UPA Smartgrid
Market Requirements

November 2008

About this Document

Name/ Number of Functionality	
Author(s)	Chris Graham-Fielding - Freedom Digital Networks
Technical Reviewer(s)	Eduardo Lluna – DS2 Joe Maier – Corinex Communications
Editor(s)	Daniel Drolet – UPA MWG
Version Number	4.2
Last Updated	November 19th 2008
Authorisation	UPA Board
Notes	
References	European Commission FP5 Projects (Smartgrids EU) European Strategic Energy Technology Plan (SET-Plan May 2007)

TABLE OF CONTENTS

Executive Summary

There are a myriad of definitions in the market as to what constitutes a Smart Grid. From Automated Metering Intelligence/Infrastructure (AMI) and Transmission & Distribution intelligence through to the inclusion of Supervisory Control And Data Acquisition (SCADA) or Distributed Power Control to Demand Side Management.

Every utility and component or solution provider has its own view. That view and definition is influenced by factors ranging from commercial or legislative drivers, through to portfolio expertise and product or application positioning.

In principle, the Smart Grid relies on gathering data collected from large numbers of intelligent sensors and processors installed on the power lines and equipment from around the power grid (e.g. switches circuit breakers, transformers, bus bars, etc.).

To a utility, a Smart Grid is a commercial imperative as well as a technological implementation. They see it as it supporting a range of Environmental targets including 8% reduction in greenhouse gas emissions from 1990 levels by 2008-2012 (Kyoto); increasing the share of renewable energy systems (RES) from 6% to 12% of gross energy consumption by 2010; increasing the share of electricity from RES to 21% of gross electricity consumption by 2010 (from 14% in 2003); increasing the share of liquid bio fuels to 5.75% by 2010; and reducing energy intensity by a further 1%/year until 2010.

Whatever the definition, it is clear and paramount that in order to serve multiple economic, commercial, legislative and environmental goals of the 21st Century, regional and national electric power grids will need to be able to support and enable communication between nodes and devices in previously unimaginable detail.

The general consensus is that to achieve this, Utilities must be capable of intelligently integrating the actions of all components and users connected to the grid. It is this holistic infrastructure that - for the purpose of this document - defines the UPA Smart Grid.

This Market Requirements Document (MRD) is therefore intended to provide a baseline to clarify the requirements against which products and services can be developed by the UPA members. The considerations include requirements ranging from reliability in a range of operating environments through to speeds that allow any product or solution to be instantaneously responsive in a wide range of applications, and a level of security to defend against cyber intrusion that could have significant economic implications.

There is no “single” element in a Smart Grid – it is an “end to end” cohesive solution

It must provide reliable and cost effective two way communication across and between vast internal and edge assets.

The UPA PLC enabled Smartgrid is key to delivering an “end to end” cohesive solution.

Introduction about the UPA

Mission

The Universal Powerline Association (UPA) aligns industry leaders in the global Power Line Communications (PLC) to harmonize global standards and regulations. The UPA aims to catalyse the growth of PLC/BPL technology by delivering UPA certified products that comply with these specified standards and regulations. All products and applications designed around UPA guidelines will communicate. The UPA provides all PLC/BPL players the opportunity to respond to key customer expectations with open standards, based on interoperability, security and coexistence.

The UPA focuses on time-to-market, guaranteeing high-performance and maximizing use of resources for access including broadband applications for telecommunication, entertainment, Utility Transmission and Distribution including metering functionality, along with in-home audiovisual and data networking applications to the benefit of all players in the PLC value chain

Background

The UPA was founded on the common belief of a set of leading companies who share the vision of a PLC landscape based on:

- World-wide standards for power line communications;
- Integrating PLC into the telecommunications landscape;
- Providing consistent, credible and unifying communication regarding PLC;
- Taking a universal view of the market and embracing all applications whether access, in-home, multimedia or other PLC applications, and
- Ensuring speed of deployment of PLC worldwide.

Smartgrid Market Overview

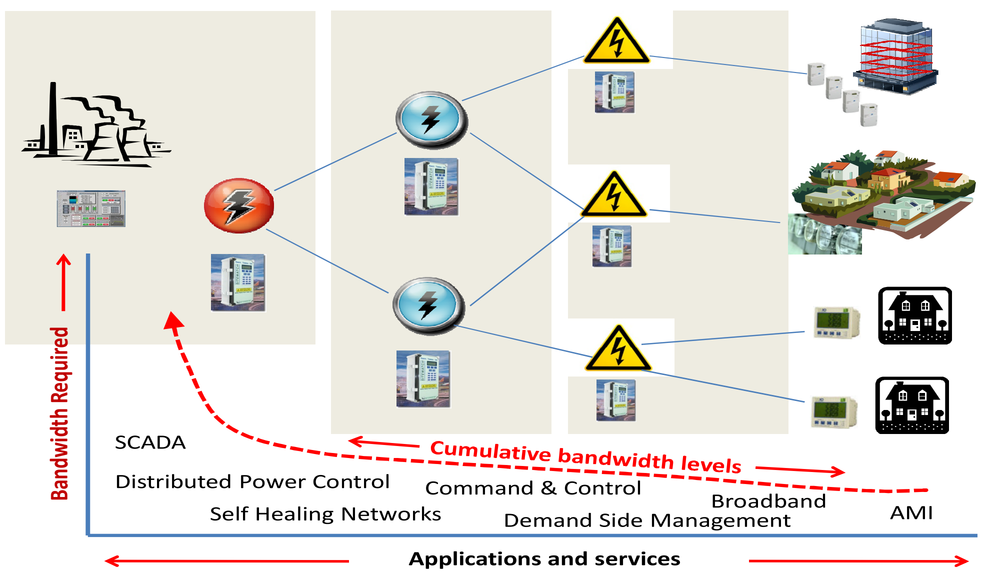
Background

The pace at which Smart Grids are being implemented varies dramatically across the globe and utilities, and is also highly dependent on commercial and legislative drivers. The global Smart Grid market is estimated to be worth $20Bn.

The diversity of Smartgrid "definitions" requires that the market overview and degrees of Smart Grid implementation gives consideration to an "evolving" market, and delivers a range of bandwidths and performance to ensure the PLC requirements can be addressed economically.

The goal being to ensure a correlation between application requirements, and the bandwidth flexibility of the PLC enabled Smart Grid. The MRD is therefore intended to help position the requirements of the evolving Power Line Communications (PLC) technology at each stage. The key to scoping the Smart Grid requirements for the Power Line Communications is in ensuring its ability to deliver and support the wide range of applications and bandwidth levels associated with this level, diversity and range of technology deployment.

For Example:



In the above diagram and at this point in time, individual applications such as metering or SCADA do not require significant bandwidth in isolation. However as the need and benefits from two way communication grow, and multiple applications seek to use the same architecture, the cumulative bandwidth will require both the appliance of both Quality of Service (to specific applications) and an interoperability with both legacy and differing bandwidth and frequency based applications. The availability of wider and greater bandwidth is essential to provide the flexibility needed.

Power Line Communications technology must therefore be capable of supporting a wide range of applications concurrently, and also meeting the range of “standards and parameters” as outlined below.

Smart Grid: Purpose & Communication Implications

A Smart Grid employs innovative products and services, together with intelligent monitoring, control, communication and self healing technologies to deliver;

Distributed Energy Generation & Management

Overview: Power networks will evolve over the coming decades with the probability of more remote and widespread generation, be that CHP (Combined Heat and Power) PhV (Photo Voltaic) and renewable energy sources such as wind and wave, plus others.

Implications: This requires improved facilitation for the connection of generators of all sizes and technologies. A cost effective, robust and uniform / open communication network is needed to facilitate that, and the UPA Smart Grid must enable this.

Demand Side Management

Overview: DSM encompasses actions that influence the quantity or patterns of use of energy consumed by end users, such as actions targeting reduction of peak demand during periods when energy-supply systems are constrained. Peak demand management does not necessarily decrease total energy consumption but could be expected to reduce the need for investments in networks and/or power plants

Implications: This requires the ability to allow electricity consumers to play a part in optimising the operation of the system, and therefore a stable and “always available” communication path is required to enable that interaction.

The communication flow and path must be robust enough to both provide consumers with greater information and respond to the way they choose to procure and secure their electricity supplies.

System Reliability.

Overview: This is the ability of the Utilities Power Grid and associated systems to satisfy customer requirements in terms of power and energy, considering forced outages and the scheduled maintenance outages of the system's equipment.

Implications: The term "reliability" is very specific in meaning and is accepted as being defined by a set of probabilistic indices even if only expected (average or mean) values are reported or predicted. Reported indices include frequency of interruptions, duration of interruptions, annual unavailability, and load and energy not supplied.

Today, a number of indices quantify the system operational performance, such as the Loss of Load Expectation (LOLE, hours/year), Loss of Energy Expectation (LOEE, MWh/year), Expected Demand Not Supplied (EDNS, MW/year), Frequency of Loss of Load (FLOL, occurrences/year), and the Energy Index of Reliability (EIR).

The Smartgrid, and therefore the communications path that enables the Smart Grid must deliver enhanced levels of reliability and security of enabling the utility to move from State Estimation (forecasting and predicting based on historical data) to Real Time management of the assets. Speed, reliability and continuity of the data flow over PLC are therefore key.

Carbon Footprint management & reduction

Overview: International legislation requires that industries (including Utilities) must be capable of supporting an 8% reduction in greenhouse gas emissions from 1990 levels by 2008-2012 (Kyoto); increasing the share of renewable energy systems (RES) from 6% to 12% of gross energy consumption by 2010; increasing the share of electricity from RES to 21% of gross electricity consumption by 2010 (from 14% in 2003); increasing the share of liquid bio fuels to 5.75% by 2010; and reducing energy intensity by a further 1%/year until 2010.

Implications: The deployment of Smart Grid technologies and therefore the use of the Power Line Communications in the UPA Smart Grid must assist in the compliance to that Legislation. Commercial imperatives and environmental impact are all drivers in the need to significantly reduce the impact of the total electricity supply system. That holistic imperative requires a holistic Smart Grid and a Holistic communications solution.

Fault Detection and Self Healing

Overview: The Smart Grid must address the ability to monitor itself and take both preventative and reactive action to maintain reliability and security of service.

Implications: Where the communication path is an element of the Smart Grid itself, the opportunity for changes in the performance of the communication provides a significant opportunity for that to be correlated to changes in the performance of the network, adding intelligence at every level, and enabling smart reactions.

Robustness

Overview: Robustness is the ability of the system to remain in operation after any sudden disturbances, such as short circuits, loss of equipment, etc. It may take into account any actions causing such disturbances, such as human errors, extreme weather conditions, terrorist activity, etc.

Robustness is often measured by deterministic indices that may include the severity of situations but ignore the likelihood. Examples are "percentage reserve" used in spinning reserve assessment, and the "n-1" or "n-2" criteria used in transmission operation and planning (meaning that the system should continue to function after a loss of 1 or 2 circuits).

Implications: The PLC enabled Smart Grid must therefore be designed to operate and maintain continuity and throughput in a range of hostile conditions and temperature ranges.

Security

Overview: The information passing through the Smart Grid system is private and commercially sensitive. The data flow on a Smart Grid deployment must therefore be secure to a level that it is guaranteed that it cannot be received or altered by unauthorised parties. The PLC enabled Smart Grid solution provides an end-to-end communication solution without dependency on an external operator, increasing the security factor of the installation

Implications: The PLC enabled Smart Grid must therefore be designed to incorporate and support the required levels of data encryption and password protection.

A powerful DES/3DES based on DTCP encryption must be supported, ensuring reliable security of data transmission and defence against cyber threats. The inclusion of 802.1Q VLAN must be considered, to support higher levels of security and allow for stream classification.

Communications

Overview: Utilities are seeking to utilise their own infrastructure for communications, both internally for their own use, and externally where licences and environments permit the deployment of digital communications services such as Broadband over Power Lines (BPL) and Voice over Internet Protocol (VoIP) for revenue generation, and digital/social inclusion.

Implications: The UPA Powerline Communications enabled Smart Grid must support all appropriate and associated legislation, Quality of Service and bandwidth requirements associated with this market development, both now and in the future.

Current and Future Smart Grid Services

In this section the prime Smart Grid features and services are described. Others will be added and identified over time.

Supervisory Control and Data Acquisition (SCADA)

A supervisory (computer) system, gathering (acquiring) data on the process and sending commands (control) to the process. Remote Terminal Units (RTUs) connect to sensors in the process and convert sensor signals to digital data. Power Line Communications is a key enabler and transport technology for the delivery to and collection of that digital data between the supervisory system to the Remote Terminal Units

Increased bandwidth rates and flexible selection of the most appropriate rate will enable the development and deployment of more advanced and distributed services as part of the SCADA infrastructure. Standards for SCADA and Sub Station Automation must be supported to address and develop this opportunity

Automatic Meter Reading / Automatic Metering Infrastructure

Systems that measure collect and analyse energy usage, from advanced devices such as electricity meters, gas meters, and/or water meters, through various communication media on request or on a pre-defined schedule. This infrastructure includes hardware, software, communications, customer associated systems and meter data management (MDM) software.
The network between the measurement devices and business systems allows collection and distribution of information to customers, suppliers, utility companies and service providers. This enables these businesses to either participate in, or provide, demand response solutions, products and services.

By providing information to customers, the system assists a change in energy usage from their normal consumption patterns, either in response to changes in price or as incentives designed to encourage lower energy usage use at times of peak-demand periods or higher wholesale prices or during periods of low operational systems reliability.

AMI "raises the bar" with regard to traditional Automatic Meter Reading (AMR) in that it enables two-way communications with the meter, but does not at this point necessarily require the higher bandwidth rates. However when taken “cumulatively” with multiple points of data collection and transfer, and coupled with the need for greater interaction and control, increased bandwidth will be required from the Power Line Communications in this area of service development. Real-time interaction and responsiveness is also a key feature and will enable true and advanced applications to interact with AMI equipment.

In addition and as Demand Side Management and customer interaction increases, the potential for meter reading to be incorporated into a range of new services evolves. Increases in bandwidth and functionality are essential to support this market evolution.

Broadband over Power Line (BPL)

Powerline communications enables the transfer of data over the electrical infrastructure, in a manner similar to the internet. In this way, Utilities can use their electrical cabling infrastructure to provide Broadband services, linking their infrastructure to the World Wide Web. BPL service deployment could be targeted for internal use (by the utility themselves) or as an external and commercially available service. The utility can offer Broadband Internet service over the same infrastructure that provides power to sockets and appliances. The nature of the utilities operating licence may influence commercial deployment and revenue generation.

Telephony for network operation

Normal operation and maintenance services have associated voice communications needs. A network capable of providing Voice over IP (VoIP) support can help reduce costs, and offers a network wide communication mechanism. This extends to, and works in, every location reached by the grid, including underground facilities.

Corporative network access

Normal operation and maintenance requires greater access to corporative information, including centralised databases or web interfaced reporting. These tasks can be simplified by providing access to the corporative network from any element in the grid. By providing sufficient bandwidth for this purpose, the Smart Grid infrastructure will help improve administrative tasks for operational purposes.

Video surveillance

Services provided by the utility are key for community development. In addition the security of utility installations is vital. Video surveillance is a very useful tool to detect non authorized intrusions or to monitor the status of equipment. Having a Smart Grid infrastructure capable of supporting the bandwidth required for video images will enhance the security of these installations.

Condition Based Maintenance

Condition-based maintenance (CBM) strategies rely on using real-time data from the infrastructure equipment to optimize and prioritise the maintenance resources. This real-time information gathering shows the current and real state of the equipment. This information helps facilitate maintenance and repair, and allows resource to be applied only when it is required.

UPA Smart Grid technical requirements:

Equipment designed according to UPA Smart Grid specifications shall:

- Support mesh ad-hoc networking – each additional node enhances coverage and redundancy
- Support overhead and underground and mixed installations
- Provide bandwidth and quality of services to support all the applications outlined in this document
- Support coexistence with other existing power line technologies.
- Comply to CE, FCC, UL, and CSA IEE regulations for safety, emissions, and immunity
- Allow for easy operation/configuration by the user if desired.
- Allow for the easy integration/compatibility with existing access systems as listed
- Allow for remote firmware upgrades without affecting normal operations
- Allow for remote management by an operator using SNMP or other protocols
- Allow for easy integration/connection with existing utility equipment working as a gateway for legacy equipment currently only providing serial interfaces
- Support and enable Low latencies (< x msec) in each hop of the network
- Keep the cost of the solution in the range that makes business plans possible
- Ensure low energy consumption
- Offer a Scalable solution
- Provide High reliability

The following sections outline the requirements in greater detail.

Connectivity layer requirements

The UPA PLC Smart Grid solution provides a connectivity layer at ISO-OSI level 2. This physical level will support all protocols using the same or higher levels on the network.

Some of the most commonly used protocols in use which will be used by Smart Grid applications and which must be supported by the connectivity layer are:

- IEC 61850 (A standard for the design of substation automation. IEC61850 is a part of the International Electrotechnical Commission's (IEC) Technical Committee 57 (TC57) reference architecture for electric power systems.)
    - The abstract data models defined in IEC61850 can be mapped to a number of protocols. Current mappings in the standard are to MMS (Manufacturing Message Specification), GOOSE, SMV, and soon to Web Services.
    - These protocols can run over TCP/IP networks and/or substation LANs using high speed switched Ethernet to obtain the necessary response times of < 4ms for protective relaying.

        - Note: Other mappings have been proposed but are not yet standardized as is the case of the ACSI-CORBA mapping.
- DNP3 (Distributed Network Protocol) Standard
    - DNP3 is a set of communications protocols used between components in process automation systems. It was developed to facilitate communications between various types of data acquisition and control equipment. Historically it plays a crucial role in SCADA (Supervisory Control And Data Acquisition) systems. It is a layer 2 protocol but modern systems can encapsulate it on TCP/IP.
- IEEE standards including
    - 802.3
    - 802.3U
    - 802.IP
    - 802.IQ
    - 802.15.4
- P1675 Standard on BPL hardware and installation
- OPERA Specifications Part 1 (IST Integrated Project 507667) & 2 (EC/IST FP6 Project Number 507667)
- NERC - NERC Standards CIP-002 through CIP-009 provide a cyber security framework for the identification and protection of Critical Cyber Assets to support reliable operation of the Bulk Electric System.
- CIP – Critical Infrastructure Protection ~ CIP 002 to CIP 009

Quality of Service, Reliability and Security

The system must support strict Quality of Service (QoS) to offer the reliability and security required for real time grid management and maintenance. It will:

- Provide QoS capabilities consistent with the requirements of each application for which the technology is intended.
    - QoS typically provides a means of controlling bandwidth utilisation, reliability, latency and jitter.
- Provide graceful degradation of application performance where possible in the event of channel degradation.
    - Depending on system configuration, in congested channel, the system will provide either the capability to deny addition of new applications or service or gracefully degrade performance of applications or services where possible in the event that a new application/service is accepted
- Provide or make control available to either an operator or end-user depending upon the service provided based on change of status and resulting need.

- Maintain quality of service (subject to available system capacity), with simultaneous operation of different applications.
- Include encryption and password protection.
- Permit transmission of digital rights-managed and copyright-protected material.
- All QoS criteria shall be consistent with IEEE 802.1q's class of service parameters.

Interoperability/co-existence with other Technologies (market view)

The reader is directed to the coexistence UPA specification, created by the UPA Coexistence WG. This document is freely available from the UPA web. The UPA worldwide philosophy requires that coexistence with other technologies already deployed or currently being deployed is critical for the success of powerline technology.

The UPA Smartgrid (using Power Line Communications as a key enabling technology) must address interoperability and/or coexistence with powerline systems including:

- Interoperability/coexistence with any other UPA standard is a mandatory requirement.

- Interoperability/coexistence with the OPERA powerline system is a mandatory requirement.

- UPA Smart Grid technological development should be aligned with ETSI and CELELEC standards wherever possible

The system must be capable of bridging with other technologies, including:

- **Wired:** Ethernet 10/100BT, USB, IEEE 1394, coaxial cable, xDSL including ADSL and FS-VDSL).
- **Wireless:** IEEE802.11, HiperLAN2, Bluetooth, IEEE802.15, UWB.

Equipment designed according to the UPA Smart Grid will ensure that:

- They support interoperability between UPA Smart Grid and UPA Command & Control Systems
- Nodes supporting UPA Smart Grid/Access interoperability shall provide a mechanism to ensure that the SLA with the OPERA network is maintained
- Nodes supporting UPA Smart Grid/Access interoperability shall provide a mechanism to notify users of a Smart Grid network of services provided by the OPERA access network for which the Smart Grid network contains nodes to support such services
    - In this context services refer to application level services such as broadband data access with a certain SLA, VoIP based on SIP/H323, MPEG4 based IPTV.
    - Such capabilities should take into account OSGI, DLNA, ADSL forum TR,s UPnP standardisation efforts

- Nodes supporting UPA Smart Grid/Access interoperability shall provide a mechanism to allow users of a Smart Grid network to subscribe to services as defined by the OPERA access network.
- Nodes supporting UPA Smart Grid/ Access interoperability shall provide a mechanism to ensure the privacy of the connected Smart Grid network
- Nodes supporting UPA Smart Grid/Access interoperability shall provide a mechanism to ensure the security of the connected OPERA network

Coexistence with DSL Technologies

The UPA Smart Grid must limit/minimise radiated radio frequency energy in frequency bands used by ADSL, ADSL2plus, VDSL and VDSL2. For this purpose, the UPA-Smart Grid will include requirements to limit transmitted signal power as specified for DSL frequency bands in this standard. The signal power, frequencies, and media characteristics for broadband power line (Wideband PLC) systems present the potential for radiating radio frequency interference (RFI) that could impair embedded transmission systems including:

- ADSL (ITU-T Rec. G.992.1 and G.992.3)
- ADSL2plus (ITU-T Rec. G.992.5)
- HDSL (ITU-T Rec. G.991.1)
- SHDSL (ITU-T Rec. G.991.2)
- VDSL (ITU-T Rec. G.993.1)
- VDSL2 (ITU-T Rec. G.993.2)
- Coaxial Cable transmission
- Wireless communication (including amateur and CB radio)
- Other radio communication systems

Coexistence with other Networks

The UPA-Smart Grid must coexist with and not cause significant degradation to nor be significantly degraded by the presence of IEEE 802.11b/g, 802.11a, and Bluetooth wireless networks.

The UPA-Smart Grid solution must include a coexistence mechanism with and not cause significant degradation to nor be significantly degraded by Amateur Radio (HAM) and other incumbent systems.

The UPA-Smart Grid must coexist with and not cause significant degradation to nor be significantly degraded by other home network technologies and access technologies (including: xDSL, HomePNA, Cable modem etc.).

The UPA-Smart Grid must coexist with and not cause significant degradation to nor be significantly degraded by products operating on the same power line that have a large installed base, an open standard, and multiple vendors. This includes at a minimum, X10, Lonworks, Homeplug Products and CE Bus.

Geographical Requirements and Regulations

The UPA Power Line Communications (PLC) enabled Smart Grid should guarantee the maximum performance for applications in the Asian, North and South America and European markets.

In order to achieve the targets described above, UPA-Smart Grid specification will allow different geographic-specific characteristics and requirements, ensuring the universal worldwide powerline objectives.

Different Regulatory requirements are required for network operation within these geographical boundaries and the UPA Smart Grid PLC technology should have appropriate communication, network and functional attributes to easily meet these requirements.

Connection with utility equipment requirements

Working as a connectivity layer the UPA PLC Smart Grid solution must be linked with the utility equipment using the possible following mechanisms for both current and legacy environments:

- Serial port
  - To include RS232 and RS485 (4 wire half/full duplex)
- MII interface

The Smart Grid solution must include a TCP/IP stack to provide an easy link with legacy equipment not including TCP/IP stack and providing only a serial port. The Smart Grid solution connected to the utility Smart Grid equipment becomes a gateway between a TCP/IP network and devices with proprietary protocols not supporting TCP/IP. The TCP/IP stack can be also used for the management system.

Benefits of the UPA Power Line enabled Smart Grid

UPA Power Line Communication (PLC) enabled Smart Grid Benefits for the Operator

The UPA Smart Grid will provide the following benefits to the utility companies:

- Greater performance and/or or capacity than comparable wireless systems.
- Easy to set up and use.
- Low cost compared to other solutions.
- Secure against cyber terrorism.
- More points of access than a fixed phone or cable/pilot network or similar infrastructure.
- Larger & more reliable coverage than wireless.
- Lower number of support calls than wireless-based distribution systems.
- Lower number of support calls than alternative fixed network distribution systems.
- Advanced remote management capabilities.
- Flexible QoS features for mixed traffic scenarios.
- Elimination of barriers for secure end-to-end connectivity.

UPA Power Line Communication enabled Smart Grid Benefits for Vendors

The UPA PLC enabled Smart Grid will provide the following benefits to the end-user:

- A recognized standard/certification guarantee for product marketing
- Minimal product returns due to resolution of interference or non-coexistence issues
- A guarantee of fit and function for Utility applications for UPA Smart Grid products

APPENDIX A - Glossary and Acronyms

ADSL	Asymmetric Digital Subscriber Line
CENELEC	European Committee for Electrotechnical Standardization
CIP	Critical Infrastructure Protection (Part of NERC)
DES	Digital Encryption Standard
DSL	Digital Subscriber Lines
DTCP	Digital Transport Copy Protection
ETSI	European Telecommunications Standards Institute
FCC	Federal Communications Commission
IEC-CISPR	International Electrotechnical Commission - Comité Internationale Spécial des Perturbations Radioelectrotechnique (International Special Committee on Radio Interference, IEC)
IEEE	Institute of Electrical and Electronics Engineers
ISDN	Integrated Services Digital Network
ISO	International Organisation for Standardization
ITU-T	International Telecommunication Union -Telecommunication Standardisation
LAN	Local Area Network
MV	Medium Voltage
NERC	North American Electric Reliability Corporation
NTU	Network Termination Unit
OFDM	Orthogonal Frequency Division Multiplexing
OPERA	Open PLC European Research Alliance
OSI	Open Systems Interconnection (ISO/IEC 7498-1)
PLC	Power Line Communication
QoS	Quality of service
SNMP	Simple Network Management Protocol (RFC 11576)
TDM	Time division multiplexing
TDMA	Time Division Multiple Access
UPA	Universal Powerline Association
VoIP	Voice over Internet Protocol
WAN	Wide Area Network