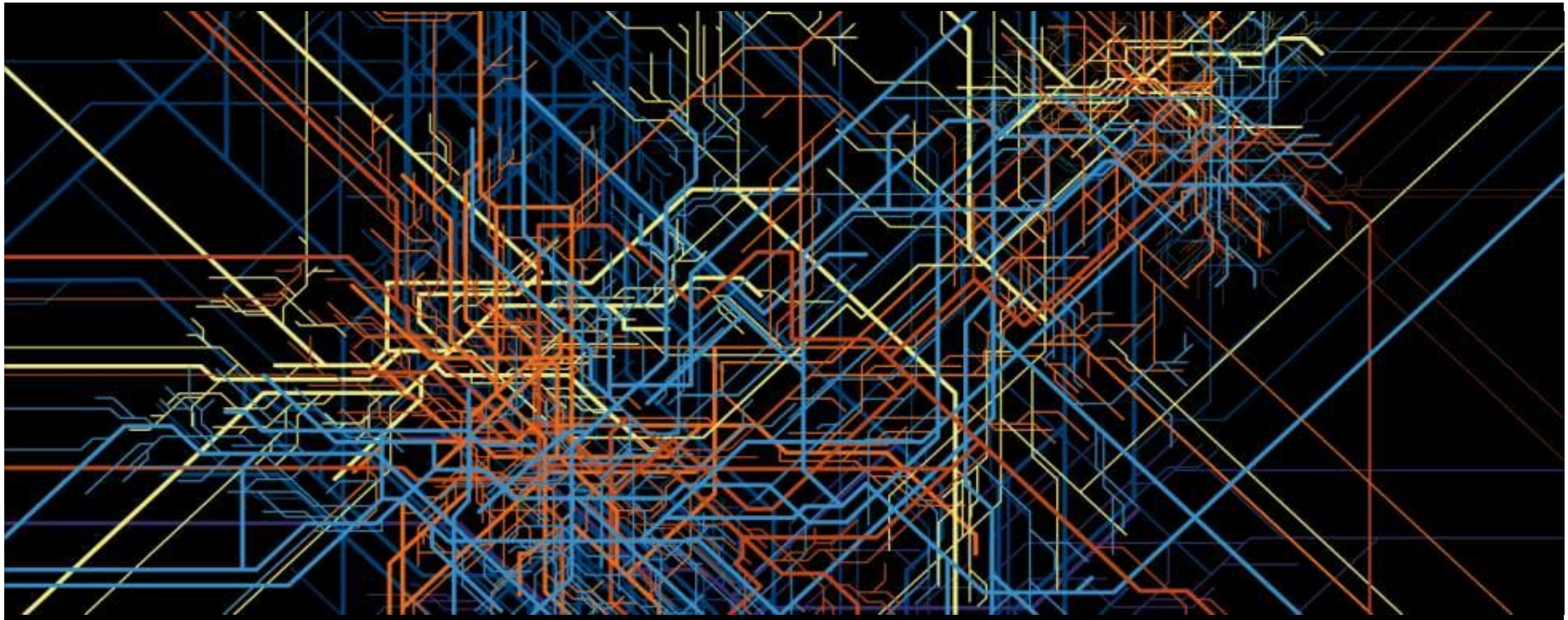


Gary Rackliffe – Vice President Smart Grids North America, ABB Inc.

Smart Grid Vision and Trends

How2Guide for Smart Grids in Distribution Networks
ISGAN, IEA, and SENER
Mexico City, March 26 – 28, 2012

Power and productivity for a better world™

ABB’s vision

As one of the world’s leading engineering companies, we help our customers to use electrical power efficiently, to increase industrial productivity, and to lower environmental impact in a sustainable way.

Global electric energy drivers

Capacity

Reliability

Efficiency

Sustainability

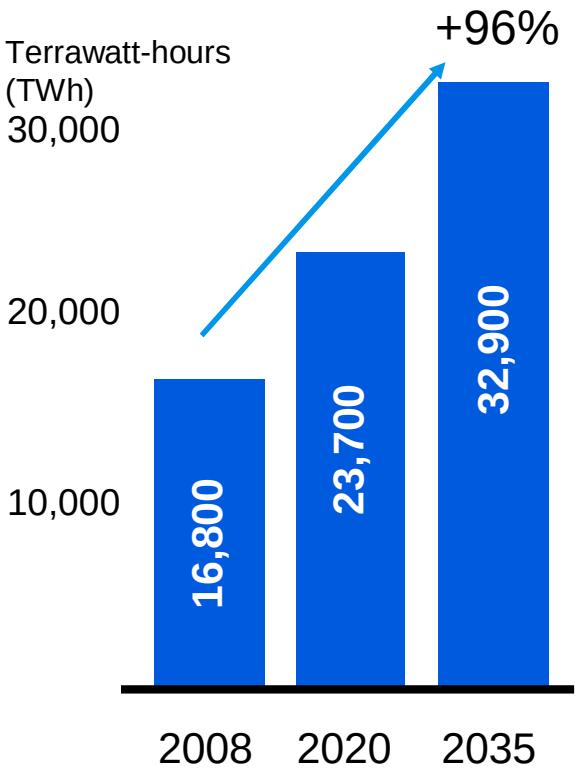
Customer Enablement

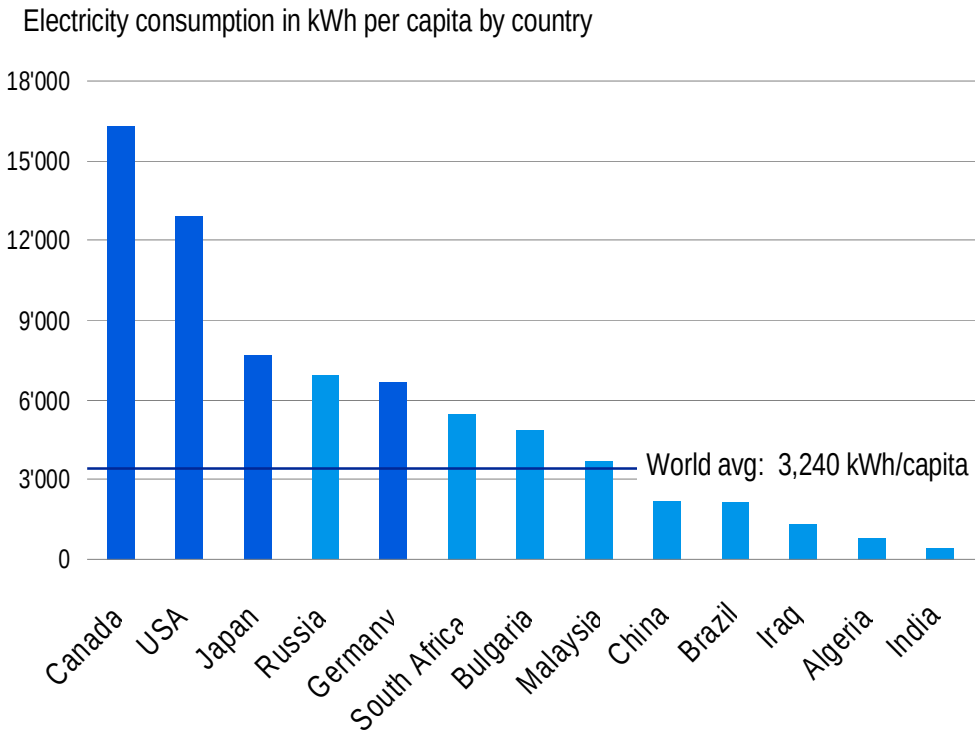
Helping the global grids work smarter not harder

Capacity – Electricity consumption to double by 2030
….but global climate concerns gathering momentum

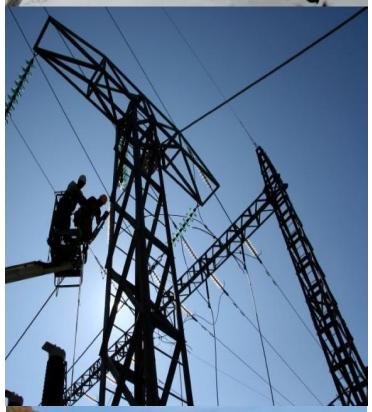
Rise in electricity consumption by 2035 (under current policies)

Source: IEA, World Energy Outlook 2010



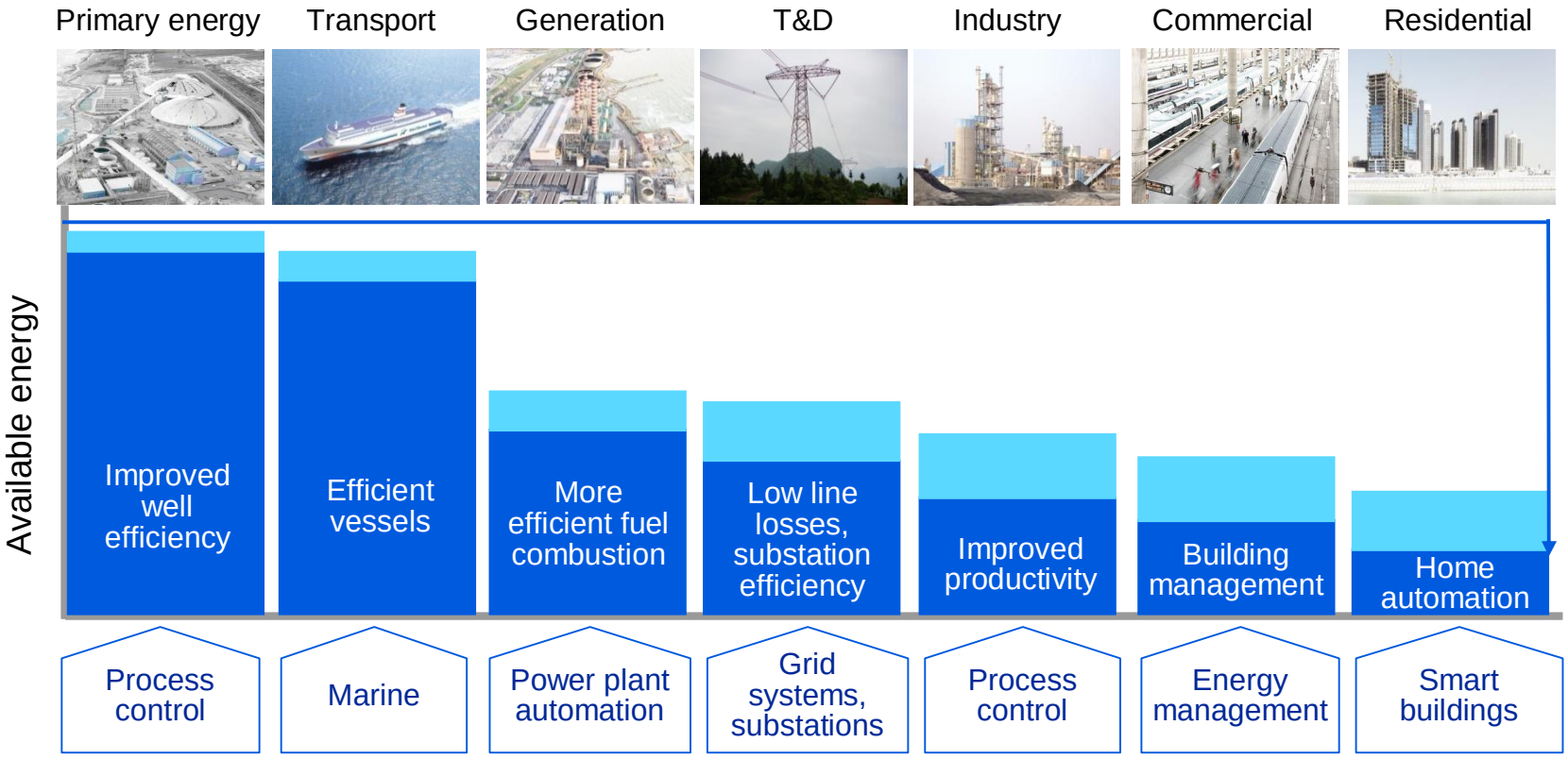


Reliability – Ensuring reliable grid operations



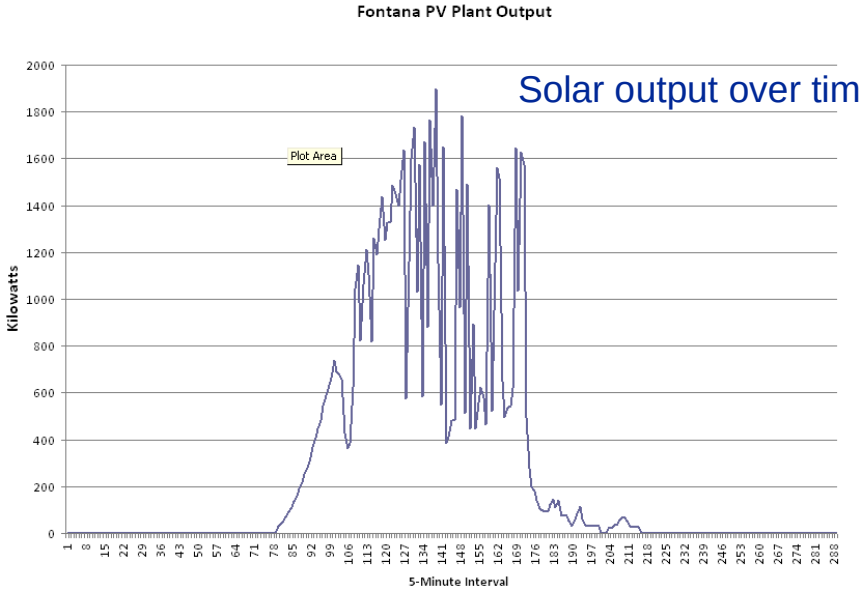
- **Distribution Management Systems (DMS)**
  - Monitor status of the grid and manage grid disturbances to reduce in outage duration.
  - Automation for Fault Detection Isolation and Restoration (FDIR)
- **Asset Health Management**
  - Manage aging and capacity constrained assets to minimize disruptions and provide asset health decision support
  - Collect condition data of assets in the field.
  - Analyze the data to determine the health of the asset and recommended actions.
  - Manage the execution of preventative and predictive maintenance
- **Transmission Grid Management**
  - Wide area monitoring
  - Voltage stability support
  - Power oscillation monitoring
  - Integration of renewables

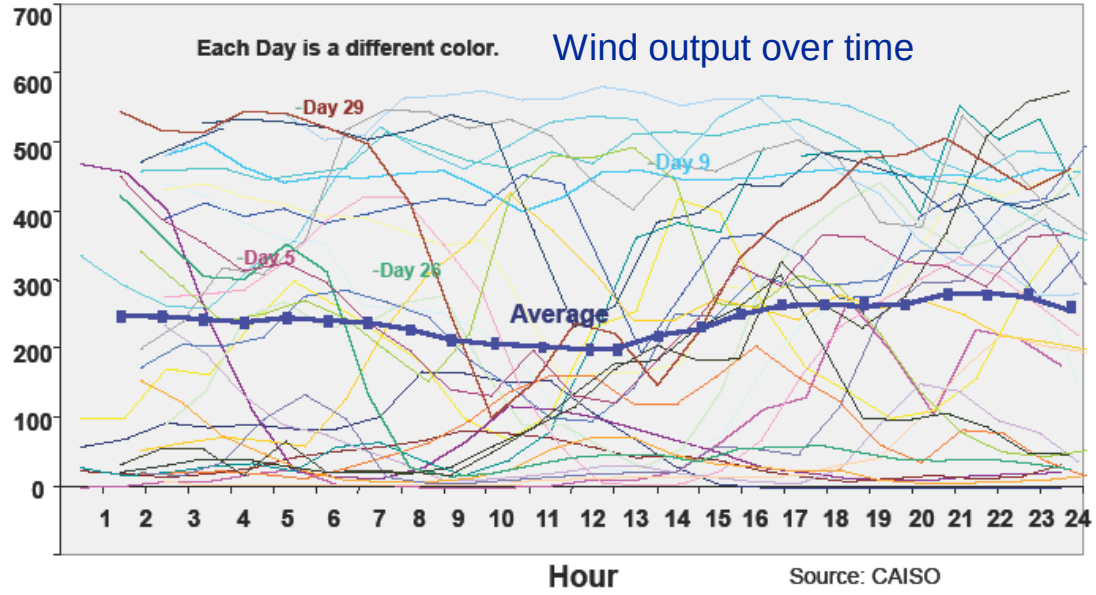
ABB in the “sweet spot” of energy efficiency



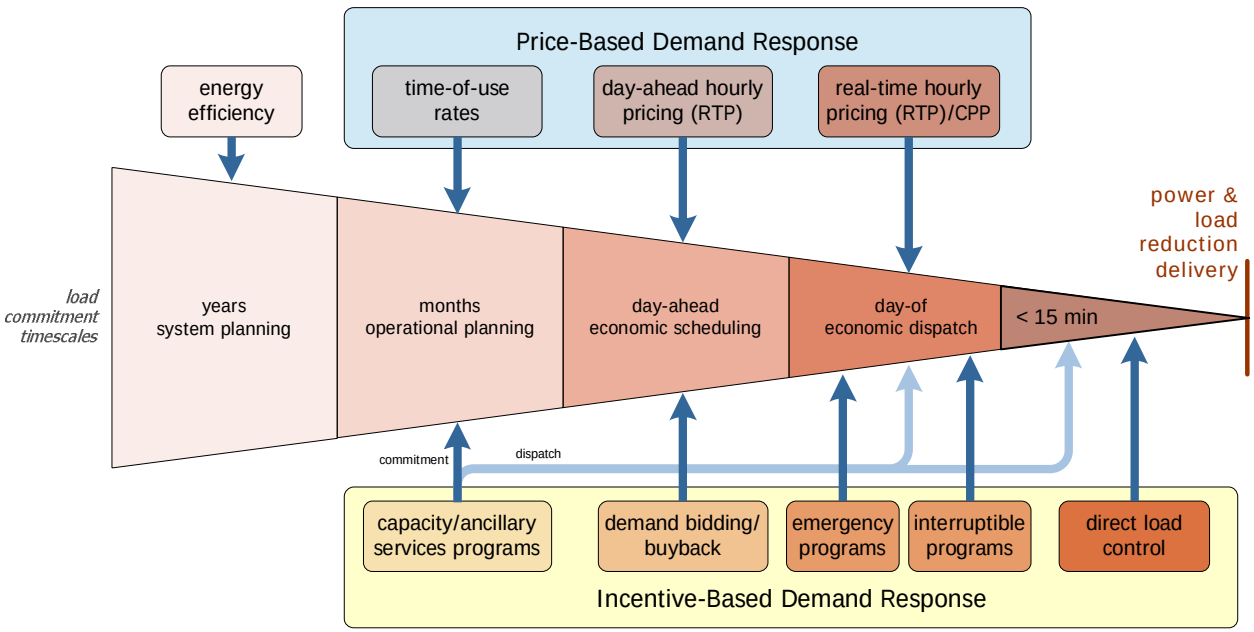
1. **80% of energy is lost along the value chain**
2. **Approximately 10% of electric energy produced by power plants is lost during transmission & distribution**
3. **More of the T&D losses occur in the distribution network.**
4. **Efficient distribution transformers and Volt/Var control improve efficiency.**

Renewable generation – variable sources





Engaging the end-use consumer



Source – DOE

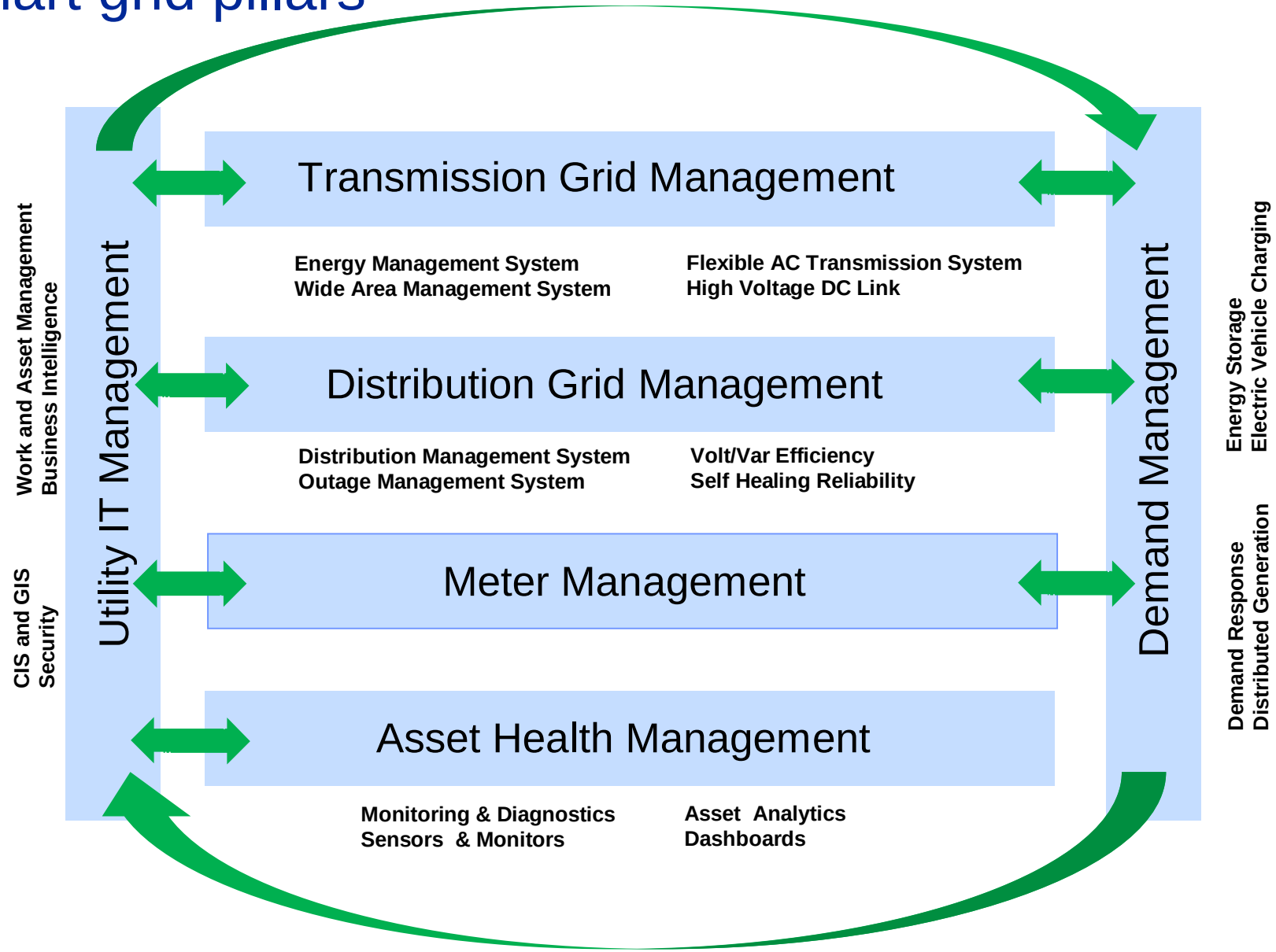
- Today residential consumers use energy without regard to the actual supply situation
- Power producers plan the supply and deliver without knowing the detailed projected consumption
- Effective information exchange and automation of appropriate actions of both parties can optimize the demand supply equation
- For US a 20% reduction potential in peak demand after full deployment of demand response is estimated – Source FERC 2009

The future electrical system must facilitate an effective dialog

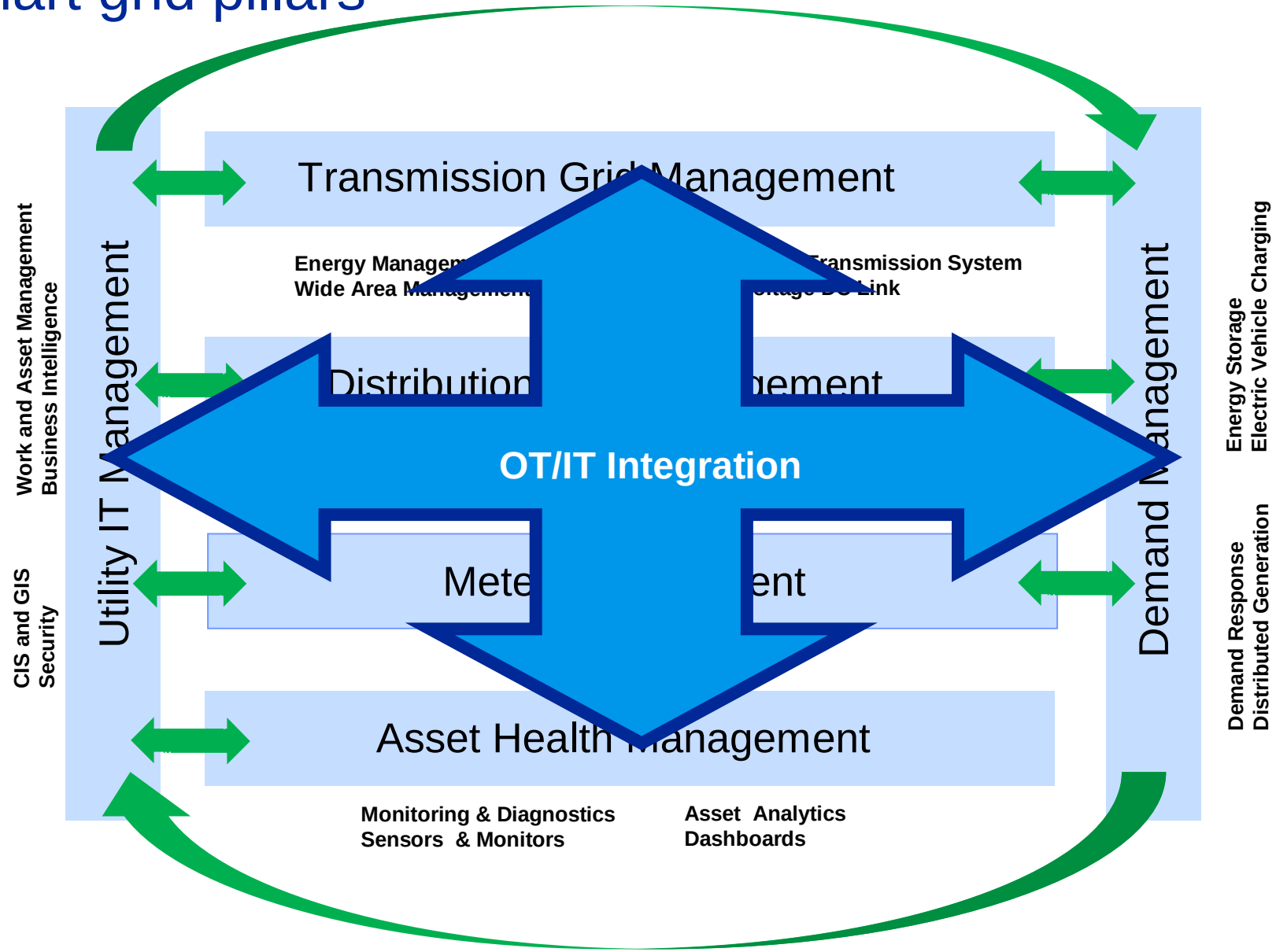
Technology solutions – how are we responding

1. **Power electronics**
   - HVDC and FACTS
   - Inverters for Solar PV
   - Drives for industrial automation
   - DC grids for data centers
2. **Creating a more flexible, adaptive grid**
   - Communications
   - Distribution grid management – FDIR, Volt/Var Efficiency
   - Demand Response
   - Energy Storage
   - Distributed Generation
3. **OT/IT integration**
   - Back office data processing – MDMS, WAMS, VPP
   - Business intelligence – Asset Health, Customer Preferences
   - Systems integration – Smart Grid Control Center

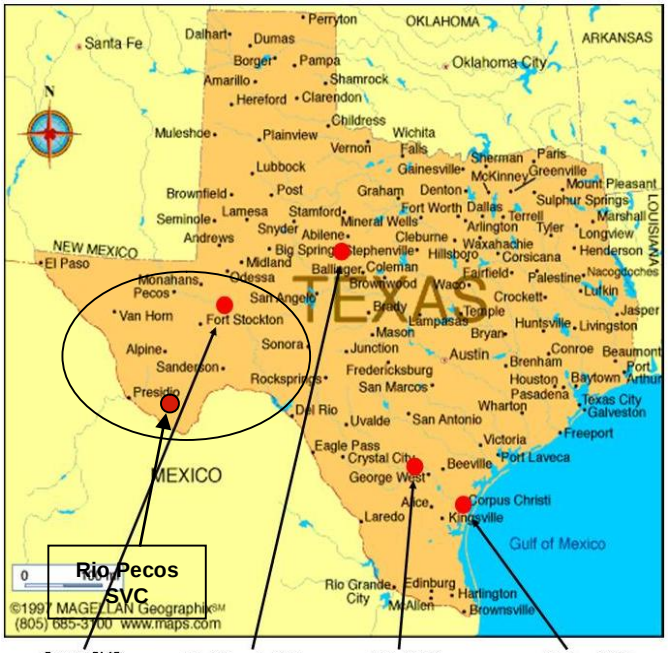
Smart grid pillars



Smart grid pillars



FACTS – wind applications in West Texas

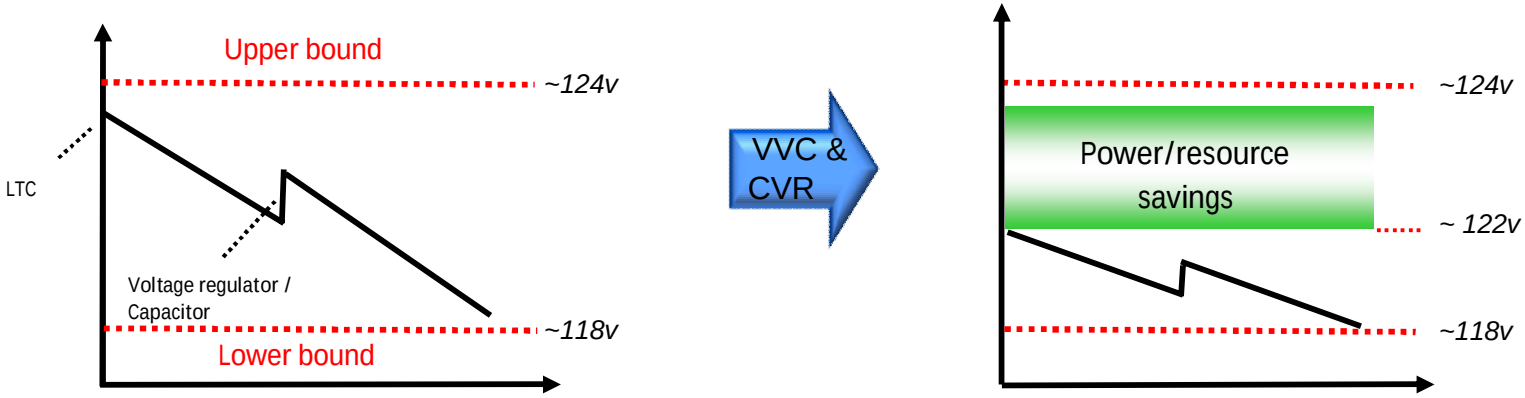


- West Central Texas: plenty of wind power
  McCamey area: 750 MW and growing;
  Central area: 1,000 MW
- Very high wind power penetration (up to 80%) and variations in import/export of active power due to rapid swings of wind farm output require continuous voltage regulation.
- Induction generators lose synchronism at low voltages and thus increase their reactive power demand, further dragging down the system voltage. **SVCs provide voltage support.**
- A **Series Capacitor,** rated 400 Mvar, has been installed at the Horse Hollow end of a 345-kV inter-tie. Horse Hollow is a very large wind farm in Texas with 750 MW. The line takes the power 300 km to the south, to Kendall in the San Antonio area.

Distribution grid management
Optimizing power for maximum efficiency

- Reactive power can account for a significant portion of distribution losses. Utilities need to manage the amount of reactive power on the grid to ensure maximum efficiency. A 1% improvement in efficiency is estimated to eliminate 100 million tons of CO2.

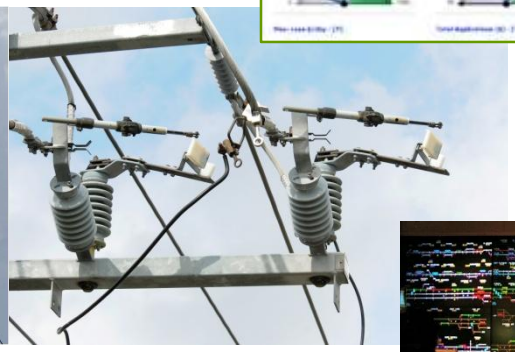
- Volt/VAr Optimization – Optimizing the balance between active and reactive power can allow for reduction of energy losses on distribution feeders. Savings of 4 – 5% can be achieved.

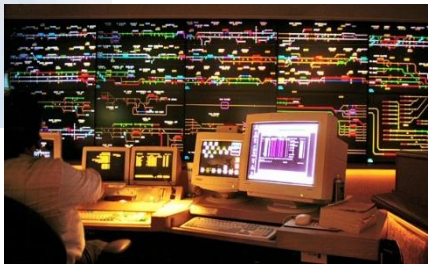


Distribution grid management
Intelligent grid improves distribution operations

Leverage energy information…

- advanced utility operations and management
- self-healing grid
- avoid disruptive events

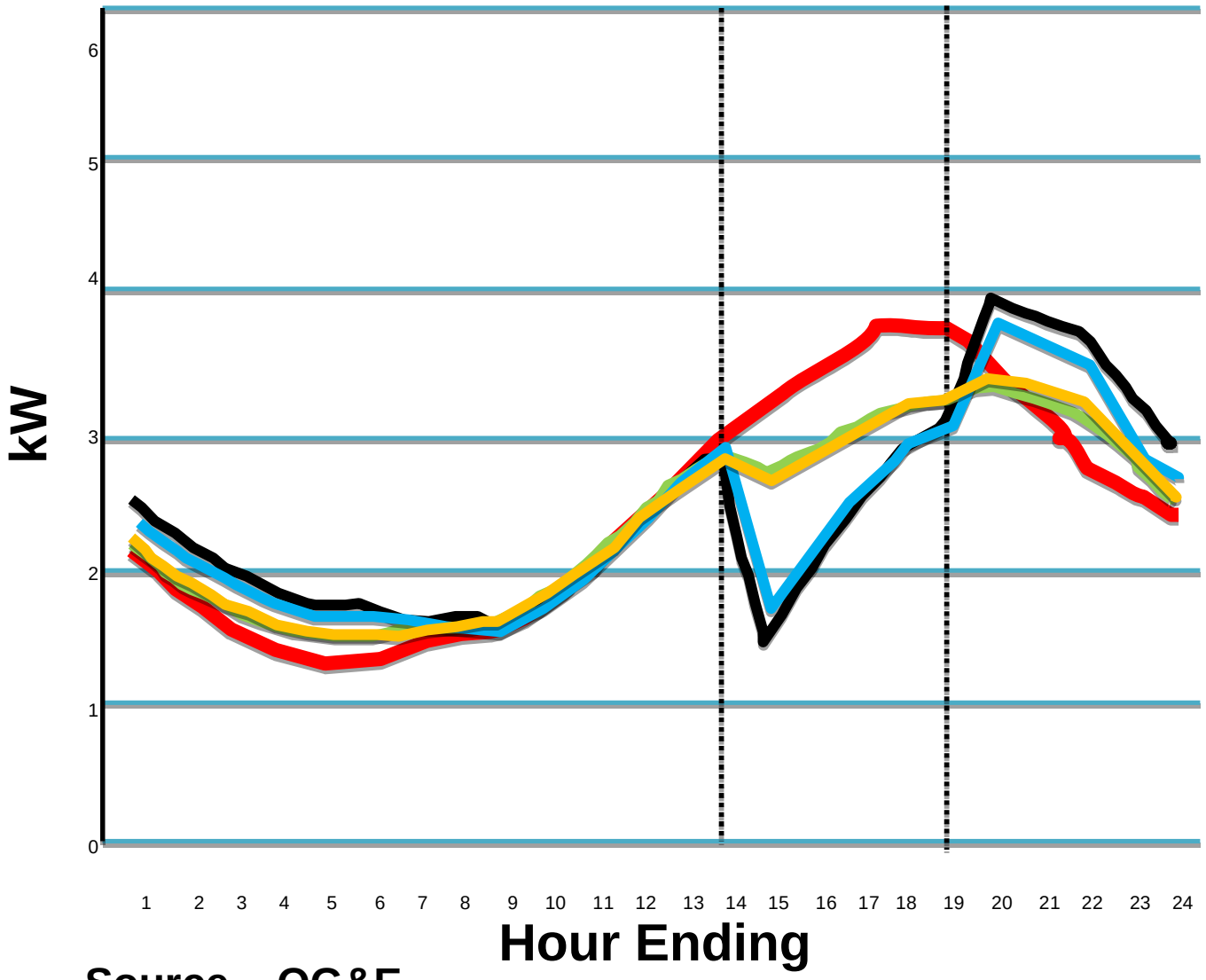




…which modernizes the grid to support the competitive electric marketplace.

Source -- CenterPoint

Demand response – VPP/CP High Weekday



Control – None of the Technologies

Programmable Communicating Thermostat

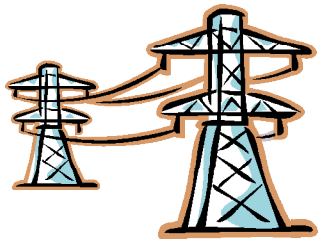
In-Home Display

Web Portal

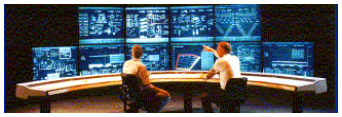
All 3 Technologies

Source – OG&E

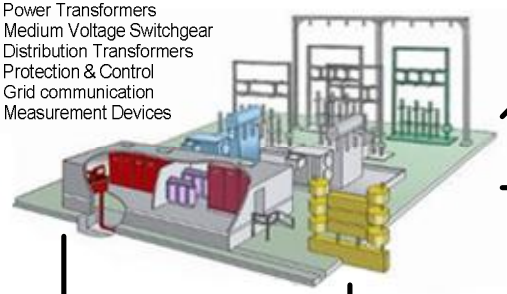
EV Charging infrastructure



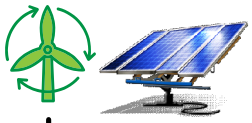
Substation
Substation Automation System
High Voltage Products
Power Transformers
Medium Voltage Switchgear
Distribution Transformers
Protection & Control
Grid communication
Measurement Devices



Network Management
Energy Management System
Generation Management System
Distribution Management System

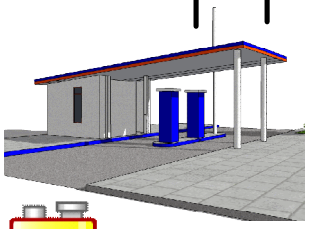


Renewable energy sources
DC/DC Converters
Grid communication
Measurement Devices



Domestic Wallbox 3-4kW
Circuit Breaker
Over Current Protection
Grid communication
Measurement Devices
Grid Communication
Charging Control Pilot
Low Voltage Connectors

Public fast charging station 100kW DC
MV Switchgear
Transformer
AC/DC converter
DC/DC Converter & Charging controller
DC Circuit Breaker
Grid communication
Measurement Devices
Remote Terminal Unit
User Interface & Billing System
LV Plugs and Cables
Residual Current Protection Device



Public slow and semi-fast charging pole 22-50kW AC
Circuit Breaker
Over Current Protection
Grid communication
Measurement Devices
Residual Current Protection Device
Low Voltage Connectors
User Interface & Billing System
Charging Control Pilot

Energy storage for grid peak leveling
Grid communication
Measurement Devices
Charging Controller

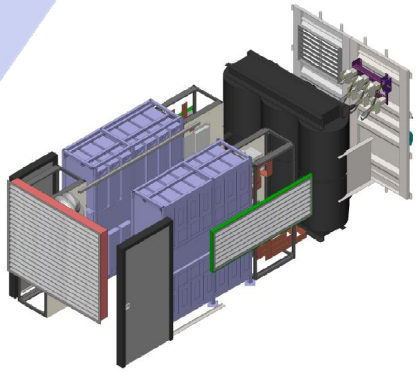
Energy storage

- Balancing power is a major issue for utilities and especially critical with large amounts of variable wind and solar energy in the supply mix
- Storage of electrical energy helps to bridge the time of reduced or missing power to activate reserves

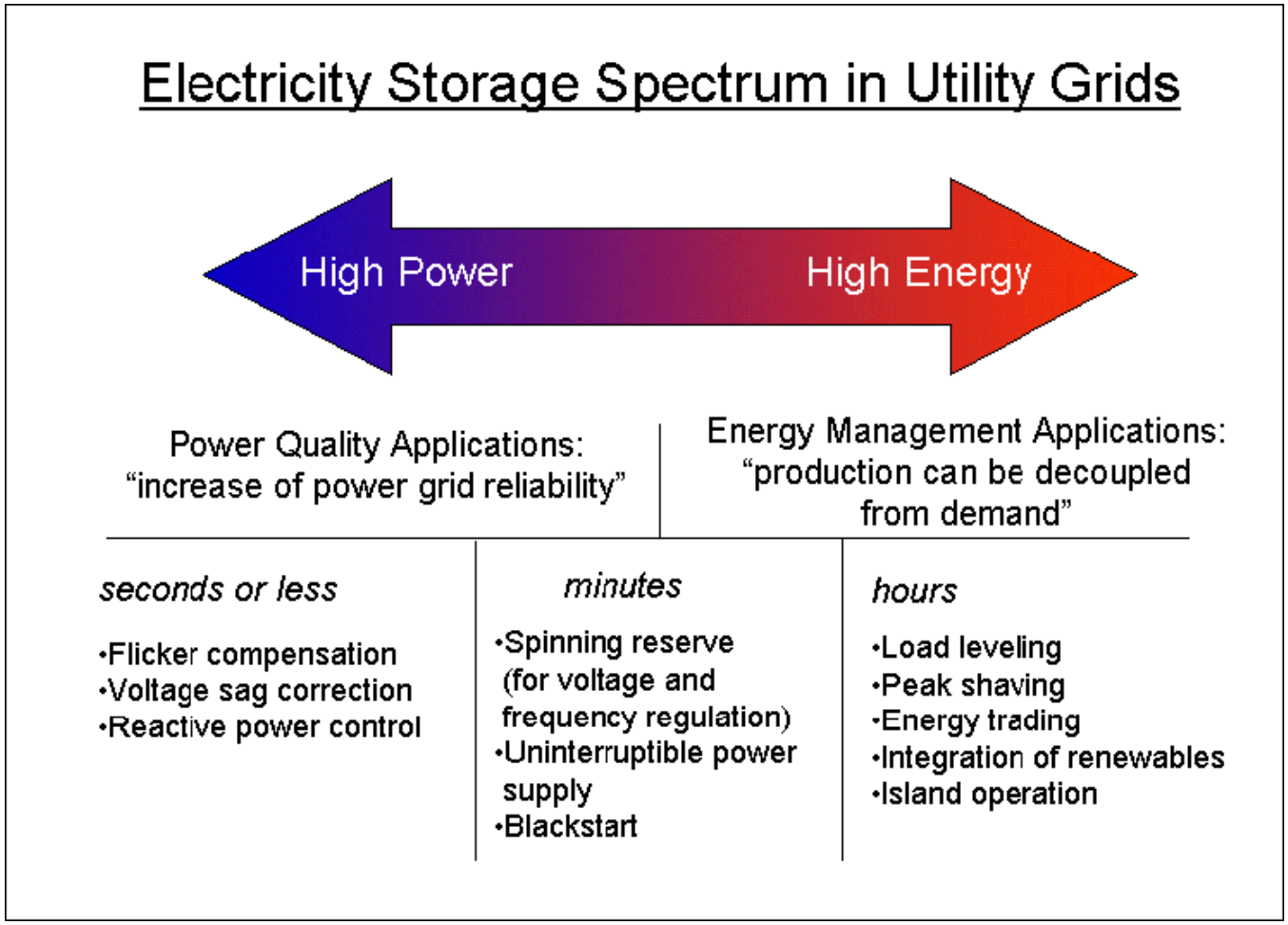
1990-2000
- Technical feasibility

2001-2010
- Commercial feasibility

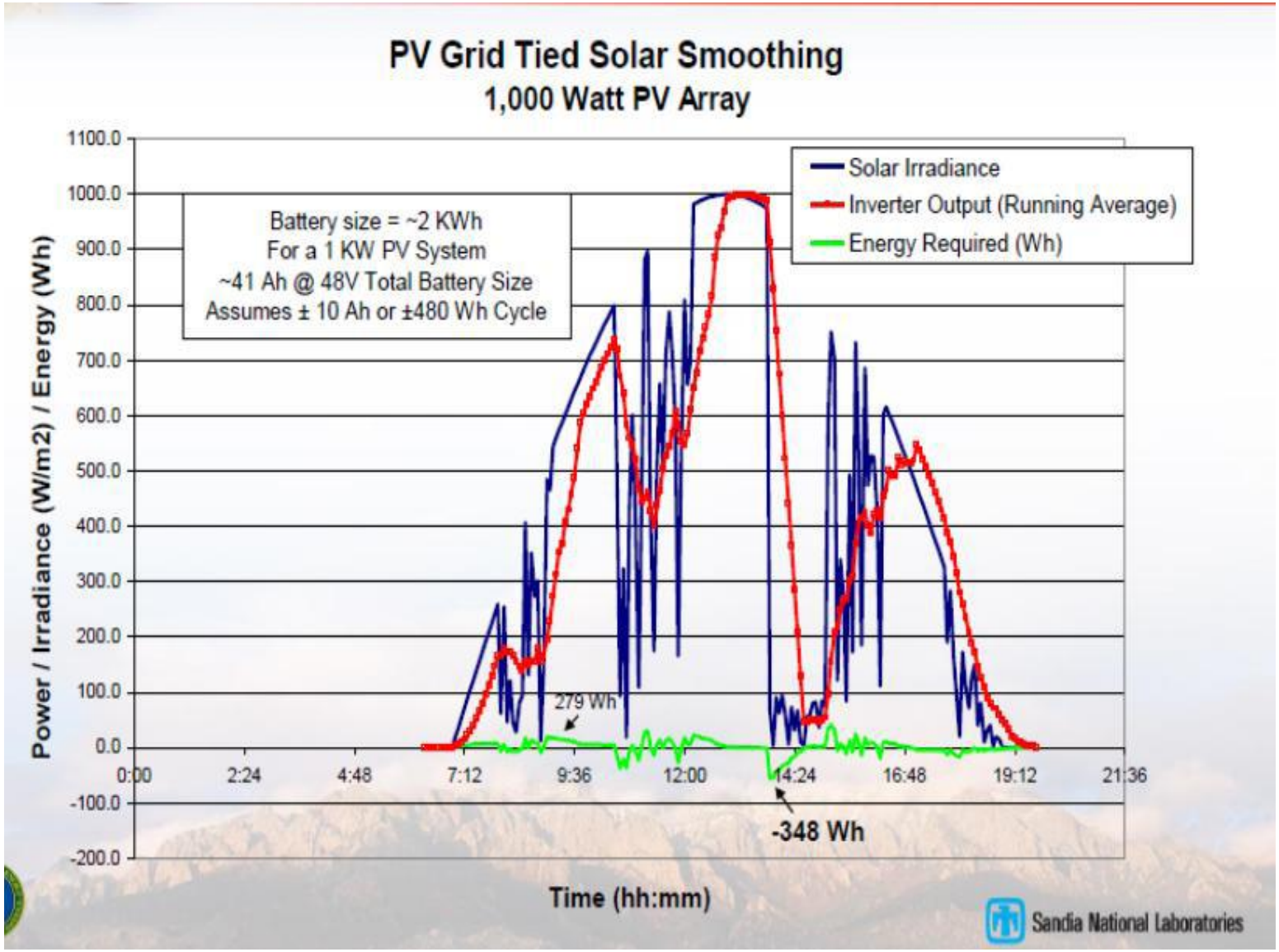
2011-2015
- Grid integration



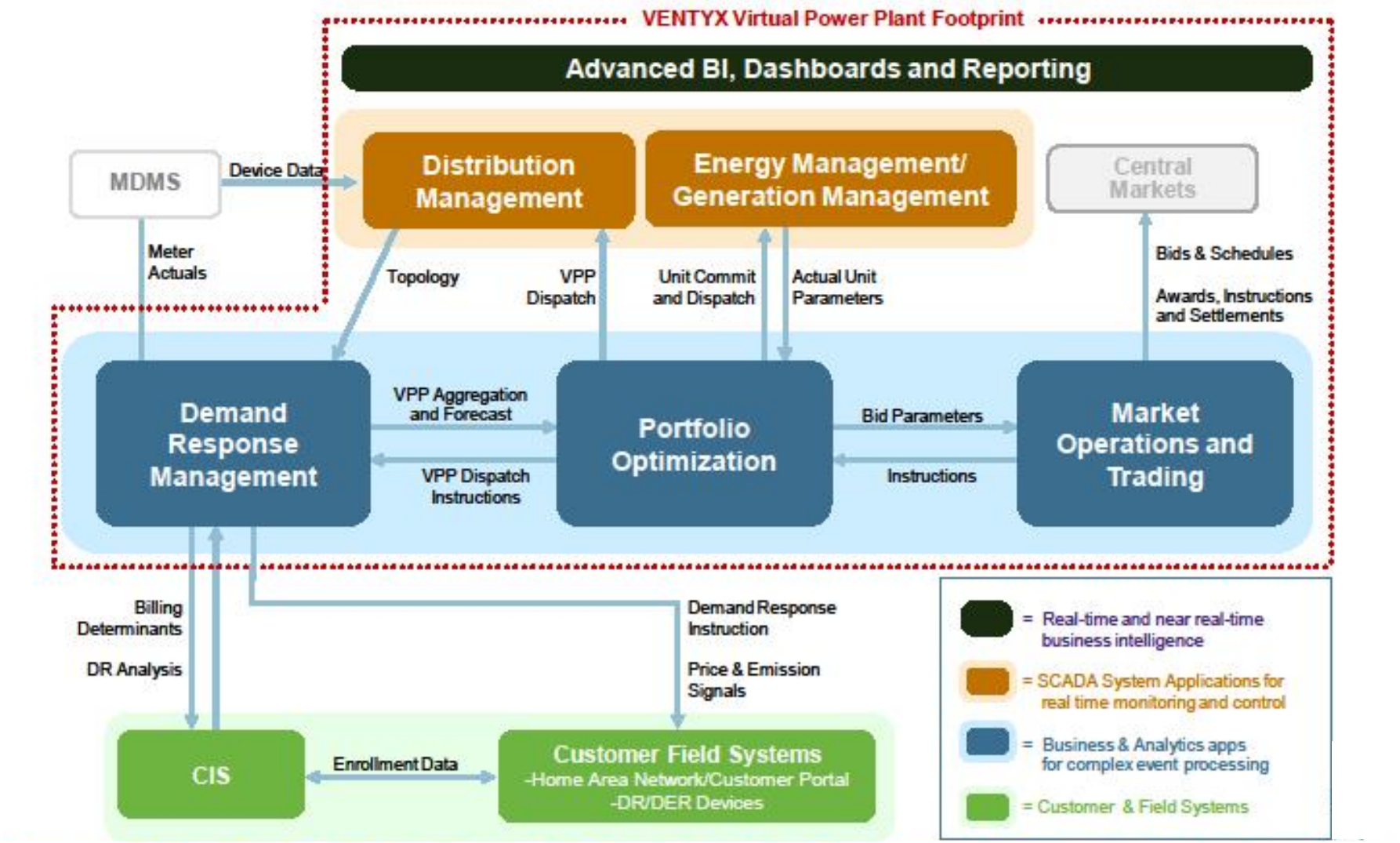
Energy storage



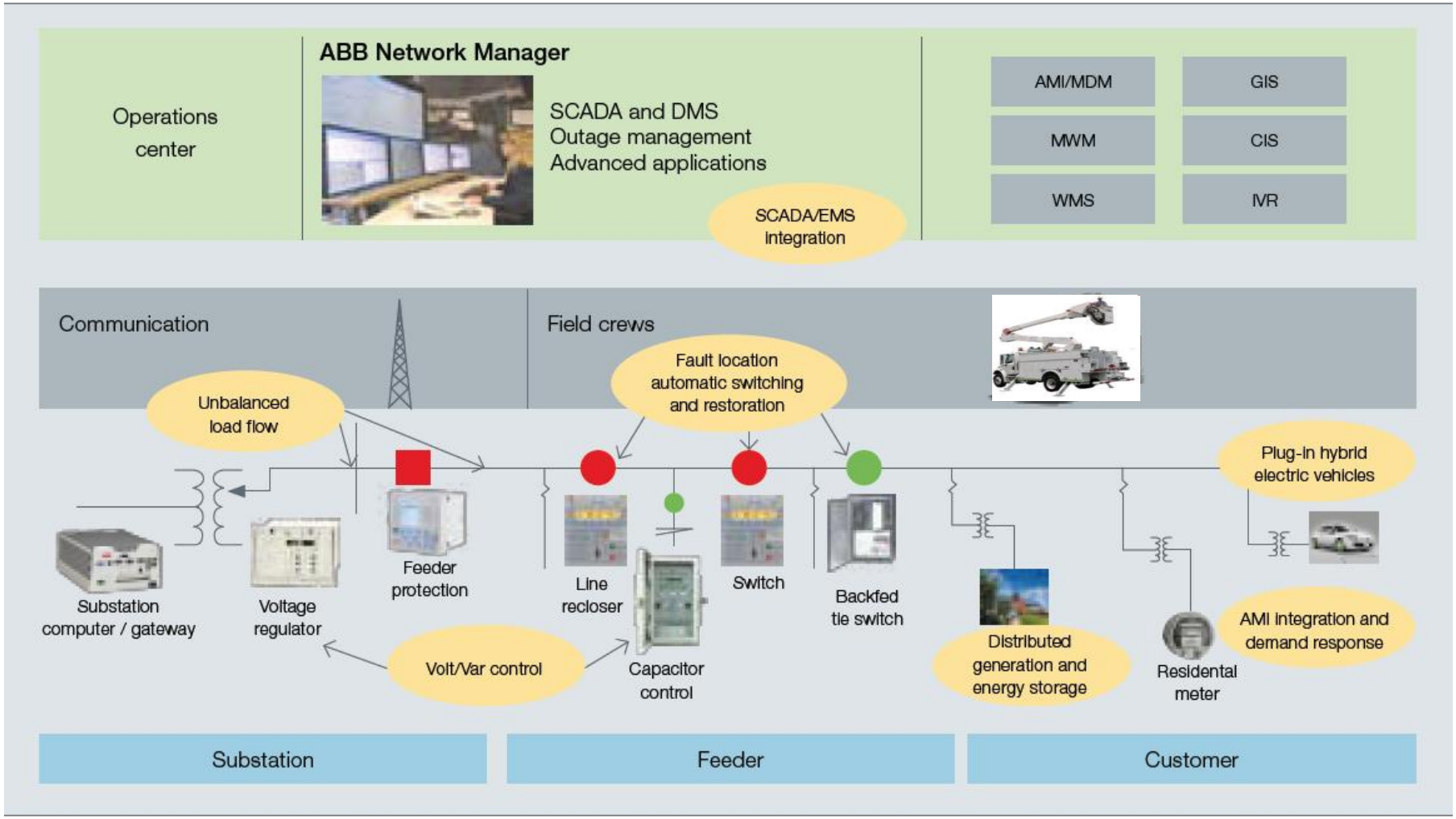
Solar PV


PV Grid Tied Solar Smoothing
1,000 Watt PV Array
Battery size = ~2 KWh
For a 1 KW PV System
~41 Ah @ 48V Total Battery Size
Assumes ± 10 Ah or ±480 Wh Cycle
Solar Irradiance
Inverter Output (Running Average)
Energy Required (Wh)
Power / Irradiance (W/m2) / Energy (Wh)
1100.0
1000.0
900.0
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
-100.0
-200.0
0:00
2:24
4:48
7:12
9:36
12:00
14:24
16:48
19:12
21:36
279 Wh
-348 Wh
Time (hh:mm)
Sandia National Laboratories

Integrating OT/IT with virtual power plants



Integrated Operations Center for Smart Grid



End-to-End Solution to Drive Asset Performance

Asset Health Management End-to-End Process

Operations Technology (OT)
Information Technology (IT)

Performance models based on embedded T&D equipment intelligence

Apparatus & Service	Sensors and Monitoring	Substation Gateway	Asset Database	Analytics & Performance Models	Work & Asset Management
Transformers Breakers Batteries HVDC & FACTS Switches Reclosers Switchgear	Transformer monitors Circuit Breaker monitors Battery Monitors Relays (IED's) Instrumentation/sensors	Substation Automation Data Concentration Communications	Equipment specs Failure data Test results Service records	**Decision Support:** 1. Operations Impact 2. Optimized Maintenance 3. Lifecycle Management 4. Recommended Work Execution	Work Management Inventory Crew Deployment

ABB T&D products, systems, service & expertise

Asset Health Center

Smart Grid Value

Summary of Estimated Cost and Benefits of Smart Grid

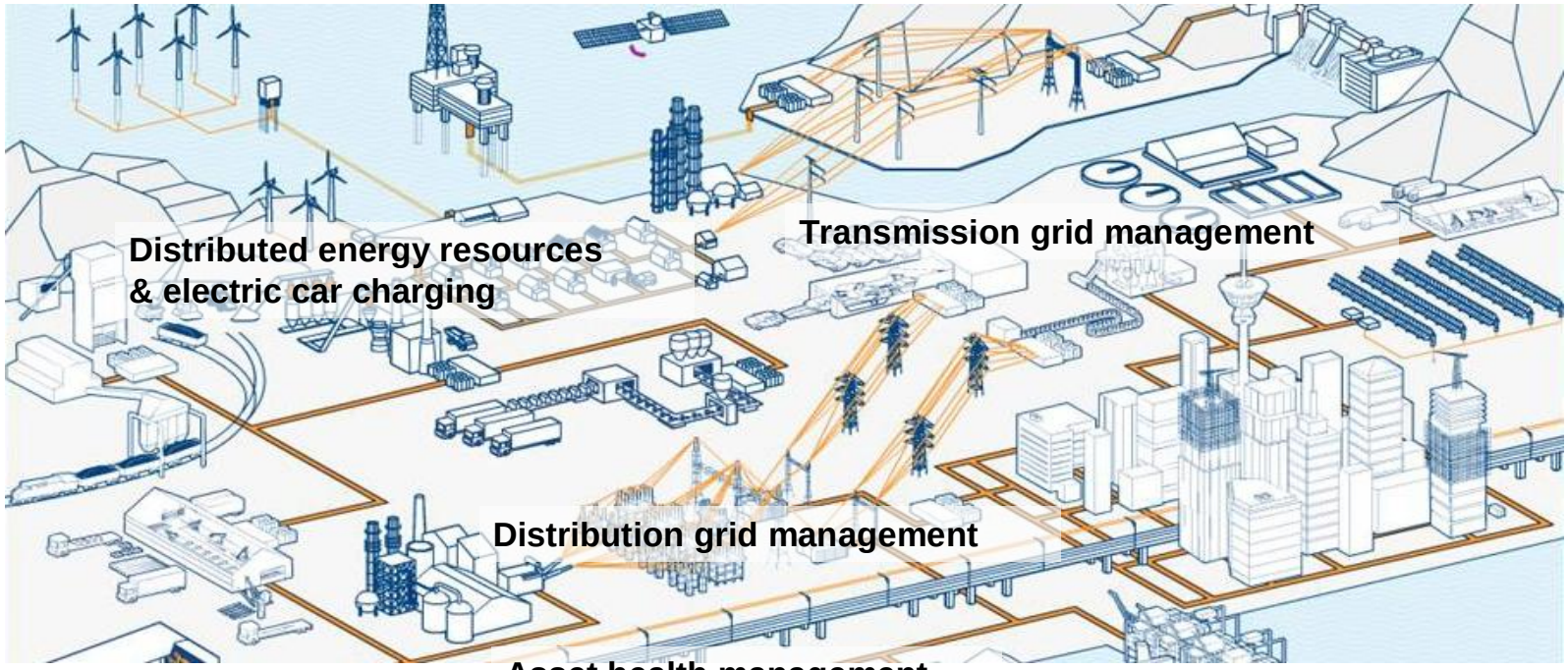
	20-Year Total ($billion)
Net Investment Required	338 – 476
Net Benefit	1,294 – 2,028
Benefit-to-Cost Ratio	2.8 – 6.0

(Provided by EPRI Report 1022519: *Estimating the Cost and Benefits of the Smart Grid)*

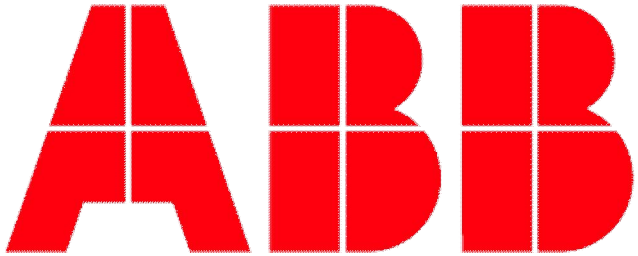
Smart Grid Landscape
An Integrated Grid Management System

The smart grid is an integrated approach to transform utilities to a future state. It requires the coordination of advanced technologies, business processes and people.

It will be a gradual transformation of the systems that have served us for many years into a more intelligent, more effective and environmentally sensitive network to provide for our future needs.



Power and productivity
for a better world™



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