Smart grid distribution and smart meters

Energy-efficient solutions
Introduction

Governments and power companies across the world have recognized that the traditional grid, which has not significantly changed in 100 years, must be replaced by more efficient, flexible and intelligent energy-distribution networks, called smart grids. These are digitally monitored, self-healing energy systems that deliver electricity or gas from generation sources, including distributed renewable sources, to points of consumption. They optimize power delivery and facilitate two-way communication across the grid, enabling end-user energy management, minimizing power disruptions and transporting only the required amount of power. The result is a lower cost to the utility and the customer, more reliable power, and reduced carbon emissions.

At STMicroelectronics, we offer a complete set of semiconductor products to implement energy, water, heat and gas meters, as well as concentrators or multi utility controllers (MUC). The portfolio includes power-line modems, 8- and 32-bit microcontrollers, 32-bit microprocessors, ASSPs for metrology, real-time clocks, EEPROMs, power supply products and security products.

ST’s smart grid strategy

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With more than 20 years of presence and investment in the field of metering and smart grids, ST has developed the widest portfolio of products and solutions meeting the needs of these segments. ST’s strategy in the smart grid can be summed up as follows: the one-stop shop for smart-grid applications. This means we supply most of the semiconductors for each application mentioned in the above picture.

The success stories with Enel in Italy, Iberdrola and Endesa in Spain, and other utilities and meter manufacturers worldwide have already demonstrated the quality of our solutions.
Energy smart meters

Smart metering essentially involves an electronic power meter supplemented by full remote control, diagnostics, power peak and consumption analysis, anti-tampering mechanisms, fault alert, time-variable tariffs, and many more possibilities. Using power-line communication (PLC) or other wired and wireless technologies to connect the meter to the service provider enables all of the above features to be feasible and compatible with future smart-grid protocols.

Block diagram

- **Basic**
  - Power supply
  - Battery charger
  - Battery
  - Battery switchover
  - Anti tampering
  - RTC
  - Monolithic solution

- **Medium**
  - Communication signal processing for AMR and domestic automation
  - RF
  - Ethernet
  - PLM
  - GSM
  - RS-485
  - RS-232
  - Smartcard reader
  - IR remote

- **Advanced**
  - Control unit
  - Energy metering IC
  - Stepper motor display
  - Reset circuit
  - LCD control
  - EEPROM
  - Breaker
  - x-axis accelerometer
Featured products

STM32®

32-bit Flash microcontrollers powered by the ARM® Cortex™-M processor

The STM32 family of 32-bit Flash microcontrollers based on the ARM Cortex™-M processor is designed to offer new degrees of freedom to MCU users. It brings a complete 32-bit product range that combines high-performance, real-time, low-power and low-voltage operation, while maintaining full integration and ease of development. It eases migration from the 16-bit world with its high level of feature integration, its easy-to-use architecture, its low-power capability and cost effectiveness.

STMicroelectronics is a lead partner in developing Cortex-M cores and, with the STM32, offers a comprehensive portfolio of advanced MCUs that we are committed to extending in capability, competitive pricing and features to cover the needs of microcontroller convergence.

Product offering

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<td>SPEAr</td>
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<td>Power supplies</td>
<td>ALTAR04-900</td>
<td>Offline all-primary-sensing switching regulator with 900 V breakdown voltage</td>
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<td>ViperPlus family</td>
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<td>Innovative 800 V avalanche-rugged SuperMESH™ power MOSFET with state-of-the-art PWM circuitry</td>
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<tr>
<td>Energy metering ICs</td>
<td>STPMC1, STPMS2</td>
<td>Poly-phase chipset representing the first modular solution for metering systems</td>
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<tr>
<td>EEPROM</td>
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<td>Serial PC or SPI EEPROM, 1 Kbit to 1 Mbit, 1.7 to 5.5 V</td>
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<td>M24LR64-R</td>
<td>Dual Interface EEPROM, 64-Kbit, I²C and ISO 15693 RF interface in MLP8 package</td>
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<td>X-axis accelerometer</td>
<td>Accelerometers</td>
<td>ST’s state-of-the-art analog and digital accelerometers feature up to ±24g full scale, high resolution, smart embedded functionalities and advanced power-saving features</td>
</tr>
<tr>
<td>RF</td>
<td>STM32W</td>
<td>The STM32W is a fully-integrated system-on-chip that integrates a 2.4 GHz, IEEE 802.15.4-compliant transceiver, 32-bit ARM® Cortex™-M3 microprocessor, Flash and RAM memory, and peripherals of use to designers of IEEE 802.15.4-based systems</td>
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<td>SPZB32W1A2.1</td>
<td>The SPZB32W1A2.1 and SPZB32W1C2.1 are ready-to-use ZigBee® modules optimized for embedded applications that require low data rate communications; the modules are based on the STM32W108CB</td>
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<td>Ethernet</td>
<td>ST802RT</td>
<td>High-performance fast Ethernet physical layer interface for 10Base-T, 100Base-TX and 100Base-FX applications</td>
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<tr>
<td>Interface ICs</td>
<td>RS-232</td>
<td>Includes transceivers with auto-power-down and standby functions, multi-channel interfaces and driver/receiver circuits</td>
</tr>
<tr>
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<td>RS-485</td>
<td>Includes very high-speed, low-power RS-485 transceivers, usually containing one driver and one receiver in half duplex configuration</td>
</tr>
</tbody>
</table>

Key features

- Flash from 16-Kbyte up to 1-Mbyte
- Cortex core
- RTC down to 1 µA
- Crypto accelerator and true random number generator
- Complete tools ecosystem
- Up to 15 communication interfaces
ALTAIR04-900
Offline all-primary-sensing switching regulator
ST’s ALTAIR04-900 is very efficient at low load (between 10 and 20% of nominal output power) as the AMR remains in this condition for the majority of the time. It is compatible with 3-phase mains voltage, either functional (connected to a 3-phase line) or surviving (wrong connection).

Two or more output voltages can be generated to supply a 3.3 V microcontroller as well as a power-line modem (12 V for instance). The IC operates in standard isolated and non-isolated flyback topology all-primary-sensing control, thus no feedback from the secondary side is required for voltage accuracy.

STPMC1/S2
Poly-phase chipset for energy measurement
ST’s poly-phase chipset represents the first modular solution for metering systems. This flexible solution is built around 2 different parts: the STPMS2 and STPMC1.

The STPMC1 works as an energy calculator. It is an ASSP designed for effective energy measurement in power-line systems. Used in combination with one or more STPMS2 ICs, it implements all the functions needed in a 1-, 2- or 3-phase energy meter. The STPMS2 smart sensor is a dual second order sigma delta (SD) modulator with embedded programmable gain amplifier (PGA). It is highly configurable through hardwired pins on SPI port. This chipset approach allows you to position the A/D conversion (STPMS2) very close to the current transducers, so minimizing noise capture from the analog tracks. Once converted, the SD streaming of voltage and current are multiplexed and transferred through a single-wire data line to a dedicated DSP inside the STPMC1. The STPMC1 can manage from 2 to 9 datastreams coming from the STPMS2 (from 1 to 5 devices) serving 3 voltage channels and 4 current channels, plus 2 optional streams for multiple purposes. Wide sensor support, SPI interface, tamper proofing by neutral current, temperature and magnetic field monitoring make this the ideal solution for multi-purpose, high-performance metering systems.
### Poly-phase measurement scheme

#### Key features
- Computes active and reactive wideband and fundamental harmonic energies
- Exclusive ripple-free energy calculation algorithm
- 112 configuration and calibration bits
- Neutral current, temperature and magnetic field monitoring
- Two 2nd order SD modulators for voltage and current
- 0.5% accuracy in 1:5000/10000 range (STPMS2)
- Complies with IEC 62052-11/62053-21/62053-22/62053-23,

#### Key benefits
- Fast digital calibration
- Higher accuracy
- Flexible approach
- Allows the use of multiple shunts

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**STPMC1 block diagram**

**STPMS2 block diagram**
STPM01, STPM10

Versatile programmable single-phase energy metrology ICs

The STPM01/STPM10 energy metrology ICs incorporate all the core circuitry required to implement the metrology of a class 1 electricity meter as well as that of a DIN or home (smart plug) meter. These devices are designed for effective measurement of active, reactive and apparent energy in a power-line system using current transformer, shunt and Rogowski coil sensors (only STPM01).

STPM10 block diagram

Key features

- Measures active, reactive, and apparent energies
- RMS current, voltage and instantaneous measurement
- Frequency measurement
- Ripple-free active energy pulsed output
- Live and neutral monitoring for tamper detection
- Fast and simple one-point digital calibration over the whole current range
- Integrated linear voltage regulators for digital and analog supply
- Selectable RC or crystal oscillator
- Supports 50/60 Hz, IEC 62052-11, IEC 62053-2x specifications
- Less than 0.1% error in the 1000:1 range
- Precision voltage reference: 1.23 V with 30 ppm/°C max
- OTP for calibration and configuration (STPM01 only)

Very simple and low cost metering applications are addressed by the STPM11, STPM12, STPM13 and STPM14. These devices are able to perform only active power measurement.

ST7570, ST7580, ST7590

STarGRID™ power line communication SoC platform

The STarGRID platform meets the needs of large-scale smart metering infrastructure deployments and future smart grid scenarios. The new platform includes different specific SoC implementations (ST7570, ST7580, ST7590), featuring:

- High modularity and flexibility: multiple modulations and protocols
- High integration: DSP PHY processor, protocol stack engine, analog front end, power-line driver, encryption and auxiliary functions in a single chip
- High scalability: future-proof implementation
- Openness: suitable for present and future open standards or proprietary protocol integration
- Ease-of-use: turnkey implementations available compliant with major protocol specifications such as IEC 61334-5-1, PRIME, Meters and More, and others
The STarGRID platform is suitable for the main applications in energy and grid control, such as smart grid, smart metering, smart building/home and e-mobility applications.

**STarGRID SoC block diagram**

- **Key features**
  - Fully integrated narrowband power-line networking system-on-chip
  - Programmable DSP processor for power-line PHY management
  - 8-bit 8051 engine for protocol controller and supervision
  - Fully integrated analog front end, with high sensitivity receiver and high linearity transmitter with intelligent gain control
  - Integrated 5 V and 1.8 V linear regulators for AFE and digital core supply
  - Fully integrated single-ended power amplifier for line driving
    - Up to 1 Arms, 14 Vpp output
    - Configurable active filtering topology
    - Very high linearity
    - Embedded temperature sensor
    - Current control feature
  - 3.3 V or 5 V I/O power supply
  - 8 V to 18 V power amplifier supply
  - Suitable for EN 50065 and FCC part 15 compliant applications
  - -40 to +85 °C temperature range
  - Suitable for multiple power-line communication standards such as PRIME, Meters and More, IEC 61334-5-1
Water/gas meters

Integrated circuits used in today’s water and gas meters are supplied by batteries, and thus power consumption is a key factor in their selection. At ST we offer a wide portfolio of high-performance ultra-low-power 8- and 32-bit microcontrollers, as well as RF transmission circuits and highly-efficient power supply devices to meet your design needs.

**Block diagram**

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<td>Power supply</td>
<td>Step-down DC-DC converters</td>
<td>Monolithic switching regulators offer input voltage capability up to 55 V, deliver output currents up to 4 A, with high switching frequency</td>
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Featured products

STM8L

8-bit ultra-low-power microcontroller family

The EnergyLite platform from ST for 8-bit STM8L MCUs is based on a proprietary 130 nm ultra-low leakage process technology. The STM8L offers specific features for ultra-low-power applications, such as advanced ultra-low-power modes, optimized dynamic run consumption and specific safety features. The balance between high performance and ultra-low power using different modes ensures optimal energy consumption, an optimal family to support many applications with special care on power savings for metering (electricity/gas/water/heat meters and scales).

Key features
- Full range from 4- to 64-Kbyte embedded Flash
- RTC with enhanced calibration and features for metering
- AES on board (optional)
- 20 pins to 80 pins
- LCD up to 8 x 40/4 x 44
- Down to 400 nA in Halt mode

Benefits
- Speed and power consumption independent of MCU power supply, ultra-low leakage
- Reduced overall run- and wait-mode current consumption by turning off clocks of unused peripherals or Flash
- Ultra-low-power modes for applications requesting regular wake up
- Suitable for many applications from complete switch off to continuous monitoring at ultra-low frequency
- Switch and adjust frequency and clock sources on the fly depending on application needs
- Autonomy for peripherals, independent from core; can switch off Flash memory and CPU (large current consumption contributors) while keeping peripherals active
- Integrated safety and security for application
- Full functionality over the complete V_{CC} range
- Smart applications ready (power meters, for example)

STM32W

32-bit RF MCUs

With a configurable total link budget up to 109 dB and the efficiency of the ARM Cortex-M3 core, the STM32W is the perfect solution to make a home energy display or to connect your meter with a display or other device of the smart grid ecosystem. This open and flexible platform supports the most popular protocol stacks such as ZigBee-PRO, 6LoWPAN, and more.

Key features
- Outstanding IEEE 802.15.4 2.4 GHz performances
- Best-in-class code density, thanks to its ARM Cortex-M3 core
- Low-power architecture
- Open platform with extra resources for application integration: configurable I/Os, ADC, timers, SPI, UART
- Main software libraries: EmberZnet PRO, RF4CE, IEEE 802.15.4 MAC
- Available in both SoC (QFN48) and coprocessor (QFN40) versions

Benefits
- Cost efficiency through a true SoC
- Open platform supporting IEEE 802.15.4-based protocol stacks
- Wide STM32 Cortex-M3 developers community
- Unmatched network throughput and latency
- Longer battery lifetime
The Dual Interface EEPROM is an electrically-erasable memory which communicates with read and write attributes through both a wired I2C interface with MCU or chipset as well as an RF interface, using the industry-standard ISO 15693 which does not require any on-board power.

It enables a wide range of use cases in the smart meter ecosystem. The first is in manufacturing and logistics where you can remotely set parameters at the last minute and update or customize settings when your meter is already in the box. You can also activate keys and trace the production process.

The second use case is during meter installation and maintenance. Here the Dual Interface EEPROM simplifies and speeds up the identification of the model and customer, or the download of event logs such as tamper or fault detection.

Finally, it could be used by consumers to interface with their meters using a hand set (NFC compatible phone). The user could download the loading curve on a mobile phone, for instance.

It gives multiple value added services to your smart grid devices. Take the lead with ST now and check the product information to improve your application.

**Key features**

- Very low static and dynamic power consumption
- Simple but very flexible data protection schemes
- Best-in-class quality memory
- Up to 40 years of data retention
- 1 million read and write cycles
Data concentrator, multi utility controller (MUC) and gateway

A data concentrator, MUC and gateway are devices acting as an interface between the utility-controlled smart grid and the home area network. They manage the data exchange between smart meters, utility providers and energy-consuming in-house objects. While a data concentrator manages the information for several homes, a multi utility controller, also known as an energy gateway, manages the data exchange for a single home.

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## Featured products

### SPEAr310 and SPEAr320

**SPEAr embedded microprocessors**

The SPEAr310 and SPEAr320 eMPUs fit naturally into the communication intensive applications needed by concentrators or multi utility controllers (aggregators) in the smart grid arena.

Built around the industry standard ARM926EJS core, SPEAr310 and SPEAr320 include a comprehensive range of communication peripherals to meet all the design constraints of concentrator applications: no need for external companion chips except the memory and power supply subsystem. The complete set of evaluation boards and software allows an efficient design.

## Key features

- ARM 926EJS @ 333 MHz (366 DMIPS)
- Linux BSP provided by ST
- Other OS supported through 3rd party network (Integrity, VxWorks, WinCE, and more)
- Industrial operating temperature range: -40 to +125 °C
- Flexible external memory interface: DDR2, NAND Flash, serial and parallel NOR Flash, SDIO/MMC, and others
- Numerous communication peripherals: 2x USB Host, USB Device, up to 5 Ethernet, up to 6x UART, 2x CAN, I²C, SPI, 4x PWM, IRDA, and more
- Cryptographic engine
- Human machine interface: 1024 x 768 x 24 LCD support, touchscreen, keyboard matrix, GPIO, and others
- 8-channel 10-bit ADC, 1 MSPS
- LFBGA289 15 x 15 mm package
STM32 F2-series
High-performance Cortex-M3 MCUs

The STM32 F2 series extends the use of the STM32 to applications with high connectivity requirements such as in MUC or AMI. The enhanced connectivity features, the extended Flash and RAM size, the operating frequency up to 120 MHz (at dynamic current consumption of 188 µA/MHz) and the embedded cryptographic algorithms with HW accelerator and FW libraries make the device very useful for complex metering applications.

Based on the high-performance ARM® Cortex™-M3 32-bit RISC core, the STM32 F2 series incorporates high-speed embedded memories (Flash memory up to 1 Mbyte, up to 128 Kbytes of system SRAM), up to 4 Kbytes of backup SRAM, and an extensive range of enhanced I/Os and peripherals.

Key features

- Adaptive real-time accelerator (ART Accelerator™) allowing 0-wait state execution performance from Flash memory, memory protection unit, 150 DMIPS
- FSMC controller for external memory
- LCD parallel interface
- 1.65 to 3.6 V application supply and I/O
- Sleep, Stop and Standby modes
- Internal 16 MHz factory-trimmed RC
- 32 kHz oscillator for RTC with calibration
- Internal 32 kHz RC with calibration
- V$_{BAT}$ supply for RTC
- Up to 15 communication interfaces (I²C, UART, USART, LIN, IrDA, SPI, FSC, CAN, SDIO)
- 10/100 Ethernet MAC
- Full speed USB device/host/OTG PHY
- 8- to 14-bit parallel camera interface

Evaluation boards

Developers take advantage of from ST's range of evaluation boards that are specifically designed to help them evaluate ST device features and start their own applications.

Product offering

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<td>EVALKITS7570-1</td>
<td>ST7570 S-FSK power-line networking system-on-chip evaluation kit for AMR</td>
</tr>
<tr>
<td>STEVAL-IPE012V1</td>
<td>Single-phase energy meter demonstration board using the STPM10 and STM8L152</td>
</tr>
<tr>
<td>STEVAL-IPP002V1</td>
<td>IEC 61334-5-1 compliant smart meter system for AMI application based on STM32, ST7570 PLM and STPMC1/STPMS1 chipset</td>
</tr>
<tr>
<td>STEVAL-IPE002V1</td>
<td>STPM10 energy meter (mono phase) - measurement board, 2 current transformers</td>
</tr>
<tr>
<td>STEVAL-IPE003V1</td>
<td>STPM10 energy meter (mono phase) - measurement board, 1 current transformer + shunt</td>
</tr>
<tr>
<td>STEVAL-IPE010V1</td>
<td>Energy meter demonstration kit motherboard based on the STPMC1 and STPMS1</td>
</tr>
<tr>
<td>STEVAL-IPE014V1</td>
<td>Energy meter demonstration kit daughterboard based on the STPMS2</td>
</tr>
<tr>
<td>STEVAL-IPE015V1</td>
<td>STPM10 single-phase meter board, 2 current transformers</td>
</tr>
<tr>
<td>STEVAL-IPE016V1</td>
<td>STPM10 single-phase meter board, 1 current transformer + shunt</td>
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<tr>
<td>STEVAL-IPE017V1</td>
<td>STPM10 single-phase meter board, 1 shunt</td>
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<tr>
<td>STEVAL-IPE018V1</td>
<td>STPM10 single-phase meter board, 1 current transformer</td>
</tr>
<tr>
<td>STEVAL-IPT002V1</td>
<td>Smartcard interface demonstration board based on the ST8024</td>
</tr>
<tr>
<td>EVLALTAR900-M1</td>
<td>SMPS for metering and PLC applications</td>
</tr>
<tr>
<td>STEVAL-ISA010V1</td>
<td>Ultra-wide range, dual-output buck converter demonstration board based on the VIPER16</td>
</tr>
<tr>
<td>STEVAL-ISA062V1</td>
<td>6 W dual-output SMPS demonstration board based on the VIPER17</td>
</tr>
<tr>
<td>DEVKIT-M24LR-R</td>
<td>Development kit for M24LR64-R</td>
</tr>
<tr>
<td>EVALSPEAr3*</td>
<td>SPEAr300/310/320 demonstration boards</td>
</tr>
<tr>
<td>STEVAL-IHP002V1</td>
<td>SmartPlug system to measure and control AC loads based on STM32, ST7740 PLM and STPM01</td>
</tr>
<tr>
<td>STEVAL-PCC012V1</td>
<td>STM32F107 connectivity gateway, demonstration board</td>
</tr>
<tr>
<td>STEVAL-IPB001V1</td>
<td>2 W, 3-phase SMPS breaker with ESBT</td>
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Note: * is used as a wildcard character for related part numbers
Featured solutions
STEVAl-IPP002V1
IEC 61334-5-1 compliant smart meter system for AMI applications

The STEVAL-IPP002V1 demonstration board can be used as a guideline to designing a typical energy meter board for smart metering applications compliant with the IEC 61334-5-1 standard. It was designed to include advanced features as well as to fit the requirements for next generation energy meters. These extra features can be included in the board by modules for easy customizing.

Key features
- Smart metering library based on free RTOS and STM32F flexible microcontroller
- S-FSK power-line communication
- High-efficiency power supply in quasi resonant mode (ALTAIR04-900)
- Energy measurement by an external metrology board for STPMC1 + STPMS1 (STEVAl-IPE010V1) or STPM1*
- LCD display to show energy consumption information
- USB and RS-232/IrDA connectivity
- Optional ZigBee communication capability
- Optional MEMS module support
- Expansion capability for smartcard interface
- RoHS compliant

Note: * is used as a wildcard character for related part numbers

STEVAl-IPE012V1
Low-cost single-phase energy meter demonstration board

The STEVAL-IPE012V1 demonstration board implements a single-phase energy meter (Class 1 accuracy with dynamic range 200:1) based on the STPM metering IC and STM8L152 microcontroller. The demonstration board is a fully functional low-cost, single-phase solution featuring parameter display, tamper management, maximum demand (MD) calculation, EEPROM data logging, and low power.

Key features
- Accuracy: Class 1 with dynamic range 200:1
- Nominal voltage: 240 V
- Nominal current: 5 A (I_{TYP})
- Maximum current: 45 A (I_{MAX})
- Operating range: 0.6 V_{BAT} to 1.2 V_{BAT}
- Meter constant: 3200 impulses/kWh
- Power frequency range: 45 Hz to 65 Hz
- Sensor: primary-side CT and secondary-side shunt
- Communication interface: IrDA
- RoHS compliant
ST in smart grid standards

ST is actively contributing to all the major industrial and standardization smart grid initiatives.

<table>
<thead>
<tr>
<th>Role</th>
<th>Details</th>
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<tbody>
<tr>
<td>Technical working group member of DKE 461 German standard</td>
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<tr>
<td>Steering committee chairman of EU Smart Grid Task Force and participant in the smart meter and smart grid specification working group</td>
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<td>Member of the G3-PLC alliance</td>
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<td>Board of Directors of Home Plug Alliance, major US industrial organization for PLC</td>
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<td>Participation in SAE international and IEC V2G JWG meetings for electric-vehicle to charging-station communication standardization</td>
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<td>Working group member of IEEE P1901.2 for the standardization of low band OFDM PLC standard for smart grids</td>
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<td>Principle member of Meters and More, the non-profit organization in Brussels for Enel/Endesa smart metering system standardization and promotion</td>
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<td>Member of NIST - PAP 15 group for PLC technology coexistence definition</td>
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<td>Technology provider of OPENmeter, the EU funded project of FP7 framework for multi-utility standardization</td>
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<td>Principle member of PRIME Alliance: driven by Iberdrola for the development of a PLC OFDM standard for smart metering applications</td>
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