Appendix A
Use Case Modeling for Smart Grids According to IEC/PAS 62559

Introduction to Use Case Modeling for Smart Grids

This chapter is based on both a project and a report the authors have prepared for the German DKE. The following aspects and requirements have been discussed and developed in German national standardization and are envisioned to be brought into the M490 mandate of the EC and the IEC SG 3 work.

Use cases were originally established for the purpose of identifying how a system behaves in relation to stakeholders. For CIM-based communications, the establishment of use cases is to document future scenarios of energy management systems. A uniform and structured documentation also provides a basis for communication between actors involved in system development, and the analysis of the use cases permits deduction of requirements for system development. Starting with the requirements defined, the conceptual design of data models, interfaces, exchange processes and protocols can take place afterwards. As the result of these efforts, the artifacts identified are to be studied with regard to their need for standardization and involvement in the standardization process.

With a sound base of use cases which cover large portions of the future energy systems that are relevant to standardization and with the resulting requirements, a basis for the design of interoperable technical solutions is created. Standardizing these solution concepts, finally, contributes to the establishment of a standards-based, open and interoperable architecture for a future energy system in which solutions from various manufacturers jointly implement the vision of a smart grid.

Alongside general use cases relevant to standardization as are described here, detailed use cases specific to individual companies and relevant to competition are necessary within those companies to enable them to develop solutions and sell them on the market. The recommendations presented in this annex are also, with some limitations, applicable to the description and management of company-specific use cases. The objective must be to support linking the two types of use cases in the long term, in order to enable companies to analyze their use cases in relation to relevant standards and, thus, promote standardization work and the development of interoperable technical solutions.

This appendix initially describes requirements for the compilation of use cases and presents recommendations in that regard. Then, on the basis of IEC/PAS 62559, a strategy for use case compilation is described and a template for use case compilation is outlined. For careful description and handling of various use cases, a classification system and conventions intended to support the process of use case identification are presented, followed by a five stage process for compilation and processing of use cases. In addition, the embedding of use cases in international standardization is outlined.

Requirements for Use Case Descriptions for the Smart Grid

Due to the complexity of the smart grid, and especially because of the large variety of both actors and systems, use case descriptions are to be used to create a common understanding for the development and identification of interfaces and data models. In this context, use case descriptions are to be established for various target groups, such as

- companies in the energy industry,
- IT manufacturers,
- equipment manufacturers,
- standardization organizations,
- legislators, and
- companies from other sectors than the energy industry.

This implies that use case descriptions for such an extensive group of stakeholders can only be established involving several participants with different background knowledge and viewpoints. Use case descriptions represent the central element for the description of requirements and the general functionality of systems, and they are to support cooperation between various experts (e.g. electrical engineers and IT experts), sectors of industry, organizations and committees. Furthermore, use cases form the basis of further standardization work and the design of interoperability and conformance tests. As a result of the complexity involved, clear methodology and classification and corresponding support by software tools and tool chains is required. National use case descriptions are also to be used to compile corresponding profiles for standards with the aim of refining international standards for use, for example, in Germany in relation to German regulatory requirements. In this context, the various levels of national and international standardization and the associated documents are to be observed.

In order to facilitate management of a large number of use case descriptions, possibly compiled by different persons with highly differing backgrounds, a structured, uniform description is necessary if consistent and structurally similar descriptions are to be created. A high level of quality and the opportunity to locate and retrieve use cases are required if the effort involved in their documentation is to be justified.

To provide for contributions to international standardization and to avoid additional consequential costs, it is advisable to present and discuss methods and model procedures for the compilation of use case descriptions in the various standardization organizations on the international level and canvass for their acceptance. This is address e.g. by the Use Cases and Sustainable processes team for the SG-CG M/490 mandate in Europe. User-friendliness of the methods is required, as are reasonable time and costs for compilation of the descriptions, especially as far as the compiler's time and the costs of the tools (TCO) are concerned.

From a technical point of view, the compilation of use cases is to be regarded as a collaborative task. In this respect, functionalities for multiple user operation and systems for the locking, commenting, release, revision tracking and version management of use cases are to be provided. In addition, further aspects such as multilingual capability could be of interest for using use cases and systems in international standardization and projects.

The large number of use cases to be expected gives rise to the following requirements:

- Organization systems: Provision of functionalities for classification, grouping, searching and navigation of use case descriptions.
- Consistency: In this regard, the objectives are to ensure uniform semantics and avoid redundancies. Both of these could, for example, be achieved by using a comprehensive model. It is also to be ensured that the descriptions are complete.

Ideally, the entire process of use case compilation should be supported from start to finish by a single integrated tool. As this usually can only be implemented at considerable cost, import and export from and to other applications should be supported.

General Recommendations on Use Case Compilation and Management

Compiling, updating and managing use cases is complex, especially with a large number of use cases. In this context, a suitable scope and the degree of detail are first to be specified and the descriptions limited. With regard to the requirements described in the previous section, the time and cost of compilation are to be minimized and the process is to be supported by software. It must be taken into account that, apart from the initial compilation of use cases, further use cases will have to be added and existing use cases adjusted. With regard to the maintenance of the use case collection, suitable criteria for classification have to be established. Attention has to be paid here to ensuring a relatively long-term applicability (resistance to change) of the criteria, so as to avoid regular reclassification.

In order to master the challenges associated with the compilation and management of use cases, it is recommended that the process be structured by implementation of the following measures:

- Use of conventions: Guidelines, for example, of naming conventions and particular UML diagrams for the presentation of graphic representations of the real-world.

- Limitation to the essentials: Avoidance of redundancies, for example, and reduction to relevant information only.
- Use of familiar/proven methods/approaches: E.g. relying on familiar/proven modeling languages such as UML.
- Tool support: Use of software tools to reduce manual work, especially for quality and consistency assurance.

In addition, the following procedure is proposed for the establishment of a strategy for use case compilation. It is strongly advisable to take previous related approaches, such as the following, into account.

- German Standardization Roadmap [12] in particular with its classification of standards.
- IEC/PAS 62559 IntelliGrid Methodology for Developing Requirements for Energy Systems [54]. This publication supplies a methodology with corresponding templates for the identification of requirements and description of use cases, and is to be adapted and refined with regard to national needs.
- Established approaches from academic research and practice: In this context, artifacts, methods and procedures are to be examined, for example reference models from the power sector, the catalogue of reference models for the energy industry (Energy-RMC) [22] (with regard to structuring), NIST [92] (domains), T&D Europe (overview) [16], Smart Grid.

Additionally, there is the opportunity for an exchange of information with other (standardization) organizations which are also dealing with the compilation of use cases for smart grids, for example to draw upon the work of the FG Smart group at ITU-T (International Telecommunication Union Standardization Sector).

Furthermore, to order and facilitate retrieval of the use case descriptions, a classification of use cases should be established. See the section entitled Organization and classification of use cases. In order to ensure a unified description of use cases by several editors, it is proposed that a template for use case writing be established, and several templates may possibly be required for different types of editors (e.g. managers, energy experts, IT experts, standardization experts or legislators). In general, the envisaged process of use case compilation and application has to be taken into account, as this should have corresponding effects on the nature of the classification criteria and templates.

The concepts, templates and classification criteria then established will certainly require iterative, continuous elaboration and adjustment. The adjustments required will, in the authors' experience, predominantly become obvious in the course of actual, practical use. Provision is to be made in advance for revisions to these central documents: These should preferably take place in the background, so as not to impede the use case compilers.

Strategy for Use Case Compilation

A number of conventions and guidelines are to be considered, especially if the management and use of various use cases from different authors and sources are to take place consistently. A conceptual description of central components in use case compilation is presented below.

The description of use cases is fundamentally to take place on the basis of IEC/-PAS 62559 [54]. In addition, the use of a central repository for a general template and various role-specific templates is recommended - for both enterprise and standardization use. The additions to IEC/PAS 62559 [54] are described in brief below:

- Central repository: Here, at a central location, various descriptions of, for instance, definitions, actors, conventions and relevant documents are to be stored. These elements are to be accessed and used accordingly during the compilation of use case descriptions.
- General template for use cases: This constitutes a complex, internal template which contains all the relevant attributes for all roles involved. For simplicity s sake, it is advisable to confront only use case experts and equivalent administrators with the general template. A role-specific template should be provided for normal use case compilers (see next point).
- Role-specific templates for use cases: Due to the complexity of use case compilation, specific templates should be established for each role and made available specifically to the various roles such as managers, energy experts, IT experts or editors/use case managers. Clarity for the use case compilers is ensured by the use of role-specific templates.

The structure of the central repository and that of the general template are roughly described below and the additions to IEC/PAS 62559 are presented.

Central Repository

The structure of the central repository is presented below, with the (German DKE) additions to the existing IEC/PAS 62559 accented in bold type.

- **Global Repository**
  - **Glossary**
    - **Terms, List of Roles (market roles / system roles), Actors List**, **Acronyms**
  - **Information Exchange**
    - **Data Objects, Data Protection Class,** Characteristics of Information Exchanges
  - **Structuring**
    - **Domains (spheres of action), General Use Case Scenarios, High-level Functions, Classification Criteria for Use Cases, Views for Use Cases**
  - **Documents**
    - **Resources**
  - **Methodology**
    - **Used Concepts / Conventions, Used Verbs**
  - **Process**
    - **Used roles within Use Case creation, Approval Status**

Template for Use Case Compilation

The structure of the use case template is described below, with the additions to IEC/PAS 62559 accented in bold type. The template is structured in two parts, a general part which contains attributes for rough description and a details part which supplements the former with more specific information, especially with regard to IT.

General:

1. Description of the User Requirements of a Function
1.1 Domain Experts
Area of Expertise, Change Description, Approval Status, Version, Date
1.2 Name of Function **+ ID and Naming conventions**
Short description (executive summary)
1.3 Scope and Objectives of Function
1.4 Narrative of Function **+ optional Diagram in UML**
1.5 Actors: People, Systems, Applications, Databases, Power System other Stakeholder **+ Market role and type of interaction**
1.6 Legal Issues: Contracts, Regulations, Policies and Constraints **+ Restriction Type, Reference**
Further Constraints: consideration of standards apart from legal documents
1.7 Preconditions and Assumptions, Post conditions and Events **+ Events / High-level functions**
Classification + support selection / identification of Use Cases
Notes + comments
2. Drawing or Diagram of Function **+ textual description**

Details:

3. Step by Step Analysis of Function
ID and name of activity
Short description of activity
3.1 Preconditions, Assumptions, **Post conditions and events (see general)**
3.2 Steps - Normal Sequence
Configuration, Quality of Service (QoS), Security, Data Management, Constraints and other (catch all) **+ Selection of information entries from repository**
3.3 Steps- Alternative, Error Management and / or Maintenance / Backup Sequences
Notes (comments)

Further Conventions/Requirements/Guidelines

It is to be ensured in the compilation of use cases that terms are used consistently and in a uniform manner. This particularly concerns the following entities, but is not limited to them.

- Actors
- Roles
- Classification criteria
- Structuring elements
- Elements of the reference architecture

It is recommended to use established and accepted terms rather than defining new terms. When new, previously non-existent terms are used, it is advisable to submit an application for acceptance of the terms to a use case manager who can decide on the adoption of the new term or can identify an existing term with an equivalent meaning which should be used in its place. Decisions on the adoption of individual terms should not be taken by individuals, but rather by consensus of several responsible persons to ensure an as intersubjective acceptance as possible.

To increase their comprehensibility and acceptance, use cases should be described in such a way that the description is as general and neutral as possible with regard to, for example, technologies, products, companies or projects. This point applies above all to the terms used in the description, for which terms established in the community (if available) should always be preferred to terms which are specific to companies, groups or projects. With regard to international acceptance, it is advisable to follow the guidelines of the IEC.

Furthermore, the stipulation of modeling languages and diagram types is to be recommended, so as to arrive at a uniform description with which, among other factors, easier and more rapid understanding by all those involved can be achieved. It may be possible to disregard the rules and conventions in order to remove obstacles in the compilation of use cases and to accelerate their initial creation, but compliance with those rules and conventions should be ensured by subsequent revision.

Organization and Classification of Use Cases

The organization and classification of use cases are important aspects enhancing the benefits of use case compilation, especially when there is a large number of use cases.

In this context, a distinction is to be made between the structuring of use cases on the one hand, which supports navigation and provides easy access to use cases for potential users, and classification criteria on the other hand, which are predominantly intended to facilitate the identification of use cases.

With regard to structuring, as in a tree diagram, the following hierarchy is proposed:

- Use case scenarios
  - Main function groups
    - Use case
      - Activities

In this regard, a use case is only to be assigned to one domain, while in contrast use case scenarios are to provide a cross-domain ordering characteristic.

The establishment of a structure or hierarchy can however only be usefully begun when several use cases have been compiled. In this respect it is to be ensured that the same degree of detail is maintained on each level wherever possible. An adjustment of the hierarchy will most probably become necessary in the course of time.

Process for General Use Case Compilation and Processing

The process of use case compilation up to elaboration for standardization purposes is divided into five phases which are described in more detail below. An overview of this process is shown in Figure A.1. The energy and IT experts perform the drafting of the use case based on practical experience in several steps. A core team, including in particular a use case manager, provides the necessary conventions and guidelines, and essentially performs an overall consistency and quality assurance function, together with editing of the use case and incorporating it in standardization. Finally, users can search for and identify the classified use cases which are relevant to their concerns.

A more detailed description of the individual roles, their requirements and functions, is presented in the next section, followed by a closer description of the individual phases of the process.

Roles in the Process of Use Case Compilation and Processing

In the following rough description of the roles involved in use case compilation, simplified distinctions are made between energy and IT experts and the core team. Furthermore, only a roughly outlined process is considered in the course of this annex, and the guidelines of the IEC have to be taken into account in further elaboration.

- **Energy expert:** Energy experts possess far-reaching expertise in a particular discipline and contribute substantive information to the use case. They identify new use cases and initiate use case compilation.
- **IT expert:** IT experts possess technical expertise above all in the ICT environment and as a rule only general, high-level knowledge of the energy field. They provide technical details for the use case and can estimate its feasibility in ICT terms.

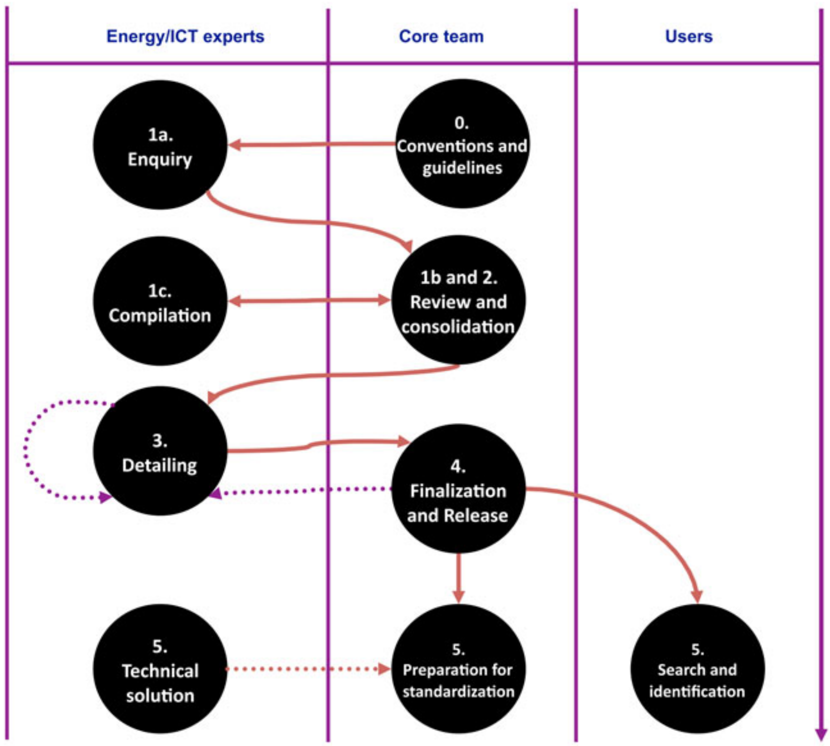

Fig. A.1 Process for use case compilation and processing

- **Core team:** The core team is composed of various experts with broad expertise covering a wide range of disciplines and is entrusted with use case compilation and the conventions involved. With their knowledge of the domain, they are responsible for assuring the quality of the contents and can assess the relevance of use cases. On account of their broad professional expertise spanning several areas of application they can classify the use case in a holistic context (assigning it, for instance, to a professional domain model or a reference architecture). There is at least one specific person in the core team who heads the team as the use case manager and communicates its decisions.

Above and beyond this, the core team includes standardization experts. These experts have outstanding knowledge of established standards and current standardization projects in various standardization organizations, and can assess and classify the relevance of new approaches in this field. Furthermore, they are familiar with the conventions and processes for submission of proposals to standardization organizations. The core team is assisted by use case administrators in the technical maintenance of the use case collection. Support from further persons, e.g. methods experts, is also conceivable.

Phase 0: Conventions and Guidelines

Objective: In this phase, conventions and guidelines which are to govern the use case compilation are established.

Procedure: The elaboration of conventions and guidelines with regard to use case compilation and management takes place within the core team. This comprises, for example, a uniformly structured template for use cases for various stakeholders, the structure of the central repository, classification of the use cases, and guidelines for instance with regard to graphical notations to be used. Recommendations on the conventions and guidelines and the motivation behind them have already been described in the previous sections.

Actors involved: Core team

Information required: Related approaches, target groups

Results: Conventions and guidelines for the use cases

Phase 1: Compilation

Objective: An initial version of the use case, which comprehensibly describes the planned use of a system and the stakeholders involved on a technical level is created in this phase. In addition, the quality of the content of the use case, its thematic relevance to existing use cases and lack of overlaps with them are to be ensured.

Procedure: Compilation or contribution of the initial use case is normally carried out by parties interested in standardization of various aspects of the use case and must be performed in accordance with IEC/PAS 62559 and/or the specific additions based upon it (cf. section entitled Template for use case compilation).

This first version of the use case is established by energy experts who identify the aims of the actors which are to be achieved by the use case. The energy expert describes the use case on the basis of a concrete example (ideally motivated by circumstances in practice), which should be kept as easily comprehensible as possible. The use case outline (step 1a) created up to this point is proposed to the core team which conducts a review and decides on the adoption and therefore further elaboration of the use case (step 1b). In this process, the thematic relevance of the use case in the context of the objective is examined and use cases with the same content are identified (with support by a software tool where appropriate). Should the aim dealt with by the use case be considered irrelevant or should use cases with the same or similar content exist, the use case managers can reject the use case or require sharpening up of the topic.

If the response of the core team is favorable, the use case is further elaborated on a technical basis. This comprises the identification of the actors involved in the use case and their unequivocal definition (if they are not as yet generally known).

Furthermore, restrictions (requirements) and references under which the use case takes place, and conditions and assumptions which must be fulfilled before the use case is performed, are defined.

Actors involved: Energy experts, core team

Information required: Concrete use case with need for technical support, list of defined actors, central repository

Results: Technical part of the use case (aims of the system, description of the use case, actors involved, restrictions and requirements, conditions and assumptions)

Phase 2: Review and Consolidation

Objective: In the consolidation phase, the terminology used and compliance with conventions etc. are reviewed, and amendments or additions made as necessary. Finally, a classification of the use case and its location in the overall context take place, so that efficient evaluation and identification are possible.

Procedure: The terminology, conventions etc. used in the technical part of the use case are reviewed and if necessary adjusted for conformity with the specified terminology. Terms not yet available in the central repository which represent essential new concepts in the use case can be included in the central repository if required.

The use case is then enhanced as required with diagrams as stipulated (e.g. particular UML diagrams - see also [17]) and existing, non-conforming diagrams are converted into a form which complies with the guidelines. This is intended to ensure the consistency of graphical notations throughout the collection of use cases and to contribute to ease of understanding for the readers.

Furthermore, possible references to laws or regulations and to standards and corresponding working groups which are relevant in the context of the use case are added at this stage.

The core team in its role of dealing with cross-cutting issues then finally classifies the use case on the basis of specified classification criteria (cf. section entitled Organization and classification of use cases).

Actors involved: Core team
Information required: Initial version of the use case from energy experts, central repository, list of actors
Results: Revised version of the technical part of the use case (adjusted terminology, references, classification)

Phase 3: Detailing

Objective: Addition of further details and workflows to the use case.

Procedure: The use case developed up to this point is provided with further detail in this phase. This is done by IT experts, who further refine the use case by adding and describing activities. These activities represent the individual steps of the use case, which have to be performed in a defined sequence to achieve the intended aim.

Over and above this, alternative sequences of the activities which may, for example, occur in the event of a fault, are also identified in this phase. Conditions and assumptions which are essential for the performance of the activity are also defined for the individual steps. The identification of the individual steps and alternative sequences may result in the necessity of introducing further steps, and so this detailing phase may have to be repeated, leading to an incremental refinement of the use case.

Actors involved: IT experts

Information required: Accepted, revised version of the use case from the use case managers, central repository, list of actors

Results: Detailed version of the use case (description of the individual activities in the use case)

Phase 4: Finalization and Release

Objective: Review of the use case and decision on further processing or release to go forward into standardization or for preparation for standardization and for the interested professional public.

Procedure: The use case, now detailed, is reviewed by the core team in this phase with regard to completeness, and once again for compliance with conventions. The terminology, conventions etc. used are checked and if necessary adjusted for conformity with the specified terminology. Terms not yet available in the central repository which represent essential new concepts in the use case can be included in the central repository if required.

The use case is enhanced as required with diagrams as stipulated (e.g. particular UML diagrams) and existing, non-conforming diagrams are converted into a form which complies with the guidelines. This is intended to ensure the consistency of graphical notations throughout the collection of use cases and to contribute to ease of understanding for the readers.

Furthermore, possible references to laws or regulations and to standards and corresponding working groups which are relevant in the context of the activities in the use case are added at this stage.

Finally, the use case is released by the use case managers for the further standardization process or the preparation process for standardization, or the use case is sent back for further processing (phase 3), so as to arrange for any changes by the IT experts.

Actors involved: Core team (especially use case manager)

Information required: Detailed version of the use case from the IT experts, central repository, list of actors

Results: Final version of the use case for the further standardization processes

Phase 5: Preparation for Standardization/Use/Identification

Objective: Extension of a use case for the relevant standardization organization and subsequent use for implementation. Additionally, identification of described use cases.

Procedure: From the finalized use cases and from any solutions which have already been developed by the energy and IT experts, the core team identifies parts to be standardized from which corresponding conceptual designs (e.g. for data modeling, interfaces, etc.) are derived, or parts to be standardized are proposed by energy and IT experts.

The standardization expert is given the task to prepare these IT parts and relevant parts of the use case and technical solution concept resulting from the requirements documented for a specific standardization organization. The use case is then prepared in accordance with the requirements of the standardization organization and goes forward into the further standardization process.

Users of the use cases can locate use cases relevant to them on the basis of the classification and use or implement the use cases and/or the resulting standards.

In the context of further use of standards, ranging up to implementation, the subsequent compilation of dedicated test use cases and standard profiles is conceivable. These are to be appropriately detailed to permit technical implementation or testing for interoperability where necessary.

Actors involved: Core team (especially standardization expert), energy and IT experts, use case users Information required: Final version of the use case from the core team, standardization organization to which the use case is to be submitted, and organization?s requirements for use cases

Results: Version of the use case prepared for the relevant standardization organization.

Appendix B
Basic Message Structure in XML Schema

Listing B.1 Basic message structure in XML Schema

```
<?xml version="1.0" encoding="utf-8"?>
<!-- Common Message Specification for ESB Integration via IEC 61968 -->
<xs:schema xmlns="http://www.iec.ch/TC57/2008/schema/message"
xmlns:xs="http://www.w3.org/2001/XMLSchema"
targetNamespace="http://www.iec.ch/TC57/2008/schema/message"
elementFormDefault="qualified" attributeFormDefault="unqualified"
version="1.0.0">
  <xs:complexType name="RequestType">
    <xs:annotation>
      <xs:documentation>Request type definition</xs:documentation>
    </xs:annotation>
    <xs:sequence>
      <xs:annotation>
        <xs:documentation>Request package is typically used to
        supply parameters for ’get’ requests</xs:documentation>
      </xs:annotation>
      <xs:element name="StartTime" type="xs:dateTime"
      minOccurs="0">
        <xs:annotation>
          <xs:documentation>Start time of
          interest</xs:documentation>
        </xs:annotation>
      </xs:element>
      <xs:element name="EndTime" type="xs:dateTime" minOccurs="0">
        <xs:annotation>
          <xs:documentation>End time of interest</xs:documentation>
        </xs:annotation>
      </xs:element>
      <xs:element name="Option" type="xs:string" minOccurs="0"
      maxOccurs="unbounded">
        <xs:annotation>
          <xs:documentation>Request type
          specialization</xs:documentation>
        </xs:annotation>
      </xs:element>
      <xs:element name="ID" type="xs:string" minOccurs="0"
      maxOccurs="unbounded">
        <xs:annotation>
          <xs:documentation>Object ID for
          request</xs:documentation>
        </xs:annotation>
      </xs:element>
      <xs:any namespace="##other" processContents="lax"
```

```
      minOccurs="0" maxOccurs="unbounded">
        <xs:annotation>
          <xs:documentation>This can be a CIM profile defined as an
          XSD with a CIM-specific namespace</xs:documentation>
        </xs:annotation>
      </xs:any>
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="ReplyType">
    <xs:annotation>
      <xs:documentation>Reply type definition</xs:documentation>
    </xs:annotation>
    <xs:sequence>
      <xs:annotation>
        <xs:documentation>Reply package is used to confirm success
        or report errors</xs:documentation>
      </xs:annotation>
      <xs:element name="ReplyCode" type="xs:string">
        <xs:annotation>
          <xs:documentation>Reply code: OK or application defined
          error code, such an IEC 61968-9
          enumeration</xs:documentation>
        </xs:annotation>
      </xs:element>
      <xs:element name="Error" type="ErrorType" minOccurs="0"
      maxOccurs="unbounded">
        <xs:annotation>
          <xs:documentation>Reply details describing one or more
          errors</xs:documentation>
        </xs:annotation>
      </xs:element>
      <xs:element name="ID" type="xs:string" minOccurs="0"
      maxOccurs="unbounded">
        <xs:annotation>
          <xs:documentation>Resulting transaction ID (usually
          consequence of create)</xs:documentation>
        </xs:annotation>
      </xs:element>
      <xs:any namespace="##other" processContents="lax"
      minOccurs="0" maxOccurs="unbounded" />
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="PayloadType">
    <xs:annotation>
      <xs:documentation>Payload container</xs:documentation>
    </xs:annotation>
    <xs:sequence>
      <xs:choice>
        <xs:any namespace="##other" processContents="skip"
        minOccurs="0" maxOccurs="unbounded">
          <xs:annotation>
            <xs:documentation>For XML payloads, usually CIM
            profiles defined using an XSD in a profile-specific
            namespace</xs:documentation>
          </xs:annotation>
        </xs:any>
        <xs:element name="Compressed" type="xs:string"
        minOccurs="0">
          <xs:annotation>
            <xs:documentation>For compressed and/or binary,
            uuencoded payloads</xs:documentation>
          </xs:annotation>
        </xs:element>
      </xs:choice>
      <xs:element name="format" type="xs:string" minOccurs="0">
        <xs:annotation>
          <xs:documentation>Hint as to format of payload, e.g. XML,
```

```
          RDF, SVF, BINARY, PDF, ...</xs:documentation>
        </xs:annotation>
      </xs:element>
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="ReplayDetectionType">
    <xs:annotation>
      <xs:documentation>Used to detect and prevent replay
      attacks</xs:documentation>
    </xs:annotation>
    <xs:sequence>
      <xs:element name="Nonce" type="xs:string" />
      <xs:element name="Created" type="xs:dateTime" />
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="UserType">
    <xs:annotation>
      <xs:documentation>User type definition</xs:documentation>
    </xs:annotation>
    <xs:sequence>
      <xs:element name="UserID" type="xs:string">
        <xs:annotation>
          <xs:documentation>User identifier</xs:documentation>
        </xs:annotation>
      </xs:element>
      <xs:element name="Organization" type="xs:string">
        <xs:annotation>
          <xs:documentation>User parent organization
          identifier</xs:documentation>
        </xs:annotation>
      </xs:element>
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="HeaderType">
    <xs:annotation>
      <xs:documentation>Message header type
      definition</xs:documentation>
    </xs:annotation>
    <xs:sequence>
      <xs:annotation>
        <xs:documentation>Message header contains control and
        descriptive information about the
        message.</xs:documentation>
      </xs:annotation>
      <xs:element name="Verb">
        <xs:annotation>
          <xs:documentation>This enumerated list of verbs that can
          be used to form message types in compliance with the IEC
          61968 standard.</xs:documentation>
        </xs:annotation>
        <xs:simpleType>
          <xs:restriction base="xs:string">
            <xs:enumeration value="cancel" />
            <xs:enumeration value="canceled" />
            <xs:enumeration value="change" />
            <xs:enumeration value="changed" />
            <xs:enumeration value="create" />
            <xs:enumeration value="created" />
            <xs:enumeration value="close" />
            <xs:enumeration value="closed" />
            <xs:enumeration value="delete" />
            <xs:enumeration value="deleted" />
            <xs:enumeration value="get" />
            <xs:enumeration value="show" />
            <xs:enumeration value="reply" />
            <xs:enumeration value="subscribe" />
            <xs:enumeration value="unsubscribe" />
```

```
      <xs:enumeration value="execute" />
      <xs:enumeration value="report" />
      <xs:enumeration value="stop" />
      <xs:enumeration value="terminate" />
    </xs:restriction>
  </xs:simpleType>
</xs:element>
<xs:element name="Noun" type="xs:string">
  <xs:annotation>
    <xs:documentation>The Noun of the Control Area identifies
    the main subject of the message type, typically a real
    world object defined in the CIM.</xs:documentation>
  </xs:annotation>
</xs:element>
<xs:element name="Revision" type="xs:string" minOccurs="0">
  <xs:annotation>
    <xs:documentation>Revision level of the message
    type.</xs:documentation>
  </xs:annotation>
</xs:element>
<xs:element name="ReplayDetection" type="ReplayDetectionType"
minOccurs="0" />
<xs:element name="Context" minOccurs="0">
  <xs:annotation>
    <xs:documentation>Intended context for information
    usage</xs:documentation>
  </xs:annotation>
  <xs:simpleType>
    <xs:restriction base="xs:string">
      <xs:enumeration value="PRODUCTION" />
      <xs:enumeration value="TESTING" />
      <xs:enumeration value="DEVELOPMENT" />
      <xs:enumeration value="STUDY" />
      <xs:enumeration value="TRAINING" />
    </xs:restriction>
  </xs:simpleType>
</xs:element>
<xs:element name="Timestamp" type="xs:dateTime"
minOccurs="0">
  <xs:annotation>
    <xs:documentation>Application level relevant time and
    date for when this instance of the message type was
    produced. This is not intended to be used by middleware
    for message management.</xs:documentation>
  </xs:annotation>
</xs:element>
<xs:element name="Source" type="xs:string" minOccurs="0">
  <xs:annotation>
    <xs:documentation>Source person or system that publishes
    the message</xs:documentation>
  </xs:annotation>
</xs:element>
<xs:element name="AsyncReplyFlag" type="xs:boolean"
minOccurs="0">
  <xs:annotation>
    <xs:documentation>Indicates whether or not reply should
    be asynchronous</xs:documentation>
  </xs:annotation>
</xs:element>
<xs:element name="ReplyAddress" type="xs:string"
minOccurs="0">
  <xs:annotation>
    <xs:documentation>Address to be used for asynchronous
    replies</xs:documentation>
  </xs:annotation>
</xs:element>
<xs:element name="AckRequired" type="xs:boolean"
```

```
      minOccurs="0">
        <xs:annotation>
          <xs:documentation>Indicates whether or not an
          acknowledgement is required</xs:documentation>
        </xs:annotation>
      </xs:element>
      <xs:element name="User" type="UserType" minOccurs="0">
        <xs:annotation>
          <xs:documentation>User information of the
          sender</xs:documentation>
        </xs:annotation>
      </xs:element>
      <xs:element name="MessageID" type="xs:string" minOccurs="0">
        <xs:annotation>
          <xs:documentation>Unique message ID to be used for
          tracking messages</xs:documentation>
        </xs:annotation>
      </xs:element>
      <xs:element name="CorrelationID" type="xs:string"
      minOccurs="0">
        <xs:annotation>
          <xs:documentation>ID to be used by applications for
          correlating replies</xs:documentation>
        </xs:annotation>
      </xs:element>
      <xs:element name="Comment" type="xs:string" minOccurs="0">
        <xs:annotation>
          <xs:documentation>Optional comment</xs:documentation>
        </xs:annotation>
      </xs:element>
      <xs:element name="Property" type="MessageProperty"
      minOccurs="0" maxOccurs="unbounded">
        <xs:annotation>
          <xs:documentation>Message properties can be used to
          identify information needed for extended routing and
          filtering capabilities</xs:documentation>
        </xs:annotation>
      </xs:element>
      <xs:any namespace="##other" processContents="lax"
      minOccurs="0" maxOccurs="unbounded" />
    </xs:sequence>
  </xs:complexType>
  <xs:element name="Message" type="MessageType">
    <xs:annotation>
      <xs:documentation>Common IEC 61968 Message
      Definition</xs:documentation>
    </xs:annotation>
  </xs:element>
  <xs:complexType name="MessageProperty">
    <xs:annotation>
      <xs:documentation>Message properties can be used for extended
      routing and filtering</xs:documentation>
    </xs:annotation>
    <xs:sequence>
      <xs:element name="Name" type="xs:string" />
      <xs:element name="Value" type="xs:string" minOccurs="0" />
    </xs:sequence>
  </xs:complexType>
  <xs:element name="RequestMessage" type="RequestMessageType">
    <xs:annotation>
      <xs:documentation>Request message
      structure</xs:documentation>
    </xs:annotation>
  </xs:element>
  <xs:element name="ResponseMessage" type="ResponseMessageType">
    <xs:annotation>
      <xs:documentation>Response message
```

```
      structure</xs:documentation>
    </xs:annotation>
  </xs:element>
  <xs:element name="FaultMessage" type="FaultMessageType">
    <xs:annotation>
      <xs:documentation>Fault message structure</xs:documentation>
    </xs:annotation>
  </xs:element>
  <xs:element name="EventMessage" type="EventMessageType">
    <xs:annotation>
      <xs:documentation>Event message structure</xs:documentation>
    </xs:annotation>
  </xs:element>
  <xs:complexType name="MessageType">
    <xs:annotation>
      <xs:documentation>Generic Message Type</xs:documentation>
    </xs:annotation>
    <xs:sequence>
      <xs:element name="Header" type="HeaderType" />
      <xs:element name="Request" type="RequestType"
      minOccurs="0" />
      <xs:element name="Reply" type="ReplyType" minOccurs="0" />
      <xs:element name="Payload" type="PayloadType"
      minOccurs="0" />
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="RequestMessageType">
    <xs:annotation>
      <xs:documentation>Request Message Type, which will typically
      result in a ResponseMessage to be returned. This isn
      typically used to initiate a transaction or a query
      request.</xs:documentation>
    </xs:annotation>
    <xs:sequence>
      <xs:element name="Header" type="HeaderType" />
      <xs:element name="Request" type="RequestType"
      minOccurs="0" />
      <xs:element name="Payload" type="PayloadType"
      minOccurs="0" />
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="ResponseMessageType">
    <xs:annotation>
      <xs:documentation>Response MessageType, typically used to
      reply to a RequestMessage</xs:documentation>
    </xs:annotation>
    <xs:sequence>
      <xs:element name="Header" type="HeaderType" />
      <xs:element name="Reply" type="ReplyType" />
      <xs:element name="Payload" type="PayloadType"
      minOccurs="0" />
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="FaultMessageType">
    <xs:annotation>
      <xs:documentation>Fault Messsage Type, which is used in cases
      where the incoming message (including the header) can not be
      parsed</xs:documentation>
    </xs:annotation>
    <xs:sequence>
      <xs:element name="Reply" type="ReplyType" />
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="EventMessageType">
    <xs:annotation>
      <xs:documentation>Event Message Type, which is used to
      indicate a condition of potential
```

```
      interest.</xs:documentation>
    </xs:annotation>
    <xs:sequence>
      <xs:element name="Header" type="HeaderType" />
      <xs:element name="Request" type="RequestType"
      minOccurs="0" />
      <xs:element name="Payload" type="PayloadType"
      minOccurs="0" />
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="ErrorType">
    <xs:annotation>
      <xs:documentation>Error Structure</xs:documentation>
    </xs:annotation>
    <xs:sequence>
      <xs:element name="level">
        <xs:annotation>
          <xs:documentation>Severity level</xs:documentation>
        </xs:annotation>
        <xs:simpleType>
          <xs:restriction base="xs:string">
            <xs:enumeration value="INFORM" />
            <xs:enumeration value="WARNING" />
            <xs:enumeration value="FATAL" />
            <xs:enumeration value="CATASTROPHIC" />
          </xs:restriction>
        </xs:simpleType>
      </xs:element>
      <xs:element name="code" type="xs:string">
        <xs:annotation>
          <xs:documentation>Application defined error
          code</xs:documentation>
        </xs:annotation>
      </xs:element>
      <xs:element name="xpath" type="xs:QName" minOccurs="0">
        <xs:annotation>
          <xs:documentation>XPath expression to identify specific
          XML element</xs:documentation>
        </xs:annotation>
      </xs:element>
      <xs:element name="details" type="xs:string" minOccurs="0">
        <xs:annotation>
          <xs:documentation>Free form text description of
          error</xs:documentation>
        </xs:annotation>
      </xs:element>
    </xs:sequence>
  </xs:complexType>
</xs:schema>
```

Appendix C
Customer Example Schema

Listing C.1 CustomerExample XML Schema generated from CIMTool

```
<?xml version="1.0" encoding="utf-8"?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
xmlns:a="http://langdale.com.au/2005/Message#"
xmlns:sawsdl="http://www.w3.org/ns/sawsdl"
xmlns="http://langdale.com.au/2005/Message#"
xmlns:m="http://iec.ch/TC57/2007/CustomerExample#"
targetNamespace="http://iec.ch/TC57/2007/CustomerExample#"
elementFormDefault="qualified" attributeFormDefault="unqualified">
  <xs:element name="CustomerExamples" type="m:CustomerExamples" />
  <xs:complexType name="CustomerExamples">
    <xs:sequence>
      <xs:element name="Customer" type="m:Customer" minOccurs="0"
      maxOccurs="unbounded" />
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="Customer"
  sawsdl:modelReference="http://iec.ch/TC57/CIM-generic#Customer">
    <xs:annotation>
      <xs:documentation>Organisation receiving services from
      ServiceSupplier.</xs:documentation>
    </xs:annotation>
    <xs:sequence>
      <xs:element name="mRID" type="xs:string"
      sawsdl:modelReference="http://iec.ch/TC57/CIM-generic#
                            IdentifiedObject.mRID">

        <xs:annotation>
          <xs:documentation>A Model Authority issues mRIDs. Given
          that each Model Authority has a unique id and this id is
          part of the mRID, then the mRID is globally
          unique.</xs:documentation>
        </xs:annotation>
      </xs:element>
      <xs:element name="name" type="xs:string"
      sawsdl:modelReference="http://iec.ch/TC57/CIM-generic#
                            IdentifiedObject.name">

        <xs:annotation>
          <xs:documentation>The name is a free text human readable
          name of the object. It may be non unique and may not
          correlate to a naming hierarchy.</xs:documentation>
        </xs:annotation>
      </xs:element>
      <xs:element name="postalAddress"
```

```
sawsdl:modelReference="http://iec.ch/TC57/CIM-generic#
                          Organisation.postalAddress">

  <xs:annotation>
    <xs:documentation>Postal address, potentially different
    than 'streetAddress' (e.g., another
    city).</xs:documentation>
  </xs:annotation>
  <xs:complexType sawsdl:modelReference=
                 "http://iec.ch/TC57/CIM-generic#
          PostalAddress">

    <xs:sequence>
      <xs:element name="postalCode" type="xs:string"
      sawsdl:modelReference="http://iec.ch/TC57/CIM-generic#
                              PostalAddress.postalCode">

        <xs:annotation>
          <xs:documentation>Postal code for the
          address.</xs:documentation>
        </xs:annotation>
      </xs:element>
      <xs:element name="streetDetail"
      sawsdl:modelReference="http://iec.ch/TC57/CIM-generic#
                              PostalAddress.streetDetail">

        <xs:annotation>
          <xs:documentation>Street detail.</xs:documentation>
        </xs:annotation>
        <xs:complexType sawsdl:modelReference=
                  "http://iec.ch/TC57/CIM-generic#StreetDetail">

          <xs:sequence>
            <xs:element name="name" type="xs:string"
            sawsdl:modelReference="http://iec.ch/TC57/CIM-generic#
                                    StreetDetail.name">

              <xs:annotation>
                <xs:documentation>Name of the
                street.</xs:documentation>
              </xs:annotation>
            </xs:element>
            <xs:element name="number" type="xs:string"
            sawsdl:modelReference="http://iec.ch/TC57/CIM-generic#
                                    StreetDetail.number">

              <xs:annotation>
                <xs:documentation>Designator of the specific
                location on the street.</xs:documentation>
              </xs:annotation>
            </xs:element>
          </xs:sequence>
        </xs:complexType>
      </xs:element>
      <xs:element name="townDetail"
      sawsdl:modelReference="http://iec.ch/TC57/CIM-generic#
                                    PostalAddress.townDetail">

        <xs:annotation>
          <xs:documentation>Town detail.</xs:documentation>
        </xs:annotation>
        <xs:complexType sawsdl:modelReference=
                          "http://iec.ch/TC57/CIM-generic#TownDetail">

          <xs:sequence>
            <xs:element name="name" type="xs:string"
            sawsdl:modelReference="http://iec.ch/TC57/CIM-generic#
```

```
                                                TownDetail.name">
                    <xs:annotation>
                      <xs:documentation>Town
                      name.</xs:documentation>
                    </xs:annotation>
                  </xs:element>
                </xs:sequence>
              </xs:complexType>
            </xs:element>
          </xs:sequence>
        </xs:complexType>
      </xs:element>
    </xs:sequence>
  </xs:complexType>
</xs:schema>
```

Appendix D
EndDeviceEvent Message Structure

Listing D.1 EndDeviceEvent message Structure

```
<?xml version="1.0" encoding="utf-8"?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
xmlns:a="http://langdale.com.au/2005/Message#"
xmlns:sawsdl="http://www.w3.org/ns/sawsdl"
targetNamespace="http://iec.ch/TC57/2009/EndDeviceEvents#"
elementFormDefault="qualified" attributeFormDefault="unqualified"
xmlns="http://langdale.com.au/2005/Message#"
xmlns:m="http://iec.ch/TC57/2009/EndDeviceEvents#">
  <xs:element name="EndDeviceEvents" type="m:EndDeviceEvents" />
  <xs:complexType name="EndDeviceEvents">
    <xs:sequence>
      <xs:element name="EndDeviceEvent" type="m:EndDeviceEvent"
      minOccurs="0" maxOccurs="unbounded" />
    </xs:sequence>
  </xs:complexType>
  <xs:complexType name="EndDeviceEvent"
  sawsdl:modelReference="http://iec.ch/TC57/CIM generic#
                        EndDeviceEvent">

    <xs:sequence>
      <xs:element name="mRID" minOccurs="0" maxOccurs="1"
      type="xs:string"
      sawsdl:modelReference="http://iec.ch/TC57/CIM-generic#
                            IdentifiedObject.mRID" />
      <xs:element name="category" minOccurs="1" maxOccurs="1"
      type="xs:string"
      sawsdl:modelReference="http://iec.ch/TC57/CIM-generic#
                            ActivityRecord.category" />
      <xs:element name="createdDateTime" minOccurs="1"
      maxOccurs="1" type="xs:dateTime"
      sawsdl:modelReference="http://iec.ch/TC57/CIM-generic#
                            ActivityRecord.createdDateTime" />
      <xs:element name="description" minOccurs="0" maxOccurs="1"
      type="xs:string"
      sawsdl:modelReference="http://iec.ch/TC57/CIM-generic#
                            IdentifiedObject.description" />
      <xs:element name="reason" minOccurs="0" maxOccurs="1"
      type="xs:string"
      sawsdl:modelReference="http://iec.ch/TC57/CIM-generic#
                            ActivityRecord.reason" />
      <xs:element name="severity" minOccurs="0" maxOccurs="1"
      type="xs:string"
      sawsdl:modelReference="http://iec.ch/TC57/CIM-generic#
                            ActivityRecord.severity" />
```

```
      <xs:element name="userID" minOccurs="0" maxOccurs="1"
      type="xs:string"
      sawsdl:modelReference="http://iec.ch/TC57/CIM-generic#
                            EndDeviceEvent.userID" />
      <xs:element name="Assets" minOccurs="1" maxOccurs="1"
      sawsdl:modelReference="http://iec.ch/TC57/CIM-generic#
                            ActivityRecord.Assets">

        <xs:complexType sawsdl:modelReference=
                        "http://iec.ch/TC57/CIM-generic#Asset">

          <xs:sequence>
            <xs:element name="mRID" minOccurs="1" maxOccurs="1"
            type="xs:string"
            sawsdl:modelReference="http://iec.ch/TC57/CIM-generic#
                                  IdentifiedObject.mRID" />
          </xs:sequence>
        </xs:complexType>
      </xs:element>
      <xs:element name="status" minOccurs="0" maxOccurs="1"
      sawsdl:modelReference="http://iec.ch/TC57/CIM-generic#
                            ActivityRecord.status">

        <xs:complexType sawsdl:modelReference=
                        "http://iec.ch/TC57/CIM-generic#Status">

          <xs:sequence>
            <xs:element name="dateTime" minOccurs="0" maxOccurs="1"
            type="xs:dateTime"
            sawsdl:modelReference="http://iec.ch/TC57/CIM-generic#
                                      Status.dateTime" />
            <xs:element name="reason" minOccurs="0" maxOccurs="1"
            type="xs:string"
            sawsdl:modelReference="http://iec.ch/TC57/CIM-generic#
                                      Status.reason" />
            <xs:element name="value" minOccurs="1" maxOccurs="1"
            type="xs:string"
            sawsdl:modelReference="http://iec.ch/TC57/CIM-generic#
                                      Status.value" />
          </xs:sequence>
        </xs:complexType>
      </xs:element>
    </xs:sequence>
  </xs:complexType>
</xs:schema>
```

Appendix E
Topology Example

Listing E.1 Complete RDF serialization for the topology example


```
<?xml version="1.0" encoding="iso-8859-1"?>
<rdf:RDF xmlns:cim="http://iec.ch/TC57/2008/CIM-schema-cim13#"
xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#">
  <cim:Substation rdf:ID="A_Z">
    <cim:IdentifiedObject.aliasName>Substation
    Z</cim:IdentifiedObject.aliasName>
    <cim:IdentifiedObject.name>Substation
    110kV/20kV</cim:IdentifiedObject.name>
  </cim:Substation>
  <cim:PowerTransformer rdf:ID="A_EF">
    <cim:Equipment.MemberOf_EquipmentContainer rdf:resource="#A_Z" />
    <cim:IdentifiedObject.name>Transformer
    EF</cim:IdentifiedObject.name>
    <cim:IdentifiedObject.mRID>2</cim:IdentifiedObject.mRID>
  </cim:PowerTransformer>
  <cim:TransformerWinding rdf:ID="A_EF1">
    <cim:TransformerWinding.connectionType rdf:resource=
    "http://iec.ch/TC57/2008/CIM-schema-cim13#WindingConnection.Y" />
    <cim:TransformerWinding.ratedS>
    40</cim:TransformerWinding.ratedS>
    <cim:TransformerWinding.ratedU>
    110</cim:TransformerWinding.ratedU>
    <cim:TransformerWinding.windingType rdf:resource=
    "http://iec.ch/TC57/2008/CIM-schema-cim13#WindingType.primary" />
    <cim:TransformerWinding.MemberOf_PowerTransformer rdf:resource="#A_EF" />
    <cim:IdentifiedObject.mRID>3</cim:IdentifiedObject.mRID>
  </cim:TransformerWinding>
  <cim:TransformerWinding rdf:ID="A_EF2">
    <cim:TransformerWinding.connectionType rdf:resource=
    "http://iec.ch/TC57/2008/CIM-schema-cim13#WindingConnection.Y" />
    <cim:TransformerWinding.windingType rdf:resource=
    "http://iec.ch/TC57/2008/CIM-schema-cim13#WindingType.secondary" />
    <cim:TransformerWinding.MemberOf_PowerTransformer rdf:resource="#A_EF" />
    <cim:TransformerWinding.ratedU>
    20</cim:TransformerWinding.ratedU>
  </cim:TransformerWinding>
  <cim:Terminal rdf:ID="A_T1">
    <cim:Terminal.ConductingEquipment rdf:resource="#A_EF2" />
    <cim:Terminal.ConnectivityNode rdf:resource="#A_CN1" />
  </cim:Terminal>
  <cim:ConnectivityNode rdf:ID="A_CN1"></cim:ConnectivityNode>
  <cim:Terminal rdf:ID="A_T2">
    <cim:Terminal.ConductingEquipment rdf:resource="#A_H" />
    <cim:Terminal.ConnectivityNode rdf:resource="#A_CN1" />
```

```
</cim:Terminal>
<cim:BusbarSection rdf:ID="A_H">
  <cim:Equipment.MemberOf_EquipmentContainer rdf:resource="#A_Z" />
  <cim:IdentifiedObject.name>Busbar H</cim:IdentifiedObject.name>
  <cim:IdentifiedObject.mRID>8</cim:IdentifiedObject.mRID>
</cim:BusbarSection>
<cim:Terminal rdf:ID="A_T3">
  <cim:Terminal.ConductingEquipment rdf:resource="#A_A1" />
  <cim:Terminal.ConnectivityNode rdf:resource="#A_CN1" />
</cim:Terminal>
<cim:Line rdf:ID="A_A">
  <cim:IdentifiedObject.name>Line A</cim:IdentifiedObject.name>
  <cim:IdentifiedObject.mRID>34</cim:IdentifiedObject.mRID>
</cim:Line>
<cim:ACLineSegment rdf:ID="A_A1">
  <cim:Conductor.length>2500</cim:Conductor.length>
  <cim:Conductor.r>0.3125</cim:Conductor.r>
  <cim:Conductor.x>0.28</cim:Conductor.x>
  <cim:Conductor.bch>235.45</cim:Conductor.bch>
  <cim:Equipment.MemberOf_EquipmentContainer rdf:resource="#A_A" />
  <cim:IdentifiedObject.name>Line A1</cim:IdentifiedObject.name>
  <cim:IdentifiedObject.mRID>10</cim:IdentifiedObject.mRID>
</cim:ACLineSegment>
<cim:Terminal rdf:ID="A_T5">
  <cim:Terminal.ConductingEquipment rdf:resource="#A_A1" />
  <cim:Terminal.ConnectivityNode rdf:resource="#A_CN2" />
</cim:Terminal>
<cim:ConnectivityNode rdf:ID="A_CN2"></cim:ConnectivityNode>
<cim:Terminal rdf:ID="A_T6">
  <cim:Terminal.ConductingEquipment rdf:resource="#A_A2" />
  <cim:Terminal.ConnectivityNode rdf:resource="#A_CN2" />
</cim:Terminal>
<cim:ACLineSegment rdf:ID="A_A2">
  <cim:Conductor.length>2500</cim:Conductor.length>
  <cim:Conductor.r>0.3125</cim:Conductor.r>
  <cim:Conductor.x>0.28</cim:Conductor.x>
  <cim:Conductor.bch>235.45</cim:Conductor.bch>
  <cim:Equipment.MemberOf_EquipmentContainer rdf:resource="#A_A" />
  <cim:IdentifiedObject.name>Line A2</cim:IdentifiedObject.name>
  <cim:IdentifiedObject.mRID>14</cim:IdentifiedObject.mRID>
</cim:ACLineSegment>
<cim:Terminal rdf:ID="A_T8">
  <cim:Terminal.ConductingEquipment rdf:resource="#A_A2" />
  <cim:Terminal.ConnectivityNode rdf:resource="#A_CN3" />
</cim:Terminal>
<cim:ConnectivityNode rdf:ID="A_CN3"></cim:ConnectivityNode>
<cim:Terminal rdf:ID="A_T7">
  <cim:Terminal.ConductingEquipment rdf:resource="#A_K" />
  <cim:Terminal.ConnectivityNode rdf:resource="#A_CN3" />
</cim:Terminal>
<cim:BusbarSection rdf:ID="A_K">
  <cim:IdentifiedObject.name>Busbar K</cim:IdentifiedObject.name>
  <cim:IdentifiedObject.mRID>18</cim:IdentifiedObject.mRID>
</cim:BusbarSection>
<cim:Terminal rdf:ID="A_T9">
  <cim:Terminal.ConductingEquipment rdf:resource="#A_B" />
  <cim:Terminal.ConnectivityNode rdf:resource="#A_CN3" />
</cim:Terminal>
<cim:ACLineSegment rdf:ID="A_B">
  <cim:Conductor.length>3000</cim:Conductor.length>
  <cim:Conductor.r>0.375</cim:Conductor.r>
  <cim:Conductor.x>0.336</cim:Conductor.x>
  <cim:Conductor.bch>282.75</cim:Conductor.bch>
  <cim:IdentifiedObject.name>Line B</cim:IdentifiedObject.name>
  <cim:IdentifiedObject.mRID>20</cim:IdentifiedObject.mRID>
</cim:ACLineSegment>
<cim:Terminal rdf:ID="A_T10">
```

```
    <cim:Terminal.ConductingEquipment rdf:resource="#A_B" />
    <cim:Terminal.ConnectivityNode rdf:resource="#A_CN4" />
  </cim:Terminal>
  <cim:ConnectivityNode rdf:ID="A_CN4"></cim:ConnectivityNode>
  <cim:Terminal rdf:ID="A_T11">
    <cim:Terminal.ConductingEquipment rdf:resource="#A_L" />
    <cim:Terminal.ConnectivityNode rdf:resource="#A_CN4" />
  </cim:Terminal>
  <cim:BusbarSection rdf:ID="A_L">
    <cim:IdentifiedObject.name>Busbar L</cim:IdentifiedObject.name>
    <cim:IdentifiedObject.mRID>24</cim:IdentifiedObject.mRID>
  </cim:BusbarSection>
  <cim:Terminal rdf:ID="A_T12">
    <cim:Terminal.ConductingEquipment rdf:resource="#A_C" />
    <cim:Terminal.ConnectivityNode rdf:resource="#A_CN4" />
  </cim:Terminal>
  <cim:ACLineSegment rdf:ID="A_C">
    <cim:Conductor.length>300</cim:Conductor.length>
    <cim:Conductor.r>0.0375</cim:Conductor.r>
    <cim:Conductor.x>0.0336</cim:Conductor.x>
    <cim:Conductor.bch>28.275</cim:Conductor.bch>
    <cim:IdentifiedObject.name>Line C</cim:IdentifiedObject.name>
    <cim:IdentifiedObject.mRID>26</cim:IdentifiedObject.mRID>
  </cim:ACLineSegment>
  <cim:Terminal rdf:ID="A_T13">
    <cim:Terminal.ConductingEquipment rdf:resource="#A_C" />
    <cim:Terminal.ConnectivityNode rdf:resource="#A_CN5" />
  </cim:Terminal>
  <cim:ConnectivityNode rdf:ID="A_CN5"></cim:ConnectivityNode>
  <cim:Terminal rdf:ID="A_T14">
    <cim:Terminal.ConductingEquipment rdf:resource="#A_M" />
    <cim:Terminal.ConnectivityNode rdf:resource="#A_CN5" />
  </cim:Terminal>
  <cim:BusbarSection rdf:ID="A_M">
    <cim:IdentifiedObject.name>Busbar M</cim:IdentifiedObject.name>
    <cim:IdentifiedObject.mRID>30</cim:IdentifiedObject.mRID>
  </cim:BusbarSection>
  <cim:Terminal rdf:ID="A_T15">
    <cim:Terminal.ConductingEquipment rdf:resource="#A_D" />
    <cim:Terminal.ConnectivityNode rdf:resource="#A_CN5" />
  </cim:Terminal>
  <cim:ACLineSegment rdf:ID="A_D">
    <cim:Conductor.length>2000</cim:Conductor.length>
    <cim:Conductor.r>0.25</cim:Conductor.r>
    <cim:Conductor.x>0.224</cim:Conductor.x>
    <cim:Conductor.bch>188.496</cim:Conductor.bch>
    <cim:IdentifiedObject.name>Line D</cim:IdentifiedObject.name>
    <cim:IdentifiedObject.mRID>32</cim:IdentifiedObject.mRID>
  </cim:ACLineSegment>
  <cim:Terminal rdf:ID="A_T4">
    <cim:Terminal.ConductingEquipment rdf:resource="#A_D" />
    <cim:Terminal.ConnectivityNode rdf:resource="#A_CN1" />
    <cim:IdentifiedObject.mRID>33</cim:IdentifiedObject.mRID>
  </cim:Terminal>
</rdf:RDF>
```

Appendix F
Description of Message Type Verbs

The following table shows commonly used Verbs in IEC 61968 (originally taken from IEC 61968-9 [57])

Proposed Verbs	Meaning	Message Body
CREATE	The CREATE verb is used to submit a request to the master system to create a new document. The master system may in turn publish the new document using the verb CREATED. The master system may also use the verb REPLY to response to the CREATE request, indicating whether the request has been processed successfully or not.	Header, Payload
UPDATE	The UPDATE verb is used to submit a request to the master system to make a change in the document based on the information in the message. The master system may in turn publish the changed document using the verb UPDATED to notify that the document has been changed since last published. The master system will use the verb REPLY to response to the UPDATE request, indicating whether the request has been processed successfully or not.	Header, Payload
CHANGE	Synonym for UPDATE	Header, Payload

CANCEL	The CANCEL verb is used to submit a request to the master system to cancel the document. The master system may in turn publish the cancelled message using the verb CANCELED to notify that the document has been cancelled since last published. The master system will use the verb REPLY to respond to the CANCEL request, indicating whether the request has been processed successfully or not. The CANCEL verb is used when the business content of the document is no longer valid due to error(s).	Header, Request
CLOSE	The CLOSE verb is used to submit a request to the master system to close the document. The master system may in turn publish the closed message using the verb CLOSED to notify that the document has been closed since last published. The master system will use the verb REPLY to response to the CLOSE request, indicating whether the request has been processed successfully or not. The CLOSE verb is used when the business document reaches the end of its life cycle due to successful completion of a business process.	Header, Request
DELETE	The DELETE verb is used to submit a request to the master system to delete the document. The master system may in turn publish the closed message using the verb DELETED to notify that the document has been deleted since last published. The master system may also use the verb REPLY to response to the DELETE request, indicating whether the request has been processed successfully or not. The DELETE verb is used when the business document should no longer be kept in the integrated systems either due to error(s) or due to archiving needs.	Header, Request

GET	The GET verb is used to submit a query request to the master system to get the current data for a given document reference code or a set of documents. The master system will use the verb REPLY to respond to the GET request.	Header, Request
CREATED	The CREATED verb is used to publish the creation of a document as a result of either an external request or an internal action within the master system of that document. This is the first time that data for this document reference code has been published as the result of internal or external request; in which case, it would use the same document reference as the CREATE message. This message type is usually subscribed by interested systems and could be used for mass updates. There is no need to reply to this message type.	Header, Payload
UPDATED	The UPDATED verb is used to publish events related to the change of a document as a result of either an external request or an internal action within the master system of that document. This could be a generic change in the content of the document or a specific status change such as "‘approved"’, "‘issued"’ etc. This message type is usually subscribed by interested systems and could be used for mass updates. There is no need to reply to this message type.	Header, Payload
CHANGED	Treat as a synonym with UPDATED	Header, Payload
CLOSED	The CLOSED verb is used to publish events related to the normal closure of a document as a result of either an external request or an internal action within the master system of that document. This message type is usually subscribed by interested systems and could be used for mass updates. There is no need to reply to this message type.	Header, Payload

CANCELED	The CANCELED verb is used to publish the cancellation of a document as a result of either an external request or an internal action within the master system of that document. This message type is usually subscribed by interested systems and could be used for mass updates. There is no need to reply to this message type.	Header, Payload
DELETED	The DELETED verb is used to publish the deletion of a document as a result of either an external request or an internal action within the master system of that document. This message type is usually subscribed by interested systems and could be used for mass updates. There is no need to reply to this message type.	Header, Payload
SHOW	Synonym to REPLY, may be deprecated.	Header, Reply, Payload
REPLY	The REPLY verb is used to return the processing result of a request for a CREATE, UPDATE, DELETE, CANCEL or CLOSE.	Header, Reply, Payload
SUBSCRIBE	The SUBSCRIBE verb is used to indicate a subscription for a type of information identified by the noun. This is realized within the integration infrastructure (e.g. JMS).	Not implemented
UNSUBSCRIBE	The UNSUBSCRIBE verb is used to indicate the termination of a subscription for a type of information identified by the noun. This is realized within the integration infrastructure (e.g. JMS).	Not implemented

Glossary

API. An application programming interface (API) is a particular interface provided to allow other software systems to access functionality of a specific system. A potential API defines, for instance, the data types that can be exchanged, dedicated functionality and how it can be used in context.

Advanced Metering Infrastructure (AMI). Advanced Metering Infrastructure are systems that typically measure, collect and analyze energy (most of the times, gas, heat or electricity) usage, and communicate with metrological devices such as electricity, gas, heat, and water meters, either on request, real-time or on a fixed schedule (which can differ from quarter of an hour to annual). The systems include hardware, software, communications, consumer energy displays and controllers, customer associated systems, Meter Data Management (MDM) software, and supplier business systems.

CENELEC. CENELEC (French: Comité Européen de Normalisation Électrotechnique) is the European Committee for Electrotechnical Standardization. It is responsible for European Standardization in the area of electrical engineering. Together with the ETSI (telecommunication) and CEN (other technical areas), CENELEC forms the European system for Standardization.

CIM users Group (CIMug). The CIM Users Group is dedicated to the promotion of the portability of existing applications and to the promotion of the ease of installation of new applications through the use of such standards as the common information model, message bus, and common data access specification. The CIM Users Group is under the administrative umbrella of the UCA International Users Group, a not-for-profit corporation.

Combined Heat and Power (CHP). Cogeneration (also called combined heat and power, CHP) is the use of a heat engine or a power station to simultaneously generate both electricity and useful heat. All power plants emit a certain amount of heat during electricity generation. This can be released into the natural environment through cooling towers, flue gas, or by other means. By contrast, CHP captures the by-product heat for heating purposes, either very close to the plant, or as hot water for district heating with temperatures ranging from approximately 80 to 130 degree Celsius. Small CHP plants are an example of decentralized energy resources.

COmpanion Specification for Energy Metering (COSEM). COSEM or Companion Specification for Energy Metering, includes a set of specifications that defines the Transport and Application Layers of the DLMS protocol.

Cyber Security. Cyber security is a branch of computer technology also known as Information Security as applied to computers and networks. The objective of cyber security includes protection of information and property from theft, corruption, or natural disaster, while allowing the information and property to remain accessible and productive to its intended users.

Decentralized Energy Resources (DER). Distributed generation, also called onsite generation, dispersed generation, embedded generation, decentralized generation, decentralized energy or distributed energy, generates electricity from many small energy sources.

Demand response. In electric smart grids, demand response (DR) is similar to dynamic demand mechanisms to manage customer consumption of electricity in response to supply conditions, for example, having electricity customers reduce their consumption at critical times or in response to market prices.

Device Language Message specification (DLMS). DLMS or Device Language Message Specification (originally Distribution Line Message Specification), is the suite of standards developed and maintained by the DLMS User Association and has been co-opted by the IEC TC13 WG14 into the IEC 62056 series of standards.

Distribution grid. The transport of generator-produced electric energy to loads is done by the grid. An electric power transmission system interconnects generators and loads and generally provides multiple paths among them. Multiple paths increase system reliability because the failure of one line does not cause a system failure. With operating voltages less than 34.5 kV, the distribution system carries energy from the local substation to individual households, using both overhead and underground lines.

Distribution system operator(DSO). A natural or legal person responsible for operating, ensuring the maintenance of and, if necessary, developing the local distribution system in a given area and, where applicable, its interconnections with other systems and for ensuring the long-term ability of the system to meet reasonable demands for the distribution of electricity. Moreover, the DSO is in most regulatory regimes responsible for regional grid access and grid stability, integration of renewables at the distribution level and regional load balancing.

DMS. The term distribution management system coins an energy management system which has to optimize, track and run the operations and optimizations in the so called distribution grid which has to be operated different than the so called transmission grid.

Domain ontology. A domain ontology (or domain-specific ontology) models a specific domain, which represents part of the world. Particular meanings of terms applied to that domain are provided by domain ontology.

E-Energy. E-Energy - Smart Grids made in Germany is a funding program of the Federal Ministry of Economics and Technology (BMWi) in an inter-ministerial partnership with the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). Climate change, the rapid surge in energy demand and dwindling natural resources present Germany with major challenges in the field of energy supply. Industry and politics must work hand in hand in future to secure an economical and environmentally compatible supply of power for all public and private sectors.

Electric Power Research Institute (EPRI). The Electric Power Research Institute (EPRI) conducts research on issues related to the electric power industry in USA. EPRI is a nonprofit organization funded by the electric utility industry. EPRI is primarily a US based organization, receives international participation. EPRI's area covers different aspects of electric power generation, delivery and its use.

Electric Vehicles (EV). An electric vehicle (EV), also referred to as an electric drive vehicle, uses one or more electric motors or traction motors for propulsion. Three main types of electric vehicles exist, those that are directly powered from an external power station, those that are powered by stored electricity originally from an external power source, and those that are powered by an on-board electrical generator, such as an engine (a hybrid electric vehicle), or a hydrogen fuel cell.

Enterprise application integration (EAI). Enterprise Application Integration (EAI) is a concept to integrate business related functions across enterprises using software and computer systems. This involves an architectural approach planning required applications and considering for instance data and business processes.

EMS. An energy management system (EMS) is a system of computer-aided tools used by operators of electric utility grids to monitor, control, and optimize the performance of the generation and/or transmission system. The monitor and control functions are known as SCADA; the optimization packages are often referred to as "advanced applications".

Enterprise Resource Planning (ERP). Enterprise resource planning (ERP) integrates internal and external management information across an entire organization, embracing finance/accounting, manufacturing, sales and service, customer relationship management, etc. ERP systems automate this activity with an integrated software application.

ESB. An enterprise service bus (ESB) is a software abstraction layer used to integrate usually distributed and heterogeneous services in Service Oriented Architectures. It is usually based on message-oriented solutions and provides for example routing mechanisms, data transformation and services registries.

Flexible Alternating Current Transmission System (FACTS). A flexible alternating current transmission system (FACTS) is a system composed of static equipment used for the AC transmission of electrical energy. It is meant to enhance controllability and increase power transfer capability of the network. It is generally a power electronics-based system.

Geographic information system (GIS). Geographic information system (GIS), geographical information system, or geospatial information system are systems designed to capture, store, manipulate, analyze, manage, and present all types of geographically referenced data. In the simplest term, GIS is the merging of cartography, statistical analysis, and database technology.

High-Voltage Direct Current (HVDC). A high-voltage, direct current (HVDC) electric power transmission system uses direct current for the bulk transmission of electrical power, in contrast with the more common alternating current systems. For long-distance transmission, HVDC systems may be less expensive and suffer lower electrical losses.

Home automation. Home automation is the residential extension of "industrial building automation". It is automation of the home, housework or household activity. Home automation may include centralized control of lighting, HVAC (heating, ventilation and air conditioning), appliances, and other systems, to provide improved convenience, comfort, energy efficiency and security.

IEC. The International Electrotechnical Commission (IEC) is a non-profit, non-governmental international standards organization that prepares and publishes International Standards for all electrical, electronic and related technologies ? collectively known as "electrotechnology".

IEEE. The Institute of Electrical and Electronics Engineers (IEEE) is a non-profit professional association dedicated to advancing technological innovation related to electricity.

Information and Communication Technologies (ICT). ICT is used as a general term for all kinds of technologies which enable users to create, access and manipulate information. ICT is a combination of information technology and communications technology. In an increasingly interconnected world, the interactions among devices, systems, and people are growing rapidly.

Intelligent Electronic Device (IED). An Intelligent Electronic Device (IED) is a term used in the electric power industry to describe microprocessor-based controllers of power system equipment, such as circuit breakers, transformers, and capacitor banks.

Internet of Energy. As with the Internet of Things, also the corresponding concept of the Internet of Energy has been coined by various stakeholders being the combination of ICT and field automation for power grid management.

ISO. The International Organization for Standardization, widely known as ISO, is an international standard-setting body composed of representatives from various national standards organizations. Founded on February 23, 1947, the organization promulgates worldwide proprietary industrial and commercial standards.

Legacy processes. Processes are considered legacy processes if new systems using EAI technologies must be integrated with those processes in terms of function coupling at migration level.

Load. If an electric circuit has a well-defined output terminal, the circuit connected to this terminal (or its input impedance) is the so called load.

Microgrid. A microgrid is a often considered a localized grouping of both electricity generation and energy storage, alongside loads that normally operates connected to a traditional, more centralized grid (so called macrogrid). This single point of common coupling with the macrogrid can be disconnected without interrupting supply security. The microgrid can function autonomously afterwards.

OPC UA. OPC Unified Architecture is the most recent OLE for process control (OPC) specification from the OPC Foundation and differs significantly from its predecessors.

Peak load. In the United States, this often occurs in the afternoon, especially during the summer months when the air conditioning load is high. The peak power load generally occurs when people return home from work, start cooking dinner, and turn up the air conditioning. During this time many workplaces are still open and consuming power.

Power transmission. Power transmission is the movement of energy from its place of generation to a location where it is applied to performing useful work.

Prosumer. Prosumer is a word formation consisting of the word professional or sometimes producer and the word consumer.

RDF. The Resource Description Framework (RDF) is defined by a set of W3C recommendations and is originally intended to serve as a standard model for meta data interchange on the world wide web using a graph-based structure. RDF data can be expressed in various formats, as e.g. XML, Turtle or N3.

Regulation. Regulation is administrative legislation that constitutes or constrains rights and allocates responsibilities. It can be distinguished from primary legislation (by Parliament or elected legislative body) on the one hand and judicial decisions on the other hand.

Requirements. In engineering, a requirement is a singular documented need of what a particular product or service should be or perform. It is most commonly used in a formal sense in systems engineering, software engineering, or enterprise engineering. It is a statement that identifies a necessary attribute, capability, characteristic, or quality of a system in order for it to have value and utility to a user.

SIA. The Seamless Integration Architecture SIA by the IEC TC 57 is the general architecture picture taking into account the layered model of existing and future IEC TC 57 standards.

SCADA. SCADA (supervisory control and data acquisition) generally refers to industrial control systems: computer systems that monitor and control industrial, infrastructure, or facility-based processes

SOA. Service-oriented architecture (SOA) is a flexible set of design principles used during the phases of systems development and integration in computing. A system based on a SOA will package functionality as a suite of interoperable services that can be used within multiple, separate systems from several business domains.

SOAP. Once known as Simple Object Access Protocol, SOAP is no longer an acronym. SOAP is used as an envelop within web services for payload delivery.

Smart Grid. A Smart grid is a type of electrical grid which attempts to predict and intelligently respond to the behaviour and actions of all electric power users connected to it - suppliers, consumers and those that do both ? in order to efficiently deliver reliable, economic, and sustainable electricity services.

Substation Automation. Substation automation refers to using data from Intelligent electronic devices (IED), control and automation capabilities within the substation, and control commands from remote users to control power system devices.

TC. A TC is a so called technical committee within IEC which is a group formed by IEC with corresponding subgroups which are reponsible for created certain standards.

Tele-control. The IEC 60870 part 5 provides a communication profile for sending basic tele-control messages between two systems, which uses permanent directly connected data circuits between the systems.

Transmission grid. The transport of generator-produced electricity to loads is done by a grid. An electric power transmission system connects generators and loads and, generally, provides multiple paths for routing among them. Multiple paths increase system reliability because the failure of one line does not cause a system failure.With operating voltage exceeding 230 kV, the transmission system interconnects generating stations and large substations located close to load centers by using overhead lines.

Transmission system operator(TSO). A transmission system operator (TSO) is an entity entrusted with transporting energy in the form of natural gas, heat and/or electrical power on a national or regional level, using a fixed, often un-bundled infrastructure.

UCA. The UCAIug as well as its member groups (CIMug, OpenAMI, and IEC61850) draws its membership from utility user and supplier companies. The mission of the CIMug is to manage and to communicate issues concerning the CIM model and to serve as the primary means for developing the CIM model consensus and consistency across the industry.

UML. The Unified Modeling Language (UML) is a standardized, formal, object-oriented modeling language, used to describe software-intensive systems. It includes the definition of graphical representations to create and represent the underlying model, and is specified and managed by the Object Management Group.

Vehicle-to-grid (V2G). The term Vehicle-to-grid (V2G) describes a system in which plug-in electric vehicles (EV), such as electric cars (BEVs) and plug-in hybrids (PHEVs), communicate with the grid to sell demand response services by either delivering electricity into the grid or throttling their charging rate.

XML. The Extensible Markup Language (XML) is defined by the Consortium (W3C) and defines a formal grammar and vocabulary for structured, textual descriptions that are machine-readable as well as readable by humans. It consists of several specifications that are publicly available from the W3C website.

References

1. JTC 1 Special Working Group on Smart Grid (SWG-Smart Grid) (2010), http://www.jtc1smartgrid.org/
2. Altova: XML Editor, Data Management, UML, and Web Services Tools from Altova (2011), http://www.altova.com/
3. Britton, J.: Designing Model Exchange Processes with CIM and 'RMA Sets'. In: 2006 IEEE PES Power Systems Conference and Exposition, pp. 487–489 (2006), http://ieeexplore.ieee.org/lpdocs/epic03/wrapper.htm?arnumber=4075799, doi:10.1109/PSCE.2006.296360
4. Burke, T.J.: OPC and Intro OPC UA (2008)
5. CEN, CENELEC, ETSI: JWG Report on Standards for the Smart Grid. Tech. rep. (2010)
6. CIMug: CIM users group Website, http://cimug.ucaiug.org
7. CIMug: Flyer: About the CIM users group (2008)
8. D2.24: EMS Architectures for the 21st Century. Tech. rep. (2009)
9. Demaree, K.: TC 57 CIM Model Manager Report (2011)
10. DeVos, A.: RDF Difference Models; Representing the Difference between two RDF Models (2002)
11. DIN: Die deutsche Normungsstrategie aktuell (2009), http://www.din.de/sixcms_upload/media/2896/DNS_2010d_akt.pdf
12. DKE: The German Standardization Roadmap E-Energy/Smart Grid. VDE (2010), http://www.dke.de/de/std/KompetenzzentrumE-Energy/Seiten/Links.aspx
13. DKE: The German Standardization Roadmap E-Energy/Smart Grid - a First Update and Report. VDE (2011), http://www.dke.de/de/std/KompetenzzentrumE-Energy/Seiten/Links.aspx
14. Effantin, C.: Available List of Tools and their position in TC57 modelling stack (2010)
15. EPRI: Harmonization of IEC 61970, 61968, and 61850 Models (2006)
16. EPRI: IntelliGrid Architecture Application Guide: Metering and Consumer Systems (2006)
17. EPRI: Integration of Advanced Automation and Enterprise Information Infrastructures: Harmonization of IEC 61850 and IEC 61970/61968 Models (2007)
18. EPRI: An Introduction to the CIM for Integrating Distribution (2008)

19. EPRI: Report to NIST on the Smart Grid Interoperability Standards Roadmap. Tech. rep., EPRI (2009)
20. EPRI: Development of the Common Information Model for Distribution and A Survey of Adoption (2010)
21. EPRI: Harmonizing the International Electrotechnical Commission Common Information Model (CIM) and 61850 (2010)
22. González, J.M.: Presentation SMB SG3 Use Cases and Profiles - Update (2010)
23. Hitzler, P., Krötzsch, M., Rudolph, S.: Foundations of Semantic Web Technologies. Chapman and Hall/CRC (2009), http://www.amazon.com/Foundations-Semantic-Technologies-Textbooks-Computing/dp/142009050X
24. IEC: Smart Grid: Global Standards for optimal electricity delivery, http://www.iec.ch/smartgrid/
25. IEC: Smart Grid Mapping tool, http://www.iec.ch/smartgrid/mappingtool/
26. IEC: 61970-450 Energy Management System Application Program Interface (EMS-API) - Part 450: CIS Information Exchange Model Specification Guide (2002)
27. IEC: 61968-3 Ed. 1: Application integration at electric utilities - System interfaces for distribution management - Part 3: Interface for network operations (2003)
28. IEC: 61970-2 Ed.1: Energy management system application program interface (EMS-API) - Part 2: Glossary (2003)
29. IEC: 61970-451 Energy Management System Application Program Interface (EMS-API) - Part 451: CIS Information Exchange Model For SCADA (2003)
30. IEC: 62325-101 DTR Ed.1: Framework for energy market communications - Part 101: General guidelines and requirements (2004)
31. IEC: 62325-102 DTR Ed.1: Framework for energy market communications - Part 102: Energy market example model (2004)
32. IEC: 62325-501 DTR Ed.1: Framework for energy market communications - Part 501: General guidelines of using ebXML (2004)
33. IEC: 62325-502 DTS Ed.1: Framework for energy market communications - Part 502: Profile of ebXML (2004)
34. IEC: 61970-1 Ed.1: Energy management system application program interface (EMS-API) - Part 1: Guidelines and general requirements (2005)
35. IEC: 61970-401 Ed.1: Energy management system application program interface (EMS-API) - Part 401: Component interface specification (CIS) framework (2005)
36. IEC: 62351-6 TS Ed.1:Data and Communication Security - Part 6: Security for IEC 61850 Profiles (2005)
37. IEC: 61970-454 Energy Management System Application Program Interface (EMS-API) - Part 454: Naming Service Specification (2006)
38. IEC: 61970-501 Ed.1.0 Energy management system application program interface (EMS-API) - Part 501: Common information model resource description framework (CIM RDF) Schema (2006), http://www.thieme-connect.de/DOI/DOI?10.1055/s-2007-985912, doi:10.1055/s-2007-985912
39. IEC: 62351-1 TS Ed.1: Data and communication security - Part 1: Introduction and overview (2006)
40. IEC: 62351-3 TS Ed.1: Data and communication security - Part 3: Profiles including TCP/IP (2006)
41. IEC: 61968-1: Application integration at electric utilities - System interfaces for distribution management - Part 1: Interface architecture and general requirements (2007)

42. IEC: 61968-4 Ed.1: Application integration at electric utilities - System interfaces for distribution management - Part 4: Interfaces for records and asset management (2007)
43. IEC: 61970-301 Ed. 1: Energy management system application program interface (EMS-API) - Part 301: Common information model (CIM) base (2007)
44. IEC: 61970-404 Ed.1: Energy management system application program interface (EMS-API) - Part 404: High speed data access (HSDA) (2007)
45. IEC: 61970-405 Ed.1: Energy management system application program interface (EMS-API) - Part 405: Generic eventing and subscription (GES) (2007)
46. IEC: 61970-407 Ed.1: Energy management system application program interface (EMS-API) - Part 407: Time series data access (TSDA) (2007)
47. IEC: 61970-453 Ed.1: Energy management system application program interface (EMS-API) - Part 453: CIM based graphics exchange (2007)
48. IEC: 62351-2 Ed.1: Data and Communication Security - Part 2: Glossary of terms (2007)
49. IEC: 61968-13 Ed.1: Application integration at electric utilities - System interfaces for distribution management - Part 13: CIM RDF Model exchange format for distribution (2008)
50. IEC: 61968-6 Application integration at electric utilities - System interfaces for distribution management - Part 6: Interface Standard for Maintenance and Construction (2008)
51. IEC: 61970-402 Ed.1: Energy management system application program interface (EMS-API) - Part 402: Common services (2008)
52. IEC: 61970-403 Ed.1: Energy management system application program interface (EMS-API) - Part 403: Generic data access (2008)
53. IEC: 61970-502-8 Ed.1: Energy Management System Application Program Interface (EMS-API) - Part 502-8: CIM Data Services (2008)
54. IEC: 62351-7 TS Ed. 1: Power systems management and associated information exchange - Data and communication security - Part 7: Network and system management (NSM) data object models (2008)
55. IEC: 62541-1 Ed. 1.0: OPC Unified Architecture Specification - Part 1: Overview and Concepts (2008)
56. IEC: 61968-11 Ed.1: Application integration at electric utilities - System interfaces for distribution management - Part 11: Common Information Model (CIM) Extensions for Distribution (2009)
57. IEC: 61968-9 Ed.1: Application integration at electric utilities - System interfaces for distribution management - Part 9: Interface for meter reading and control (2009), http://www.thieme-connect.de/DOI/DOI?10.1055/s-2007-985912, doi: 10.1055/s-2007-985912
58. IEC: 61970-452: Energy Management System Application Program Interface (EMS-API) - Part 452: CIM Transmission Network Model Exchange Profile (2009)
59. IEC: 61970-552-4: CIM XML Model Exchange Format (2009)
60. IEC: 62351-7 TS Ed.1: Power systems management and associated information exchange - Data and communication security - Part 7: Network and system management (NSM) data object models (2009)
61. IEC: 62357 Second Edition: TC 57 Architecture - Part 1: Reference Architecture for TC 57 - Draft (2009)
62. IEC: 61968-1 System Inferfaces For Distribution Management - Part 1: Interface Architecture and General Recommendations (2010)
63. IEC: 61968-14 System Interfaces For Distribution Management - XML Naming and Design Rules (2010)

64. IEC: 61970-456 Energy Management System Application Program Interface (EMS-API) - Part 456: Solved Power System State Profiles (2010)
65. IEC: 62325-450 Deregulated Energy Market Communication - Part 450: Profile and Context Modelling Rules (2010)
66. IEC: 62361-100 Ed. 1.0 Harmonization of Quality Codes across TC 57 - Part 100: Naming and design rules for CIM profiles to XML schema mapping (2010)
67. IEC: 61968-1-1 Implementation Profile for IEC 61968 (2011)
68. IEC: 61968-100 (Draft): Application integration at electric utilities - System interfaces for distribution management - Part 100: Implementation Profiles for IEC 61968 (2011)
69. IEC: 61968-14 (Draft): Application integration at electric utilities - System interfaces for distribution management - Part 14: MultiSpeak - CIM Harmonization (2011)
70. IEC: 61968-2 Application integration at electric utilities - System interfaces for distribution management - Part 2: Glossary (2011)
71. IEC: 61968-8 Application integration at electric utilities - System interfaces for distribution management - Part 8: Interface Standard for Customer Support (2011)
72. IEC: 62351-8 Ed. 1.0 Power systems management and associated information exchange - Data and communications security - Part 8: Role-based access control (Draft) (2011)
73. IEC: 62351-9 Power systems management and associated information exchange - Data and communications security - Part 9: Cyber security key management for power system equipment (NWIP) (2011)
74. IEC: IEC 62325: Framework for Energy Market Communications - Part 351: CIM European Market Model Exchange Profile (2011)
75. IEC: IEC International Standards (IS) (2011), http://www.iec.ch/standardsdev/publications/
76. IEC: International Electrotechnical Commission (IEC) (2011), http://www.iec.ch
77. IEEE: P2030 Draft Guide for Smart Grid Interoperability of Energy Technology and Information Technology Operation with the Electric Power System (EPS). Tech. rep. (2009)
78. International Standardization Organization (ISO): ISO 8879:1986(E). Information processing âĂŤ Text and Office Systems âĂŤ Standard Generalized Markup Language (SGML). Tech. Rep. 1, Geneva (1986)
79. ISO, IEC: ISO / IEC Directives Part 1: Procedures for the technical work (2011)
80. ISO, IEC: ISO / IEC Directives Part 2: Rules for the structure and drafting of International Standards (2011)
81. Japanese METI: International Standardization Roadmap for Smart Grid (2010)
82. Josuttis, N.M.: SOA in Practice, vol. 253. O'Reilly (2007)
83. JWG SG: Smart grid Mandate: Standardization Mandate to European Standardisation Organisations (ESOs) to support European Smart grid Deployment. Tech. rep., European Comission, Brussels (2011)
84. Kostic, T., Frei, C., Preiss, O., Kezunovic, M.: Scenarios for data exchange using standards IEC 61970 and IEC 61850. In: UCA User Group meeting, Cigre Paris, pp. 1–5 (2004), http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Scenarios+for+Data+Exchange+using+Standards#0
85. Kostic, T., Preiss, O., Frei, C.: Towards the Formal Integration of Two Upcoming Standards. IEC 61970 and IEC 61850. In: Little, E.H. (ed.) Proceedings fo the 2003 LESCOPE Conference, Montreal, May 7-9. IEEE Publishing (2003)
86. Lange, J., Iwanitz, F., Burke, T.J.: OPC: Von Data Access bis Unified Architecture. VDE (2010)

87. Mahnke, W., Leitner, S.H., Damm, M.: OPC Unified Architecture (2009), http://books.google.com/books?id=de9uLdXKj1IC\&pgis=1
88. Maizener, A., Sanson, J.l.: CimSyntaxGen Add-In User Guide V2 (2011)
89. Maligue-Clausse, S., Maizener, A., Sanson, J.L.: CimConteXtor User Guide V2 (2011)
90. National Institute for Standards and Technology: The NIST Definition of Cloud Computing (Draft). Tech. rep. (2011)
91. NIST: Guidelines for Smart Grid Cyber Security: Smart Grid Cyber Security Strategy, Architecture, and High-Level Requirements Vol 1,Tech. Rep. (August 2010)
92. NIST: NIST Framework and Roadmap for Smart Grid Interoperability Standards (2010)
93. NIST Smart Grid Collaboration: Priority Action Plans, http://collaborate.nist.gov/twiki-sggrid/bin/view/SmartGrid/PriorityActionPlans
94. Østergaard, J.: European SmartGrids Technology Platform-Vision and Strategy for Europes Electricity Networks of the Future (2006), http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:European+SmartGrids+Technology+Platform#3
95. Object Management Group: OMG Unified Modeling Language (OMG UML), Infrastructure (2010), http://www.omg.org/spec/UML/2.3/Infrastructure/PDF/
96. Object Management Group: OMG Unified Modeling Language (OMG UML), Superstructure (2010), http://www.omg.org/spec/UML/2.3/Superstructure/PDF/
97. OFFIS and SCC Consulting and MPC management coaching: Untersuchung des Normungsumfeldes zum BMWi-Förderschwerpunkt 'E-Energy - IKT-basiertes Energiesystem der Zukunft' (2009)
98. Österlund, L.o.: WG13 CIM Model Manager Report (2010)
99. Pilone, D., Pitman, N.: UML 2.0 in a Nutshell (In a Nutshell (O'Reilly)). O'Reilly Media (2005), http://www.amazon.com/UML-2-0-Nutshell-OReilly/dp/0596007957
100. Postina, M., Trefke, J., Steffens, U.: An EA-approach to Develop SOA Viewpoints. In: 2010 14th IEEE International Enterprise Distributed Object Computing Conference, pp. 37–46. IEEE (2010), http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?arnumber=5630229
101. Power Info: CIMSPY - Power Info - Utility IT Solution Provider (2011), http://www.powerinfo.us/index.html
102. Rohjans, S., Piech, K., Mahnke, W.: Standardized Smart Grid Semantics using OPC UA for Communication. IBIS - Interoperability in Business Information Systems 6(10) (2011)
103. Rohjans, S., Piech, K., Uslar, M., Cabadi, J.F.: CIMbaT - Automated Generation of CIM-based OPC UA-Address Spaces. In: IEEE SmartGridComm. 2011, Brussels (2011)
104. Rohjans, S., Uslar, M., Appelrath, H.J.: OPC UA and CIM: Semantics for the smart grid. In: Transmission and Distribution Conference and Exposition, 2010 IEEE PES, pp. 1–8 (2010)
105. Rohjans, S., Uslar, M., Bleiker, R., González, J., Specht, M., Suding, T., Weidelt, T.: Survey of Smart Grid Standardization Studies and Recommendations. In: First IEEE International Conference on Smart Grid Communications (2010)

106. Santodomingo, R., Rodriguez-Mondejar, J.A., Sanz-Bobi, M.A.: Ontology Matching Approach to the Harmonization of CIM and IEC 61850 Standards. IEEE (2010), http://ieeexplore.ieee.org/lpdocs/epic03/wrapper.htm?arnumber=5622017
107. SGCC: Framework and Roadmap for Strong and Smart Grid Standards (2009)
108. SMB Smart Grid Strategic Group (SG3): IEC Smart Grid Standardization Roadmap (2010)
109. Sommerville, I.: Software Engineering, 9th revise edn. Addison-Wesley Longman, Amsterdam (2010), http://www.amazon.de/Software-Engineering-Ian-Sommerville/dp/0137053460/ref=sr_1_1?ie=UTF8\&qid=1308056747\&sr=8-1
110. Specht, M., Osterloh, A.: Erweiterung des Common Information Model zur Modellierung von dezentralen Energieprodukten an einem regionalen Marktplatz. Informatik (2010)
111. The Open Group: TOGAF Version 9 - The Open Group Architecture Framework (TOGAF), 9th edn. (2009)
112. UN/CEFACT: XML Naming and Design Rules (2006), http://scholar.google.com/scholar?hl=en&btnG=Search&q=intit%le:XML+Naming+and+Design+Rules#1
113. Uslar, M.: Ontologiebasierte Integration heterogener Standards in der Energiewirtschaft. Ph.D. thesis, Edewecht (2010)
114. Uslar, M., Dahlem, N.: Semantic web technologies for power grid management. In: Koschke, R., Herzog, O., Rödiger, K.H., Ronthaler, M. (eds.) GI Jahrestagung (1). LNI, vol. 109, pp. 242–250. GI (2007)
115. Uslar, M., Rohjans, S., Bleiker, R., González, J.M., Suding, T., Specht, M., Weidelt, T.: Survey of Smart Grid Standardization Studies and Recommendations - Part 2. In: IEEE Innovative Smart Grid Technologies Europe (2010)
116. Uslar, M., Rohjans, S., Specht, M., Gonzales, J.: What is the CIM lacking? In: IEEE SmartGridComm 2010 (2010)
117. World Wide Web Consortium (W3C): RDF Primer (2004), http://www.w3.org/TR/rdf-primer/
118. World Wide Web Consortium (W3C): RDF Semantics (2004), http://www.w3.org/TR/rdf-mt/
119. World Wide Web Consortium (W3C): RDF Vocabulary Description Language 1.0: RDF Schema (2004), http://www.w3.org/TR/rdf-schema/
120. World Wide Web Consortium (W3C): Resource Description Framework (RDF): Concepts and Abstract Syntax (2004), http://www.w3.org/TR/rdf-concepts/
121. World Wide Web Consortium (W3C): XML Schema Part 0: Primer Second Edition (2004), http://www.w3.org/TR/xmlschema-0/
122. World Wide Web Consortium (W3C): XML Schema Part 1: Structures Second Edition (2004), http://www.w3.org/TR/xmlschema-1/
123. World Wide Web Consortium (W3C): XML Schema Part 2: Datatypes Second Edition (2004), http://www.w3.org/TR/xmlschema-2/
124. World Wide Web Consortium (W3C): Extensible Markup Language (XML) 1.1, 2nd edn. (2006), http://www.w3.org/TR/xml11/

125. World Wide Web Consortium (W3C): Namespaces in XML 1.1, 2nd edn. (2006), http://www.w3.org/TR/xml-names11/
126. World Wide Web Consortium (W3C): Extensible Markup Language (XML) 1.0, 5th edn. (2008), http://www.w3.org/TR/REC-xml/
127. World Wide Web Consortium (W3C): OWL 2 Web Ontology Language Primer (2009), http://www.w3.org/TR/owl-primer/
128. World Wide Web Consortium (W3C): OWL 2 Web Ontology Language RDF-Based Semantics (2009), http://www.w3.org/TR/owl-rdf-based-semantics/
129. World Wide Web Consortium (W3C): W3C RDF Validation Service (2011), http://www.w3.org/RDF/Validator/
130. Xtensible Solutions, Inc.: CIMEA Webpage (2011), www.cimea.org

Index