Smart Grids
Sinergias entre redes eléctricas e de comunicação

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19 Março 2013

Company overview

Over 60 years of history with strong operational and financial track record.

A Portuguese company present in over 65 countries in all 5 continents.

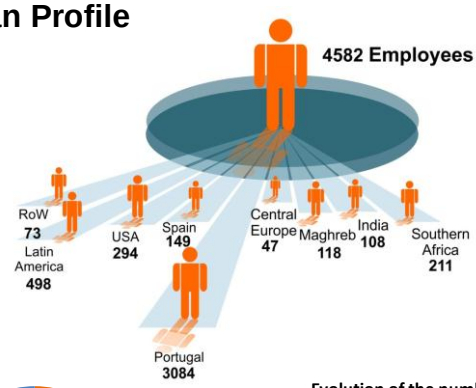
Efacec currently employs more than 4,600 employees and over 1 billion Euros of turnover.

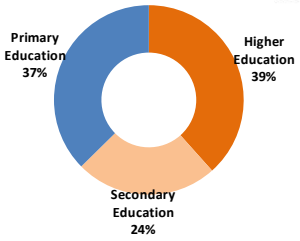
The company is present in sectors at the forefront of technological development, including energy, transportation, and the environment.

It is renowned for developing state-of-the-art technologies, demonstrating high levels of competence, quality and entrepreneurship.

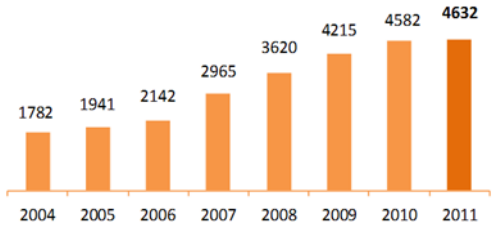
Privately owned equally by well-known Portuguese industrialist family companies – *Grupo José de Mello* and *Têxtil Manuel Gonçalves*

Human Profile





Evolution of the number of employees



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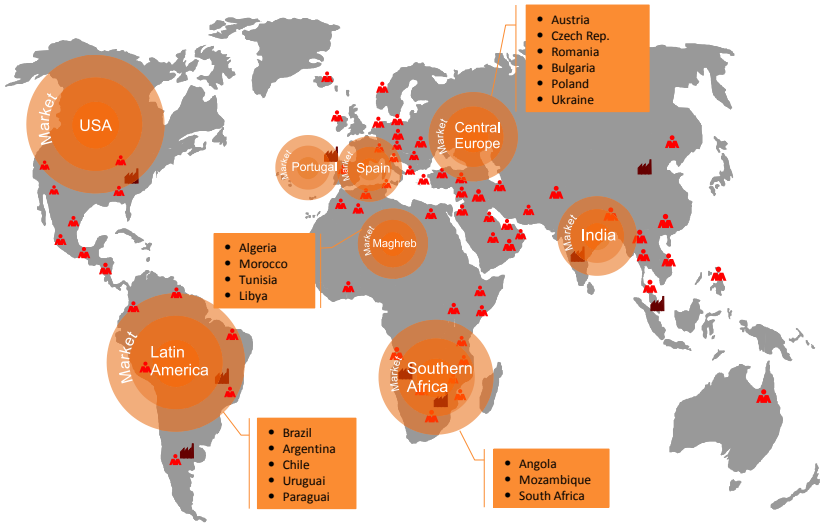
Note: Since 2004, for headcount purposes, China is no longer considered to be part of RoW (Rest of the World).

Business geographies



Efacec is mostly based in **8 geographic regions**: Portugal, Spain, Central Europe, Maghreb, Southern Africa, USA, Latin America , India.

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Business Areas

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Energy	Engineering, Environment and Services	Transport and Logistics
▪ Transformers	▪ Engineering	▪ Transport
▪ Switchgear	▪ Automation	▪ Logistics
▪ Servicing	▪ Maintenance	
	▪ Environment	
	▪ Renewables	

Business Units

Business Areas

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Energy	Engineering, Environment and Services	Transport and Logistics
▪ Transformers	▪ Engineering	▪ Transport
▪ Switchgear	▪ Automation	▪ Logistics
▪ Servicing	▪ Maintenance	
	▪ Environment	
	▪ Renewables	

Business Units

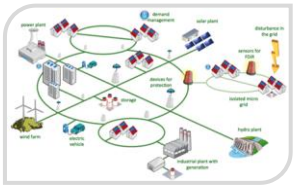
Automation

Power Generation and Renewable Energies

- Control centers for production management (SCADA/GMS)
- Thermoelectric and hydroelectric power plants automation; Wind farm automation; Automation of other electrical power production facilities using renewable energies; Electric traction grids and transport systems
- SCADA systems for electric traction grid management
- Integrated supervision systems for technical infrastructures
- Integrated traction substation protection, command and control systems

Transmission Networks

- Control centers for the management of electrical networks (SCADA/EMS)
- Integrated substation protection, command and control systems



Distribution Networks

- Power network management control centers (SCADA/DMS)
- Integrated for substation protection, command and control systems
- Distribution automation remote control systems
- Smart grid solutions

Distribution Networks - Changing drivers

ENVIRONMENTAL SUSTAINABILITY

Need for new generation technologies, as alternative to fossil resources in order to reduce external energy dependency and to fulfil environmental obligations

RELIABILITY AND QUALITY OF SUPPLY

Face the obsolescence of assets installed on the electric network, its capacity limitations and the security risks inherent. Increase the reliability performance avoiding blackouts.

CONSUMER *EMPOWERMENT*

The consumer wants to participate and be able to make decisions in order to optimise its energy consumption, more aware and better informed, assuming a more active role. Consumer evolves to be a producer with microgeneration - *Prosumer*.

EUROPEAN ENERGY MARKET

Increased competitiveness advocated for Europe (Lisbon Strategy) involves the existence of a highly competitive energy sector in terms of prices and wealth of services.

Distribution Networks Progress

	Current Grid	Smart Grid
Communication	Limited and one-way (typically not real-time)	Two-way (real-time)
Customer interaction	Limited	Extensive
Generation	Centralized	Centralized and distributed
Power flow control	Limited	Bi-directional, automated
Reliability	Prone to failures and cascading outages Essentially reactive	Automated, pro-active protection Prevents outages before they start
Restoration following disturbance	Manual	Self-healing
System topology	Radial (generally one-way power flow)	Open-mesh/Meshed (dynamic power flow pathways)

Adapted from Research Reports International

Practical definition of Smart Grids

Conventional **Passive Distribution Network**

+

Sensors and Measurements dispersed and profuse

+

Remotely controlled **Actuators** and widely dispersed

+

Wide **Communications Infrastructure** with **Open Protocols**

+

Distributed Intelligence and equipments with **Local Algorithms**

+

Integrated Management and Control architecture

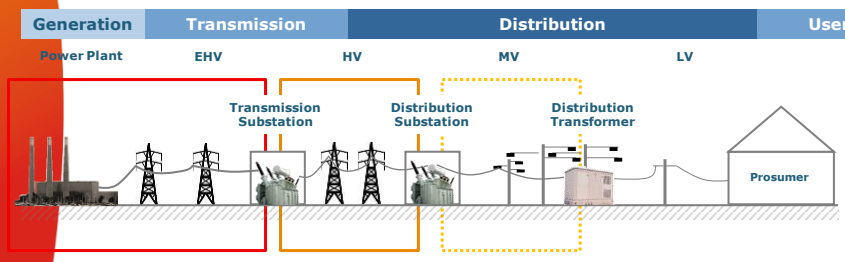
+

Economic Sustainability (benefits > costs)

=

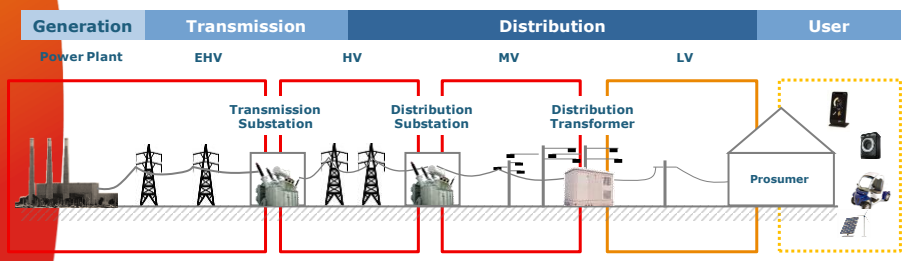
Smart Grid

Intelligence and communications



Automation Reach

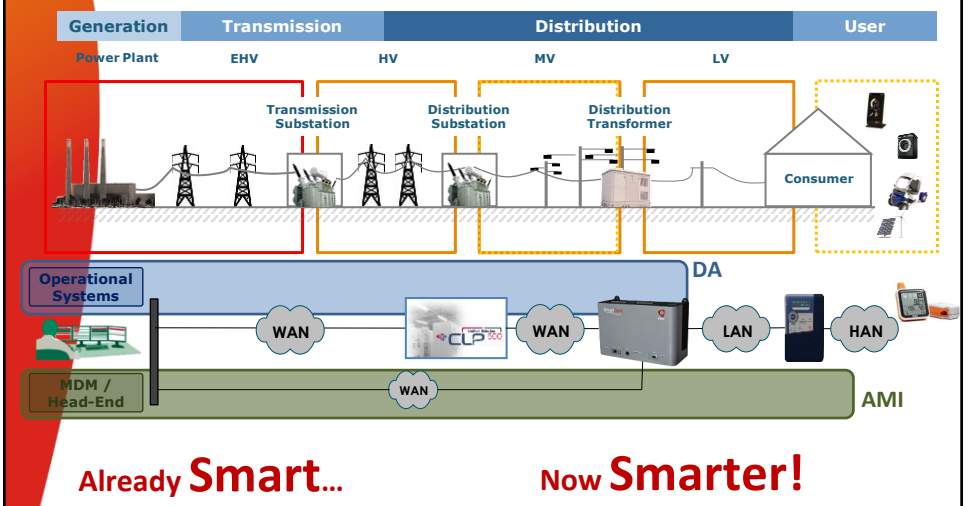
Intelligence and communications



Communication and Information System

Automation Reach

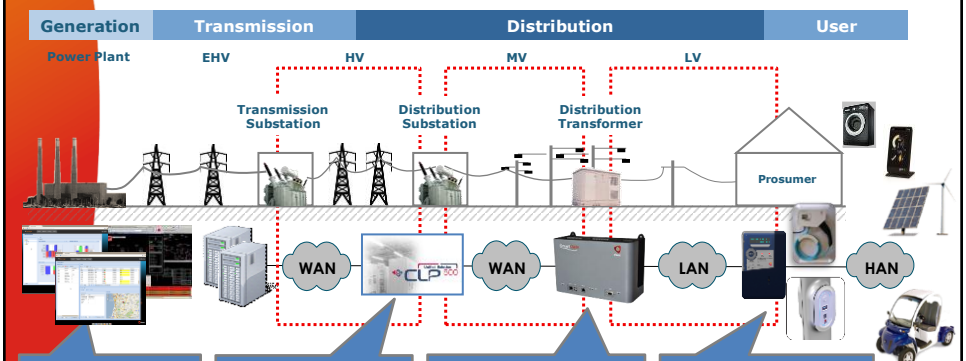
Network Elements



Already **Smart**...

Now **Smarter!**

Distribution Network – an intelligent asset



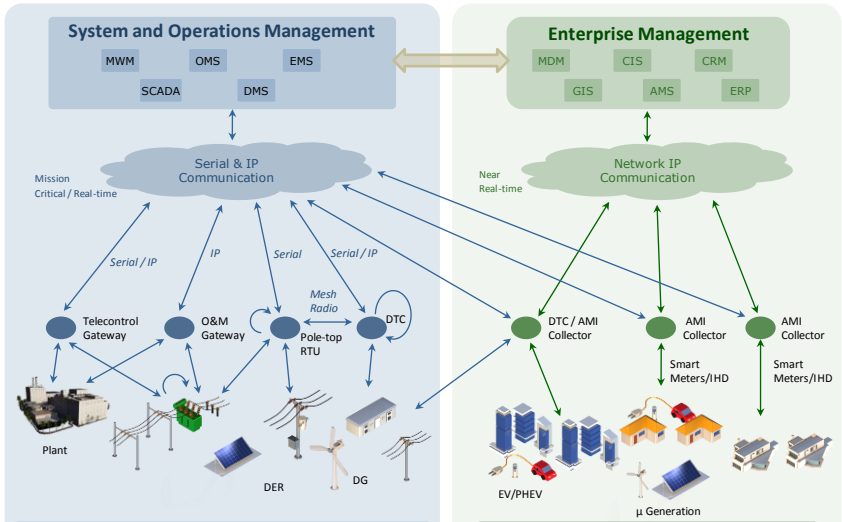
Central Systems (operational & commercial)
- Management
- Operation
- Data management
- Integration with IT
- ...

Smart Substation Controller (SSC)
- Advanced functionalities
- Self-healing
- Voltage Regulation
- Virtual Power Plant
- ...

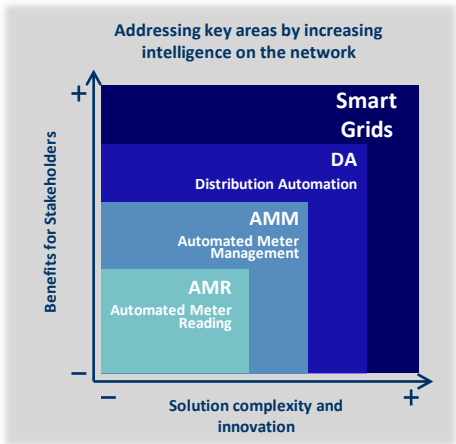
Distribution Transformer Controller (DTC)
- Monitoring & Control
- Metering
- Data concentrator
- Microgeneration, load storage and EV control
- ...

EV charger/Smart Meter
- Metering
- Remote operation
- Flexible tariffs
- HAN interface
- QoS information
- Customer interaction
- ...

Communications and control



Functionalities scope



Smart Metering & Energy Management
Customer-centric approach; provide new set of services; promote energy efficiency

Microgeneration
Create conditions for secure and reliable integration of distributed RES in large scale, maintaining network stability, security and reliability

Smart Grids
Improve intelligence, supervisory and control of the distribution network; promote efficiency and quality of supply

Functionalities scope

Automated metering infrastructure

+

Efficiency improvement and introduction of new business models & services

+

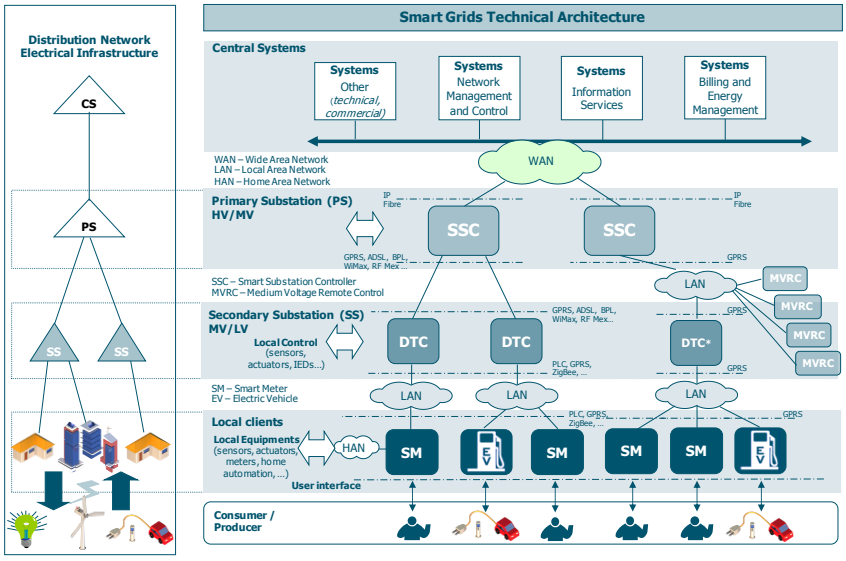
Capacity to increase integration of Renewables and the electric vehicle

+

Increase automation level and intelligence on the network

Smart Grids

Reference Architecture



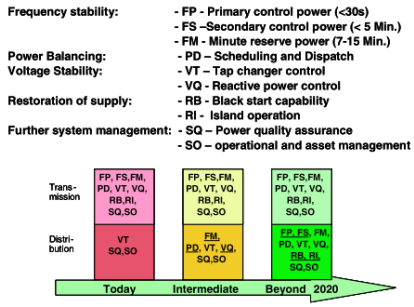
Conquering new markets

- R&D initiatives and pilot projects provided the essential drive

- Synergies between utilities, manufacturers and academy/scientific institutions consolidate know-how
- Originated unprecedented new product line development including different stages:
  - Specification
  - Development
  - Implementation
  - Testing
  - Certification
  - Market launch

Communication infrastructure

- The power and communication networks are the infrastructure for the Smart Grid
  - SCADA
  - Self-Healing Network
  - Demand Response
  - Virtual Power Plants
  - Load / Generation Forecast
  - Asset Optimization
  - Plug-in Electric Vehicles
  - ...



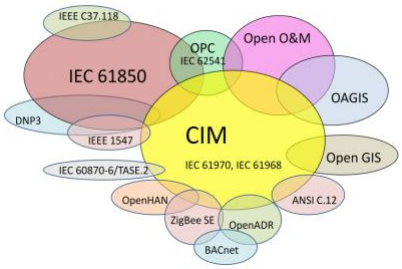
New applications will introduce new requirements

Communication infrastructure

- New applications will introduce new requirements
  - Connectivity
    - More and more interconnected devices
    - Larger network with a larger geographic implantation
  - Bandwidth
    - More nodes imply more data exchanged
    - New protocols are typically more verbose
  - Response time
    - Algorithms for microgrids, virtual power plants, etc. will need a fast and real-time communication network
  - Interoperability
    - Integration of devices from different vendors
    - Communication between devices using different communication technologies

Communication standards

- Standardization effort for the Smart Grid platform
  - EU
    - European Smart Grids Technology Platform, sponsored by the European Commission
  - US
    - NIST (National Institute of Standards and Technology)



Communication Architecture

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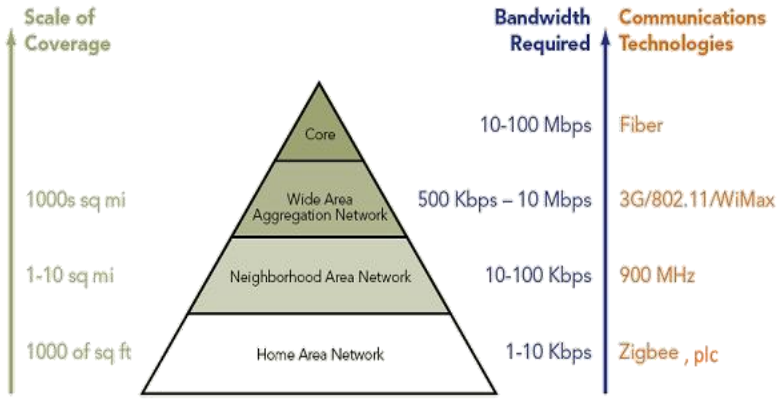
- Coverage vs. Bandwidth



Communication Architecture

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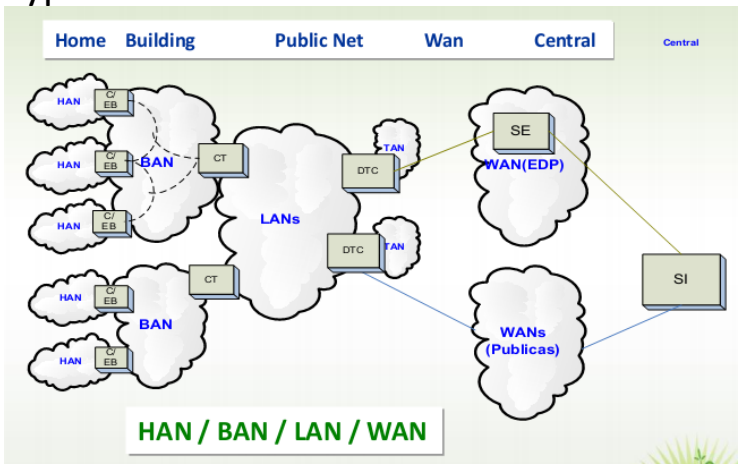
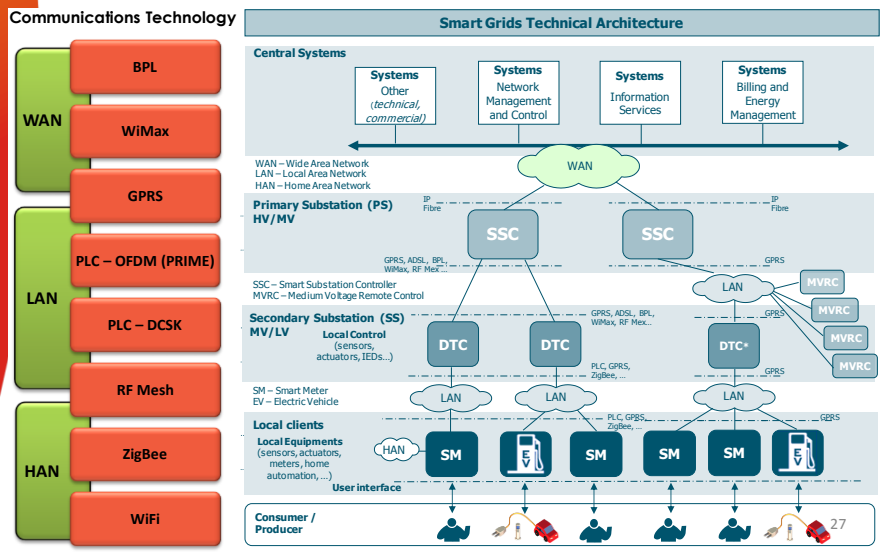
- Typical communication architectures



Communication Architecture

- Typical communication architectures

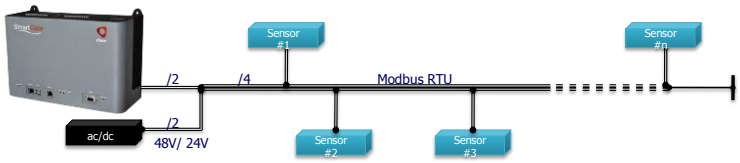


Communication Architecture

- Communication architecture
  - WAN
    - Wide Area Network
    - Support for the necessary wide area coverage
    - Typically interconnecting the central systems to the MV/LV substations
    - GPRS, LTE, WiMax, FO, etc.
  - LAN
    - Local Area Network
    - In the EU approach typically bellow the MV/LV substation, last mile for LV customer access
    - PLC, Wireless
  - HAN
    - Home Area Network
    - Communication network inside the LV customer's house
    - Integration of In Home Displays, Load Control devices, Metering devices
    - ZigBee SEP, Wavenis, Zwave, etc.

Communication Architecture

- Communication architecture
  - TAN
    - Transformer Area Network
    - Integration of IEDs and Intelligent Sensors in the MV/LV substation
    - Modbus on RS485, etc.



TAN example

  - BAN
    - Building Area Network
    - Aggregation of meters inside a building
    - Short range wireless, RS485, PLC, etc.

Smart Grid Communication Network

- Main communication network requirements
  - Support for multiple technologies
    - Use the most adequate technology in each geographic location and for each bandwidth requirement
  - Wide area network coverage
    - Sensors, actuators and intelligence where needed, even where this need is not foreseen today
  - Interoperability
    - Seamless integration of new applications and devices
  - Quality of Service
    - Network traffic prioritization
    - Coexistence of different needs on the same network (real-time vs. non real-time)

Smart Grid Communication Network

- Main communication network requirements
  - Reliability
    - Network service level, redundant paths where needed
  - Scalability
    - From hundreds of substations to millions of meters to tens of millions of in home devices
  - Security
    - The network operation depends on the correct behaviour of the communication network
    - The use of advanced encryption algorithms is necessary to avoid injection of malicious data
    - There are encryption technologies available (AES128, etc.). These technologies need some additional computing power and introduce also communication overhead.
    - Robust authentication methods needed
  - Open standards based
    - Future proof investment

Smart Metering communication network is a driver for the Smart Grid introducing communication networks on the LV network

Communication Technologies

- Available technologies
  - Mesh radio
    - The network is made of several nodes behaving together as a single network
    - The nodes can act as repeaters, and any node can be connected to one or more nodes
    - It is possible that messages exchanged between two nodes take different network paths
    - High redundancy / resilience if there is a high number of nodes and if the nodes are highly interconnected

Communication Technologies

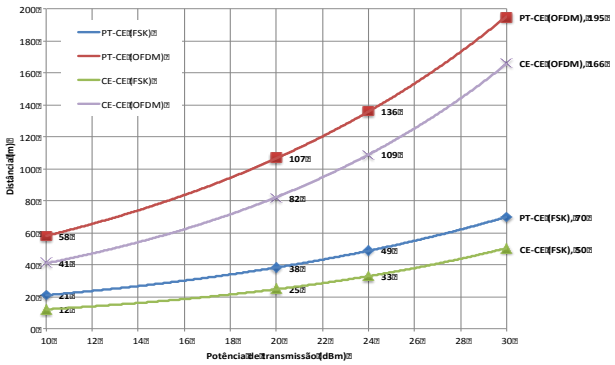
- Available technologies
  - Mesh radio
    - IEEE 802.15.4 (PHY)
      - ZigBee SEP
      - 6LoWPAN (IPSO)
        - » Seamless UDP/IP routing
        - » Internet of things
    - WiFi Mesh
      - Proprietary
      - Standards based (802.11s)
      - IP based

Communication Technologies

- Available technologies
  - Mesh radio
    - Proprietary
      - Radio
      - Mesh Algorithms
      - Protocols
      - Frequency band
    - Frequency spectrum available is not the same everywhere
      - ISM bands are different worldwide
      - Spectrum regulation is different worldwide
    - Transmission power limits are different (US / EU)
      - Output power vs. Effective Radiated Power
    - New standard recently available
      - IEEE 802.15.4g - Smart Utility Networks

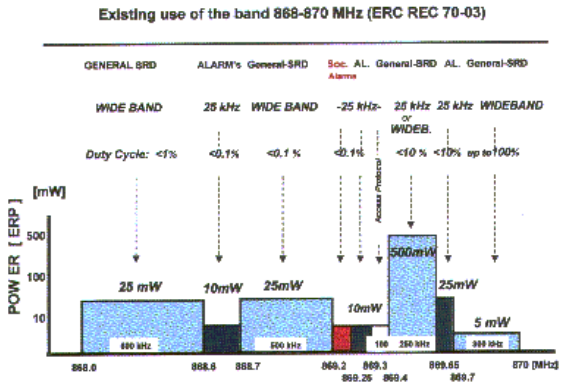
Communication Technologies

- Available technologies
  - IEEE 802.15.4g
    - Introduces OFDM as one of the possible modes



Communication Technologies

- Available technologies
  - Radio
    - Use of sub GHz band to increase range
    - ISM band limitations (Europe)



Communication Technologies

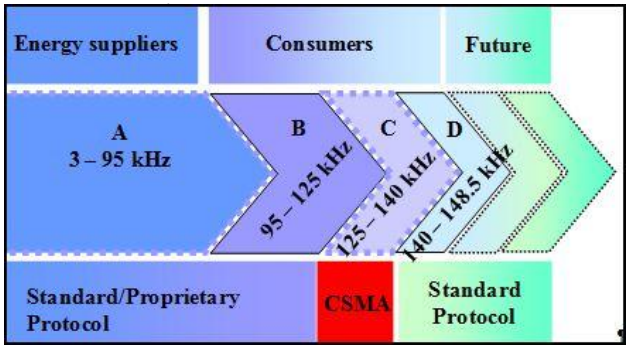
- Available technologies
  - 6LoWPAN
    - IPv6 over Low-Power wireless Area Networks
    - Defined by IETF standards
    - RFC 4919, 4944
    - Stateless header compression
    - Enables a standard socket API
    - Minimal use of code and memory (less than 27kB flash use)
    - Direct end-to-end Internet integration
    - Multiple topology options

Communication Technologies

- Available technologies
  - GPRS / EDGE / UMTS / HSPA / LTE / TETRA
    - IP access
  - WiMax
    - IP access
  - PLC
    - HomePlug Green Phy
      - 1Mbps effective data rate (3.8 Mbps peak PHY rate)
      - IPv6 support
    - BPL
      - Proprietary, Standard (IEEE 1901)
      - 200 Mbps
      - Carriers frequency: 2 MHz to 30 MHz
      - IP access

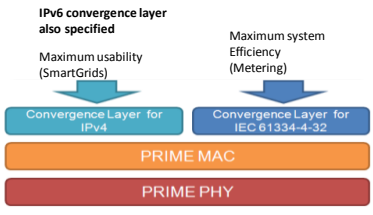
Communication Technologies

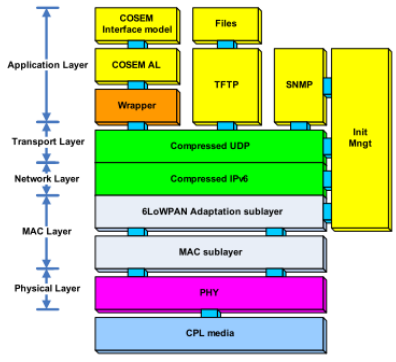
- Available technologies
  - PLC – Cenelec Bands



Communication Technologies

- Available technologies
  - PLC
    - OFDM (on CENELEC A - low bandwidth)
      - PRIME – IPv4 Convergence Layer available (IPv6 CL also specified)
      - G3-PLC - IP Layer 6LoWPAN compliant





IP is the common denominator!

Communication Technologies

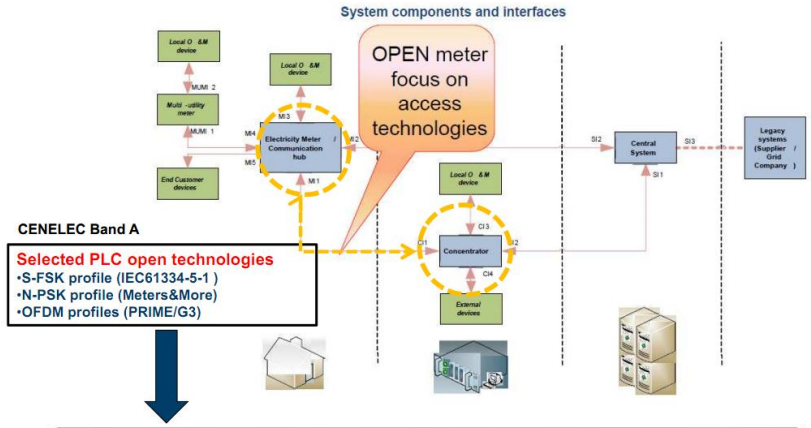
- Available technologies
  - PLC (PRIME / G3 / SFSK)

Standard	Technology	Band	Data rate
PRIME	OFDM	42-88kHz	21 - 128kbps
G3	OFDM	35-90kHz	2.4 - 46kbps
IEC 61334	SFSK	60-76kHz	1.2 - 2.4kbps

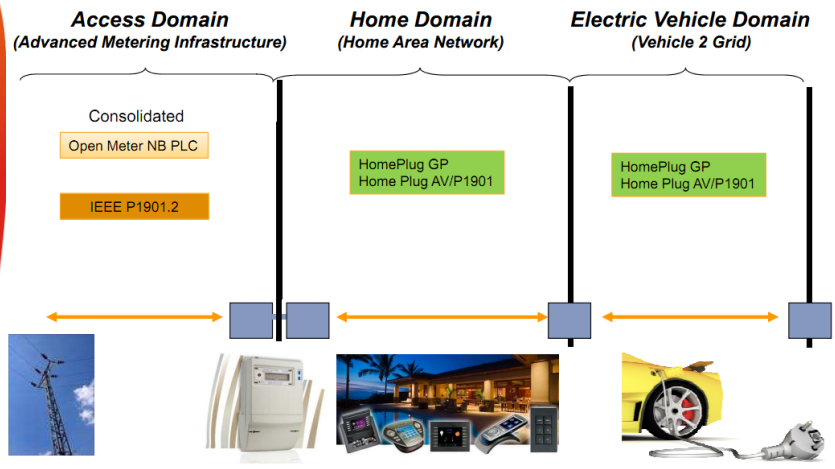
Communication Technologies

- Available technologies
  - OpenMeter

OPENmeter
Open Public Extended Network Metering

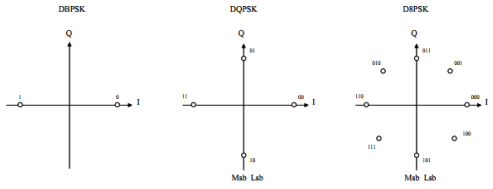


Communication Technologies



Communication Technologies

- Available technologies – Some details
  - PLC
    - PRIME
      - PRIME uses CENELEC A only from 41.992 kHz to 88.867 kHz
        - » Below 40kHz the network impedance could be very low and with many dynamic changes
        - » Noise increases exponentially at lower frequencies
      - OFDM
        - » 97 carriers
        - » Raw bandwidth from 20 kbps up to 120 kbps
          - DBPSK, DQPSK, D8PSK modulations depending on the channel quality



DBPSK, DQPSK and D8PSK mapping

Communication Technologies

- Available technologies
  - PLC
    - PRIME
      - Each network node can act as a switch node
      - Periodic Beacon messages transmitted by every switch node
        - » Channel access information
        - » Network Synchronization for service nodes
        - » Switch keep alive information
      - Phase association algorithm
        - » The base node could detect the phase where the meter is connected
      - IEC 61334-4-32, IPv4, (IPv6) convergence layers
        - » IEC 61334-4-32 used for metering
        - » IPv4 / IPv6 dedicated to new Smart Grids applications

Communication Technologies

- Available technologies
  - PLC
    - G3
      - G3 uses CENELEC A from 35.9 kHz to 90.6 kHz
      - 36 carriers instead of PRIME 97 carriers
      - Raw bandwidth up to 46 kbps
        - DBPSK, DQPSK and D8PSK modulations depending on the channel quality
      - IEEE 802.15.4 and 6LoWPAN based MAC layer
      - Provides standard UDP and SNMP interface to applications

Communication Network today

- Current technologies in the field
  - WAN
    - Fibre on the HV/MV substations
    - GPRS / EDGE / UMTS / TETRA available for the MV and LV networks
  - LAN
    - PLC on the LV network
    - Wireless Mesh
- And next?

Communication Network in the future

- Possible upgrade alternatives to the MV and LV communication network
  - Fibre / Copper (xDSL) on the MV/LV substations
    - Managed by the Utility or managed by a Telco
  - Mesh radio networks covering LV network (or LV/MV network)
    - Managed by the Utility or managed by a Telco
  - HSPA / LTE covering MV and LV network
  - BPL between HV/MV substations and MV/LV substations
    - Owned and managed by the Utility
  - FTTH
  - Internet

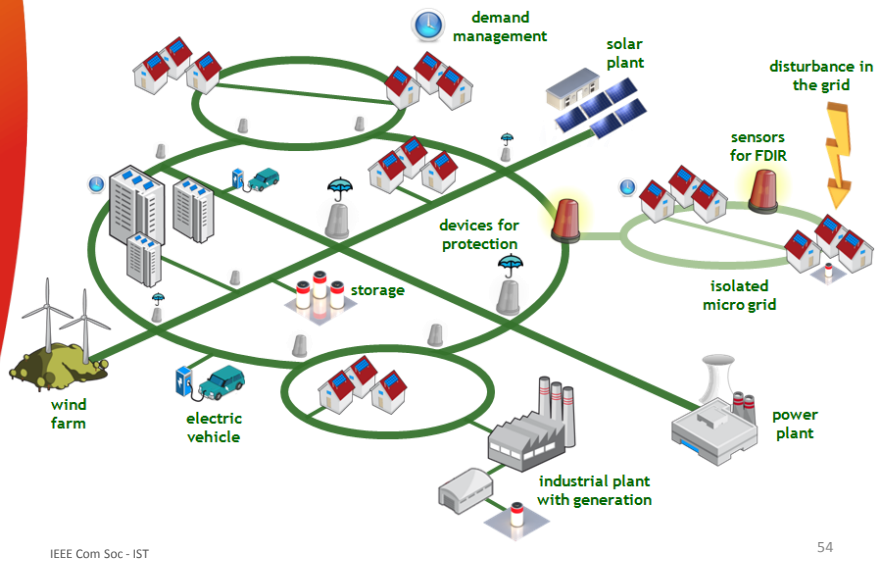
Communication Network in the future

- Possible upgrade alternatives to the MV and LV communication network
  - OFDM PLC on LV (or MV) network
    - Owned and managed by the Utility
    - Higher bit rate, enabling new applications
    - PRIME, G3, etc. working on a larger bandwidth (IEEE 1901.2, up to 500kHz)
  - WiMAX
    - Managed by the Utility or by a Telco
    - AusNet / Australia - GE / Motorola – All meters deployed until the end of 2013
  - New radio frequency bands will be available in the US and EU for Smart Grid communication.

SmartGrid Communication Network

- Conclusions
  - Future requirements uncertainty needs an evolutionary network solution
  - Seamless integration of new functions and devices
  - There is no single technology that solves all the problems
  - Open Standards based solution is more future proof
  - IP based network with convergence gateways for non IP network segments
  - **Future proof network!**

Towards overall integration



Obrigado pela atenção!

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19 Março 2013