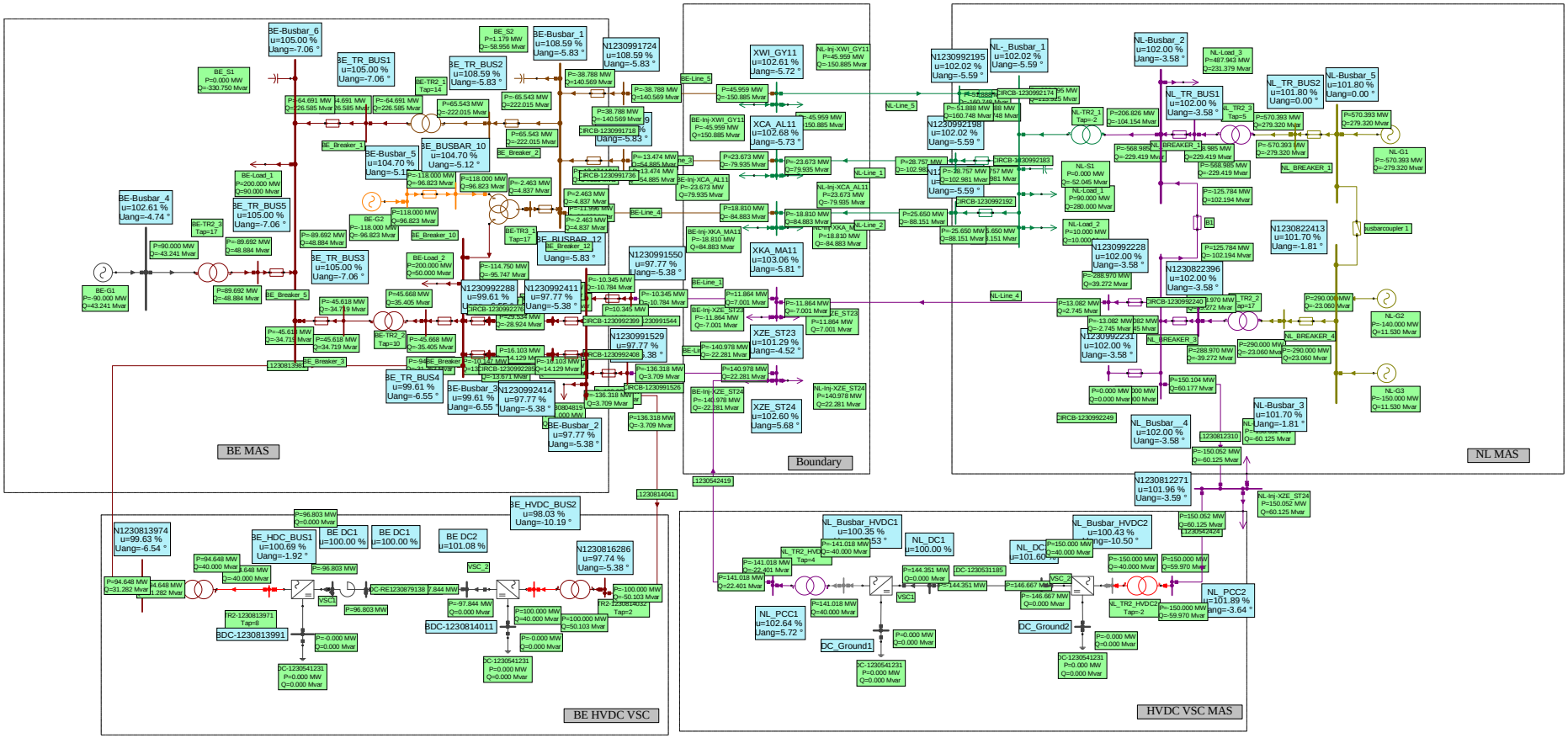

Figure 8 Type 2 – assembled

Micro Grid Type 2

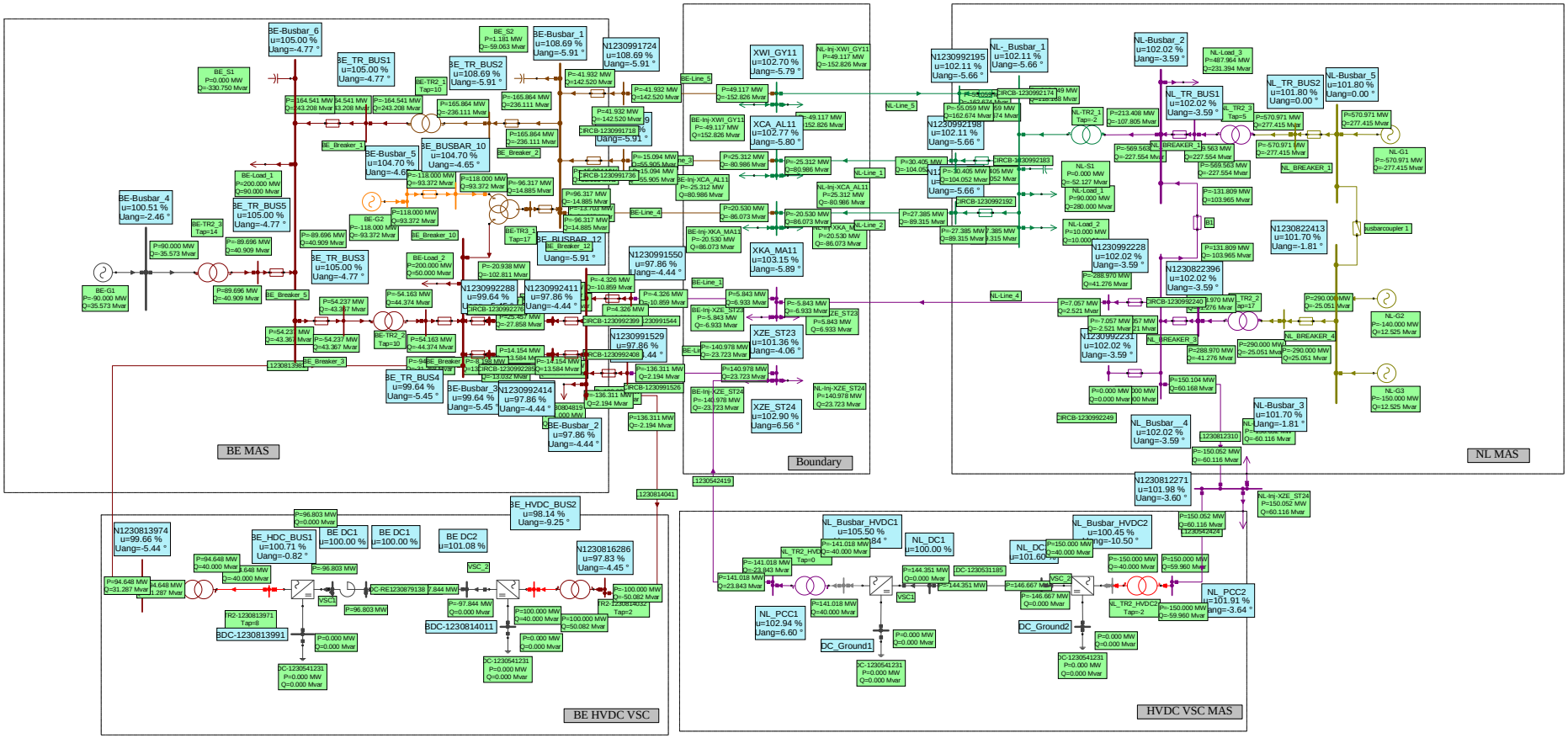

Figure 9 Type 2 – assembled NO TRAFO REGULATION

Micro Grid Type 3

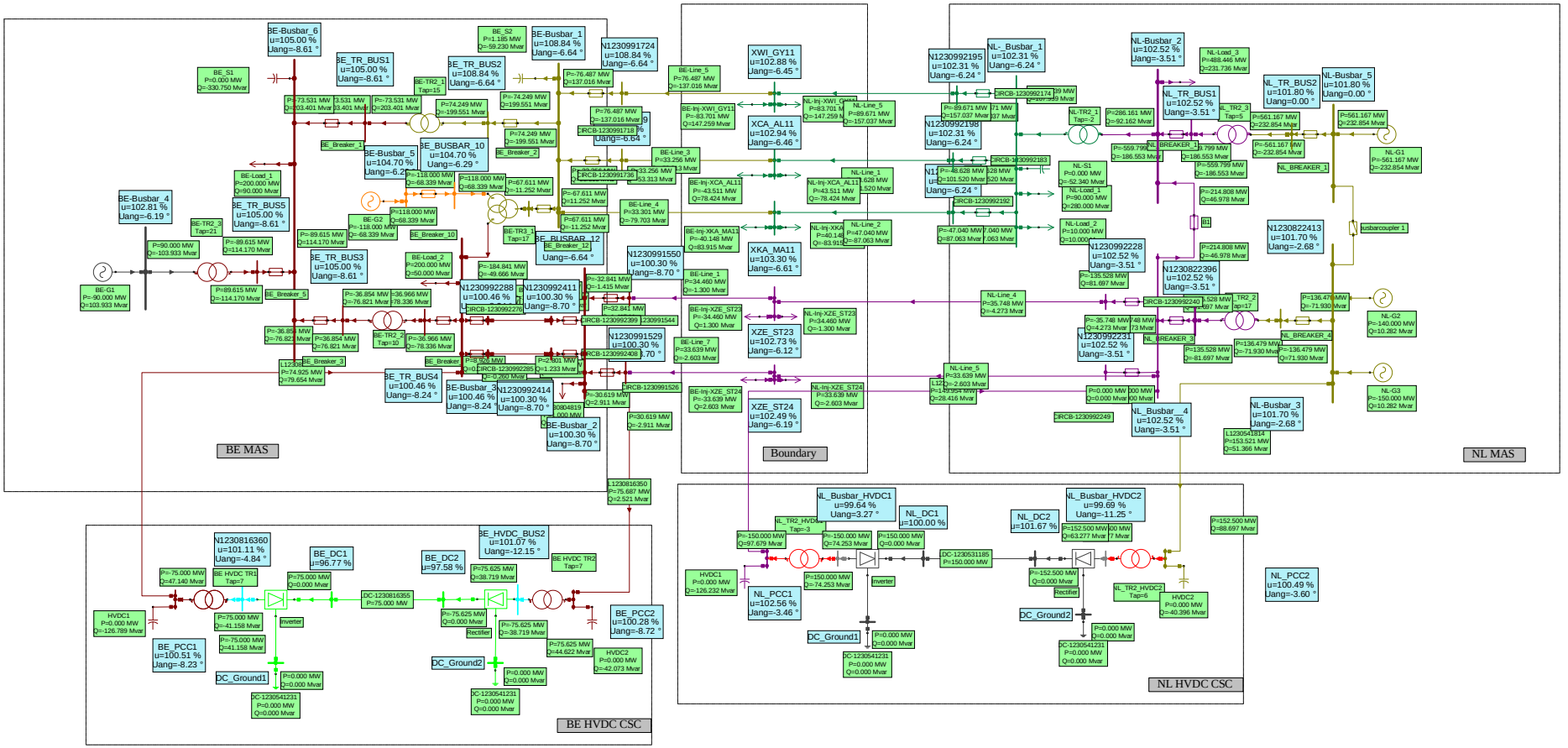

Figure 10 Type 3 – assembled

Micro Grid Type 3

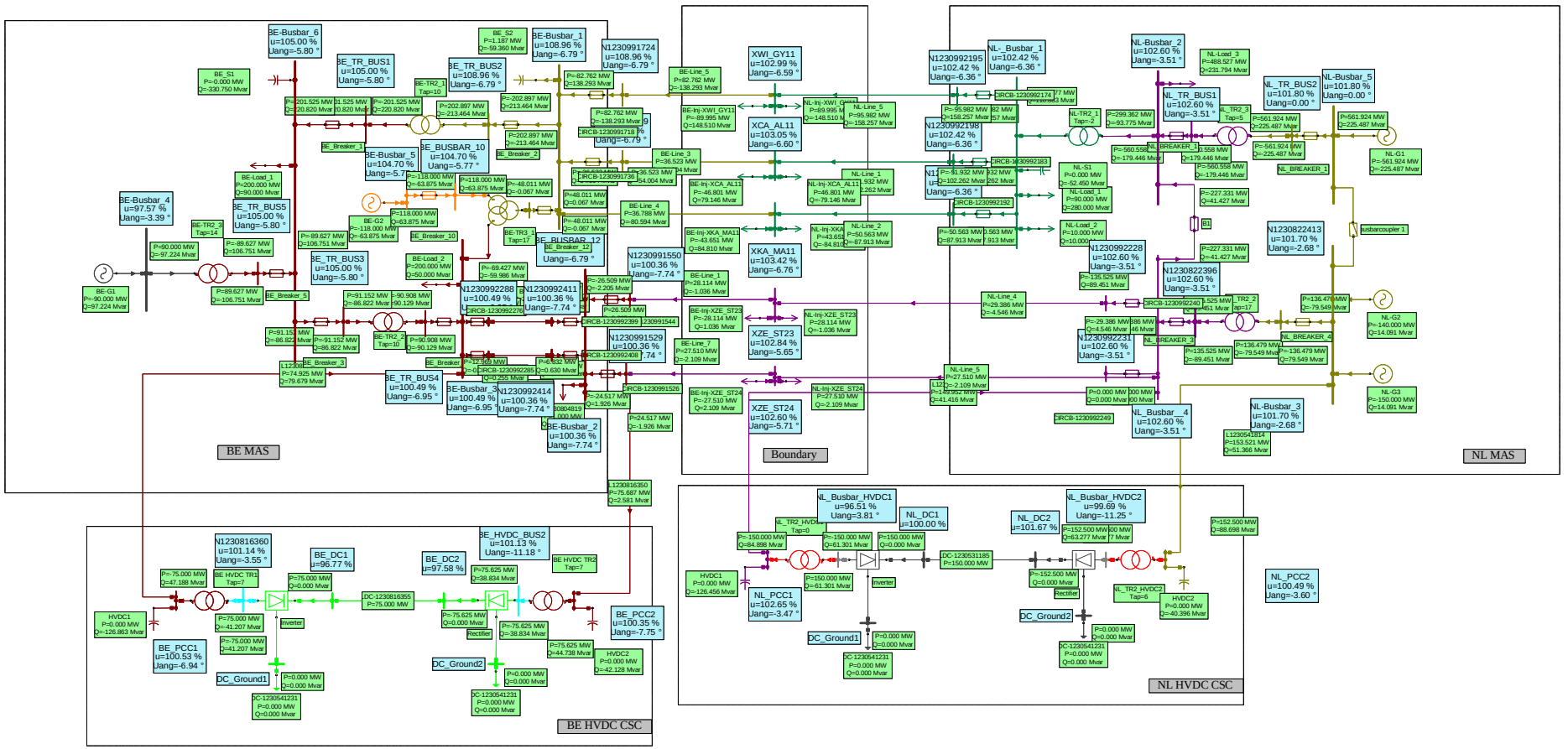

Figure 11 Type 3 – assembled NO TRAFO REGULATION

Micro Grid Type 4

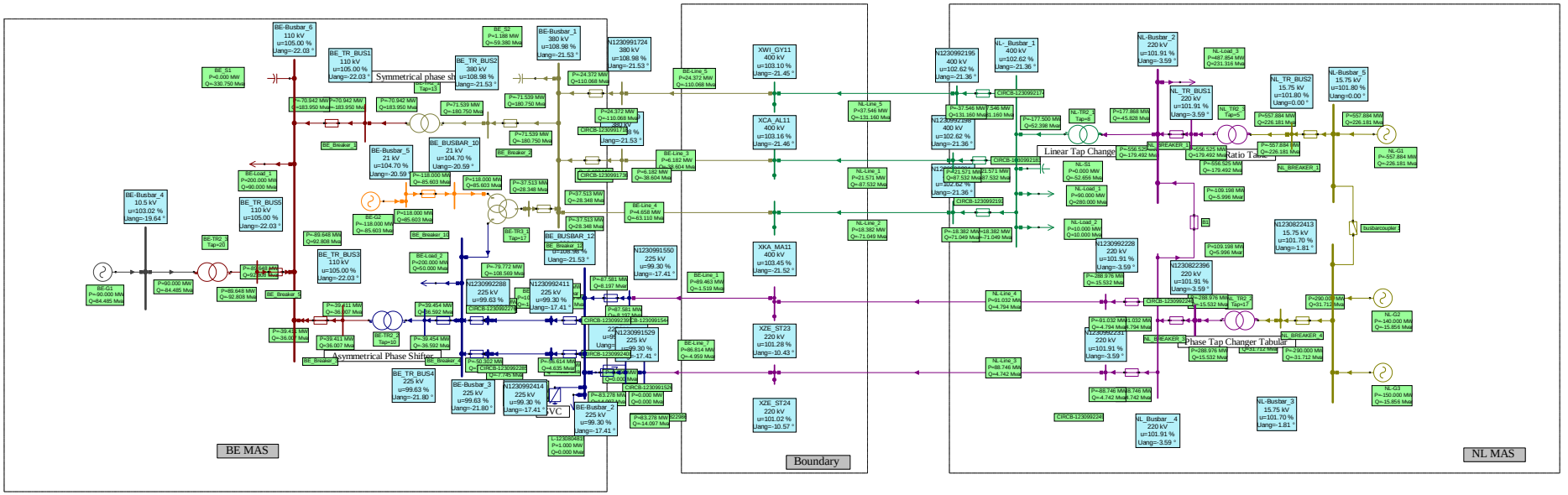

Figure 12 – Type 4 – assembled

Micro Grid Type 4

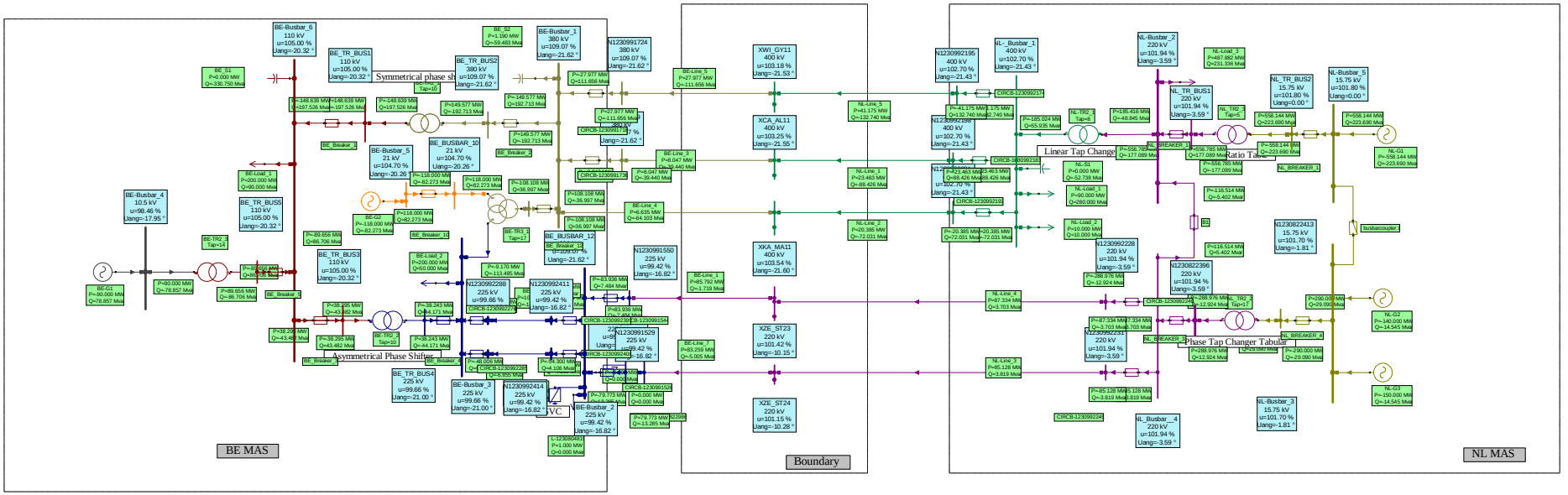

Figure 13– Type 4 – assembled NO TRAFO CONTROL

Figure 14 Geographical illustration