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TECHNICAL REPORT

colour inside

Power systems management and associated information exchange – Part 1: Reference architecture

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

POWER SYSTEMS MANAGEMENT AND ASSOCIATED INFORMATION EXCHANGE –

Part 1: Reference architecture

FOREWORD

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IEC 62357-1, which is a technical report, has been prepared by IEC technical committee 57: Power systems management and associated information exchange.

This first edition cancels and replaces the first edition of IEC 62357 published in 2003 and constitutes a technical revision. This edition includes the following significant technical changes with respect to the previous edition:

a) update of the description of the various standards activities within TC 57 and the way they individually and collectively contribute to meeting the objectives of TC 57;

b) update of the areas where harmonization of existing standards within TC 57 is needed and provision of detailed recommendations regarding harmonization of the CIM IEC 61968/61970 and IEC 61850 standards;

c) definition of a new layered architecture to help direct longer term goals and activities to ensure compatibility of all new standards developed in TC 57;

d) alignment of the architecture on other internationally recognized architecture standards, such as the UN/CEFACT Core Components Technical Specification;

e) incorporation of lessons learned during development of the current standards and their application on actual utility projects;

f) provision of new guidance on the role of TC 57 standards in the Smart Grid.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
57/1184/DTR	57/1255/RVC

Full information on the voting for the approval of this technical report can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 62357 series, published under the general title *Power systems management and associated information exchange*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

0.1 General

The objectives of IEC/TR 62357-1 are to

– provide a framework to show how the various standardisation activities within IEC Technical Committee 57 relate to each other and how they individually and collectively contribute to meeting the objectives of IEC Technical Committee 57, and

– develop a strategy to combine and harmonize the work of these various activities to help facilitate a single, comprehensive plan for deployment of these standards in product development and system implementations.

IEC/TR 62357-1 provides updates and defines a layered reference architecture to help direct longer term goals and activities, specifically to ensure compatibility of all new standards developed in TC 57 by benefitting from lessons learned during development of the current standards and their application on actual utility projects as well as through application of other internationally recognized architecture standards, such as the UN/CEFACT Core Components Technical Specification.

The second edition of IEC 62357-1 currently being prepared will reflect the progress recently achieved from the international Smart Grid (SG) initiatives and the CIGRE D2.24 large system architecture vision. This second edition will also reflect the most recent editions of the TC 57 standards including IEC 61850 series and IEC 61968 series, IEC 61970 series, and IEC 62325 series.

0.2 Objectives and overview of this technical report

0.2.1 Overview

IEC TC 57 is chartered with developing standards for electric power system management and associated information exchange in the areas of generation, transmission and distribution real-time operations and planning as well as information exchange to support wholesale energy market operations. This technical report has three objectives with respect to TC 57's current and future work. It also has a fourth objective regarding the role of TC 57 standards in development and implementation of the Smart Grid.

0.2.2 Existing TC 57 standards and architecture

The first objective of this technical report is to provide a reference architecture to show how the various existing standards activities within IEC TC 57 relate to each other today and how they individually and collectively contribute to meeting the objectives of TC 57. Clause 3 describes each of the working groups and their current scope of work, while Clause 4 shows how all the standards developed to date fit into an overall architecture

0.2.3 Areas for harmonization

The second objective is to identify areas where harmonization between TC 57 standards is needed and to suggest possible approaches to achieve it in order to facilitate a single, comprehensive, optimal plan for deployment of these standards in product development and system implementations. Clause 5 describes the data modelling and service definition approaches currently used in TC 57. Clause 6 describes way these modelling standards and services are mapped to concrete technologies, while Clause 7 discusses the harmonization needed to ensure that these existing modelling and technology mapping standards are compatible, if not totally integrated.

0.2.4 Future vision for TC 57 standards architecture

The third objective is to define a vision for the future reference architecture that will help direct longer term goals and activities. More specifically the goal is to ensure compatibility of all new standards developed in TC 57 by benefitting from lessons learned during development of the current standards and their application on actual utility projects as well as through application of other internationally recognized architecture standards, such as the UN/CEFACT Core Components Technical Specification.

Clause 8 defines the fundamental architecture principles established to guide the structure of new standards work, specifically proposing a layered architecture that recognizes internationally accepted concepts for a layered architecture including an abstract information model, a business context layer, message assembly layer, and an implementation or technology mapping layer. Clause 9 discusses the conclusions.

0.2.5 Role of TC 57 standards in the smart grid

The fourth objective is to provide an overview of the TC 57 standards and their role in the Smart Grid. Now that the TC 57 standards, such as the IEC 61968 series, IEC 61970 series and IEC 61850 series, have been recognized as pillars for realization of the Smart Grid objectives of interoperability and device management, it is imperative that a correct understanding of these standards and their application be made available to the key stakeholders and all other interested parties involved in implementing the Smart Grid.

0.3 Rationale

The need for this technical report was motivated by three major factors:

a) there are multiple independent standards initiatives that need to be coordinated and harmonized to facilitate information exchange between systems using these various standards;

b) there is a need to have a comprehensive vision of how to deploy these standards for actual system implementations and integration efforts;

c) there needs to be a vision of the future so that additional work can take into account the evolving communications and modelling technologies, and can be incorporated within a clearly defined architectural framework.

There are several different initiatives within TC 57, each dealing with a selected part of real-time operations and planning. Each has a specific objective and may have sufficient breadth of scope to provide the bulk of the relevant standards needed for product vendors to develop products based on those standards.

0.4 Trend toward model driven architectures and integration

In today's utility enterprise, where information exchange between the various generation, distributed resource, transmission, and distribution management systems, as well as customer systems and other IT systems is not only desirable but necessary, each system plays the role of either the supplier or consumer of information, or more typically both. That means that both data semantics and syntax need to be preserved across system boundaries, where system boundaries in this context are interfaces where data is made publicly accessible to other systems or where requests for data residing in other systems are initiated. In other words, the "*what"* of the information exchange is actually much more important for system integration purposes than "*how"* the data is transported between systems.

Most previous efforts to define system architectures have dealt primarily with the *how* (i.e., definition of protocols for transporting the data), with a focus on utilizing as many existing ISO or TCP/IP standards as possible to provide the various layers in the ISO OSI seven-layer

reference model for protocol profiles.[1] However, the increasing use of object modelling techniques to define the data for information exchange within the different standards initiatives has properly shifted the focus away from the *how* to the *what.* Of even more importance, this trend has resulted in the separation of the data from the protocol standards, creating a new layer of abstraction for the data model as well as the data exchange methods that is independent of the underlying infrastructure. The consequence of this is that a common data model and a few generic data-driven interface patterns can be used for all information exchange independent of the underlying protocols selected for a given system implementation. This new architecture is known as a Model-Driven Architecture (MDA), or when applied to integration of systems and applications, as Model-Driven Integration (MDI). Actual implementations can then take advantage of the current industry architectural trends, such as Service Oriented Architectures (SOA) and the use of Web services.

Standardization efforts within TC 57 began several years prior to development of the MDA/MDI architectural concepts. As a result, there was little or no collaboration between working groups. Each working group chose its own modelling language/notation and more importantly generated their own object and service model definitions. This was not done intentionally, and in fact each initiative had perfectly good reasons for their choices given the limited scope of their domain of application. But the consequence is that instead of one object model for each physical entity in the generation, transmission and distribution operations domains being standardized, at least two or more object models exist in most cases with different definitions for classes, attributes, data types, and relationships between classes. Furthermore, in most cases different modelling languages have been used as well.

0.5 Purpose of the reference architecture

To achieve the first objective of this technical report, a reference architecture for power system information exchange is defined to describe all the existing object models, services, and protocols within TC 57 and how they relate to each other. Then, to meet the second objective, a strategy is developed to show where harmonization is needed, and if possible, to recommend how to achieve a common model. Where changes cannot be made due to maturity of standards, then recommendations for adapters to make the necessary transformations between models are made. The third objective of this technical report is achieved by defining a new future reference architecture that recognizes the importance of a single, internally consistent semantic layer to avoid unnecessary seams (i.e., the concept of a seamless architecture), while facilitating information exchange over a variety of industry-standard transport infrastructures. This new reference architecture provides a framework for growth and incorporation of new, evolving technologies without invalidating the existing standards developed by TC 57.

0.6 Scope of reference architecture

0.6.1 General

Originally the charter and title of TC 57 was "Power system control and associated telecommunications". The focus was on developing different protocol standards to address the data communications requirements of different parts of power system control, such as data communications over low-speed serial lines, distribution line carrier protocols, and inter-control center communications protocols.

Later as the scope of the TC 57 work broadened to include data exchange between applications within an energy management system as well as inter-computer system data exchange between distribution management systems and deregulated energy market communications, the charter was changed to "Power system management and associated information exchange", so that the focus shifted from lower lever protocol development to

1 The original EPRI UCA project, for example, had the focus of settling on the use of MMS and a few standard profiles for transporting data rather than on the semantics of information transfer between systems.

development of more abstract data models and generic interfaces at higher levels in the architecture. This shift resulted in the creation of new working groups to address the new business functions embraced by the new TC 57 charter, which includes:

- energy management,
- SCADA and network operation,
- substation protection, monitoring, and control,
- distribution automation,
- distributed energy resources (DER),
- demand response and load control,
- meter reading and control,
- customers,
- work,
- network expansion planning,
- operational planning and optimization,
- maintenance and construction,
- records and asset management,
- market operations,
- reservations,
- financial,
- energy scheduling.

0.6.2 IEC standards included in reference architecture

The scope of the reference architecture for power system information exchange embraces all these areas from both the abstract information modelling perspective (i.e., platform independent models) as well as the technology mappings for implementation (i.e., platform specific models).

Figure 1 shows where some of these standards are used in the utility operations environment. Not all standards listed above are shown and not all end field devices/systems are shown. More detailed descriptions and illustrations are provided in Clause 3.

The reference architecture for power system information exchange includes the following IEC TC 57 standards (responsible working groups are shown in parentheses):

IEC 60495, *Single sideband power-line carrier terminals (WG20)*

IEC 60663, *Planning of (single-sideband) power line carrier systems (WG20)*

IEC 60870-5 (all parts), *Telecontrol equipment and systems – Part 5: Transmission protocols (WG3)*

NOTE 1 IEC 60870-5 series covers reliable data acquisition and control on narrow-band serial data links or over TCP/IP networks between SCADA masters and substations.

IEC 60870-6 (all parts), *Telecontrol equipment and systems – Part 6: Telecontrol protocols compatible with ISO standards and ITU-T recommendations (WG7)*

NOTE 2 IEC 60870-6 series covers the exchange of real-time operational data between control centres over Wide Area Networks (WANs). This series is known officially as TASE-2 and unofficially as ICCP.

IEC 61334 (all parts), *Distribution automation using distribution line carrier systems (WG9)*

NOTE 3 IEC 61334 series covers data communications over distribution line carrier systems.

IEC 61400-25 (all parts), *Wind turbines – Part 25-1: Communications for monitoring and control of wind power plants*

NOTE 4 IEC 61400-25 series covers monitoring and control of wind power plants and associated communication. The standards developed by JWG 25 are based on IEC 61850 series.

IEC 61850 (all parts), *Communication networks and systems for power utility automation (WG10, WG17, WG18)*

NOTE 5 IEC 61850 series covers communication networks and systems in substations. These standards are known unofficially as the UCA2 protocol standards. They also include standards for hydroelectric power plant communication, monitoring, and control of distributed energy resources and hydroelectric power plants.

IEC 61968 (all parts), *Application integration at electric utilities – System interfaces for distribution management (WG14)*

NOTE 6 IEC 61968 series covers Distribution Management System (DMS) interfaces for information exchange with other IT systems. These include the distribution management parts of the CIM and extensible Markup Language (XML) message standards for information exchange between a variety of business systems, such as meter data management, asset management, work order management, Geographical Information Systems (GIS), etc.

IEC 61970 (all parts), *Energy management system application program interface (EMS-API) (WG13)*

NOTE 7 IEC 61970 series facilitate integration of applications within a control centre, exchange of network power system models with other control centres, and interactions with external operations in distribution as well as other external sources/sinks of information needed for real-time operations. These standards include the generation and transmission parts of the Common Information Model (CIM), profiles for power system model exchange and other information exchanges, and XML file format standards for information exchange.

IEC 62325 (all parts), *Power systems management and associated information exchange – Data and communications security (WG16)*

NOTE 8 IEC 62325 series covers deregulated energy market communications.

IEC 62351 (all parts), *Power systems management and associated information exchange – Data and communications security (WG15)*

NOTE 9 IEC 62351 series covers data and communication security.

IEC 62488 (all parts), *Power line communication systems for power utility applications (WG20)*

NOTE 10 IEC 62488 series covers data power line communication systems for power utility applications.

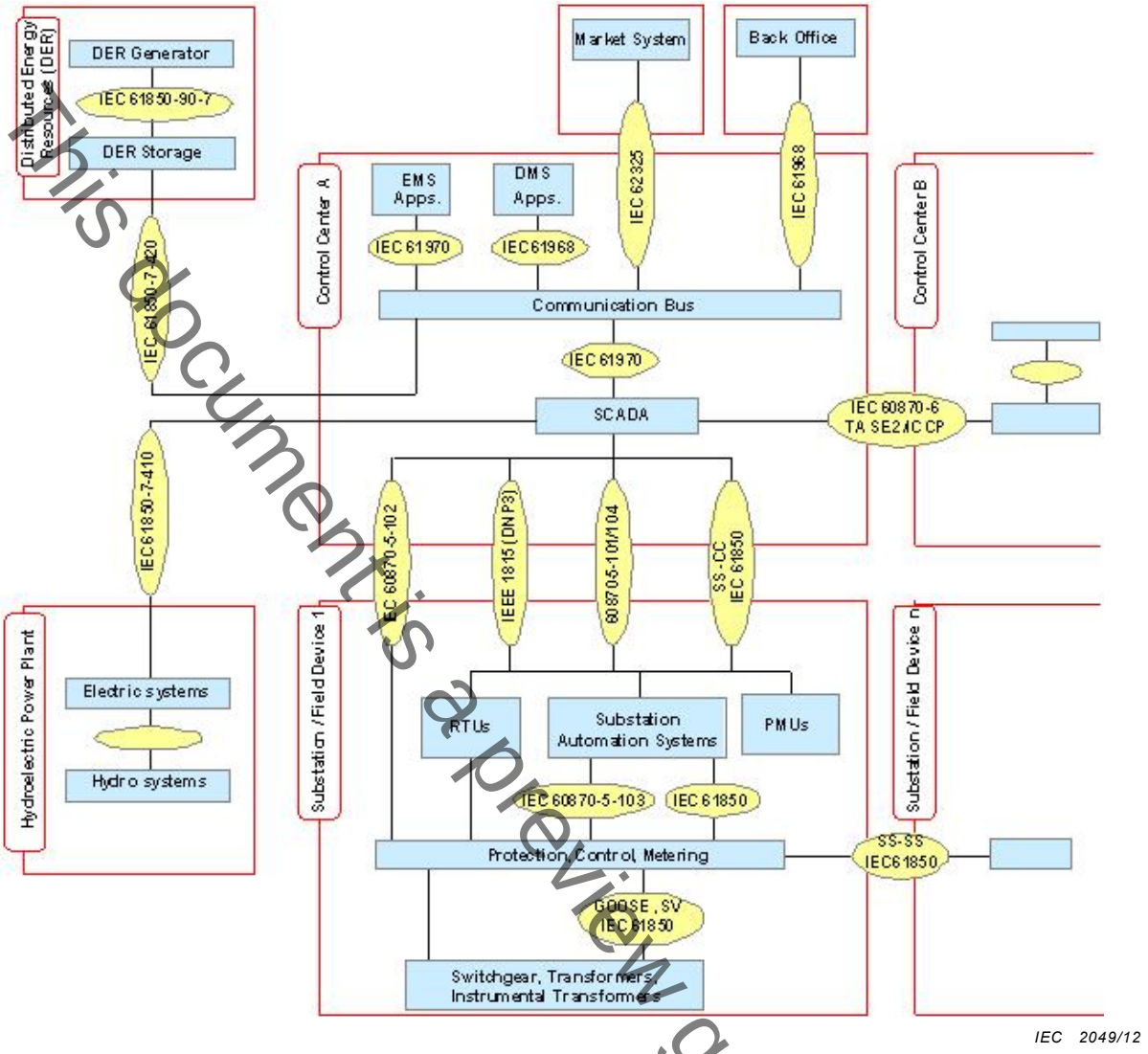

Figure 1 – Application of TC 57 standards to a power system

0.6.3 TC 57 organization and formal liaisons

Figure 2 shows the organization of the IEC TC 57 working groups that are responsible for producing these standards. The formal TC 57 liaisons with external organizations and industry consortiums are also shown and listed below with additional detail:

- **CIGRE**: Category A
  - SC D2-24 Information systems and telecommunications – EMS architectures for the 21st century
  - SC B5-38: Protection and automation
- **ITU-T** (International Telecommunication Union) – Telecommunications sector which is responsible the efficient and timely production of standards covering all fields of telecommunications on a worldwide basis, as well as defining tariff and accounting principles for international telecommunication services**.** Category A with TC57.
- **UCAIug** (UCA International User Groups), including CIM, OpenSG, and 61850: Category D with WG10, WG13 and WG14
- **ebIX** (European forum for energy business information exchange): Category D with WG16
- **ENTSO-E** (European Network of Transmission System Operators for Electricity), responsible for Europe-wide planning and operations for all cross-border exchanges of electricity: Category D with WG13 and WG16

- **IEEE** (Institute of Electrical and Electronic Engineers) **PES** (Power Engineering Society) **PSCC** (Power Systems Communications Committee) **Security Subcommittee**: Category D with WG15
- **UN/CEFACT** (United Nations/Center for Trade Facilitations and Electronic Business), a United Nations body that is in charge of trade facilitations and have launched an initiative for e-commerce known as ebXML, a suite of specifications to enable enterprises to conduct business over the Internet. Included is a mechanism for enterprises to register core components in XML meta-language, so that other enterprises can determine what information is available, and can then establish dynamic interactions automatically: MoU (Memo of Understanding) between IEC and UN/CEFACT

Later in the introduction the activities of each of the IEC TC 57 working groups is described. As shown the activities are coordinated by the Convener's Advisory Group (CAG) and WG19, which functions as an architecture board to ensure standards developed fit a common architectural framework and are compatible with existing standards.

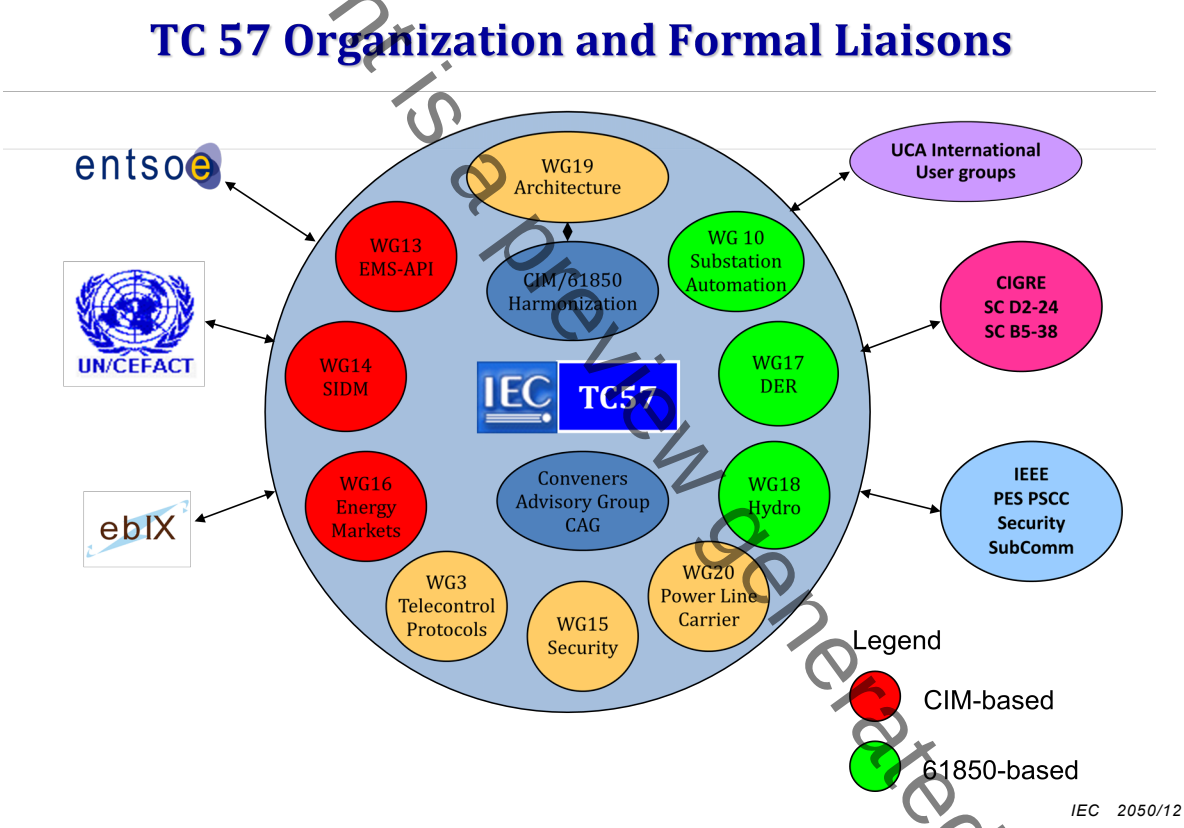

Figure 2 – TC 57 organization and formal liaisons

0.6.4 IEC internal liaisons

Current IEC internal liaisons include:

- IEC TC 4 Hydraulic turbines
- IEC TC 8 Systems aspects for electrical energy supply
- IEC TC 13 Electrical energy measurement, tariff- and load control
- IEC SC 17C High-voltage switchgear and controlgear assemblies
- IEC TC 38 Instrument transformers
- IEC TC 65 Industrial-process measurement, control and automation
- IEC TC 88 Wind turbines (IEC 61400-25-1 to -6)

- IEC TC 95 Measuring relays and protection equipment

0.6.5 Related standards activities

In addition to the formal liaisons, there are other standards-related activities that are relevant to TC 57 and are the source of either existing or planned standards that can be adopted (perhaps with some tailoring to meet utility-specific needs) for use within TC 57. Figure 2 graphically depicts these activities and domains of application. Of particular interest are the following:

National Institute of Standards and Technology (NIST), the non-regulatory federal agency within the U.S. Department of Commerce responsible for generating the Smart Grid Roadmap and defining standards for the Smart Grid.

North American Energy Standards Board – Electricity (NAESBE), an industry forum for the development and promotion of standards which will lead to a seamless marketplace for wholesale and retail electricity, as recognized by its customers, business community, participants, and regulatory entities.

IEEE, in particular the IEEE PES committees, including the power system relaying Committee, and the substations committee, as well as the IEEE Communications Society, IEEE SCC36, and IEEE SCC21.

OPC, an industry consortium responsible for standards related to the integration of near real time applications – primarily in the process control, manufacturing, and utility sectors. WG13 is working closely with OPC to leverage their unified architecture set of interface services for exchanging CIM-based data**.**

Open Application Group (OAG), an industry consortium responsible for Enterprise Application Integration (EAI) solutions. WG14 is working closely with the OAG to develop standard XML messages for information exchange between distribution management systems and other IT systems.

MultiSpeak, a collaboration of the National Rural Electric Cooperative Association (NRECA) in the USA. The MutiSpeak Initiative has developed and continues to expand a specification that defines standardized interfaces among software applications commonly used by electric utilities.

European Transmission System Operator (ETSO), a consortium of European TSOs that define standards for information exchange. They rely on the UN-CEFACT standardisation process.

European Federation of Energy Traders (EFET), an organization that federates the traders in Europe.

World-Wide Web Consortium (W3C), a consortium that develops interoperable technologies (specifications, guidelines, software, and tools) to lead the Web to its full potential, among these technologies are XML, RDF, OWL, Web services.

Internet Engineering Task Force (IETF) Internet Services

International Standards Organization (ISO) Security and Metadata Repository Standards

Electric Power Research Institute (EPRI), although not a standards organization as such, was a source for a number of the drafts which became standards within TC 57 via the Control Center Applications Program Interface (CCAPI) project.

0.7 Purpose of the future reference architecture for power system information exchange

The future reference architecture is built upon the current TC 57 reference architecture and the many utility requirements that went into defining that architecture. However, it also takes into account new concepts and evolving technologies in the information industry at large. In some cases these are incorporated into the future reference architecture, not necessarily because they are better than what has been developed to-date, but because the electric industry must and will follow technology trends from other industries where these are proven to be cost-beneficial. In other cases, the electric power industry is just now getting into new areas, such as market operations, where some of the needed technologies are being defined elsewhere.

POWER SYSTEMS MANAGEMENT AND ASSOCIATED INFORMATION EXCHANGE –

Part 1: Reference architecture

1 Overview

1.1 Scope

This part of IEC 62357, which is a Technical Report, specifies a reference architecture and framework for the development and application of IEC standards for the exchange of power system information.

This technical report provides an overview of these standards as well as guidelines and general principles for their application in distribution, transmission, and generation systems involved in electric utility operations and planning.

The future multi-layer reference architecture described in this technical report takes into account new concepts and evolving technologies, such as semantic modelling and canonical data models, in order to build on technology trends of other industries and standards activities to achieve the interoperability goals of the Smart Grid.

1.2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 61850 (all parts), *Communication networks and systems for power utility automation*

IEC 61968 (all parts), *Application integration at electric utilities – System interfaces for distribution management*

IEC 61970 (all parts), *Energy management system application program interface (EMS-API)*

2 Abbreviations

For the purposes of this document, the following abbreviations apply.

ACSI	Abstract Communication Service Interface
AHWG	Ad Hoc Working Group
API	Application Program Interface
ASCII	American Standard Code for Information Interchange
ASN	Abstract Syntax Notation
CASE	Computer Aided Software Engineering
CASM	Common Access Service Methods
CC	Control Centre
CCAPI	Control Centre Application Program Interface
CCTS	Core Component Technical Specification
CDA	Common Data Access
CES	Component Execution System
CIM	Common Information Model