



European Network of
Transmission System Operators
for Electricity

INTEROPERABILITY TEST "CIM FOR SYSTEM DEVELOPMENT AND OPERATIONS" 2011

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FINAL REPORT

FOREWORD

ENTSO-E conducted, along with European and American vendors and Transmission System Operators (TSOs), a common information model (CIM) interoperability test (IOP) – ENTSO-E IOP "CIM for System Development and Operations" 2011. The test was organized and directed by ENTSO-E from 11 to 15 July 2011 at ENTSO-E's premises, in Brussels.

The future ENTSO-E CIM-based data exchange format (ENTSO-E CIM profile), which complies with the International Electrotechnical Commission (IEC) CIM standard, was tested on a large number of products owned by 18 vendors. Alstom grid, BCP Busarello + Cott + Partner AG, CESI, DlgSILENT, DMS Group, EDF R&D, EKC, FGH, General Electric, General Electric Energy, Intercompro AG, Nexant, Open Grid Systems, RTE, Siemens Power Technologies International, SISCO, TIBCO and Tractebel participated in the test that was observed by 20 test witnesses from TSOs including Statnett (Norway), Amprion (Germany), TenneT TSO B.V. (Netherlands), TenneT TSO GmbH (Germany), Transelectrica (Romania), TERNA (Italy), EPCON (subsidiary of PSE-Operator, Poland), swissgrid (Switzerland), REN (Portugal), Elia (Belgium), EMS (Serbia), ESO EAD (Bulgaria), National Grid (UK), PSE-Operator (Poland) and ENTSO-E. The on-site test was supported by experts from ITG (France) and Zamiren (France).

The test is considered as a part of the ENTSO-E CIM profile development process. In addition, key goals were to test and validate the latest IEC CIM standard as well as the correct implementation of the 1st edition of the ENTSO-E CIM Profile which is currently used for some of the ENTSO-E data exchanges. The implementation schedule for the ENTSO-E CIM profile that has been tested is subject to ENTSO-E decision as it is defined by the ENTSO-E roadmap for implementation of future updates of the data exchange format as previously announced.

A set of test procedures were defined which provided step-by-step instructions to be followed to successfully complete each test. A set of official test cases were prepared by Siemens PTI, General Electric, DlgSILENT and ENTSO-E for use by all test participants.

Two CIM XML validation tools (CIMSpy and CIMdesk) were used to validate the correctness of the official test cases as well as each set of CIM XML files produced by the participants during the test.

The second edition of the ENTSO-E CIM Profile was created using the tool - CimConteXtor.

The results achieved during the test are in line with the expectations of the participants. The test results are summarized and presented in detail in this report showing the specific tests successfully completed by each vendor and the test case files that were exchanged.

Issues recorded during the testing and proposed resolutions are included in this report, along with some guidelines on how to implement the CIM standards within the TSO/utility enterprise. Details on the products tested, the test procedures and test record forms are included in the report appendices.

ACKNOWLEDGEMENTS

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- ENTSO-E – Chavdar Ivanov for directing the IOP, for assistance in witnessing the IOP, for preparation of test procedures, ENTSO-E CIM Profile document, the official test files and the final report.
- Jean-Luc Sanson (ITG) and Andre Maizener (Zamiren) for supporting preparation of the 2nd edition of the ENTSO-E CIM Profile using the tool CimConteXtor.
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- All participating vendors, for the hard work in a very short time to develop the necessary software for testing and providing inputs to the issues discussed during the preparatory work as well as during the IOP.

In addition, ENTSO-E acknowledges IEC TC57/WG13 members and CIM user group that provided assistance and supported ENTSO-E IOP in various ways.

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1 INTRODUCTION

1.1 BACKGROUND INFORMATION

In 2009 the ENTSO-E member TSOs have been underlining their commitment to apply the CIM-based data exchange format in all data exchange processes. This format is based on the CIM standards of the International Electrotechnical Commission and was initially tested during the UCTE interoperability test in March 2009. Using CIM will improve TSO cooperation and will have a direct impact on the outputs, the Third Energy Package of the EU mandates ENTSO-E to produce. For the first time the CIM-based exchange format is used in early 2010 for preparing network models as a basis for system development studies. One important example in this context is the Ten-Year Network Development Plan, which will benefit from the upcoming CIM-based data exchanges for network modelling. In addition to applying the CIM-based data exchange format for the exchange of system studies, the exchange of system operations data (performed on an hourly or daily basis) will be adjusted to the use the CIM-based data exchange format. The support from vendors is essential in this context since they are providing software tools required for the effective use of the new data exchange format.

On 11 December 2009 ENTSO-E decided to organize two Common Information Model (CIM) interoperability tests per year to support the development of the ENTSO-E CIM-based data exchange format and the CIM Standard issued by the International Electrotechnical Commission (IEC). Moreover, ENTSO-E agreed on a roadmap for the implementation of future updates of the CIM-based format for exchanges of system operations and system studies. The purpose of these tests is to demonstrate the interoperability of the ENTSO-E CIM-based data exchange format and the IEC CIM-based standard taking into account all changes proposed to be included in the updated CIM standard. The tests are also designed in order to allow vendors to verify the correctness of the implementation of the updated CIM standard and to support ENTSO-E processes towards achieving the objectives given to ENTSO-E by the EU Third Energy Package. More specifically, the Regulation 714/2009 on conditions for access to the network for cross-border exchanges in electricity states that ENTSO-E has to adopt common network operation tools to ensure the coordination of network operation, to elaborate network codes on data exchange and interoperability rules as well as transparency rules.

The adoption of the ENTSO-E CIM interoperability tests and the CIM/XML-based data exchange format is a direct contribution to the above mentioned tasks since it supports data exchanges and ensures the interoperability of the tools used in the ENTSO-E data exchange processes. The experience gained from the process of developing CIM-based data exchange format and its implementation will directly contribute to the task to develop network codes required by the Third Energy Package by the European Union. The interaction is obvious taking into account the fact that data exchange processes and formats used in these processes will be part of several network codes.

In 2009, ENTSO-E agreed to organize up to two CIM Interoperability tests per year:

- The ENTSO-E IOP "CIM for System Development and Operations" that covers all needs of system development and operations such as operational to operational exchanges, operational to planning, short circuit data, planning, dynamics exchanges and the interface with distribution. Specific data collection and data processes can also be tested. The goal is to allow and facilitate any kind of study in TSOs' scope: static analyses, dynamic studies, short circuit assessments, etc.;
- The ENTSO-E IOP "CIM for Energy Market" that covers needs of market exchanges. It contributes to the further development of the IEM (European Internal Energy Market) by actively supporting market harmonization and integration and plays a crucial role for demonstrating the correctness of European market CIM profile.

This document reports the results of the ENTSO-E Interoperability Test „CIM for System Development and Operations“ 2011.

1.2 OBJECTIVES

The IEC is publishing international standards based on the CIM as a generalized abstract information model and is progressing data interface specifications based on the CIM to exchange power system models. The ENTSO-E CIM IOP is an important step in validating these standards as well as the new draft of the 2nd edition of the ENTSO-E CIM Profile which specifies those parts of the CIM needed to support the ENTSO-E business processes.

ENTSO-E IOP is a stage in the development process of the next ENTSO-E CIM based data exchange format, which will become official data exchange format once endorsed by the ENTSO-E committees responsible for these data exchanges. The IOP helps to verify CIM profile definitions and debug vendors' tools in order to ensure smooth implementation process once ENTSO-E decision is taken.

The general objectives of the ENTSO-E interoperability tests and demonstrations were to:

1. Demonstrate interoperability between different products based on the ENTSO-E CIM Model Exchange Profile (here after referred to as the ENTSO-E CIM profile). This included applications from EMS and Planning as well as independently developed applications from third party suppliers.
2. Validate the ENTSO-E CIM Profile document. The goal was to ensure it is correct, complete and ready to be used in ENTSO-E data exchanges or identify issues to be further corrected and verified during the next ENTSO-E IOP.
3. Demonstrate the exchange of power system models using the CIM with an RDF Schema and XML representation of the model data.
4. Demonstrate that the test participants' applications work effectively with the CIM XML files by comparing power flows in the test models.

5. Demonstrate that the application vendors can interoperate via the ENTSO-E CIM profile by showing that CIM cases produced by one vendor can be consumed by the others.

Specific objectives of the ENTSO-E IOP 2011 included validation of the:

- File header - the new IEC 61970-552;
- Model Authority Sets;
- Model assembling process: assembling of models submitted by different model authority sets;
- Exchange of data for dynamics calculations;
- Exchange of data for short circuit calculations according to IEC 60909;
- Exchange of diagram layout - IEC 61970-453;
- Exchange of GIS data;
- Exchange between SCADA/EMS and „planning“ tools;
- Exchange of difference files;
- Partial exchange of CIM profiles (equipment, topology, state variables and dynamics, etc).

The IOP 2011 also validated vendor's implementation of the 1st edition of the ENTSO-E CIM Profile, the edition that is currently used for some of the ENTSO-E data exchanges. Therefore some of the tests were performed with both editions of the ENTSO-E CIM Profile.

2 SUMMARY OF TEST RESULTS

Test procedures defined for the ENTSO-E Interoperability test described 33 tests that cover all necessary functionalities to be applied in the ENTSO-E data exchanges. Due to the large number of tests and tools that were tested during the IOP not all predefined tests could be performed by all vendors and using all official test models and the two editions of the ENTSO-E CIM Profiles. In addition, some of the tools that were tested do not support some of the data exchanges such as data for dynamic calculations or short circuit calculations.

The test procedures document (Appendix B) provides guidelines how to score the tests performed by vendors. In general more attention in terms of quality and correctness was paid to the exchanges done with the 1st edition of the ENTSO-E CIM profile. The tests in which 2nd edition of the profile is involved has been witnessed taking into account that the main objective is to confirm the correctness of the profile. The goal of the scores recorded in the test record forms is to provide information on the ENTSO-E CIM profile support status and

identify implementation gaps to be covered in order to ensure smooth data exchanges among ENTSO-E TSOs and to support IEC CIM standards development.

The scores applied in the test do not have any ranking intention and must not be used to support any commercial interest by any of the involved in the ENTSO-E IOP participants.

The following table summarises the tests performed using the 1st edition of the ENTSO-E CIM Profile.

Table 1. Summary tests - 1st edition of the profile

Tool	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9	Test 10
e-terrasource 2.0.1	x	x	x	x	x	x	x	x	x	x
Neplan 5.4.5b	x	x	x	x	x	x	x	x	x	x
CRESO 6.30	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SPIRA 6.33.1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SICRE 7.0	✓	x	✓	x	x	✓	✓	x	✓	x
PowerFactory 14.0	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
TNA 1.8	✓	✓	✓	✓	✓	x	✓	✓	✓	x
Migration Converter 2.7	x	x	x	x	x	x	x	x	x	x
Integral 7	✓	x	x	x	x	x	x	x	✓	x
Enterprise Gateway	x	x	x	x	x	x	x	x	x	x
PSLF 18b	✓	✓	✓	✓	✓	✓	✓	x	✓	✓
ISPEN 2.10	✓	✓	x	x	x	x	x	x	x	x
SCOPE 12.3	x	x	x	x	x	x	x	x	x	x
CIMPhony 2	✓	✓	✓	✓	✓	✓	✓	x	✓	x
Convergence 0.7	✓	✓	✓	✓	x	x	x	x	x	x
ODMS 8.0.1.5	✓	✓	✓	✓	✓	✓	✓	x	✓	✓
PI-AF 2.000	✓	x	✓	x	x	✓	✓	x	✓	✓
SMS GDA Server 5.0	✓	x	✓	x	x	✓	✓	x	✓	✓
Intelledge for CIM 2	x	x	x	x	x	x	x	x	x	x
Eurostag 4.6	✓	✓	x	x	x	x	x	x	x	✓

The tests performed using the 2nd edition of the ENTSO-E CIM profile are summarised in tables 2, 3 and 4 below. The following tools: Eurostag 4.6, Intelledge for CIM 2, CIMclipse 0.1, Convergence 0.7 have not performed tests using the 2nd edition of the ENTSO-E CIM Profile.

Table 2. Summary tests (Test 1 to Test 10) - 2nd edition of the profile

Tool	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9	Test 10
e-terrasource 2.0.1	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗
Neplan 5.4.5b	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CRESO 6.30	✓	✓	✓	✗	✗	✓	✓	✗	✓	✓
SPIRA 6.33.1	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓
SICRE 7.0	✓	✗	✓	✗	✗	✓	✓	✗	✓	✗
PowerFactory 14.1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
TNA 1.8	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓
Integral 7	✓	✓	✓	✗	✗	✗	✗	✓	✓	✓
Enterprise Gateway	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓
PSLF 18b	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓
ISPEN 2.10	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓
SCOPE 12.3	✓	✓	✓	✓	✓	✗	✓	✗	✓	✓
CIMPhony 2	✓	✓	✓	✓	✓	✗	✓	✗	✓	✓
ODMS 8.0.1.5	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓
PI-AF 2.000	✓	✗	✓	✗	✗	✓	✓	✗	✓	✓
SMS GDA Server 5.0	✓	✗	✓	✗	✗	✓	✓	✗	✓	✓

Table 3. Summary tests (Test 11 to Test 18) - 2nd edition of the profile

Tool	Test 11	Test 12	Test 13	Test 14	Test 15	Test 16	Test 17	Test 18
e-terrasource 2.0.1	✗	✗	✗	✗	✗	✗	✗	✗
Neplan 5.4.5b	✗	✗	✗	✗	✓	✗	✓	✗
CRESO 6.30	✗	✗	✗	✗	✗	✗	✗	✗
SPIRA 6.33.1	✗	✗	✗	✗	✗	✗	✗	✗
SICRE 7.0	✗	✗	✗	✗	✓	✗	✓	✗
PowerFactory 14.1	✗	✗	✗	✗	✓	✓	✓	✗
TNA 1.8	✓	✓	✓	✓	✗	✗	✗	✗
Integral 7	✗	✗	✗	✗	✗	✗	✗	✗
Enterprise Gateway	✓	✓	✓	✓	✓	✓	✗	✗
PSLF 18b	✗	✗	✗	✗	✓	✓	✓	✗
ISPEN 2.10	✗	✗	✗	✗	✗	✗	✗	✗
SCOPE 12.3	✗	✗	✗	✗	✗	✗	✗	✗
CIMPhony 2	✓	✓	✓	✓	✗	✗	✗	✗
ODMS 8.0.1.5	✓	✓	✓	✓	✓	✓	✓	✗
PI-AF 2.000	✗	✓	✗	✓	✓	✗	✗	✓
SMS GDA Server 5.0	✗	✓	✗	✗	✓	✗	✗	✗

Table 4. Summary tests (Test 27 to Test 33) - 2nd edition of the profile

Tool	Test 27	Test 28	Test 29	Test 30	Test 31	Test 32	Test 33
e-terrasource 2.0.1	x	x	x	x	x	x	x
Neplan 5.4.5b	x	x	✓	x	x	✓	x
CRESO 6.30	x	x	x	x	x	x	x
SPIRA 6.33.1	x	x	x	x	x	x	x
SICRE 7.0	x	x	x	x	x	x	x
PowerFactory 14.1	x	✓	x	x	x	✓	x
TNA 1.8	x	x	x	x	✓	✓	x
Integral 7	x	x	x	x	x	x	x
Enterprise Gateway	✓	x	x	✓	✓	✓	✓
PSLF 18b	x	x	x	x	x	x	x
ISPEN 2.10	x	x	x	x	x	x	x
SCOPE 12.3	x	x	x	x	x	x	x
CIMPhony 2	x	x	x	✓	✓	✓	✓
ODMS 8.0.1.5	✓	✓	✓	✓	✓	✓	✓
PI-AF 2.000	x	x	x	x	x	x	x
SMS GDA Server 5.0	x	x	x	x	x	x	x

Above tables are based on the record forms completed during the IOP. Therefore it is recommended that individual test record forms (Appendix C) for each Product/Tool are checked in order to see the results from the interoperability.

EDF R&D successfully performed an unstructured test using Migration Converter 2.7 and the 1st edition of the ENTSO-E CIM Profile. This unstructured test covers data conversion from the UCTE ASCII data exchange format to ENTSO-E CIM Profile (1st edition).

Tests 19, 20, 21, 22, 23, 24, 25 and 26 were not performed by any of vendors due to the lack of test models.

All single test record forms that show complete information on files exchanged during the IOP and tool summary forms are available in Appendix C. The IOP files are available in the CIM user group web site (www.cimug.org).

3 SUMMARY OF IDENTIFIED ISSUES

3.1 ISSUES ADDRESSED TO IEC

ENTSO-E IOP identified the following issues that need to be further discussed within IEC WG13 and agreed among IEC members:

No	CIM Issues	ENTSO-E IOP Proposal
1	Switch class	"retained" attribute should be added to 61970-452 as required. ENTSO-E profile will also use this attribute.
2	Missing documentation for classes in the Dynamics package	MetaBlockConSignal, MetaBlockConnection MetaBlockConnectivity, MetaBlockOutputReference MetaBlockSignal, MeetaBlockState MetaBlockStateReference, GovCT2, GovDUM, GovGASM, GovGAST, GovGAST2, GovGASTWD, GovHydro0, GovHydro2, GovHydro3, GovHydro4, GovHydroDD, GovHydroPID, GovHydroPID2, GovHydroR, GovHydroWEH, GovHydroWPID, GovRAV, GovSteamCC, GovSteamEU, GovSteamFV2, GovSteamFV3, GovSteamSGO, GovWT1P, GovWT1T, GovWT2P, GovWT2T, GovWT3P, GovWT3T, GovWT4P, GovWT4T, TLCFB1, RotatingMachine.parametersFormType CEnumeration is not used: InputSignalCodeJ; IldBaseType
3	Dynamics package	<ul style="list-style-type: none"> - All attributes names should be looked at and follow naming rules except the names of the attributes in classes for standard models - Additional classes should be added when the package is extended. These classes are representing additional standard models. The classes or their function MotorSync, ProtectiveDevice, SourceModels, StaticVarDevice should be integrated in the package.
4	MAS in the header of SV in the assembled model	Required if the SV covers only one MAS and empty if SV covers more than one MAS.
5	ENTSO-E extension package	All attributes, classes, etc from this package should be added to CIM16. The association ReactiveCapabilityCurve.EquivalentInjection should be added as well.
6	GovCT1	The type of GovCT1.rSelect should be changed to an enumeration DroopSignalFeedbackType with enumValues:electricalPower, none, fuelValveStroke, governorOutput.
7	TransformerEnd class	The association TransformerEnd.BaseVoltage must be added in IEC 61970-452.
8	PowerTransformer class	A note in PowerTransformer class should be added to explain that the association PowerTransformer.BaseVoltage is not exchanged.
9	TapChanger class	The note " <i>The attribute ltcflag specifies whether or not a TapChanger has load tap changing capabilities. If the ltcFlag is true, the attributes "highStep", "lowStep", "neutralStep", and "normalStep" are all required</i> " should be deleted. The following attributes: "highStep", "lowStep",

		"neutralStep", and "normalStep" should be required.
10	ControlArea class	The association ControlArea.EnergyArea should be optional as it is used only for "operation" exchanges and not for "bus-branch" (planning) exchanges.
11	PhaseTapChangerNonLinear class	The attribute xMedian should be renamed to xMin.
12	SynchronousMachine class	The attributes xDirectTrans, xQuadSubtrans, xDirectSubtrans, xDirectSync, xQuadSync, xQuadTrans should have type "PU" instead of "Reactance"
13	EquivalentInjection class	Additional attributes should be added to represent extended ward.
14	EquivalentNetwork issue	The association EquivalentEquipment to EquivalentNetwork should be optional in IEC 61970- 452 and UML (official CIM).
15	File header	Difference model header. The header structure has changed since 2010, but the 552 does not provide the right format for the new header. According to IEC 61970-552, page 24, the header is embedded in the DifferenceModel statement. The IEC 61970-552 should be corrected so that header is parallel with the DifferenceModel statement.
16	Diagram layout (619170-453) - DiagramObject class	The documentation of the DiagramObject.rotation should specify the meaning of zero degrees and the rotation direction (clockwise/counter clockwise)
17	SvShortCircuit class	The class should be reconsidered. It is suggested to be deleted. It does not contain input data, only results, but it is unclear for which short-circuit settings the result values are given (single phase, 3-phase, etc.; max or min currents; short-circuit location, etc.).

3.2 PROFILE ISSUES

A few profile related issues were identified during the IOP. These issues apply on the 2nd edition of the ENTSO-E CIM Profile, IOP version issued on 7 July 2011. In the updated version of the 2nd edition of the ENTSO-E CIM Profile [3], issued on 31 July 2011, all issues described in this section **are corrected**.

The issues listed in the table below have been resolved during the IOP. The decision was taken among all IOP participants.

No	Profile Issues	ENTSO-E IOP decision
1	Diagram class	Name should inherit from IdentifiedObject.

2	The association ControlArea.EnergyArea	The note attached to the association should be shown in the html.
3	IdentifiedObject.name in Topology profile	IdentifiedObject.name should be required as it is in the IEC 61970-456.
4	ExternalNetwork class	The attribute maxZ0ToZ1ratio should be renamed to maxZ0ToZ1Ratio.
5	SynchronousMachine class	The attribute lkk should be renamed to ikk
6	Terminal class in Equipment profile	sequenceNumber is required for ACLineSegment in case of MutualCoupling and for EquivalentBranch. The note in the profile will be corrected. The attribute sequenceNumber is optional in the profile for all other classes, but it is recommended to exchange the sequenceNumber.
7	SynchronousMachine class	r, x, r0, r2, x0, x2 in PU. Other attributes of the SynchronousMachine which are in the DY profile and described in the [1] should be corrected as well.
8	ExternalNetwork class	Additional attributes governorSCD and referencePriority should be added. A reference to RegulatingControl should be added. maxP, minP, maxQ and minQ should be added as in EquivalentInjection.
9	EquivalentInjection class	The association to ReactiveCapabilityCurve should be deleted.
10	EnergyArea class	The class should be marked as operation.
11	EquivalentShunt class	The attributes which are ENTSO-E extensions should be deleted.
12	AsynchronousMachine.efficiency	The description of the attribute should be changed to: "Efficiency of the AsynchronousMachine at nominal operation in percent. Indicator for converter drive motors. Used for short circuit data exchange according to IEC 60909"
13	AsynchronousMachine.lockedRotorRatio	The description of the attribute should be changed to: "Locked rotor ratio (R/X). Used for short circuit data exchange according to IEC 60909"
14	AsynchronousMachine class	The attribute lockedRotorRatio should be renamed to rxLockedRotorRatio
15	AsynchronousMachine class	The following note should be added: "The attribute rxLockedRotorRatio is an optional attribute even if short circuit data is exchanged because IEC 60909 defines

		default values depending on motor size."
16	AsynchronousMachine class	The attribute nominalFrequency should be added as ENTSO-E extension. Description "Nominal frequency". CIM Datatype: Frequency
17	AsynchronousMachine class	The attribute nominalSpeed should be added as ENTSO-E extension. Description "Nominal speed". CIM Datatype: RotationSpeed
18	BusbarSection class	The following note should be added: "The attribute ipMax is an optional attribute even if short circuit data is exchanged, as not always entered by the user (e.g. the IEC 60909-4 example test model described in Chapter 6.2 of the standard does not include these values."
19	ExternalNetwork class	The following note should be added: "The attributes ikSecond and voltageFactor are optional attributes even if short circuit data is exchanged. These attributes are used only if short circuit calculations are done according to superposition method."
20	ExternalNetwork.ikSecond	The description of the attribute should be changed to: "Indicates whether initial symmetrical short-circuit current and power have been calculated according to IEC (Ik)".
21	ExternalNetwork.voltageFactor	The description of the attribute should be changed to: "Voltage factor in pu, which was used to calculate short-circuit current Ik and power Sk".
22	ExternalNetwork class	The attribute maxInitialSymShCPower should be deleted as it is redundant to maxInitialSymShCCurrent
23	ExternalNetwork class	The attribute minInitialSymShCPower should be deleted as it is redundant to minInitialSymShCCurrent
24	PowerTransformer.beforeShortCircuitAnglePf	The description of the attribute should be changed to: "The angle of power factor before short circuit (phib in the IEC 60909-0). It is used for calculation of the impedance correction factor KT defined in IEC 60909-0. This is the worst case power factor. Used to define operating conditions."
25	PowerTransformer.beforeShCircuitHighestOperatingCurrent	The description of the attribute should be changed to: "The highest operating current (Ib in the IEC 60909-0) before short circuit (depends on network configuration and relevant reliability philosophy). It is used for calculation of

		the impedance correction factor KT defined in IEC 60909-0."
26	PowerTransformer. beforeShCircuitHighestOperatingVoltage	The description of the attribute should be changed to: "The highest operating voltage (Ub in the IEC 60909-0) before short circuit. It is used for calculation of the impedance correction factor KT defined in IEC 60909-0. This is worst case voltage on the low side winding (Section 3.7.1 in the standard). Used to define operating conditions."
27	PowerTransformer. operationalValuesConsidered	The description of the attribute should be changed to: "It is used to define if the data (other attributes related to short circuit data exchange) defines long term operational conditions or not. Used for short circuit data exchange according to IEC 60909."
28	RotatingMachine	The attribute ratedP should be deleted.
29	AsynchronousMachine	New attribute - ratedP should be added as ENTSO-E extension, short-circuit. The description of the attribute is: "Rated mechanical power (Pr in the IEC 60909-0). Used for short circuit data exchange according to IEC 60909." CIM Datatype: ActivePower
30	RotatingMachine.ratedPowerFactor	The attribute should be only marked as ENTSO-E extension. The description of the attribute should be changed to: "Power factor (nameplate data). It is primarily used for short circuit data exchange according to IEC 60909."
31	RotatingMachine.ratedU	The attribute should be only marked as ENTSO-E extension. The description of the attribute should be changed to: "Rated voltage (nameplate data, Ur in IEC 60909-0) in kV. It is primarily used for short circuit data exchange according to IEC 60909."
32	SynchronousMachine.satDirectSubtransX	The description of the attribute should be changed to: "Direct-axis subtransient reactance saturated, also known as Xd"sat."
33	SynchronousMachine.satDirectSyncX	The description of the attribute should be changed to: "Direct-axes saturated synchronous reactance (xdsat); reciprocal of short-circuit ration. Used for short circuit data exchange, only for single fed short circuit on a generator. (Section 4.3.4.2. in the IEC 60909-0)."
34	SynchronousMachine class	The following note should be added: "The

		attribute satDirectTransX is not required for short circuit data exchange according to IEC 60909."
35	Enumeration SynchronousGeneratorType	<p>The following attributes should be added:</p> <ul style="list-style-type: none"> - turboSeries1; description: "Turbo Series 1 in the IEC 60909" - salientPole1; description: "Salient Pole 1 in the IEC 60909" <p>Because turboSeries1 and salientPole1 have been added to SynchronousGeneratorType, the following two notes have to be deleted</p> <ul style="list-style-type: none"> - "salientPole maps to salientPole1 in the IEC 60909 if short circuit data exchange" - "roundMotor maps to turboSeries1 in the IEC 60909 if short circuit data exchange"

4 CONCLUSIONS AND RECOMMENDATIONS

The conclusions of the ENTSO-E Interoperability test "CIM for System development and Operations" 2011 can be summarized as follows:

- Various vendors that provide tools for "system operational" environment as well as for "system planning" environment attended ENTSO-E IOP and demonstrated CIM compatibility using both 1st edition and the draft version of the 2nd edition of the ENTSO-E CIM Profile.
- The IOP successfully tested the most important features of the ENTSO-E CIM Profiles. Test procedures and test models were validated for further use.
- The 2nd edition of the ENTSO-E CIM profile has a wide scope and it is based on the latest IEC draft standards and fully covers all classes and definitions described in IEC 61970-452 (CPSM profile), 61970-456, 61970-453, etc. The profile was created in UML environment, which facilitates maintenance process.
- The outcome of the test and the final post IOP version of the 2nd edition of the ENTSO-E CIM profile developed in preparation stage are a solid basis for further ENTSO-E discussion in accordance with the ENTSO-E roadmap for future implementation of the updates to the ENTSO-E CIM profile. IOP participants acknowledged ENTSO-E decision process on implementation of the 2nd edition of the profile and expressed their support for shortening the implementation period (in case of positive ENTSO-E decision) so that the new 2nd edition of the profile becomes the official ENTSO-E data exchange format in the beginning of 2012.

- Important issues to be addressed to IEC/WG13 as well as profile related issues were identified and discussed. ENTSO-E IOP participants agreed on proposals to IEC/WG13 that are listed in this report.
- Complete interoperability between all tools could not be seen due to the large scope of the test and the large number of tools that have different level of development and different features that they support.
- ENTSO-E and ENTSO-E IOP participants expect that the following items will be treated with high priority and included in the updated version of IEC CIM Standards (items sorted by priority):
 - Update of the CIM standard in order to cover exchange of dynamics data. The process started with EPRI project "CIM for Dynamics" and the approach was tested again during ENTSO-E IOP. All deliverables should be implemented in the IEC standard and harmonised to have consistent CIM modelling. All additional standard models that are drafted should be included in the CIM and the UML finalized before the end of 2011 so that ENTSO-E IOP 2012 could be focused on dynamics data exchange covering the full scope of modelling approaches. Necessary elements to allow proper modelling of wind turbines and their control systems should be considered in this update. The liaison between IEC TC57 and TC88 should be used as much as possible in addition to ENTSO-E working groups.
 - CIM should allow adequate modelling of HVDC links and their controls.
 - Adequate methods for exchange of the specification of different profiles between existing tools should be agreed and standardized in order to allow error free interpretation of profile definitions by tools that create the profiles and validate instance data against these profiles.
 - Collection of use cases and covering exchanges between transmission and distribution systems is necessary in order to create an adequate data exchange profiles between transmission and distribution. These profiles should be linked as much as possible with existing profiles to avoid overlap of data exchanges.

The following recommendations to the future IOPs or CIM development in general were expressed:

- Continuous maintenance of the ENTSO-E profile is necessary in order to facilitate IOP preparation work.
- The profile to be used in the IOP should be fixed well ahead of the on-site test. In order to achieve this goal substantial commitment by vendors and IEC/WG13 is expected during the process of updating of IEC standards and revising the definitions in the draft versions of the profiles.

- IEC CIM standards should have stable development roadmap as much as possible. Features that have been already implemented and used in real data exchanges should be kept unchanged in case no significant problem is found. Necessary major changes should be properly documented and presented to wider auditory in order to receive wide acceptance ahead of issuing of the updated IEC CIM standards. This issue is critical for future ENTSO-E IOPs. It is expected that upcoming CIM16 will resolve the issues identified in the ENTSO-E IOP 2011 and will not change already existing approaches. Depending on the status of the CIM16 by the end of 2011 the profile for the ENTSO-E IOP 2012 could be based on the UML from IOP 2011 and take only necessary classes from CIM16 rather than migrating completely to CIM16.
- IEC, CIM user group and ENTSO-E should work in close cooperation to define CIM/XML test files that cover as much use cases as possible. It is preferable that these test files are referenced in the IEC CIM standards.
- Exchange of test models created by vendors is necessary in order to simulate exchanges of real data as much as possible. Each tool has its special functionalities that are often used by users during the real data exchanges to model different parts on the power system. The usage of different modelling approaches that are in most cases tool dependent creates difficulties when applying CIM in real data exchange in case the conversion process related to these specific functionalities have not been properly tested during an IOP. It is recommended that all vendors publish their test models valid for existing CIM profiles and maintain them.

5 REFERENCES

- [1] Reference Manual for Exchanging Standard Power System Dynamic Models: Based on the IEC 61970 Common Information Model (CIM). EPRI, Palo Alto, CA: 2009. 1020200.
- [2] ENTSO-E CIM Profile, ENTSO-E CIM Model Exchange, 1st edition version 10 May 2009 and the annex published after the ENTSO-E IOP 2011.
- [3] ENTSO-E CIM Profile, ENTSO-E CIM Model Exchange, 2nd edition, version 31 July 2011.

6 APPENDIX A: INFORMATION ON TOOLS TESTED/USED IN THE IOP

Appendix A is included as a separate file.

7 APPENDIX B: TEST PROCEDURES

Appendix B is included as a separate file.

8 APPENDIX C: TEST RECORD FORMS

Appendix C is included as a separate file.