ICT in Energy Technology: Its Role in Building the Smart Grid

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THE NORDIC LEADER IN ENERGY TECHNOLOGY

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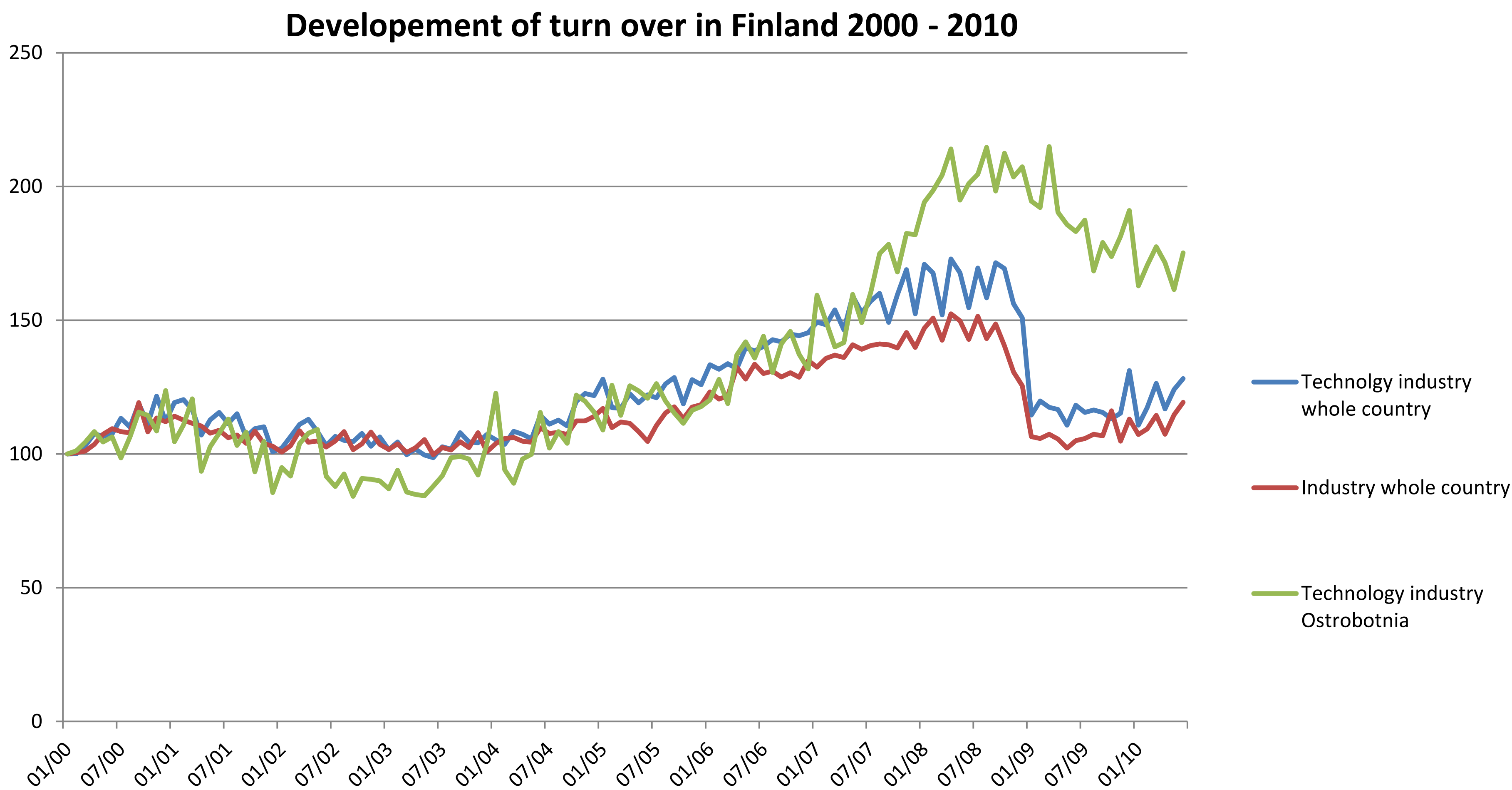
Ostrobotnia in national comparison, technology industry



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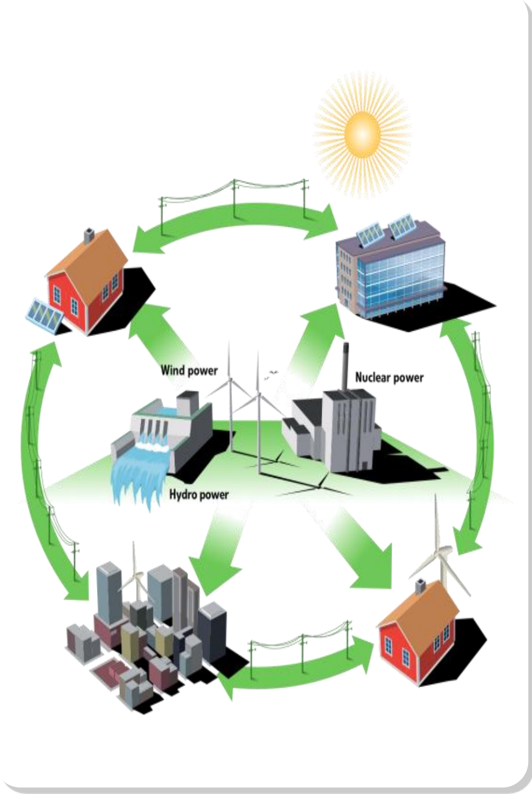
What this presentation is about?

- Definition of Smart Grid
- Future energy challenges
- Energy Technologies Smart Grid Enabled
- Conclusion

The Smart Team

Team	Task
Goos Tom & Serge De Pooter	✓ PLC Network Programming
Pieter Boijen & Chris Menten	✓ DataBase & applications
Sami Paavilainen, Marek Krajewski	Residential Gateway
Marek Kwitek	✓ HMI, user interface
Rachid Daerden, Cédric Devroye &	✓ Power Meter HW
Yenthe Blockx & Sim Jacobs	✓ Integrating the system components
Franco Cavressi	✓ Smart Combustion Engine
Jari Koski	Interoperability: DEMVE

Again another presentation about Smart Grid!



Smart grid

EU:10 steps to Smart Grids – a roadmap

Vaasan ammattikorkeakoulu
Vasa yrkeshögskola
University of Applied Sciences

Source: Eurelectric

Definition: What is a Smart Grid? (1/2)

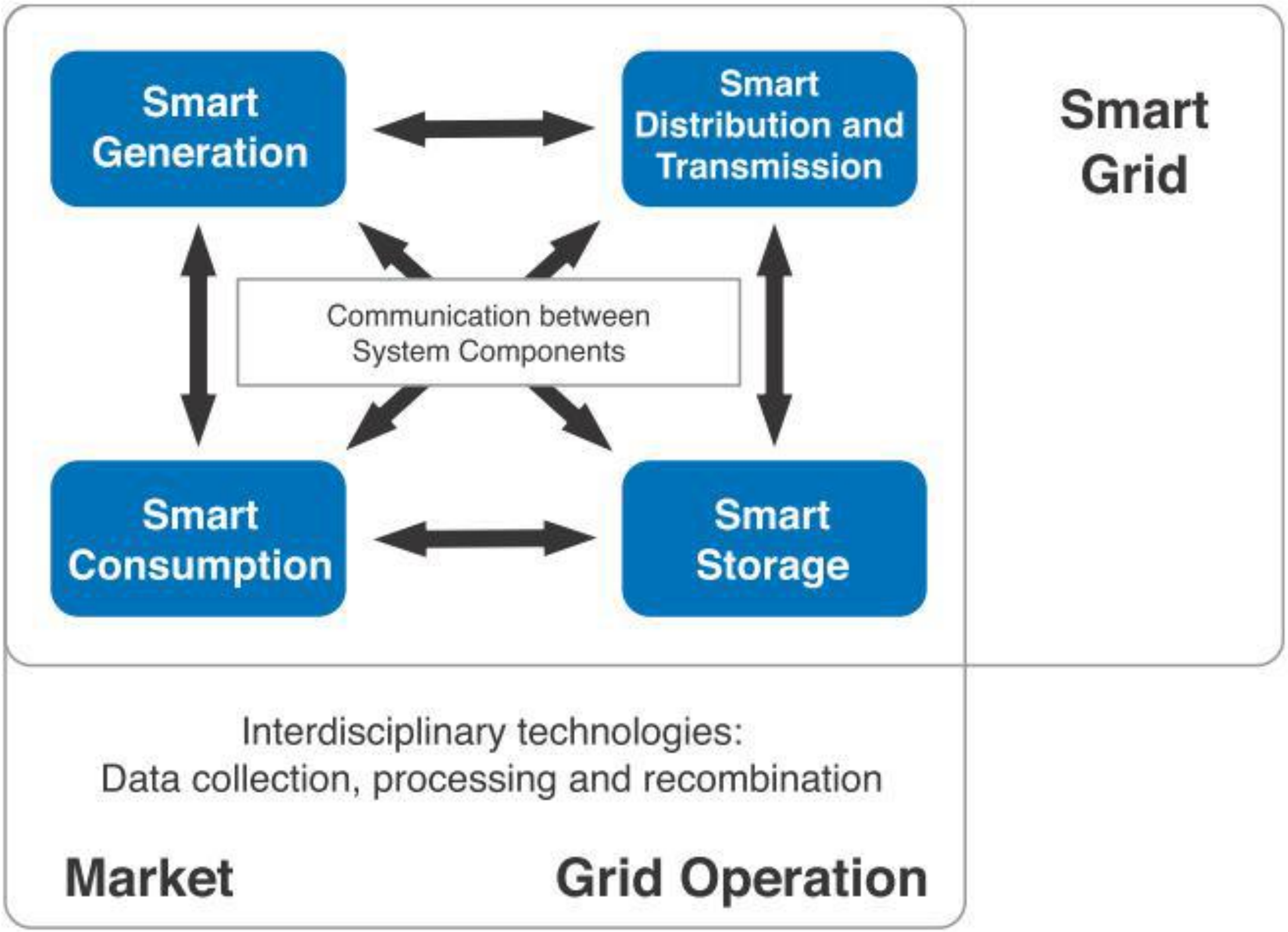
”A **Smart Grid** is an **electricity network** that can cost efficiently integrate the **behaviour** and **actions** of ALL USERS connected to it (***generators***, ***consumers*** and those that ***do both)***

– in order to ensure an:

- **economically efficient**, ***sustainable power system*** with **low losses** and high levels of **quality** and **security** of supply and safety.”

Source: EU Commission Task Force for Smart Grids

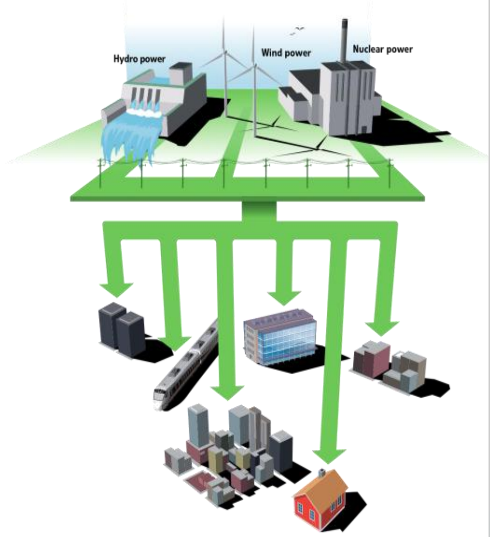
Definition: Smart definition (2/2)



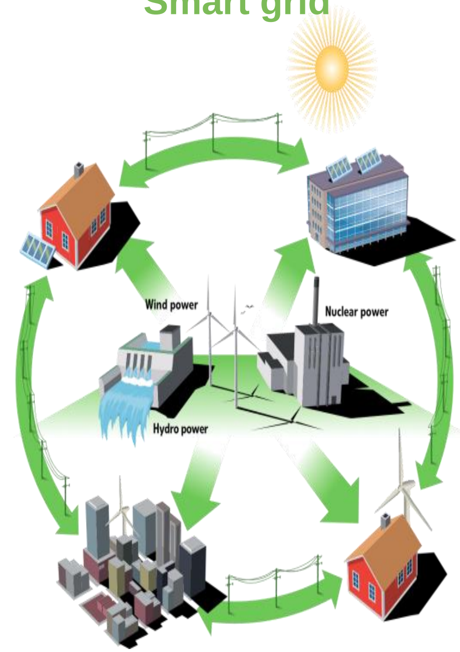
Source: Antonio Matamala. Web2Energy (W2E) – Smart Grids

Increased renewable energy production and active consumers require smarter grid…

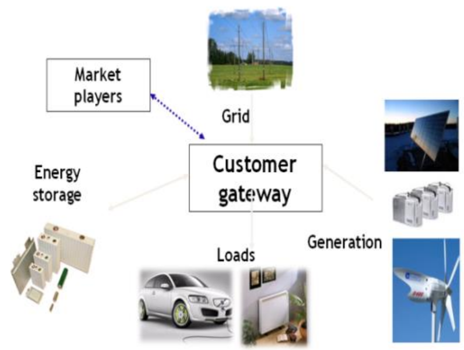
Traditional grid



Smart grid



Future customers

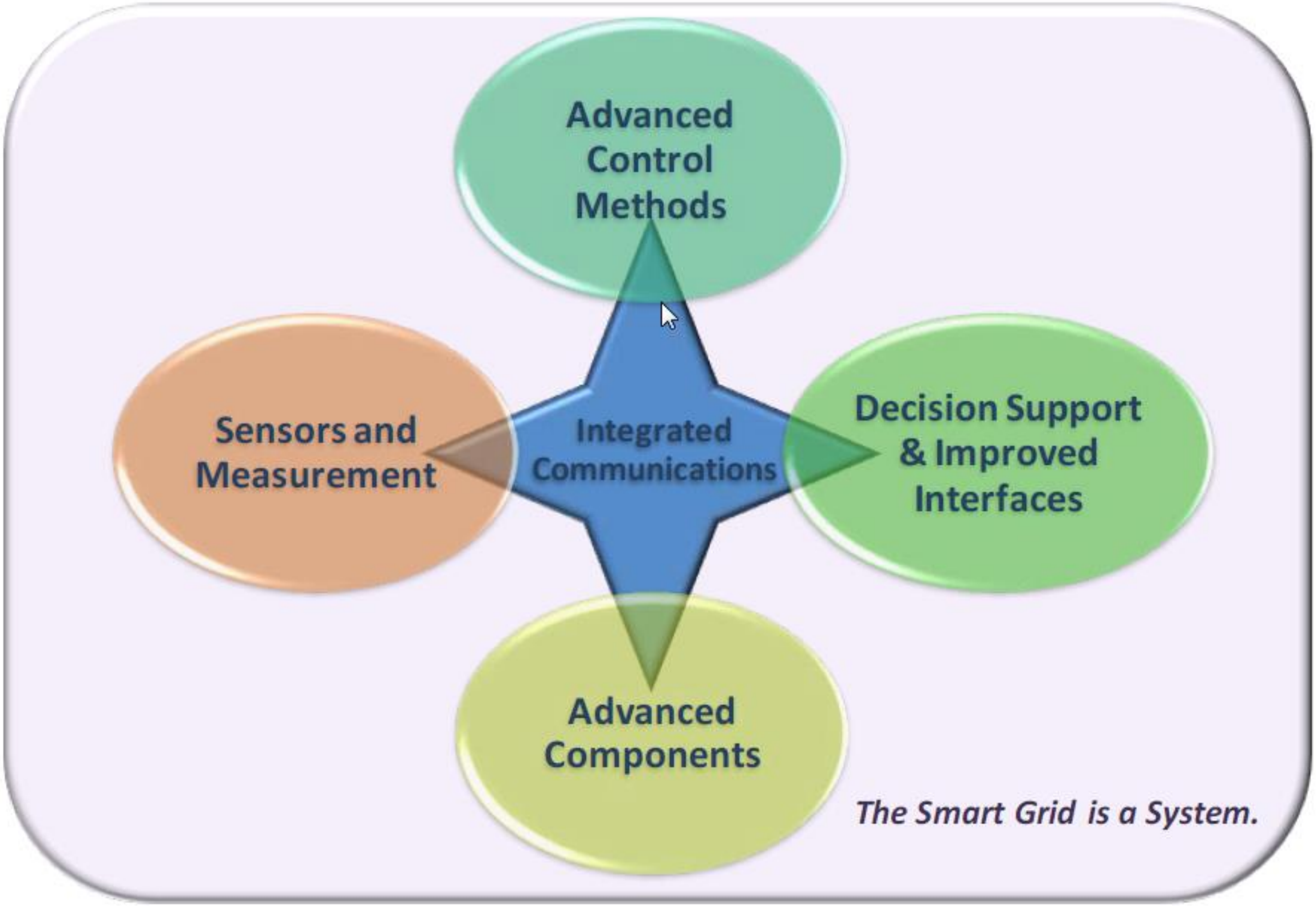


The **data network** at present is **limited**. It does not provide **bi-directional** **information** about **energy consumption patterns**, which can be utilized for **better decision making.**

…and smarter consumption.

Source: Fortum

Smart Grid key Technology Areas



Source: NETL

Intelligent Electronic Devices (IED)

SPAA 120 C
Feeder Protection Relay
SPA BUS
Outdated Since 2009

Relion 615

IEC 61850, Modbus, DNP3, IEC60870, etc.

1995 2000 2009 2010 2015 2020 2025 2030…

Global Challenges (1/4)

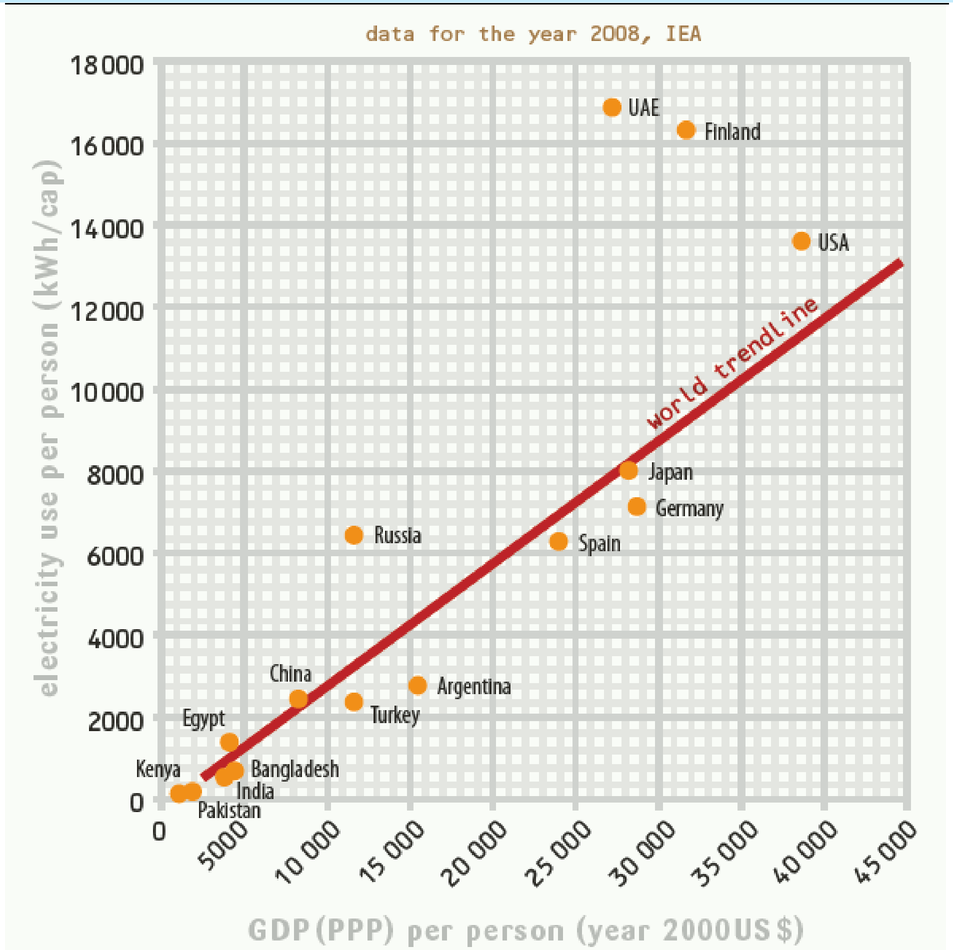
- **Growth:**
  - Population
  - Economy
- **Sustainability:**
  - Climate Change & Pollution
  - Limitation of resources

More Energy

Acceptance of different type of Electricity Supply:

- Difficulties in Building infrastructure
  - Changes in: grid topology, data model, voltage dips & Fluctuations..etc

Global Challenges (2/4)



Electricity use in relationship with GDP (PPP), data year 2008

Source: Jakob Klimstra & Markus Hotakainen, Smart Power Generation

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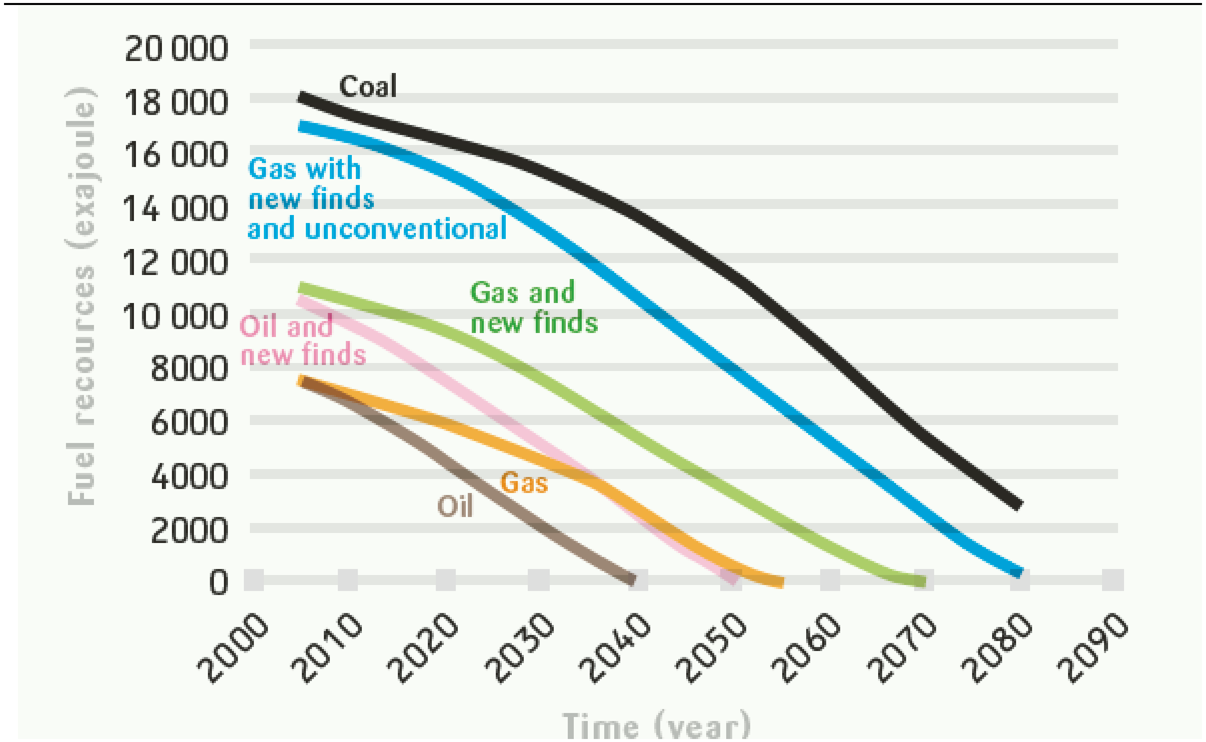
Global Challenges (3/4)

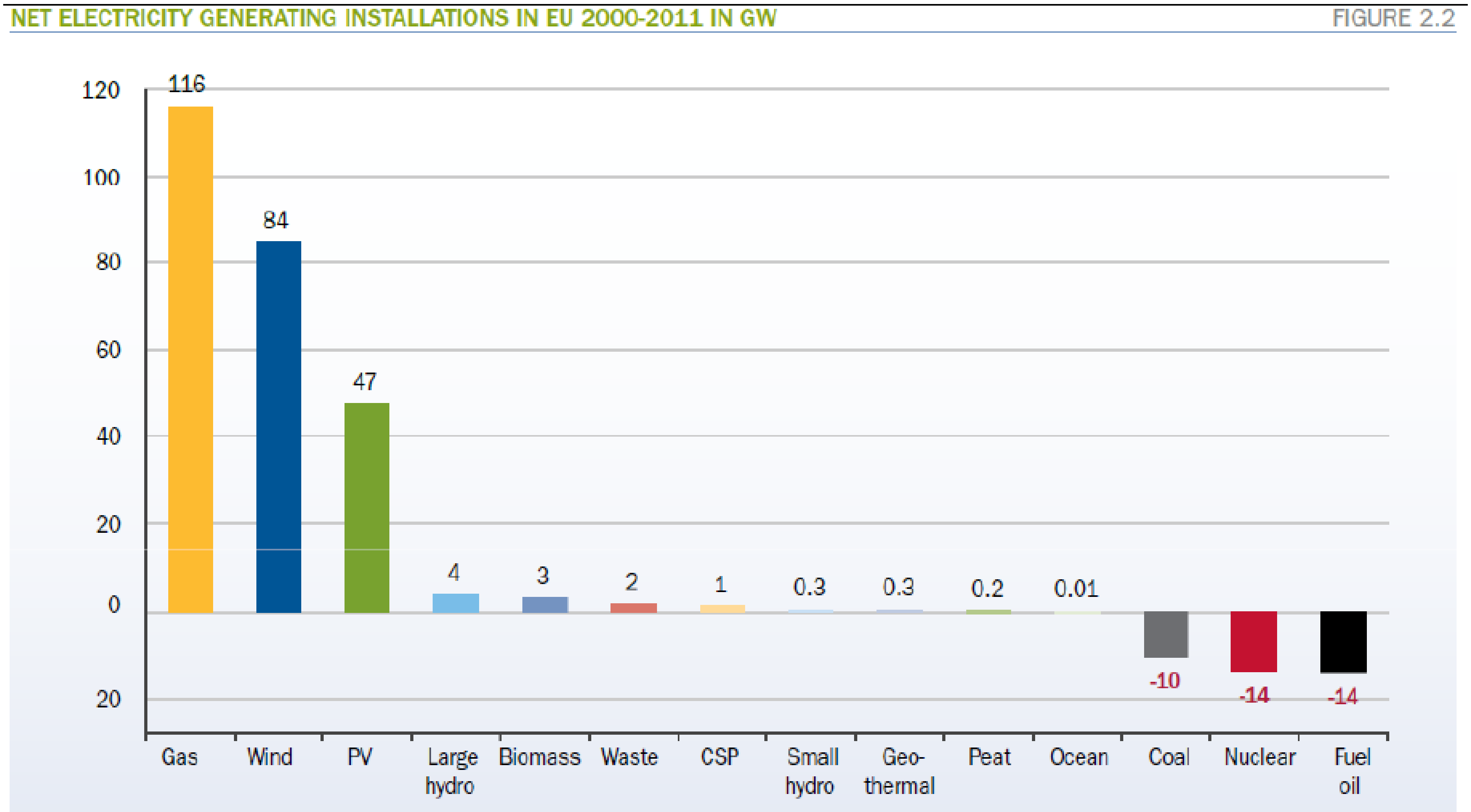


Estimated reserves of the major fossil fuels in the world and their depletion.

1 year of fossil fuel use, take the earth one million years to store.

Source: Jakob Klimstra & Markus Hotakainen, Smart Power Generation

Global Challenges (4/4)



Source: Patrik Holm, Mervento Ltd

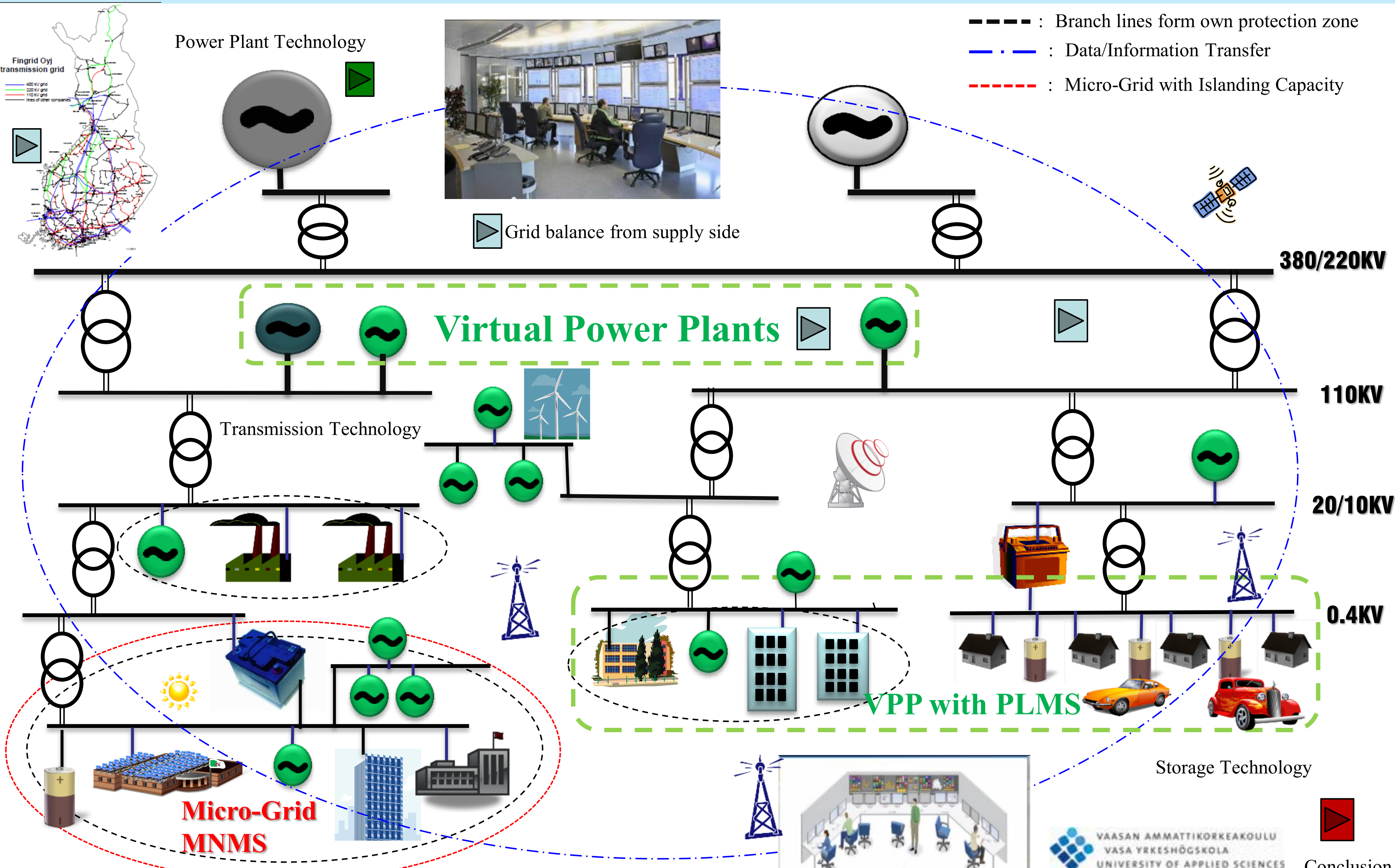
Conclusion 1

- The world's energy markets are facing inevitable change. The **need for energy is growing** everywhere.
- Renewable energy sources and new technologies are important topics of discussion. **Markets are being clearly and increasingly regulated**, not only by business economics, but also on political grounds
- In 2007, the EU agreed on the so-called **20-20-20 objective**, which includes increasing the share of renewable energy sources to 20% of the EU's total consumption by 2020.
- Creates opportunities within
  - **Renewable energy**
  - **Energy efficiency**
- This calls for
  - Innovation
  - International know-how
  - Strong networks

Challenges of the Future Network

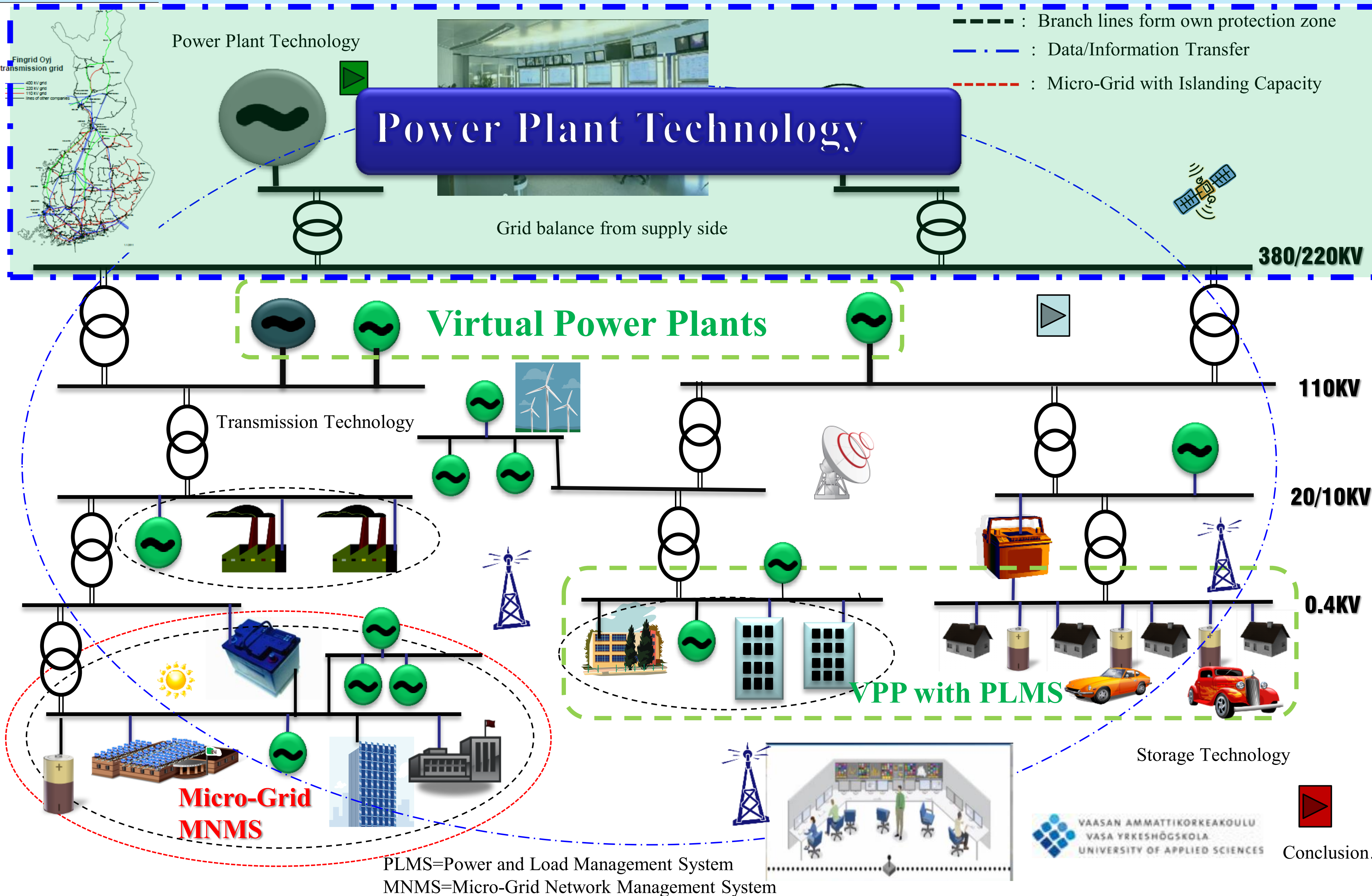
- Increased penetration of renewable ....(How to integrate)
- Effect of Renewable on the grid.................(How to connect)
- Efficient Transmission ....(How to optimise)
- Faster Fault location.................................(How to isolate/heal)
- Faster Reaction to peaks ....(How to balance)
- Decentralised power generation ....(How to synchronise)
- Faster Load manipulation......................(How to distpatch)
- Managing net flow back into the network.... (how to backups)
- Communication(SA-DC/LV-MV) ....(Interoperability)
- Managing Carbon emissions .... (How to reduce)
- Forcasting .....(Weather, Market, load, Cost)
- ..etc

Energy System of the Future (Multi-Direction)

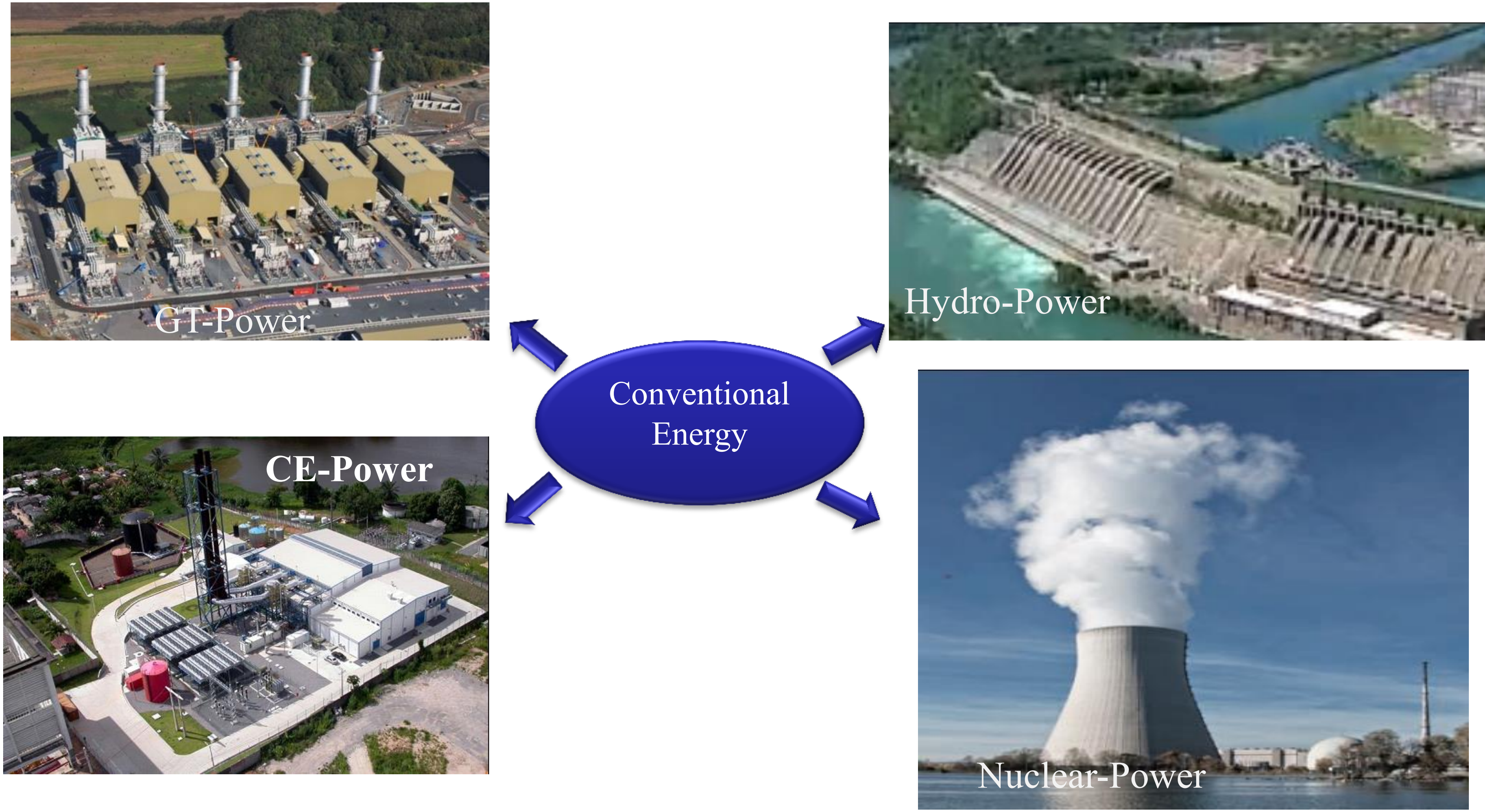


PLMS=Power and Load Management System
MNMS=Micro-Grid Network Management System

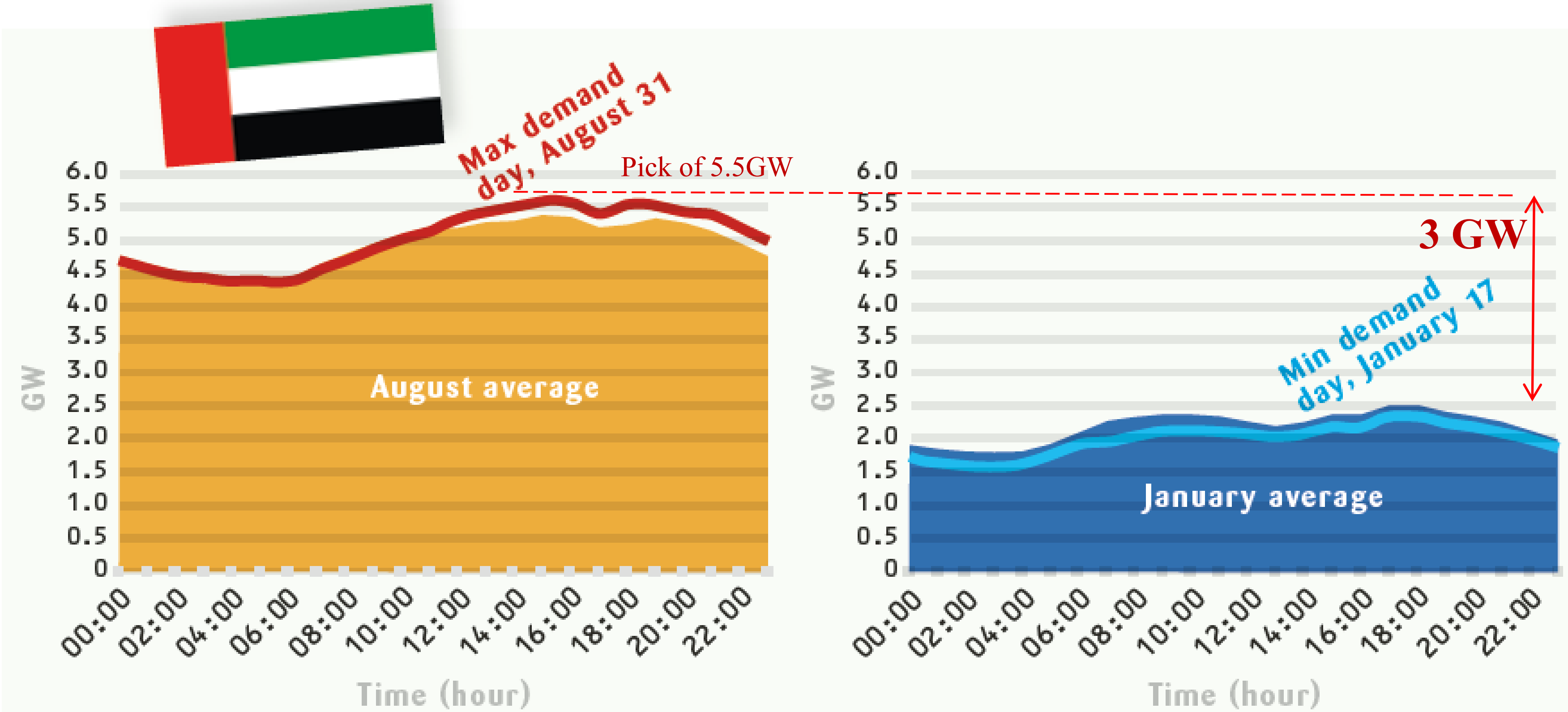
Energy System of the Future (Multi-Direction)



Power Plant Technology (1/)



Power Plant Technology: Base Load Variability (1/)



Daily electricity demand patterns, one in summer and one in winter, in Abu Dhabi (year 2008).

The large differences in demand between summer and winter make that the utilization factor of the power stations in Abu Dhabi is only about 40%.
Renewable Energy combined with flexible power plants would be an economical choice for Abu Dhabi

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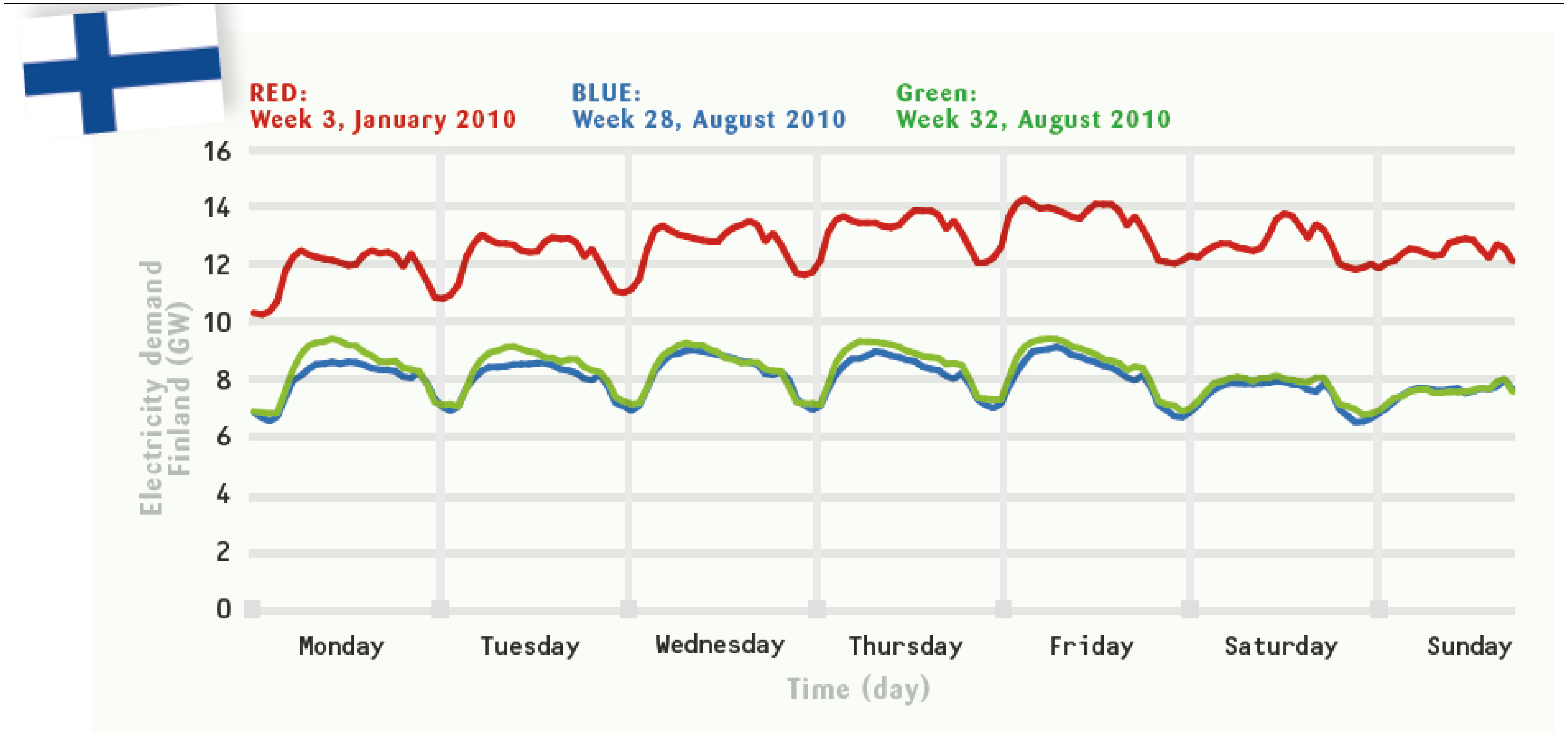
Source: Jakob Klimstra & Markus Hotakainen, Smart Power Generation

Power Plant Technology: Base Load Variability (1/)



Typical weekly electricity demand curves in Finland. 53% for Industry, 27% for other

The relatively large year-round base load of **7 GW** makes in Finland very suitable for nuclear. and coal-fired power plants. Such plants have maximum economic performance for a high utilization factor.
Demand in Finland does not show typical peaks.
Since the Finnish system is part of **the Nordel network**, system balancing is mainly done with its own hydropower with support from Norwegian and Swedish hydropower.

Source: Jakob Klimstra & Markus Hotakainen, Smart Power Generation

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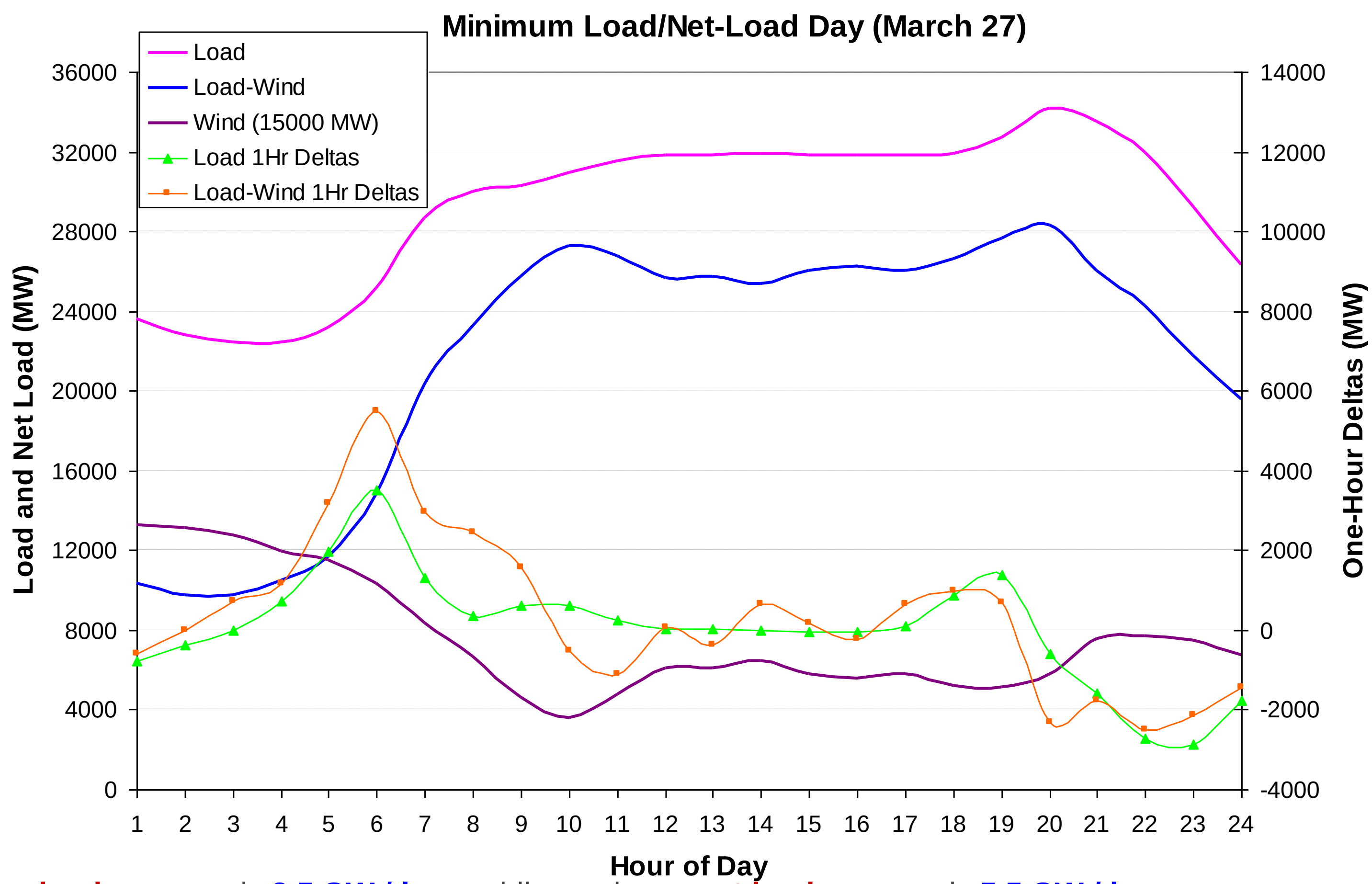
Power Plant Technology: Variability caused by Renewable Energy (1/)

Load curve dynamics – Texas, 15 GW Wind



Maximum **load ramp up** is **3,5 GW / hour** while maximum **net load ramp** up is **5,5 GW / hour**

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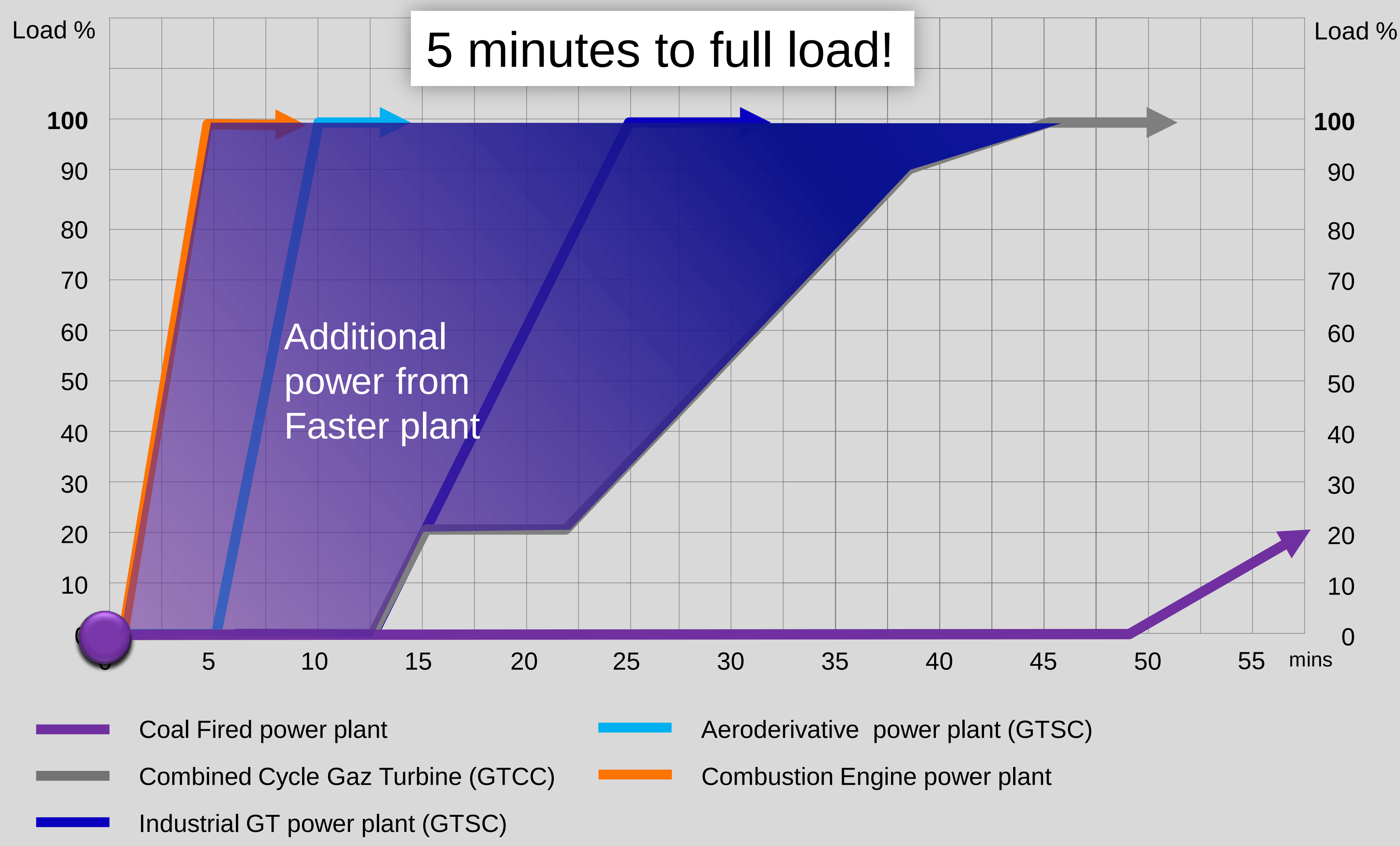
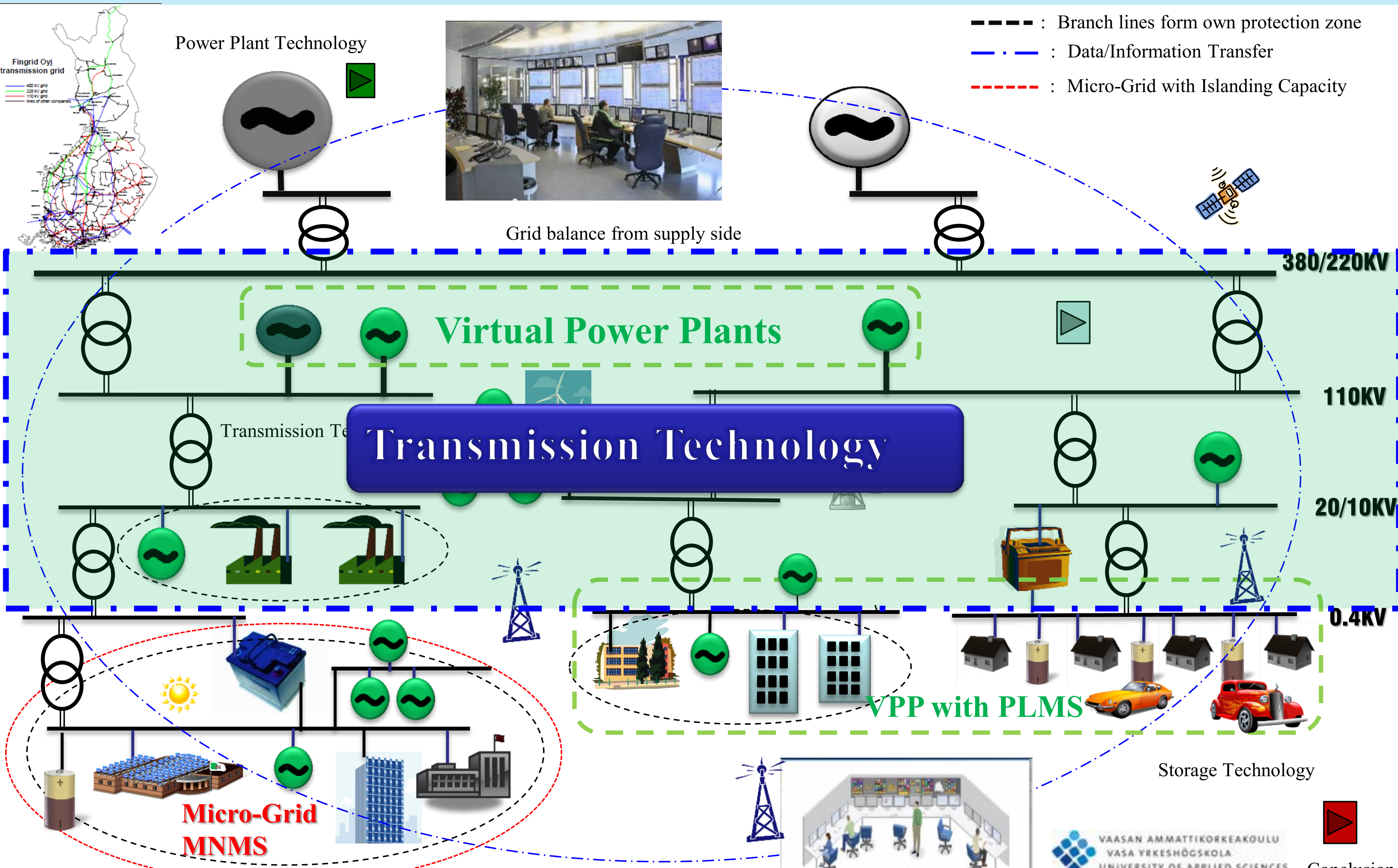
Power Plant Technology: Grid Balance from the supply side (1/3)

Up-regulation sequences for different power plants

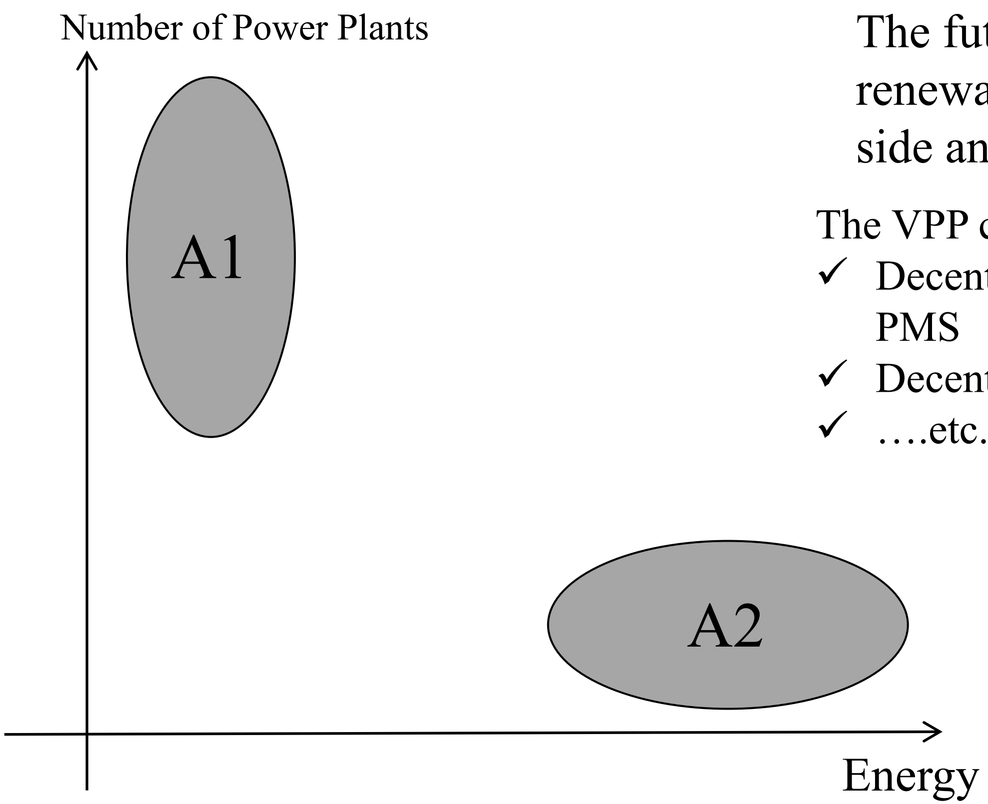


Energy System of the Future (Multi-Direction)



PLMS=Power and Load Management System
MNMS=Micro-Grid Network Management System

Transmission Technology: Distributed & Virtual Power Plant



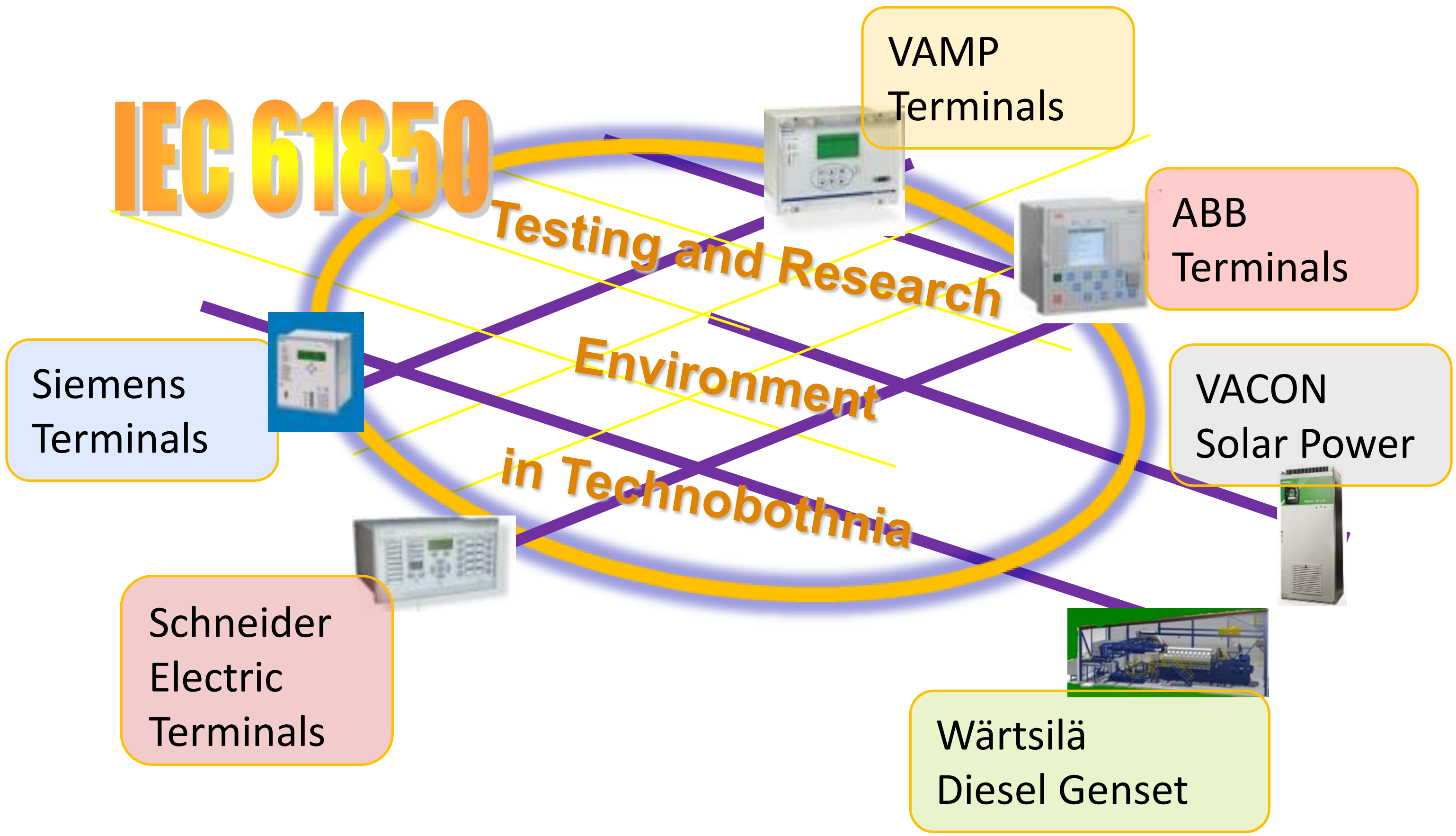
The future of the electrical network will include renewable energy sources from both the supply side and distribution side

The VPP can be the combination of:

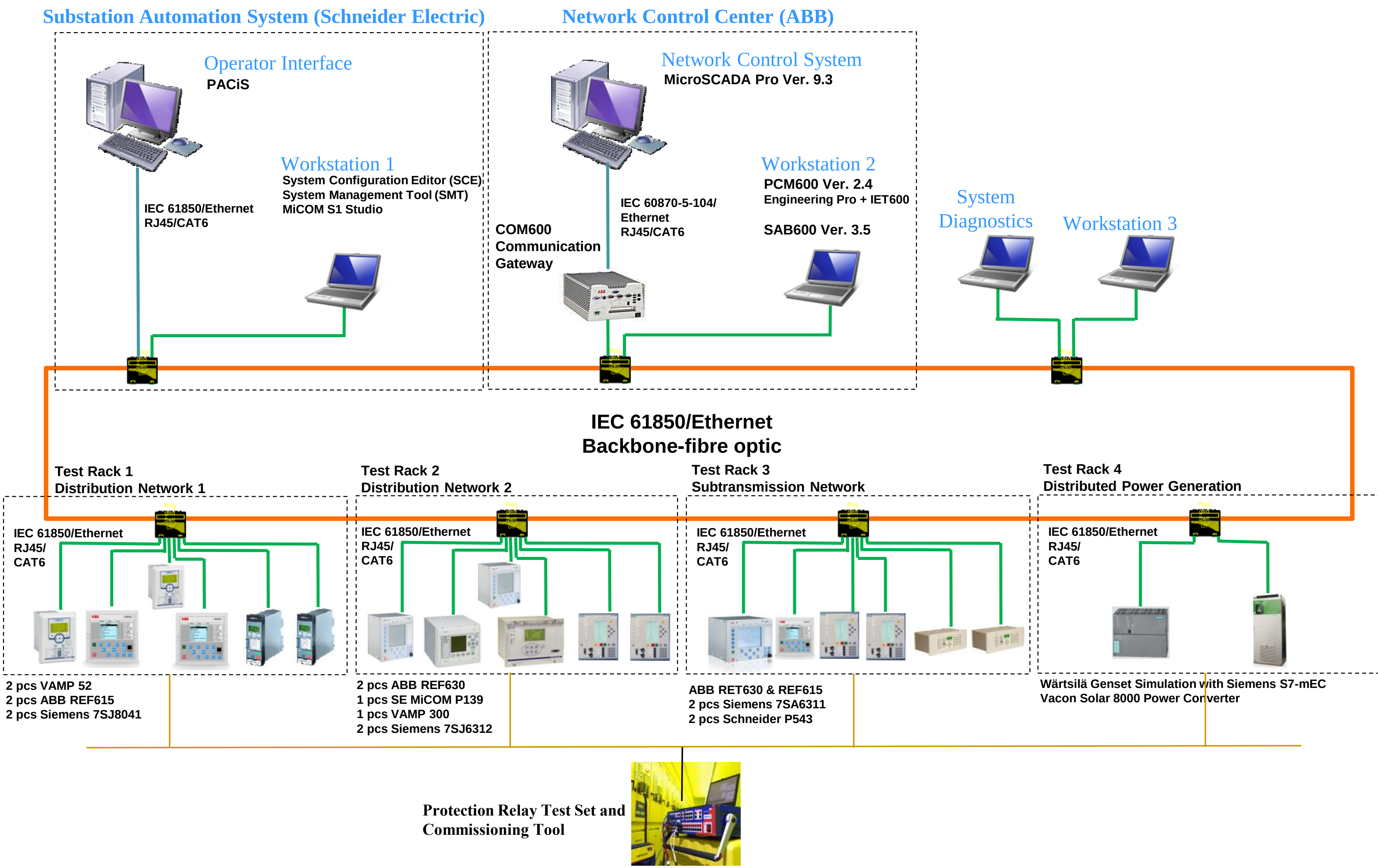
- ✓ Decentralised Wind pp, heat pumps, a CHP and industrial PMS
- ✓ Decentralised Solar pp, PIEV, PIHV and a residential PMS
- ✓ ….etc.

Grid Stability requests **balance** between **power generation** and **consumption**

The DEMVE-Project: IEC 61850 Multi Vendor Environment



IEC 61850 Multi Vendor System Diagram



Participants in DEMVE -Project

VAASA VASA

VASEK
Vaasanseudun Kehitys Oy
Vasaregionens Utveckling Ab

VAASAN SÄHKÖVERKKO
VASA ELNÄT

KATTERNÖ GROUP

ABB

Schneider Electric

VAMP

VACON
DRIVEN BY DRIVES

WÄRTSILÄ

FINGRID

Helsingin Energia
Helen Sähköverkko Oy

e·on

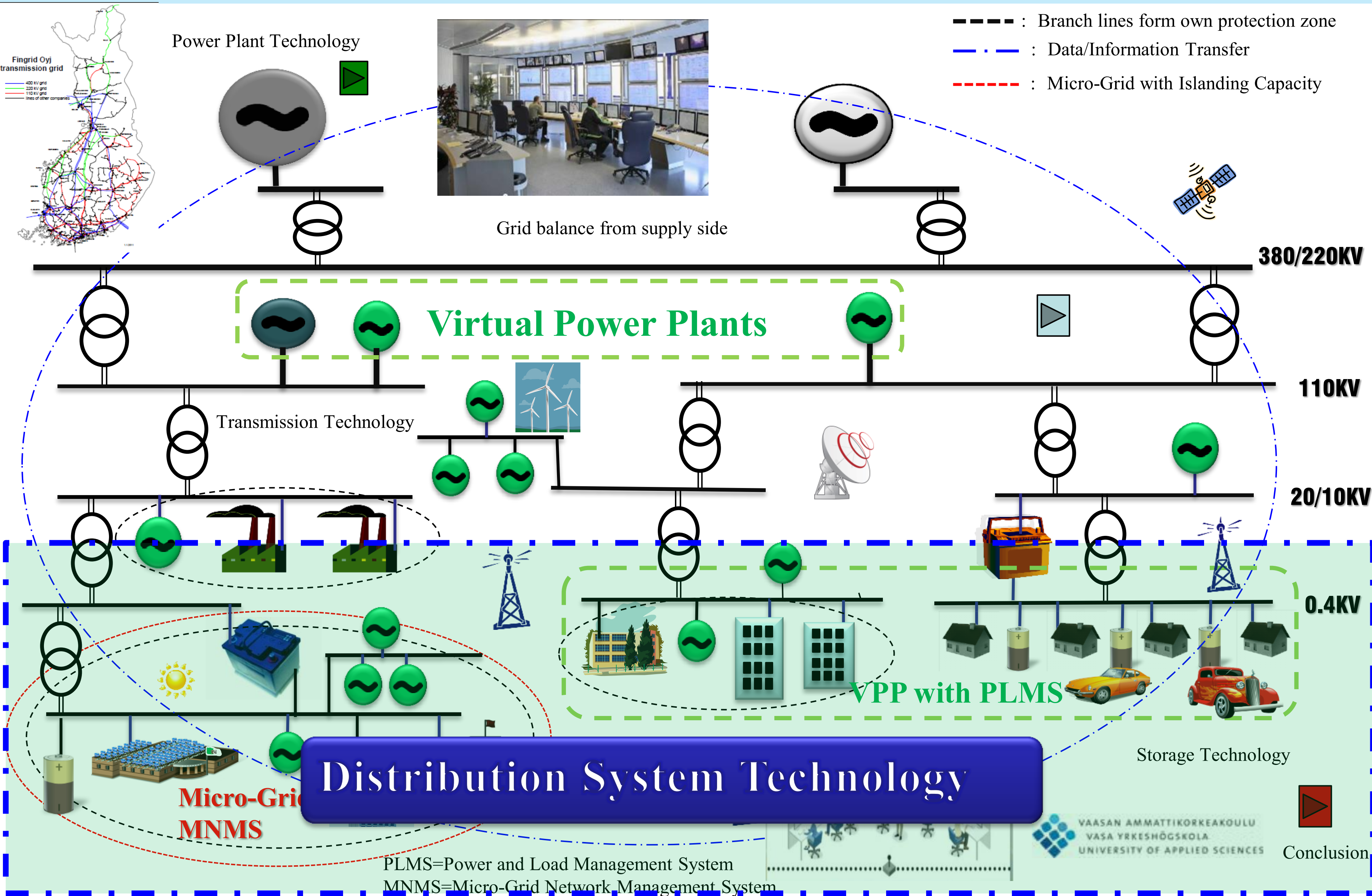
Fortum

Energiateollisuus

adato

VIMPELIN
VOIMA OY

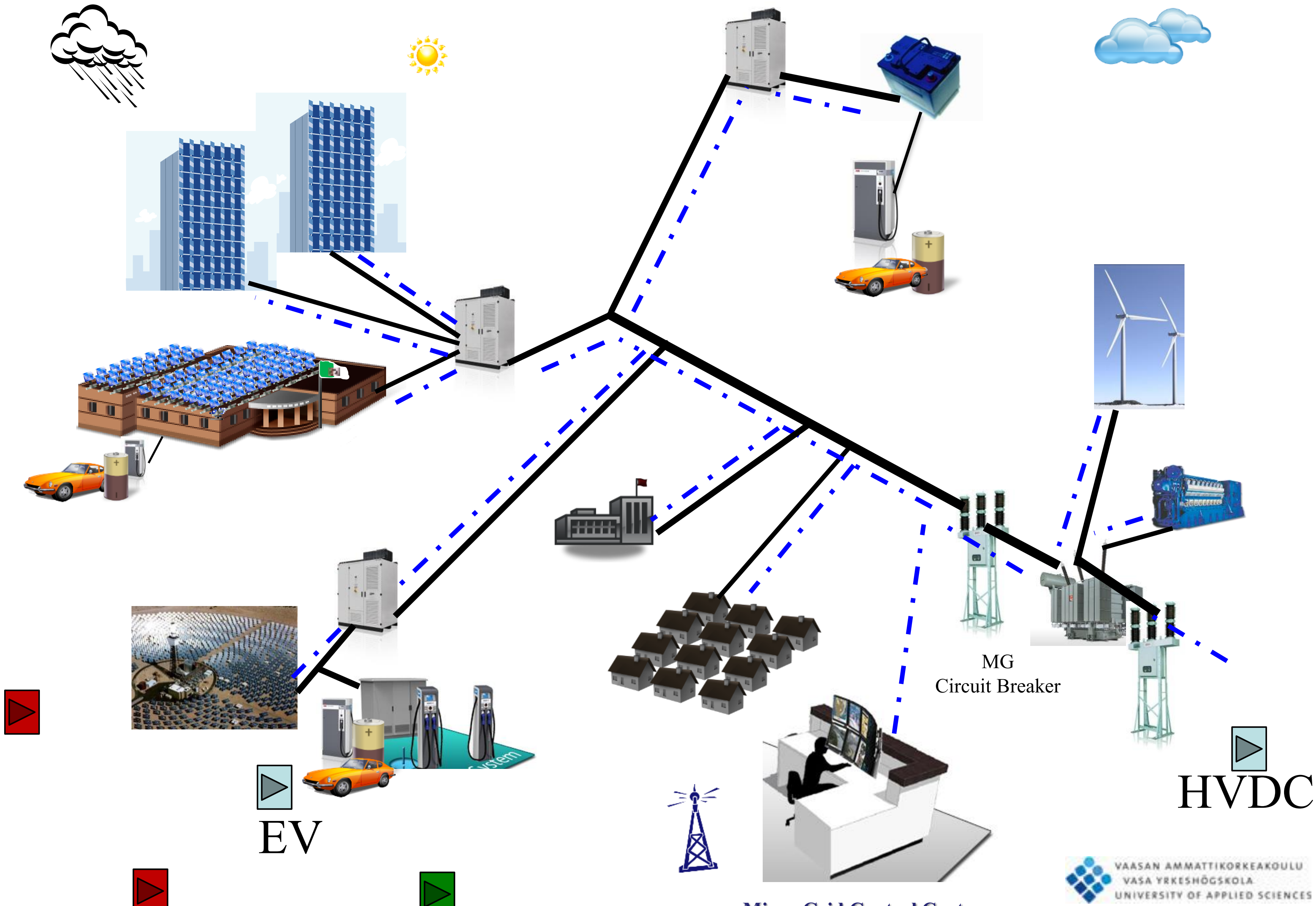
Energy System of the Future (Multi-Direction)



LV and Distribution System Technology

- Micro Grid
- Intelligent Protection
- Energy Storage Technology
- Electrical Vehicle

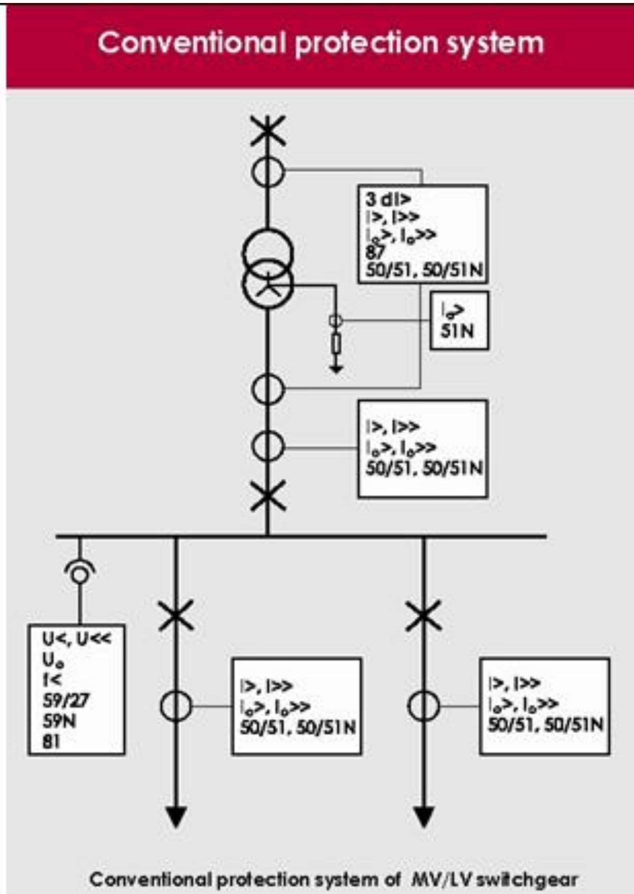
Micro-Grid

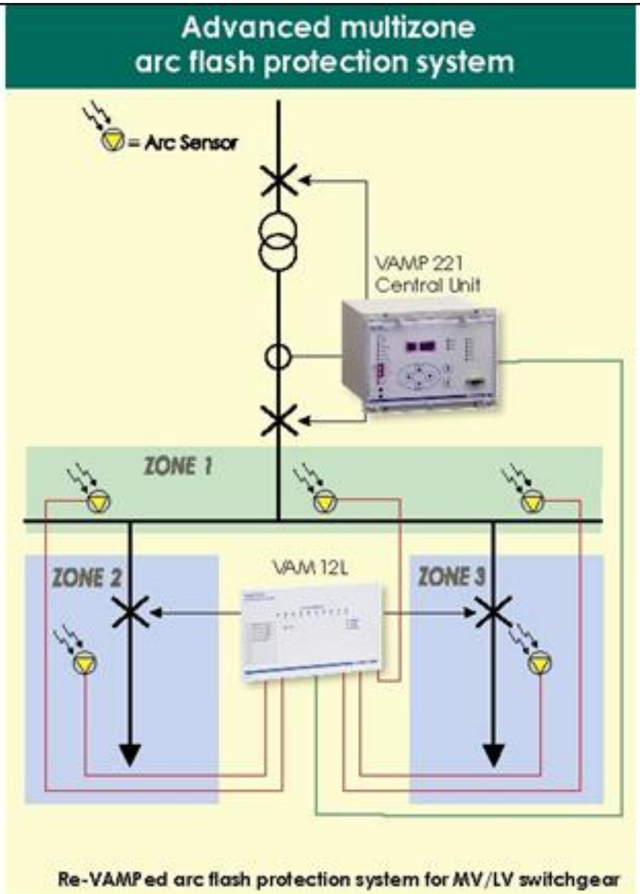


Conclusion….

Continue….

Intelligent protection (1/3)





Total fault clearing time typically:
Outgoing feeder 50 (relay) + 50 (CB) =**100 ms**
+ 15ms (Auto-Recolosing)
Incoming feeder 350 (relay)+ 50 (CB) = **400 ms**

Total fault clearing time typically:
Outgoing/Incomming feeder 7 (relay) + 50 (CB) =**57 ms**

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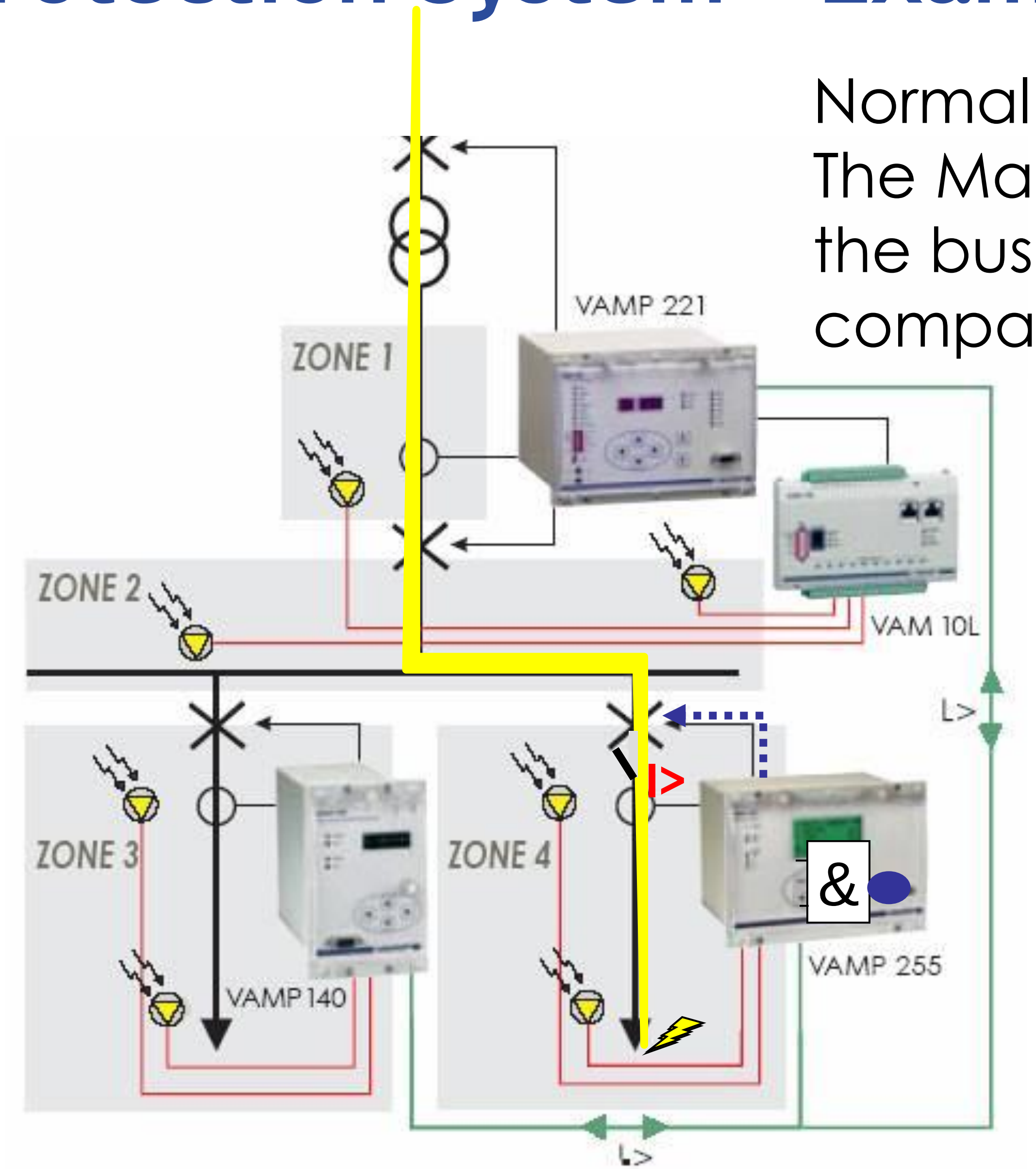
Protection System - Example 1 (3/3)



Normal situation:
The Main transformer feeds the busbar. A fault in the cable compartment.

Only the faulted outgoing feeder tripped. Busbar and other feeders still in service.

Energy Storage Technology: Electrical Vehicle (1/9)

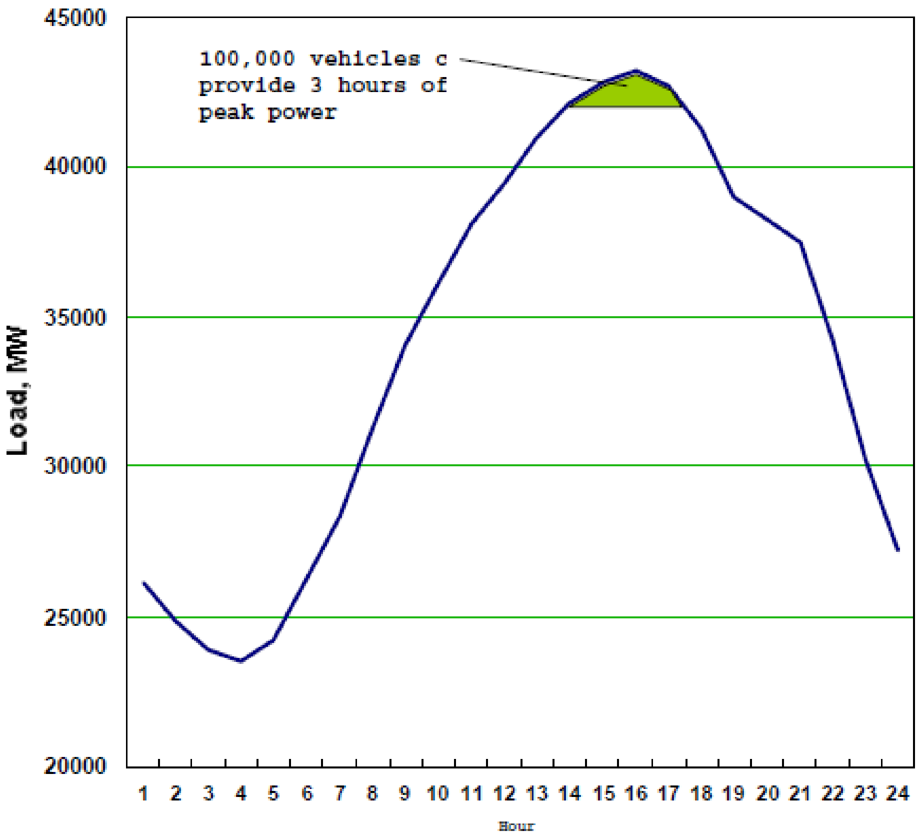


Figure Source: Alec Brooks, Tom Gage; ntegration of Electric Drive Vehicles with them the Electric Power Grid -- a New Value Stream

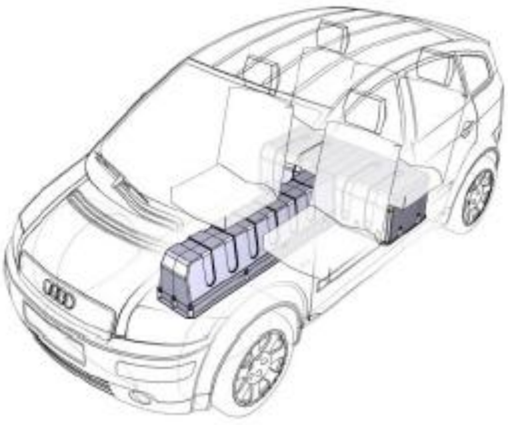
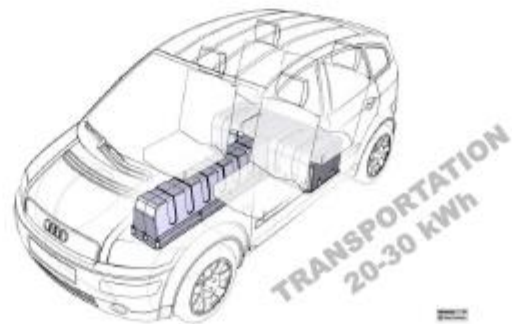
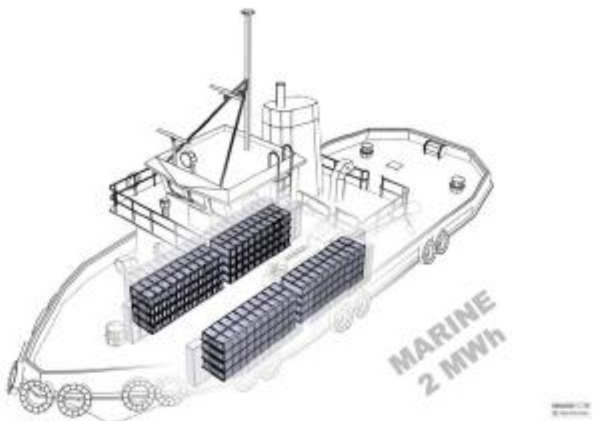
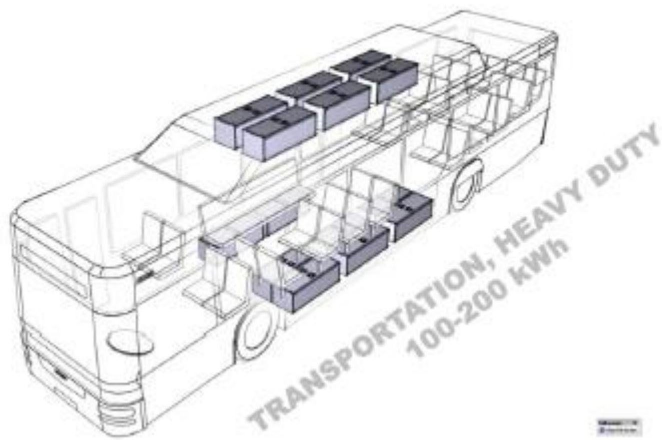


Figure source:Mika Räsänen. Lithium Batteries for the long run
European Batteries: http://www.europeanbatteries.com/

Energy Storage Technology: Application (2/9)







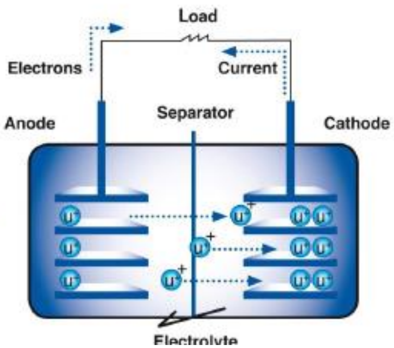


Figure source: Mika Räsänen. Lithium Batteries for the long run. http://www.europeanbatteries.fi /

Energy Storage Technology: Electrical Vehicle (3/9)

Energy Storage Technology: Electrical Vehicle (4/9)

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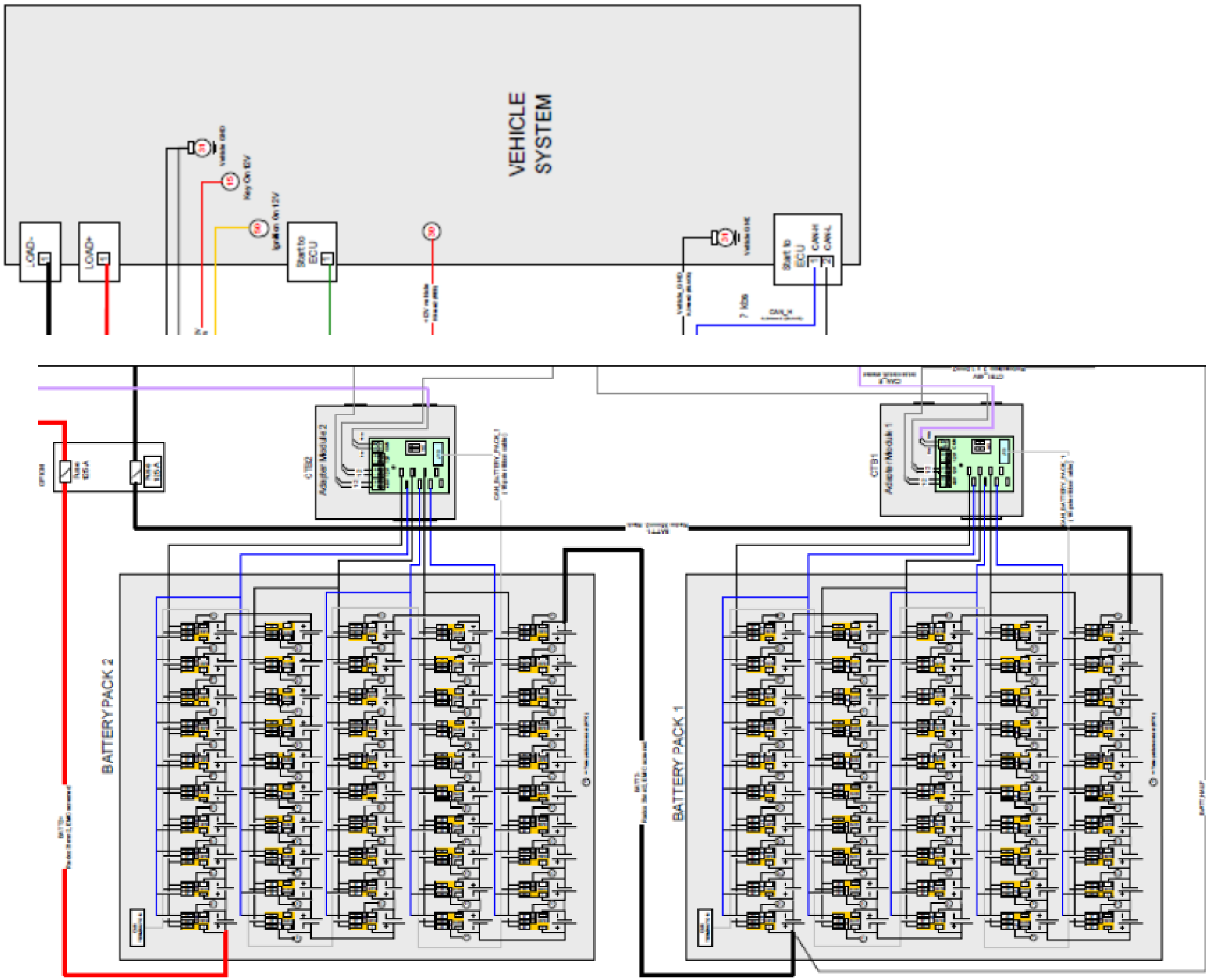
Energy Storage Techmology: Electrical Vehicle (5/9)

Energy Storage Technology: Electrical Vehicle (6/9)



The bottleneck of Smart Grid: DS & Consumers

- Reliable Commication and IT systems
- Data acquisition and control:
  - MV source-Grid
  - MV Source-Load
  - MV to LV

Intelligent Substation

- **Monitoring low voltage stations**
- **Monitoring consumer appliances**
- **Modelling Consumer Behavior**
- **....**

Intelligent Metering

→ Transactivity
Intelligent Pricing

But must be implemented ino the existing electrical network

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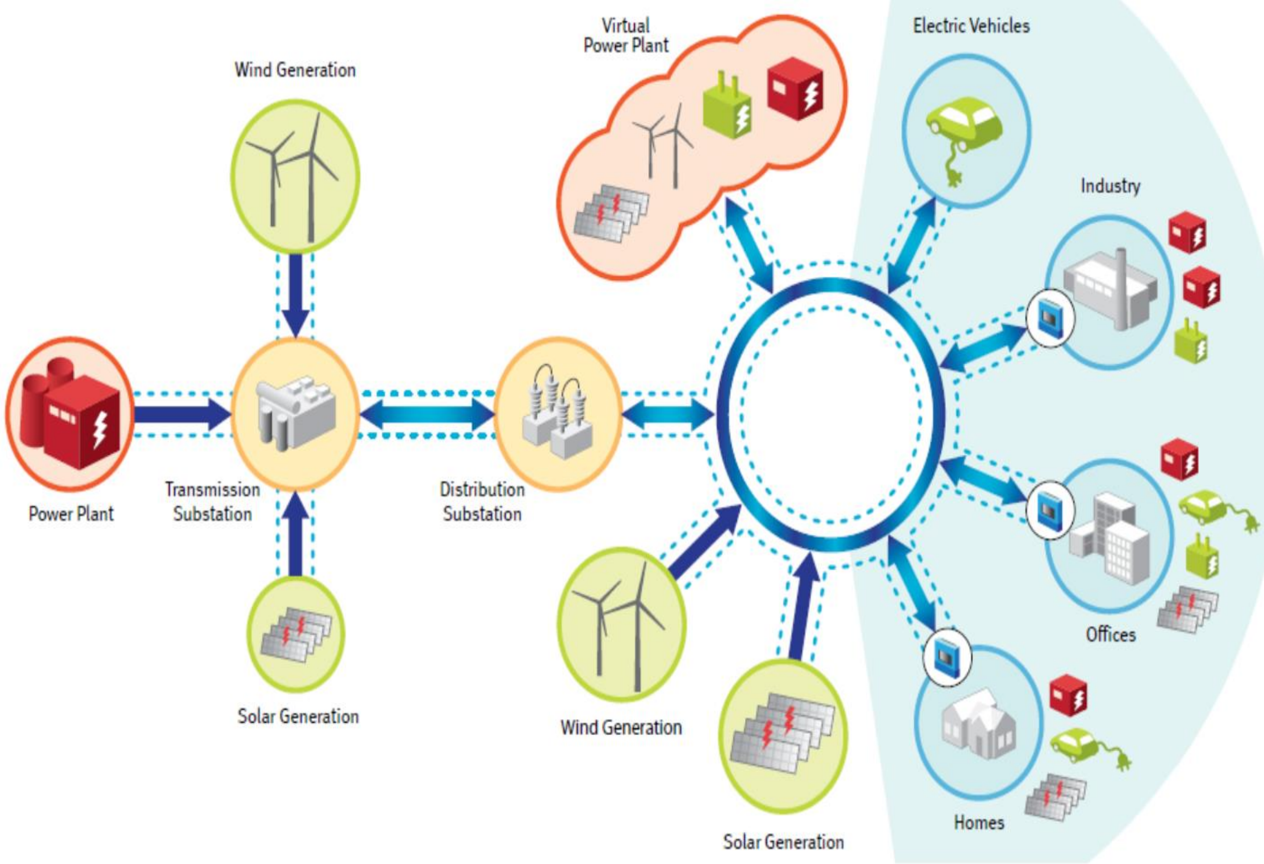
Conclusion 2

- Power Plant Technology is getting more flexible with advanced CC to make it smart grid enabled
- VPP & DC Technology for the Optimization of Transmission
- Protection System are getting smarter

The bottleneck of Smart Grid: Customer



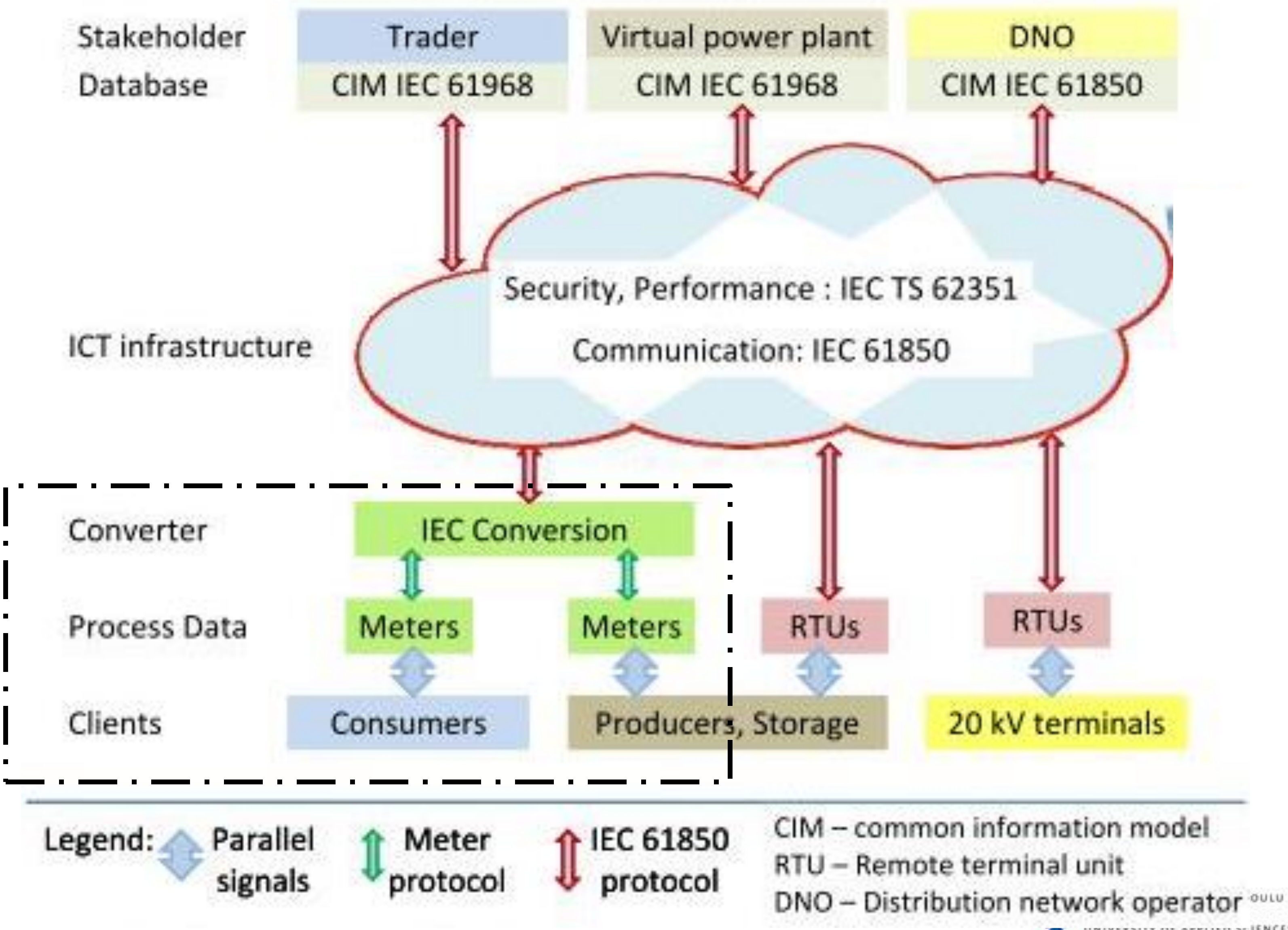
Key Questions:

1. How to understand the **customer behavior** and **usage patterns**
2. How to establish a **data Network** between the **grid** and **consumers**

AMI: Advanced Metring Infrastructure

DMI: Demande Side Man

The cornerstones of Smart Grid: Communication



Source: Antonio Matamala. Web2Energy (W2E) – Smart Grids

The IEC 61850 standard

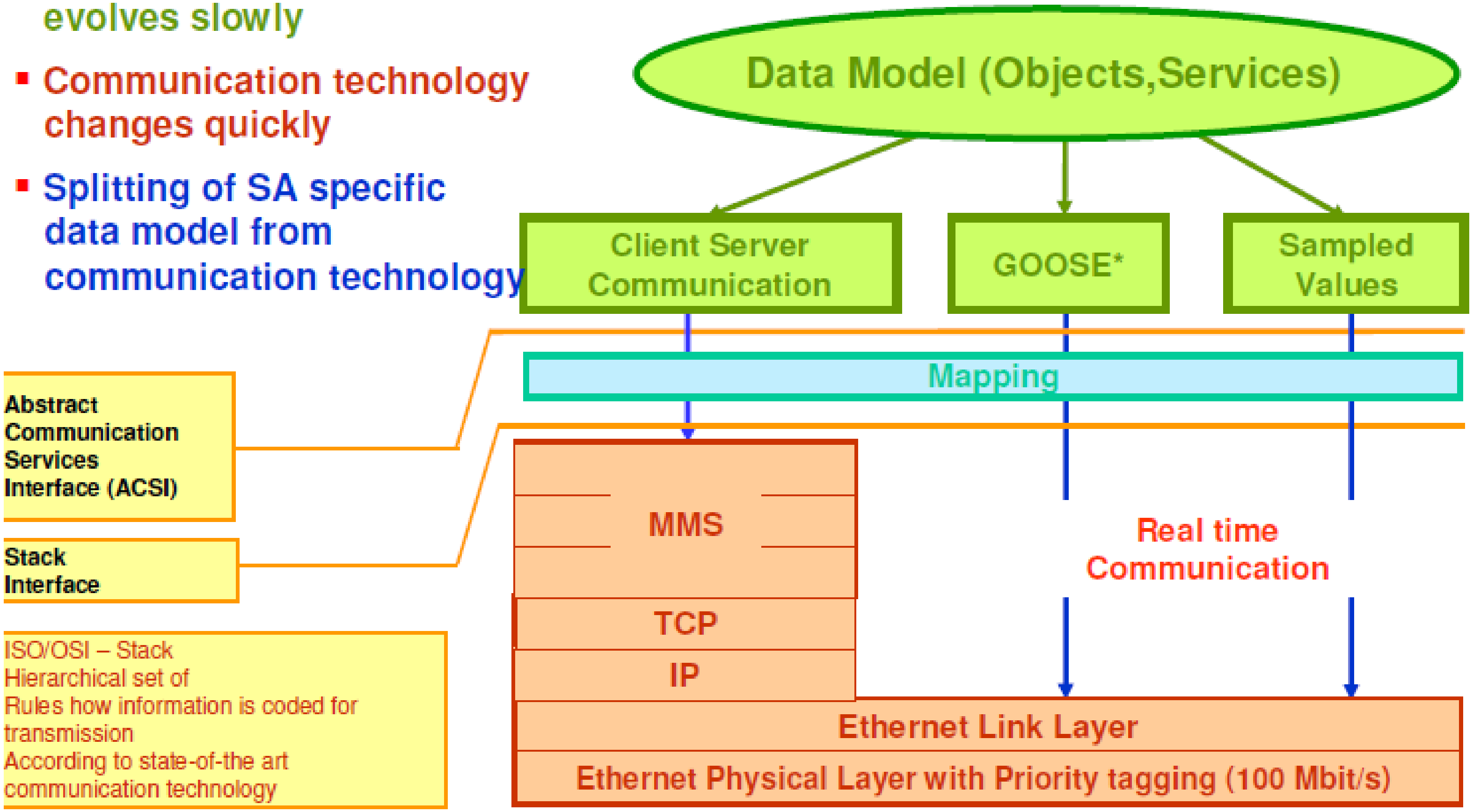
IEC 61850 is the international standard that defines the **hardware** and **communication** requirements for all products within substation automation.

IEC 61850-3 is the hardware standard of general requirements ensures environmental and **EMI immunity** of network devices used in substations.

Best possible solution for the SA is the IEC 61850

- SA specific data model evolves slowly
- Communication technology changes quickly
- Splitting of SA specific data model from communication technology

- *Model according to state-of-the-art SA technology*



* Generic Object Oriented Substation Event

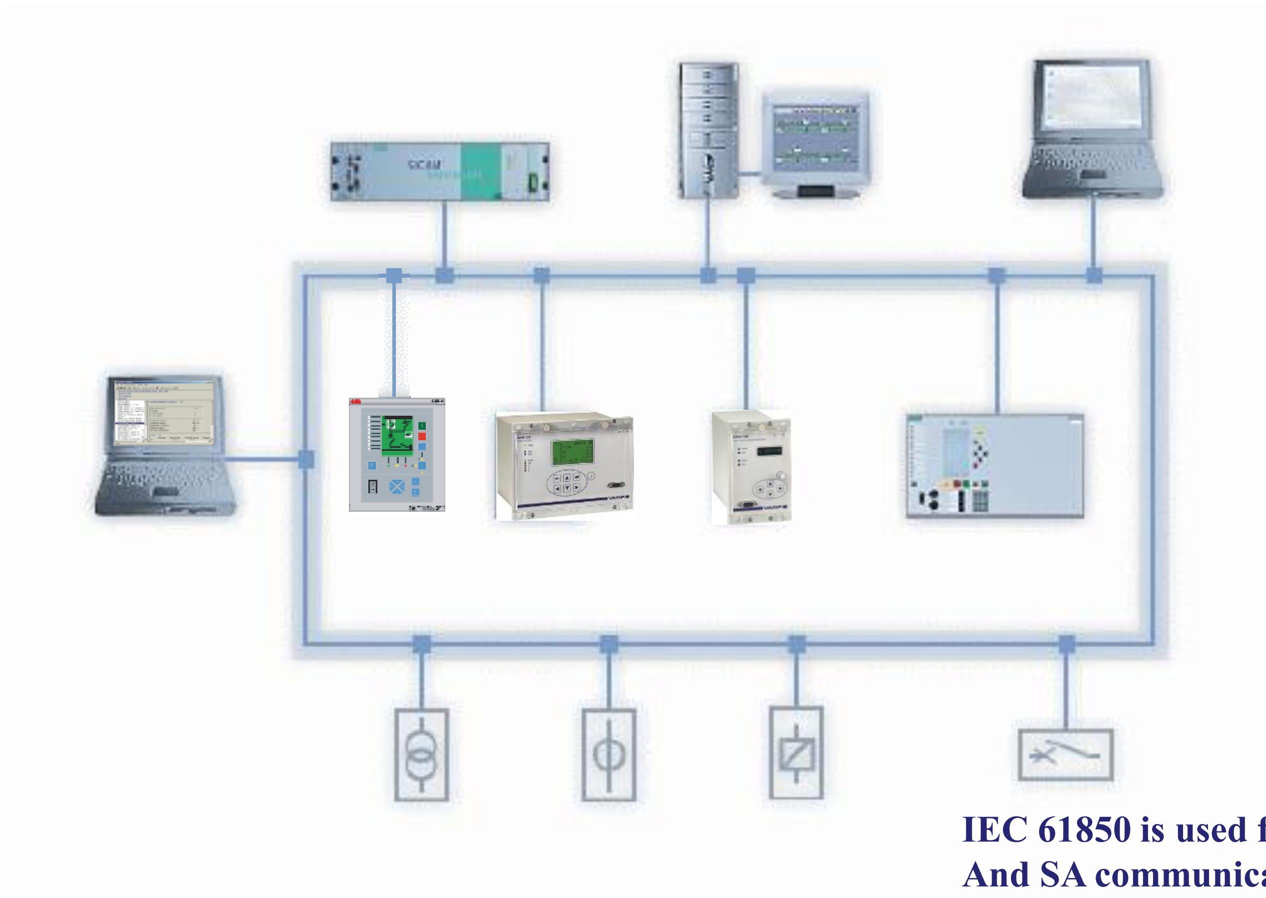
- *Stack selection according to the state-of-the-art Communication technology*

Figure source: Klaus Peter Brand , ABB Power Technologies AB

MMS: Manufacturing Message Specification

Interoperability at the SA level: IEC 61850

- Different SA elements can exchange data .



IEC 61850 is used for grid integration
And SA communication for all
Transmission and Distribution

Figure source: http://www.vamp.fi

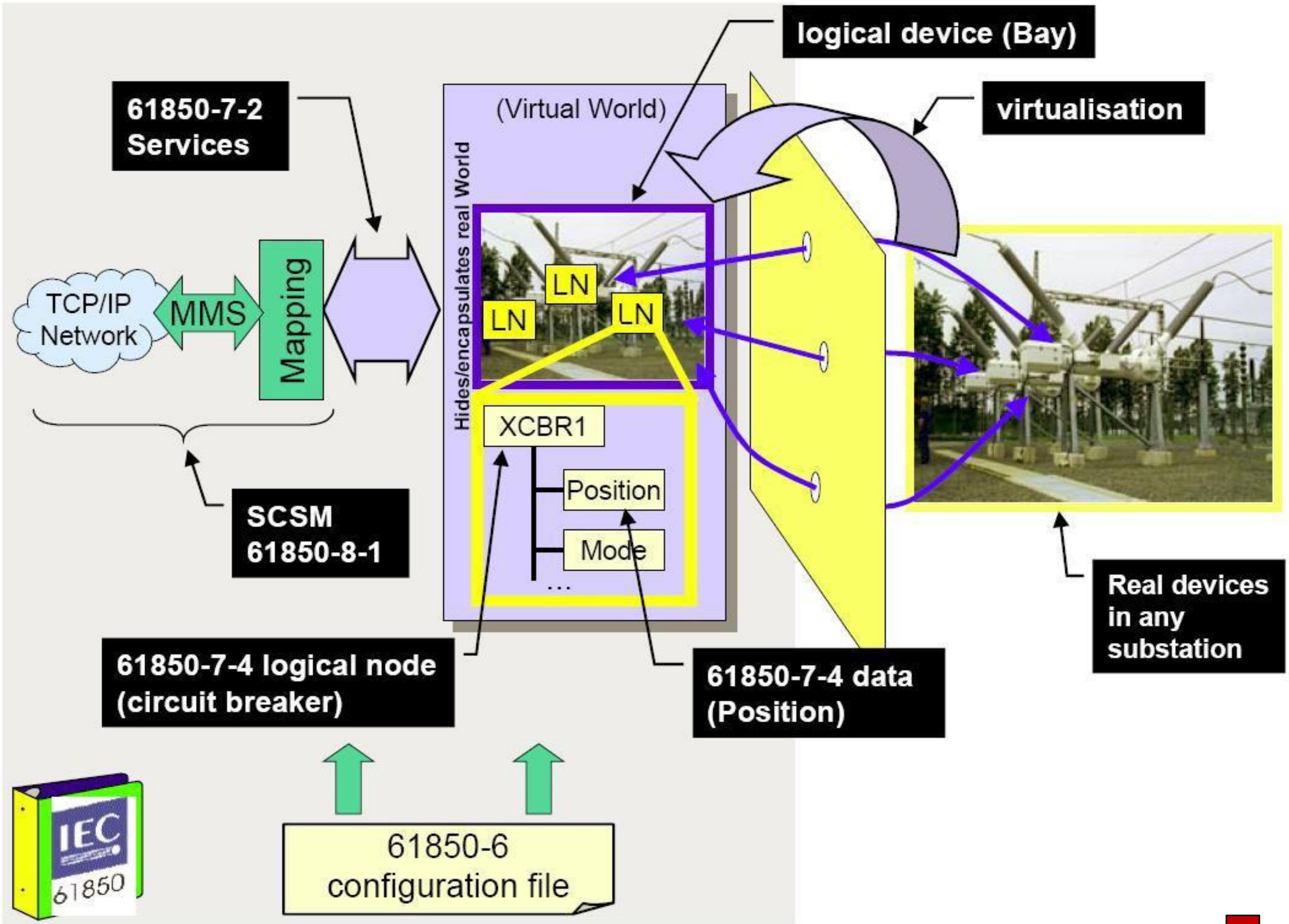
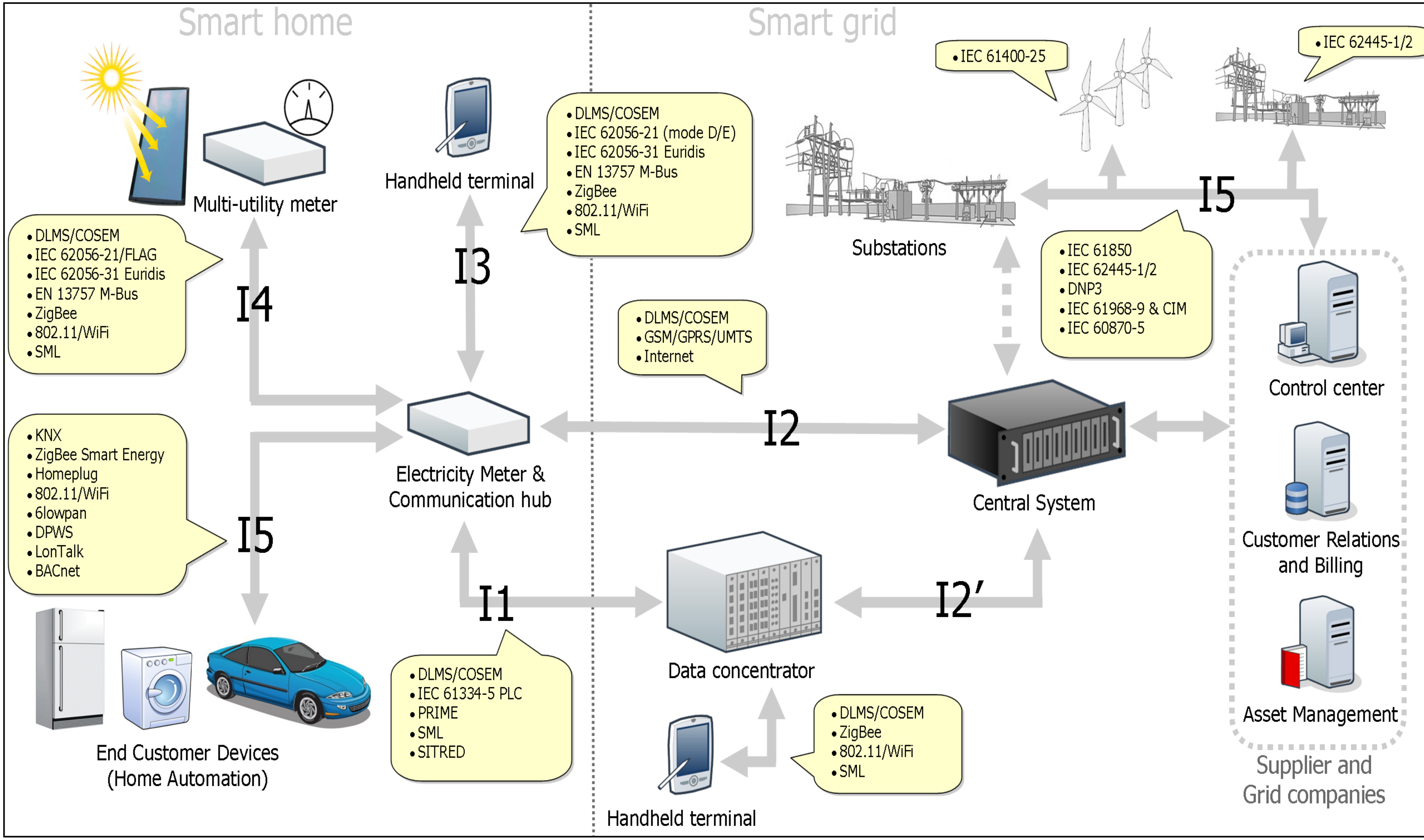


Figure source: Jianqin Zhang & Carl A. @ Illinois Security Lab, IU

Interoperability at the consumer level: PLC



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Smart Meter Project

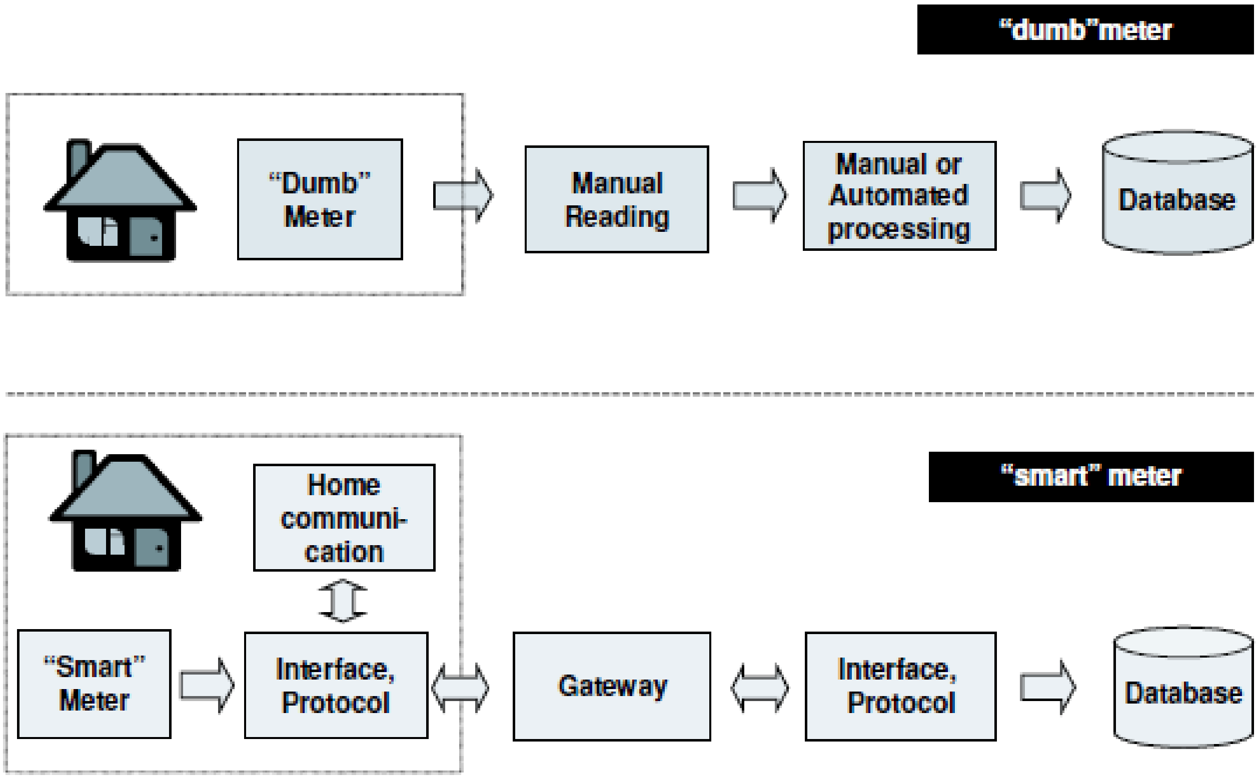
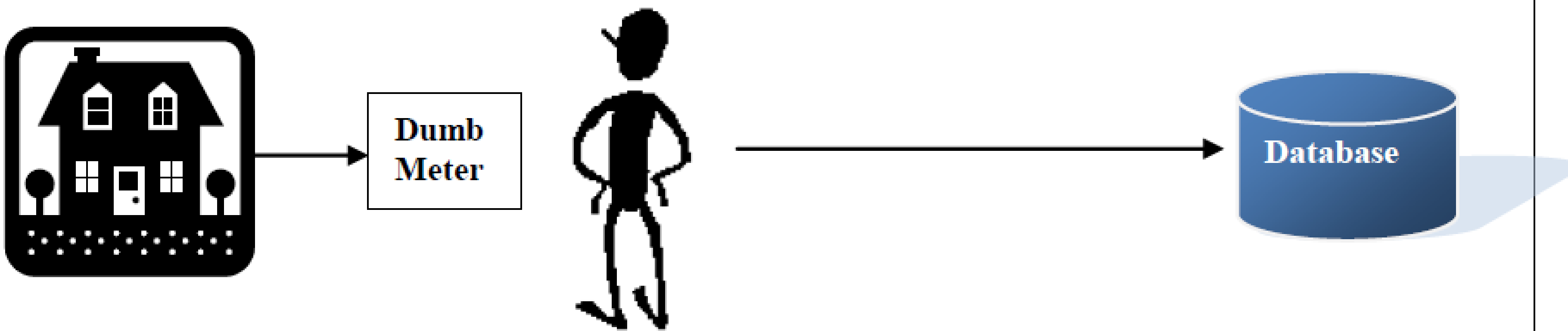


Figure source: Rob van Gerwen, Saskia Jaarsma and Rob Wilhite .Smart Metering by, KEMA, The Netherlands, July 2006

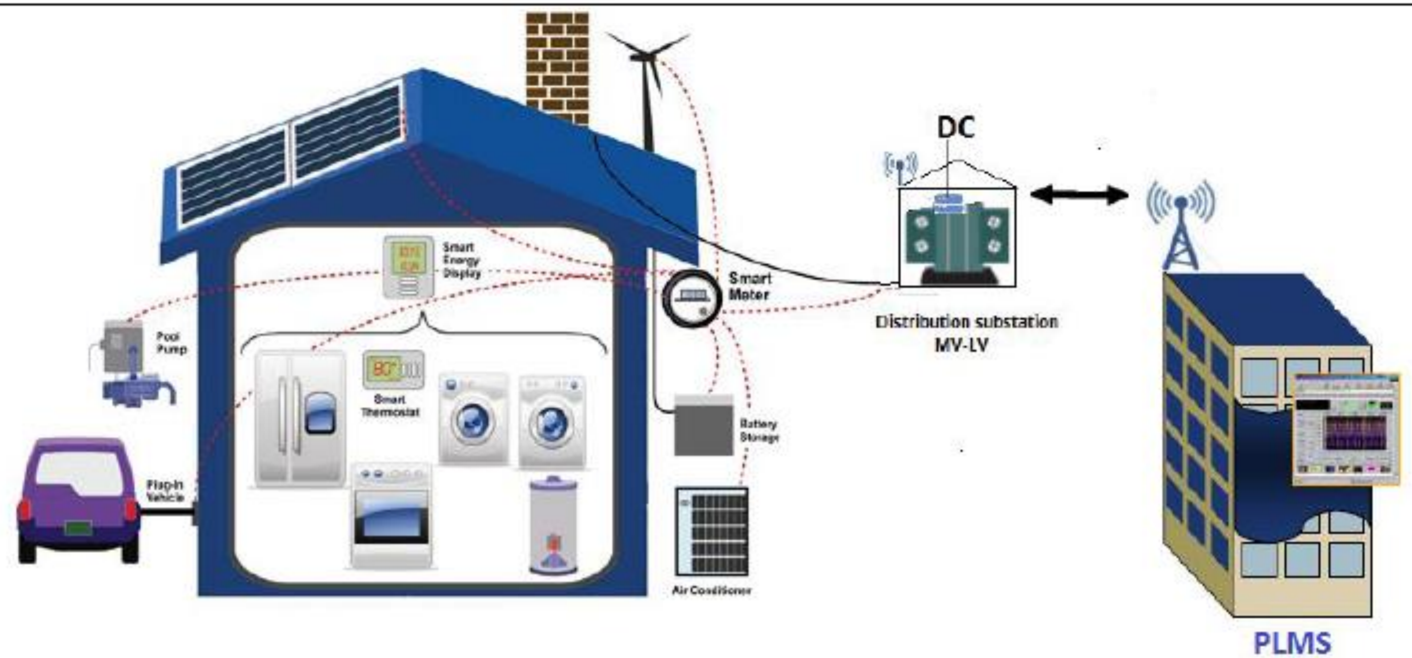
Smart Meter: Where we are?



Dumb Meter: manual operations

Electronic Meter With Communication Channel: Automatic Meter Reading

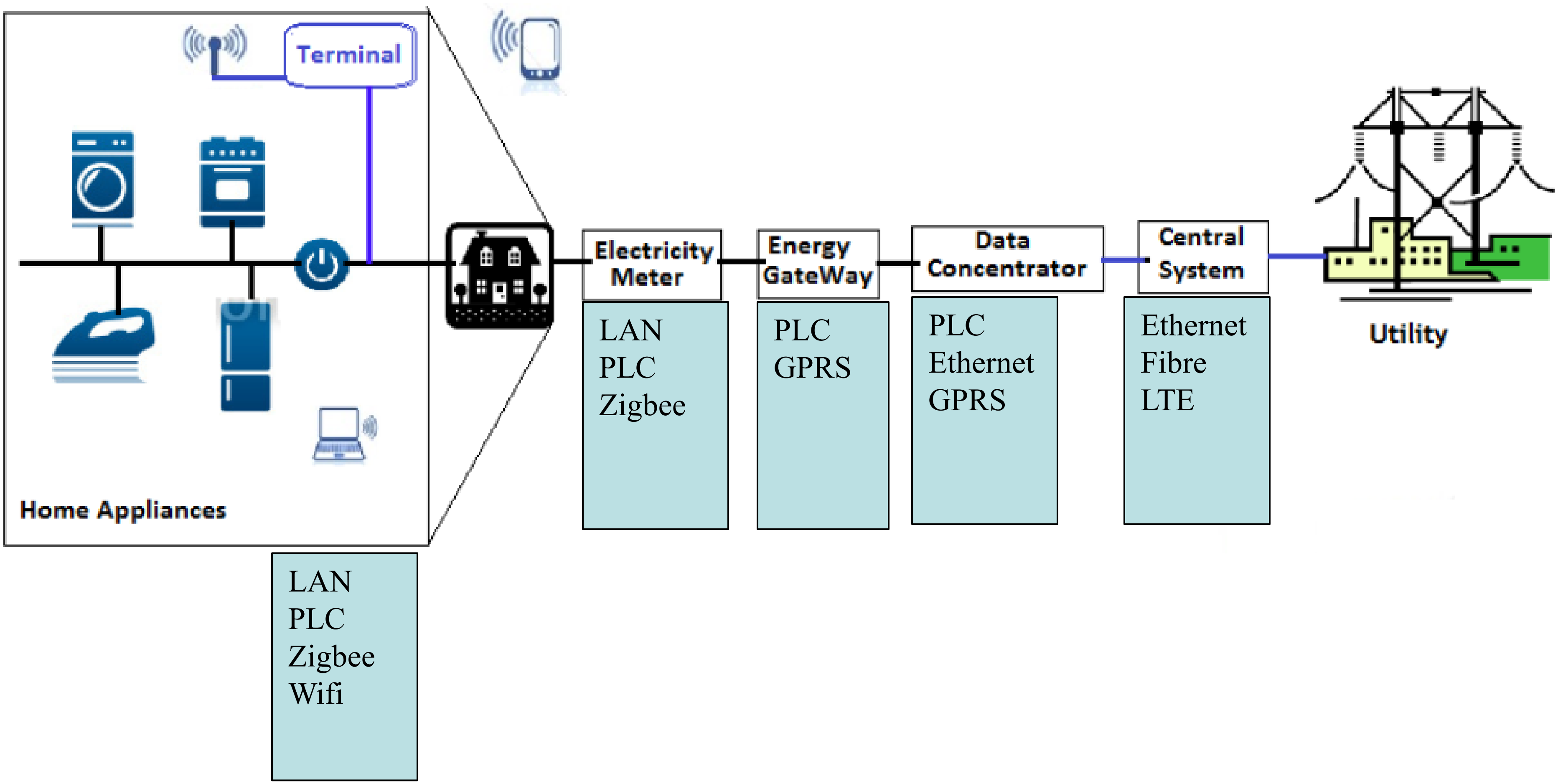
Smart Meter: Where we want to go



PLMS: Power and Load Management System. DC: Data Concentrator

Smart Meter

Smart Meter: System Architecture



Smart Meter Project

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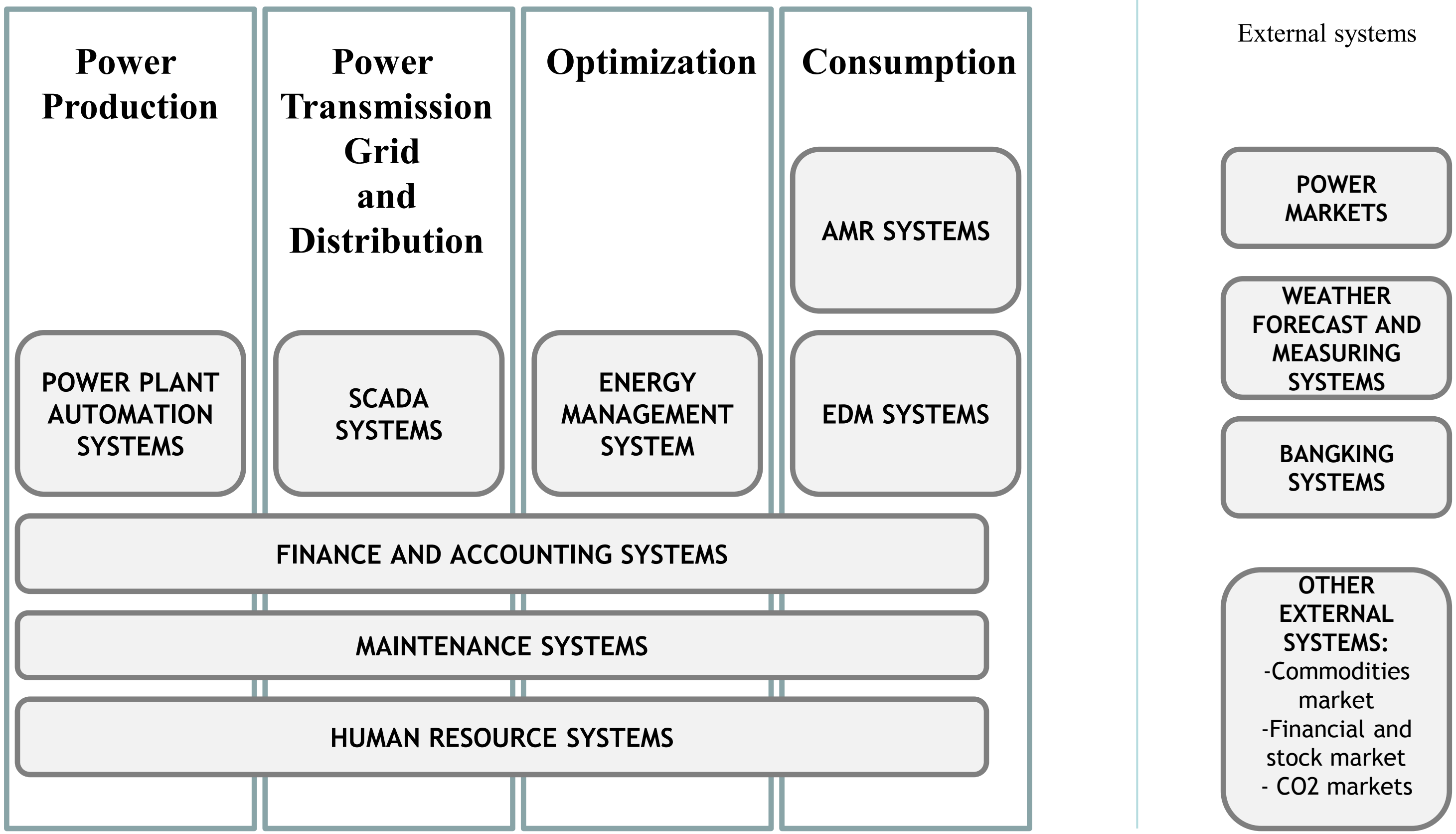
Conclusion: Multi Level Integration

SMART GRID is the Interconnections of multi-level national energy systems that can be only enabled by advanced ICT



The model of national level ICT system interconnections in future Smart Grid

EDM=Energy Data Management
AMR=Automatic Meter Reading

Conclusion

ICT technology will enable both consumers and suppliers to see the grid as resource and a real opportunity to Innovation and new business