Smart Grid Technologies

USAID – The Fundamentals of Energy Systems for Program Managers

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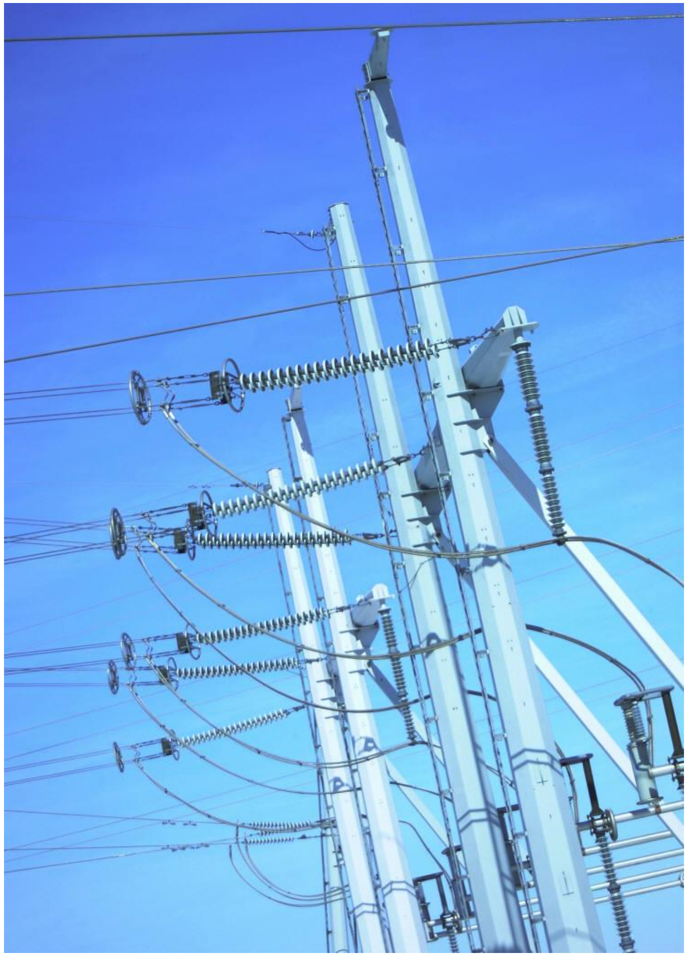
What you will learn (the takeaways):

- Key Drivers and Benefits of Smart Grid
- What are the some of the prominent technologies available within the smart grid area?
- Use of these technologies to enable renewable integration and other challenges to the electric system (like losses)
- Case Studies



Question set #1

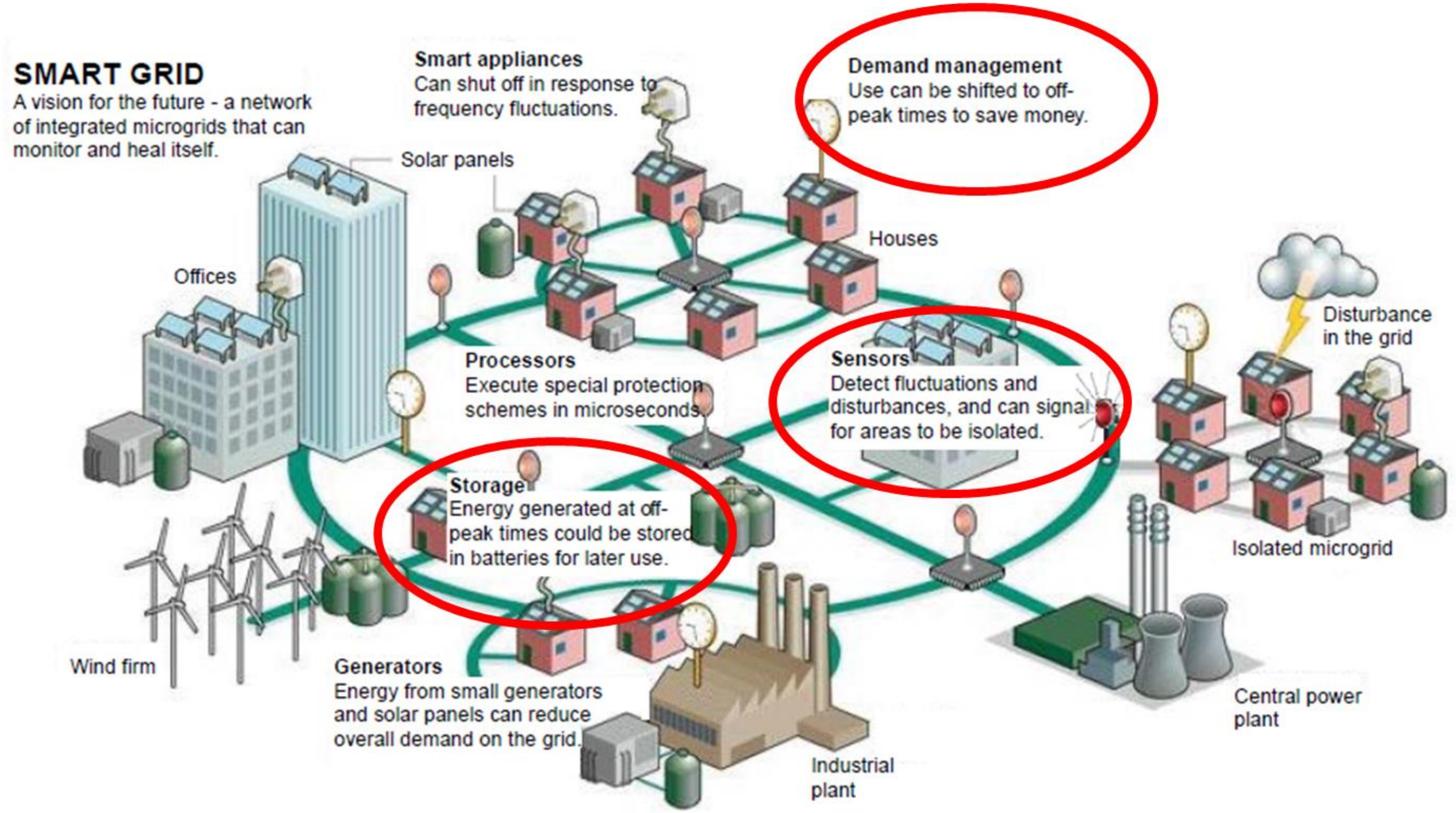
1. Smart Grid is a relatively new idea, it has never existed in the pas
    - True?
    - False?

2. Are certain portions of the electric system “smarter” than others? Why?

Key Components of Traditional Transmission and Distribution Grid

- SCADA – Supervisory Control And Data Acquisition – to receive power system data from the field and control equipment. Usually consists of the following elements
  - Master Station(s)
  - Field Remote Terminal Units (RTU's) – installed at substations and generation plants to collect data and control the devices
  - Communication between Master and Field RTU's
- EMS – Energy Management System

What is Smart Grid?

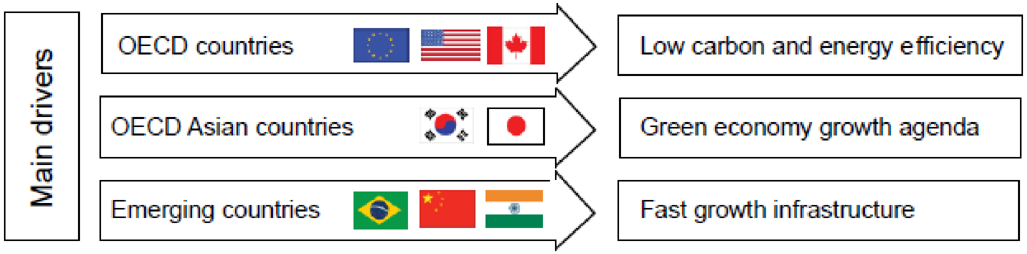


We will focus on prominent technologies in the transmission, customer and distribution related domains

Interaction of Participants in Each Domain of Smart Grid

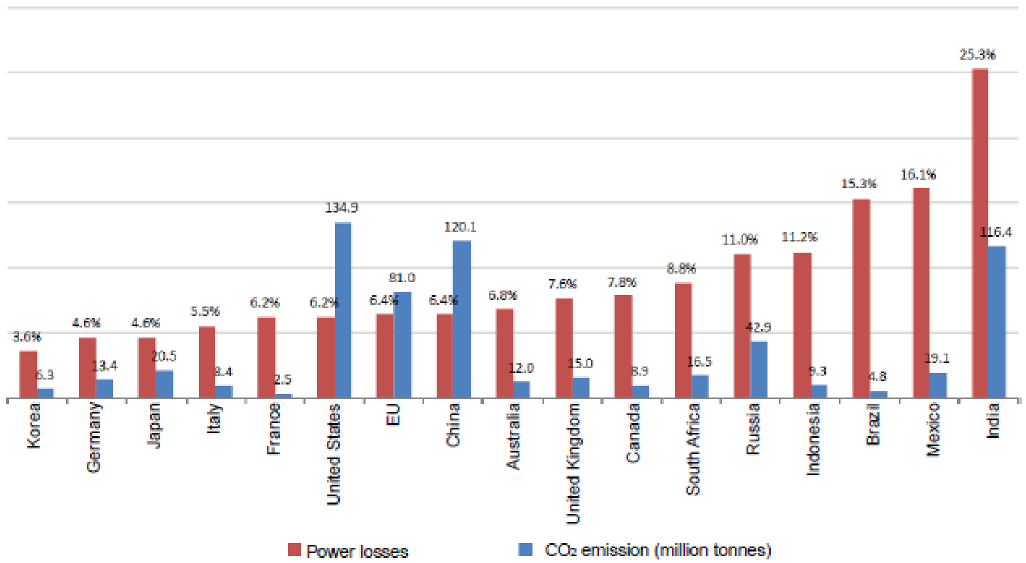
Domain	Actors in the Domain
1 - Customer	The end users of electricity. May also generate, store, and manage the use of energy. Traditionally, three customer types are discussed, each with its own domain: residential, commercial, and industrial.
2 - Markets	The operators and participants in electricity markets.
3 - Service Provider	The organizations providing services to electrical customers and utilities.
4 - Operations	The managers of the movement of electricity.
5 - Bulk Generation	The generators of electricity in bulk quantities. May also store energy for later distribution.
6 - Transmission	The carriers of bulk electricity over long distances. May also store and generate electricity.
7 - Distribution	The distributors of electricity to and from customers. May also store and generate electricity.

Key Drivers of Smart Grid Globally – Reduction of Losses and Power Theft Are Key Items in Developing Countries



Power losses at the grid and resulting CO_2 emissions of MEF countries in 2006

Source: Major Economies Forum on Energy and Climate, December 2009, *Technology Action Plan: Smart Grids*



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Solar Energy Revolution in Namibia using Smart Grid

https://www.youtube.com/watch?v=mUmIe-ijIVE

Economic Attractiveness of Smart Grid Technologies – U.S National Example

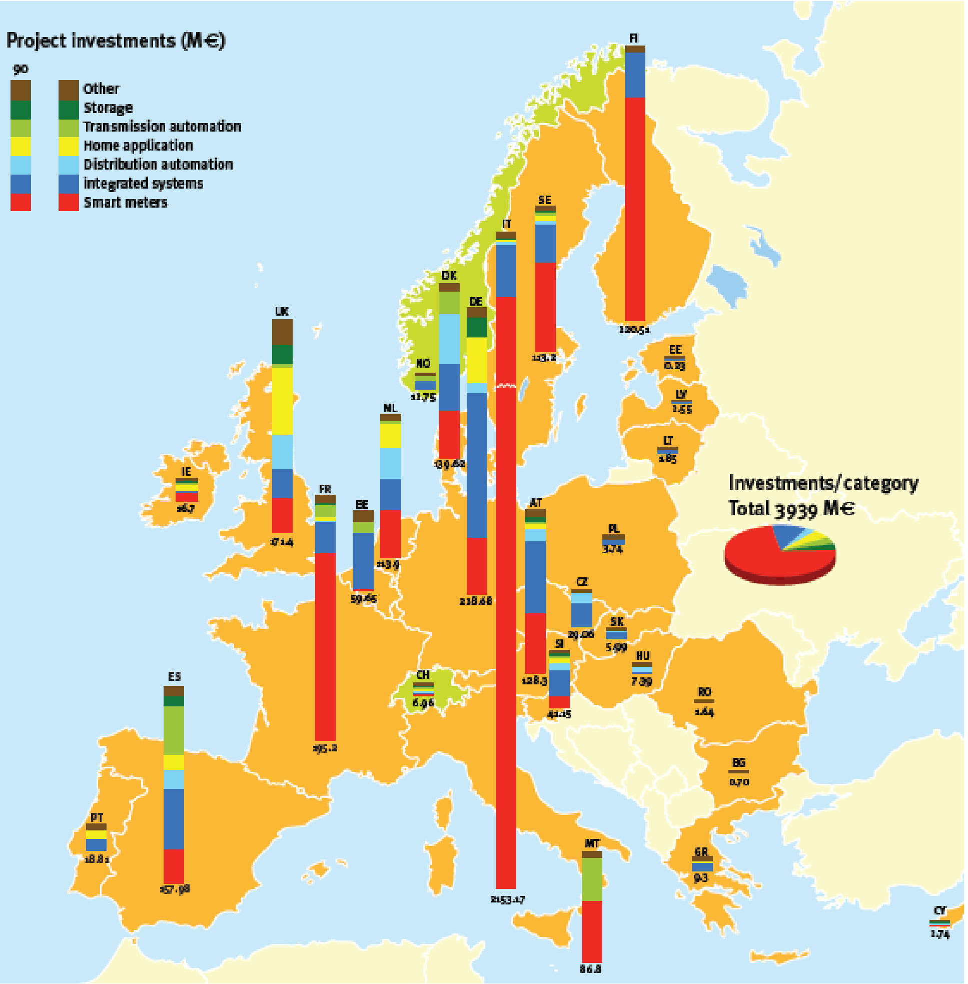
Attribute	Net Present Worth (2010) $B	
	Low	High
Productivity	1	1
Safety	13	13
Environment	102	390
Capacity	299	393
Cost	330	475
Quality	42	86
Quality of Life	74	74
Security	152	152
Reliability	281	444
Total	**1294**	**2028**

Summary of Estimated Costs and Benefits of the 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

Economic benefits in developing countries could be even higher

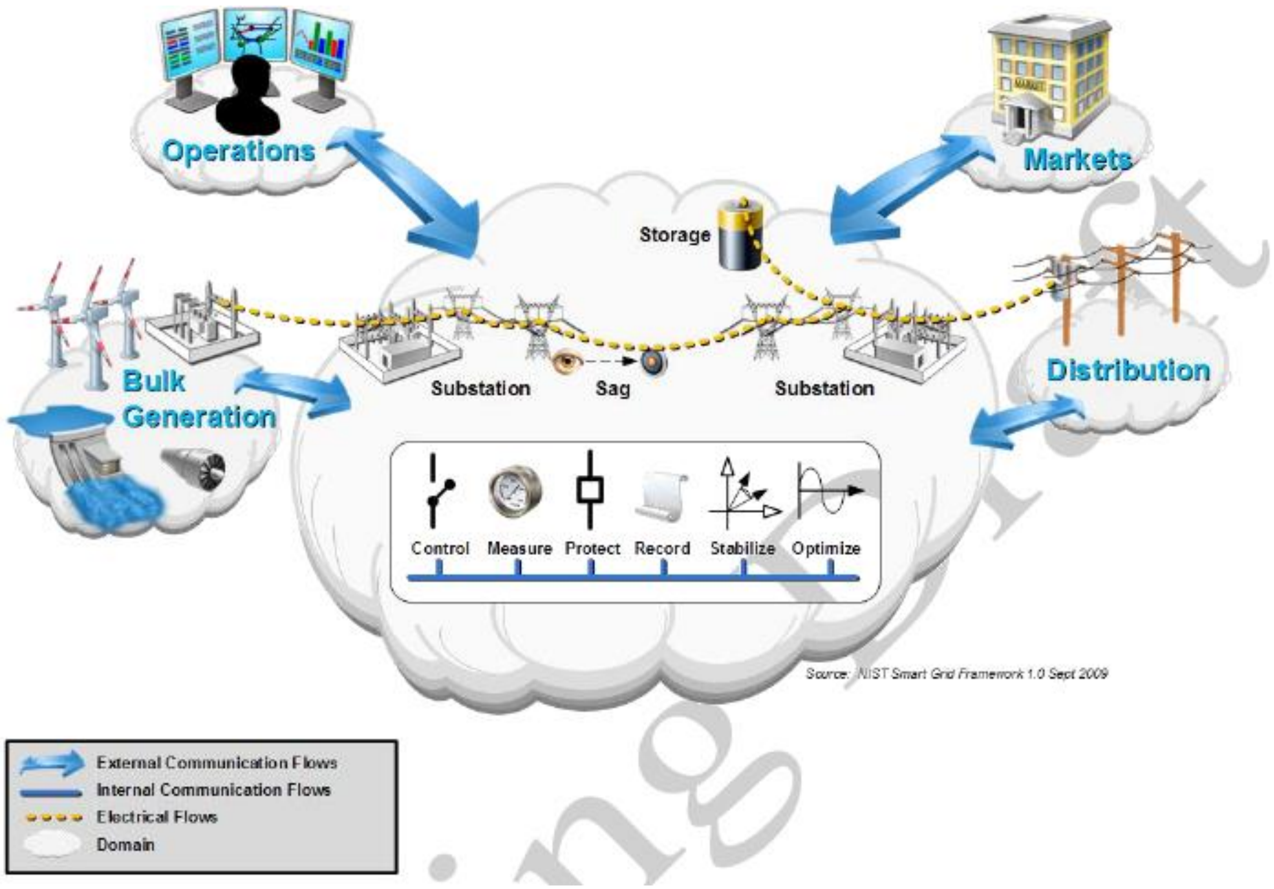
Europe – Smart Grid Investments and Technology Breakdown – Smart Meters Dominate



Denmark's Success Story with Smart Grids For Renewable Integration

- About 30% of energy from wind generation
- Smart grid technologies
- High Voltage Direct Current (HVDC)
- Demand response (DR) control for heating loads and smart charging of electric vehicles
- Microgrids and cogeneration plants

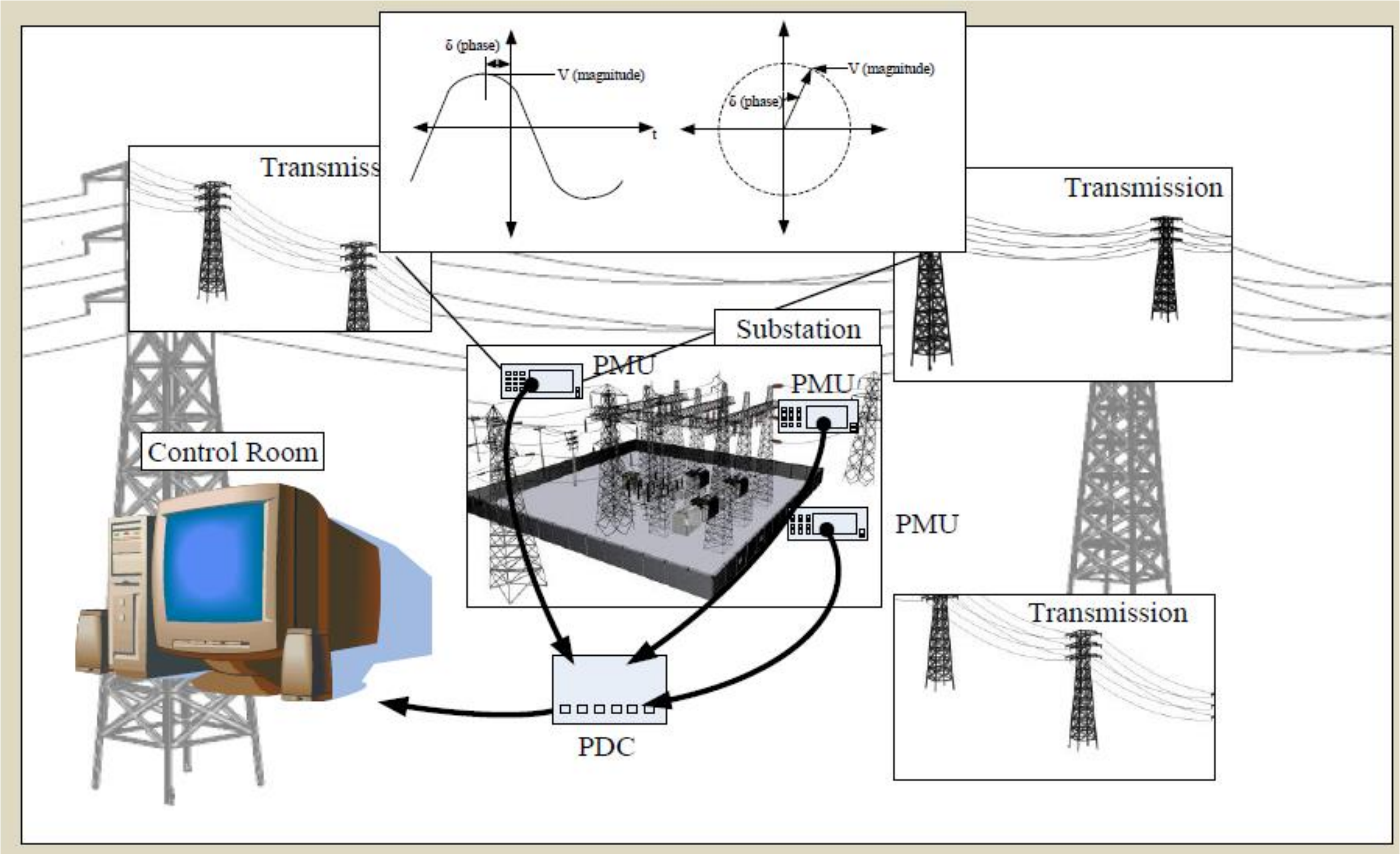
Overview of Transmission Related Technology Domain



Transmission – Sensors and Measurement Devices are Critical Components

Temperature, Current and Leakage Current Sensors used in the Transmission System

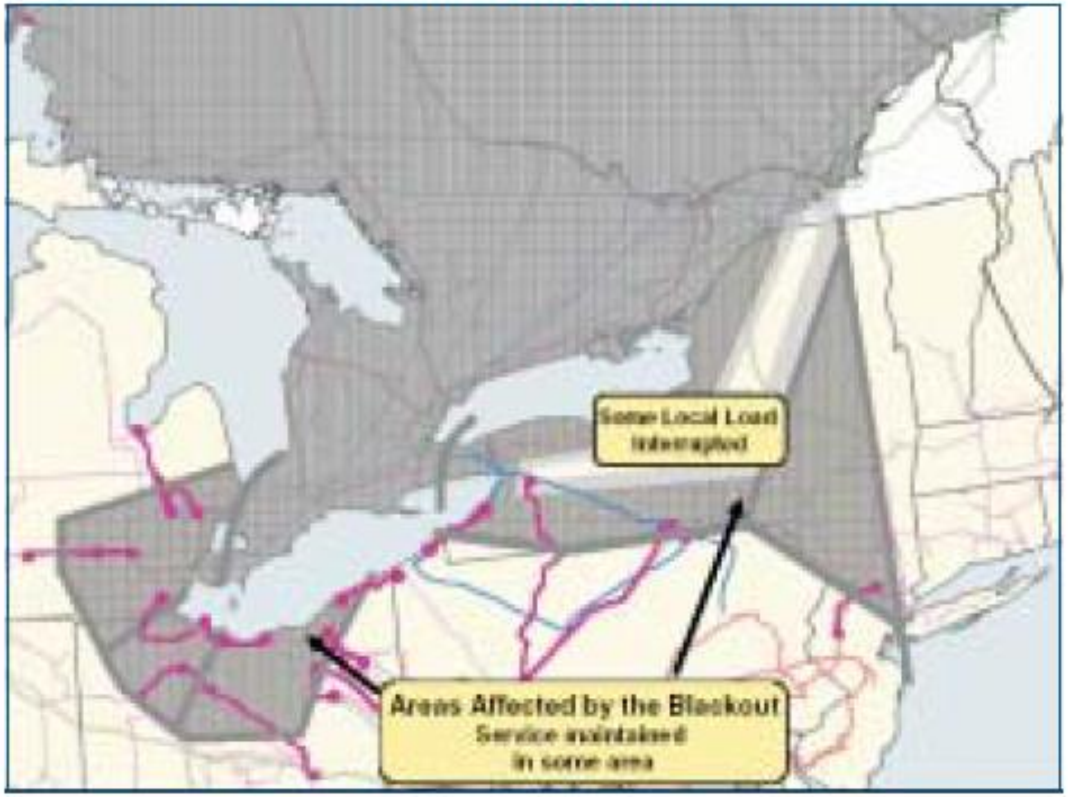
Transmission - Phasor Measurement Units (PMU) or Synchrophasors Could Help Avoid Grid Disturbances and Blackouts



Operational Reliability Benefits of Synchrophasors – 2003 Blackout Example

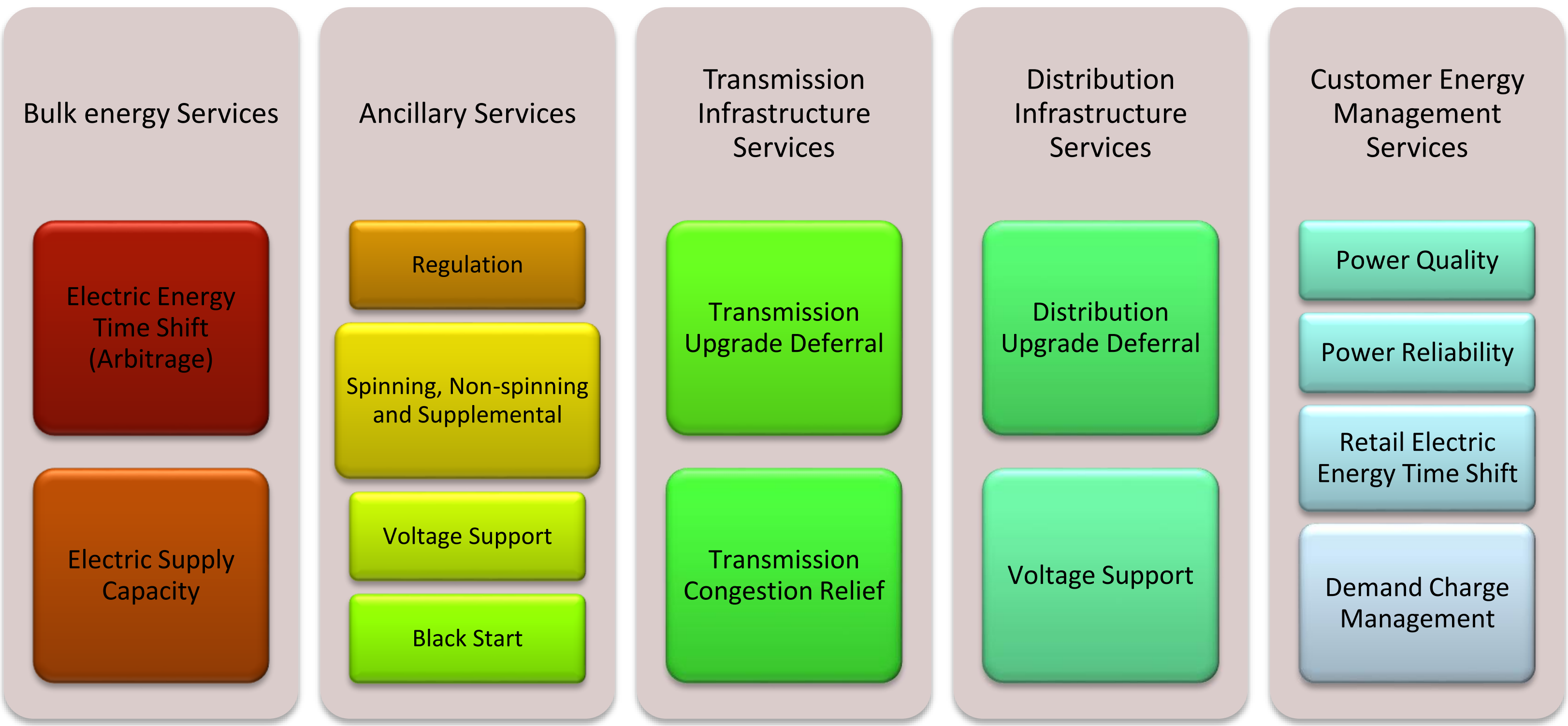
Canada 2003

Figure 6.29. Area Affected by the Blackout

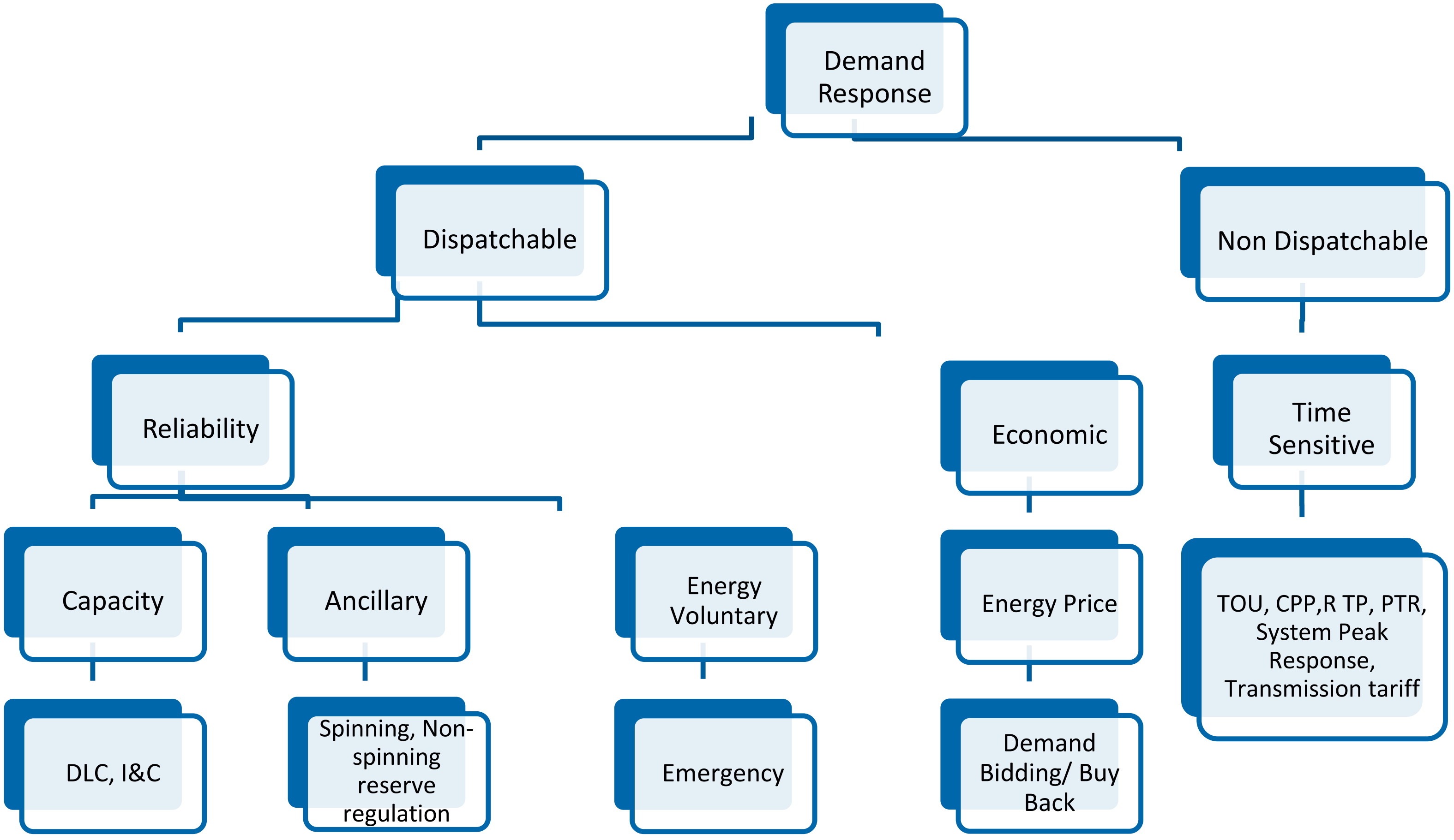


Customer End – Dispatch and Optimization of Energy Storage Devices

Effective dispatch and optimization of storage technology could help maximize utilization of renewable energy production and assist in meeting local demand when renewable energy production is in deficit, or alternatively, absorbing a surplus of renewable energy production for later utilization.



Customer End - Demand Response Could Provide Options for Managing Flexibility of Power Supply



Customer End - Advanced Metering Infrastructure (AMI) Coupled with Demand Response (DR) Has Significant Potential for Reducing Theft, Increasing Efficiencies

AMI (Full Two way)

- Integrated service switch
- Time based rates
- Remote meter programming
- Power quality
- HAN Interface

AMR Plus

- Daily or On Demand Reads
- Hourly Interval Data
- Outage Notification
- Other Commodity reads

AMR (One way)

- Automated Monthly Read
- One Way Outage Detection- Last Gasp
- Tamper Detection
- Load Profiling

Customer End – AMI and DR Costs Reasonable Compared to Generation Options

Technology	Capital and O&M costs	Typical payback	Risks/ Disadvantages
Advanced metering infrastructure (AMI)	$50-$250/meter; up to $500/meter including com-munications and IT; O&M $1/meter/ month	3- to 10-year pay-back; depends on existing and new systems	PR/education issues can be touchy
Demand response (DR)	$240/kW capacity (vs. $400/kW for gas peaking plant); O&M costs low	<3 years	PR/education is-sues can be touchy; trade-off with user comfort

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Tanzania Example – AMR System Reducing Energy Theft and Losses

Impact of AMR Meters on Losses

	Before AMR Year 2006	After AMR Year 2010
Total Energy Theft Cases	**62**	**12**

Energy Theft Cases DROPPED from 62 cases involving LPUs in 2006 to 12 cases only in 2010

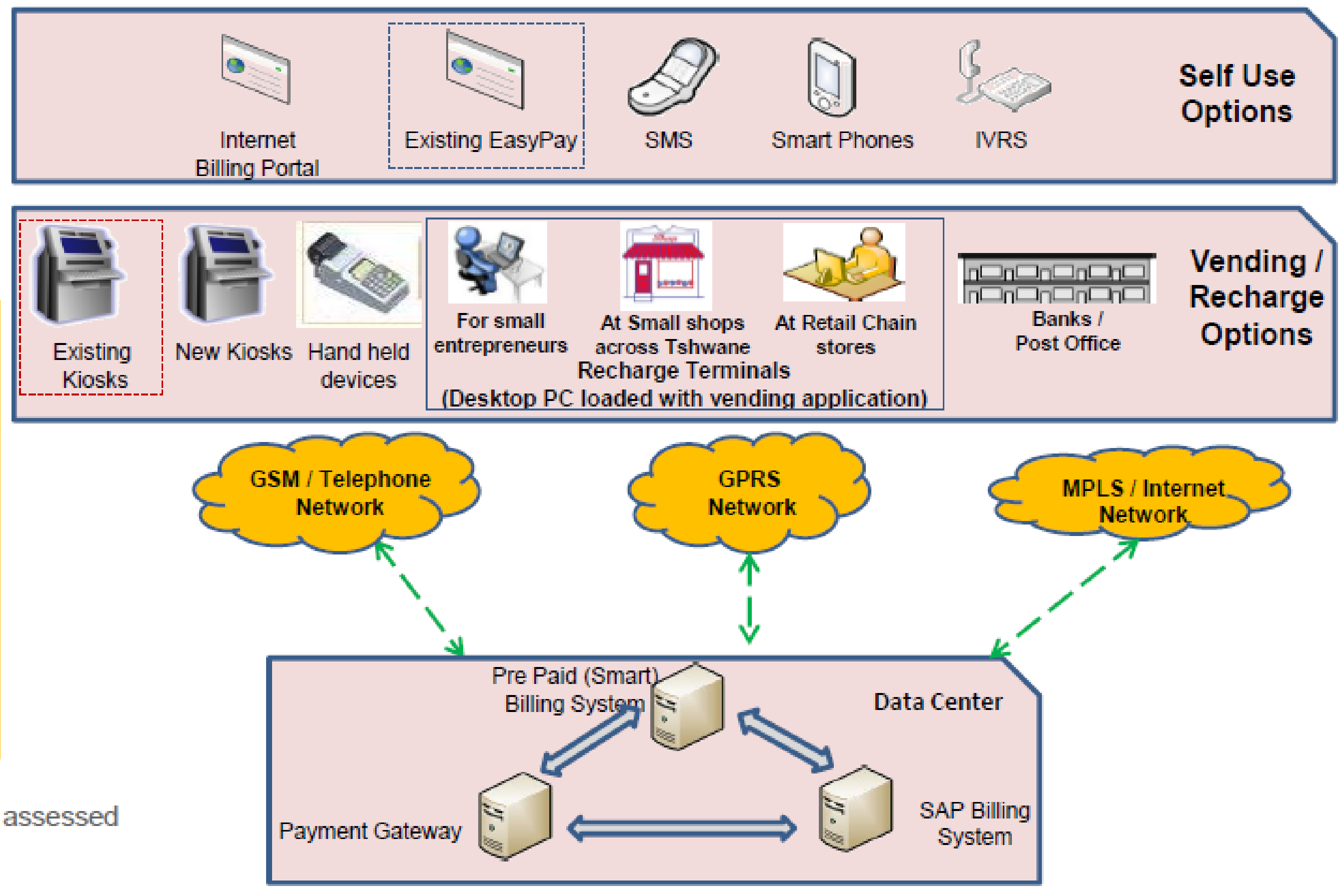
Overall Losses dropped from 26% in 2006 to 20% by the end of December 2010.

Major contributing Factor is AMR Metering System.

Why?: Several customers who tried to tamper were caught following the alarms sent by the system. Information spread to others so they are scared to attempt!

City of Tshwane (CoT) - Zambia Smart Prepaid Electricity Meter Example

Salient Features
Multiple vending options
Self service available – Recharge, View history, Usage, etc.
Real-time Re-charge
Remote recharge
Low balance SMS / Automatic Phone call alerts
Recharge SMS confirmation
Cheque payment also available



Integration to be assessed

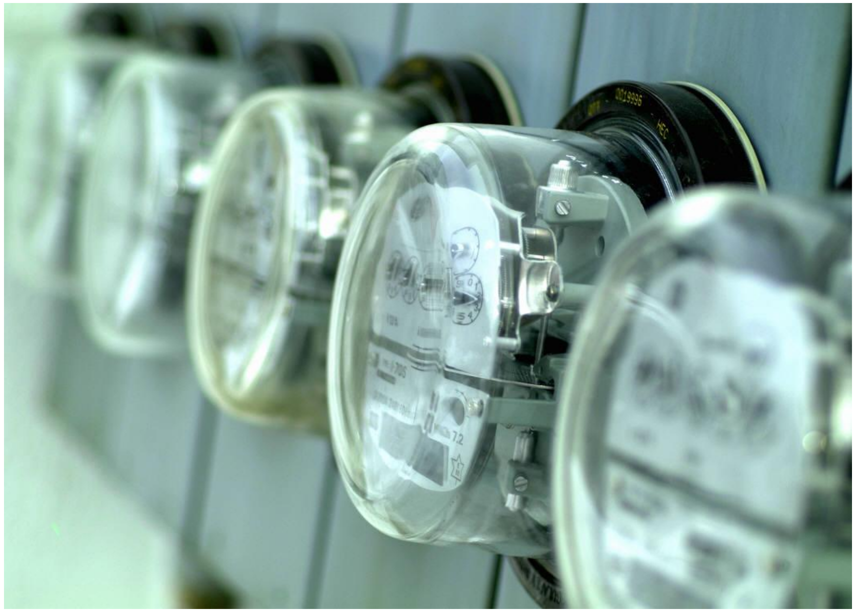
Customer End - Smart Meters Helping Xcel Energy

http://www.youtube.com/watch?v=V1cyxBCkIgo

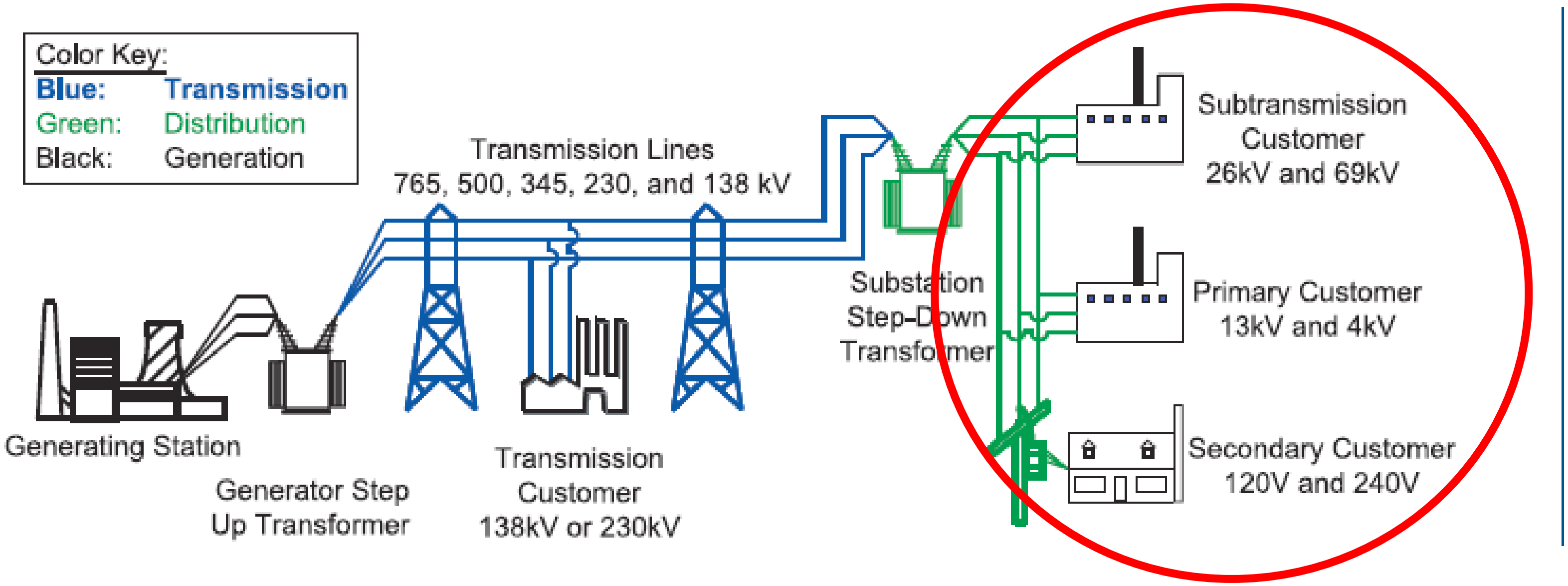
Question set #2

1. Cost is the only impediment for implementation of Smart Meters and AMI
   - True?
   - False?

2. What are some of the key challenges to implementing smart grid programs?



Distribution – Automation, Integrated Volt Var Control (IVVC) and Conservation Voltage Reduction (CVR) Can All Help in Reducing Losses

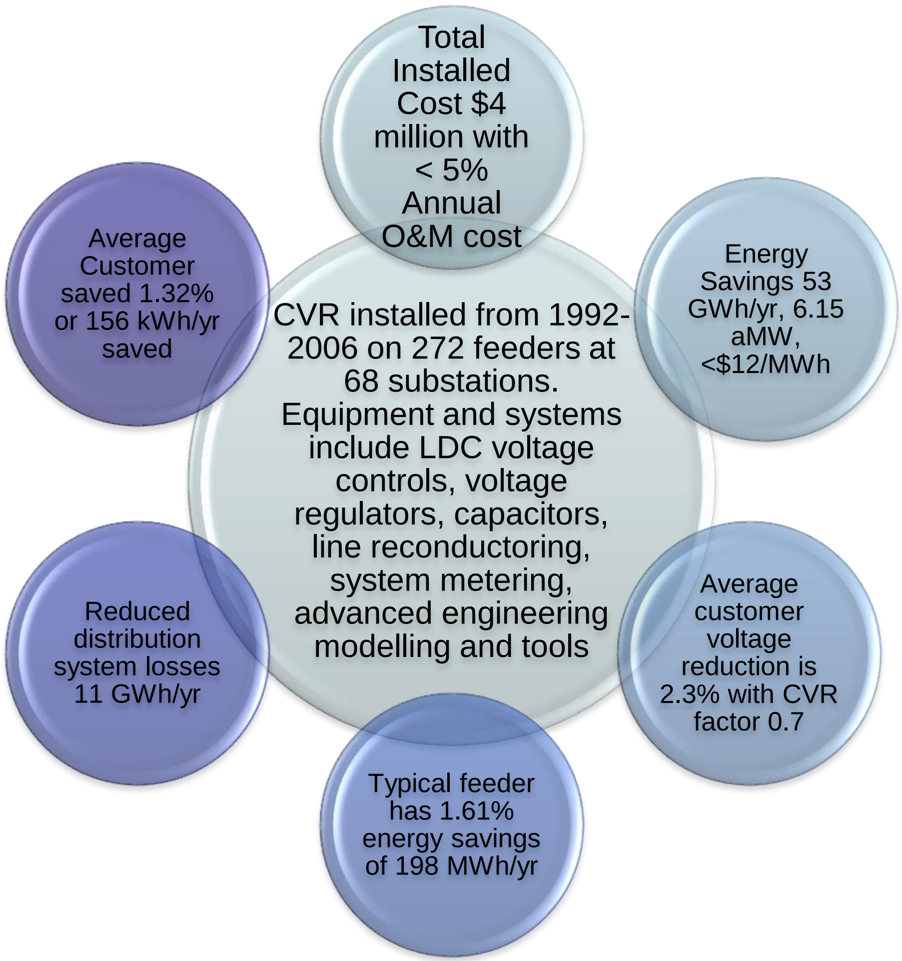


CVR: Coordinating voltage regulator and LTC controls to reduce feeder voltage levels provide load reduction on substations and feeders.

Integrated Volt/VAR Control (IVVC): Coordinated Control of substation load tap changers, feeder voltage regulators and capacitor banks ensure VAR and voltage profiles to optimize these benefits.

Distribution – Snohomish, Washington/US Example

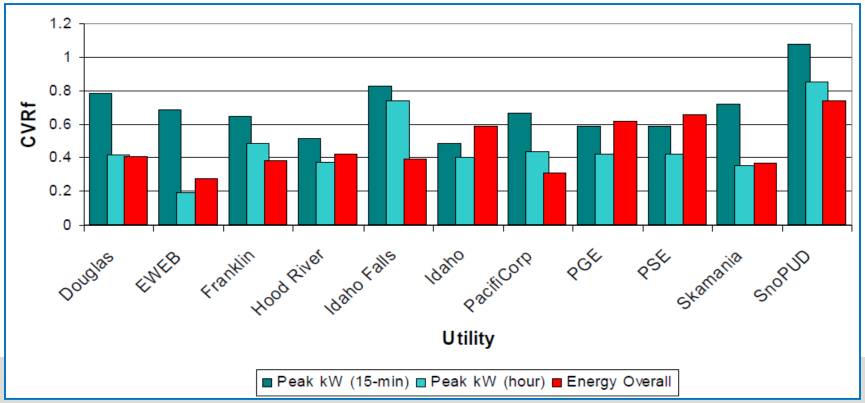
CVR Experience



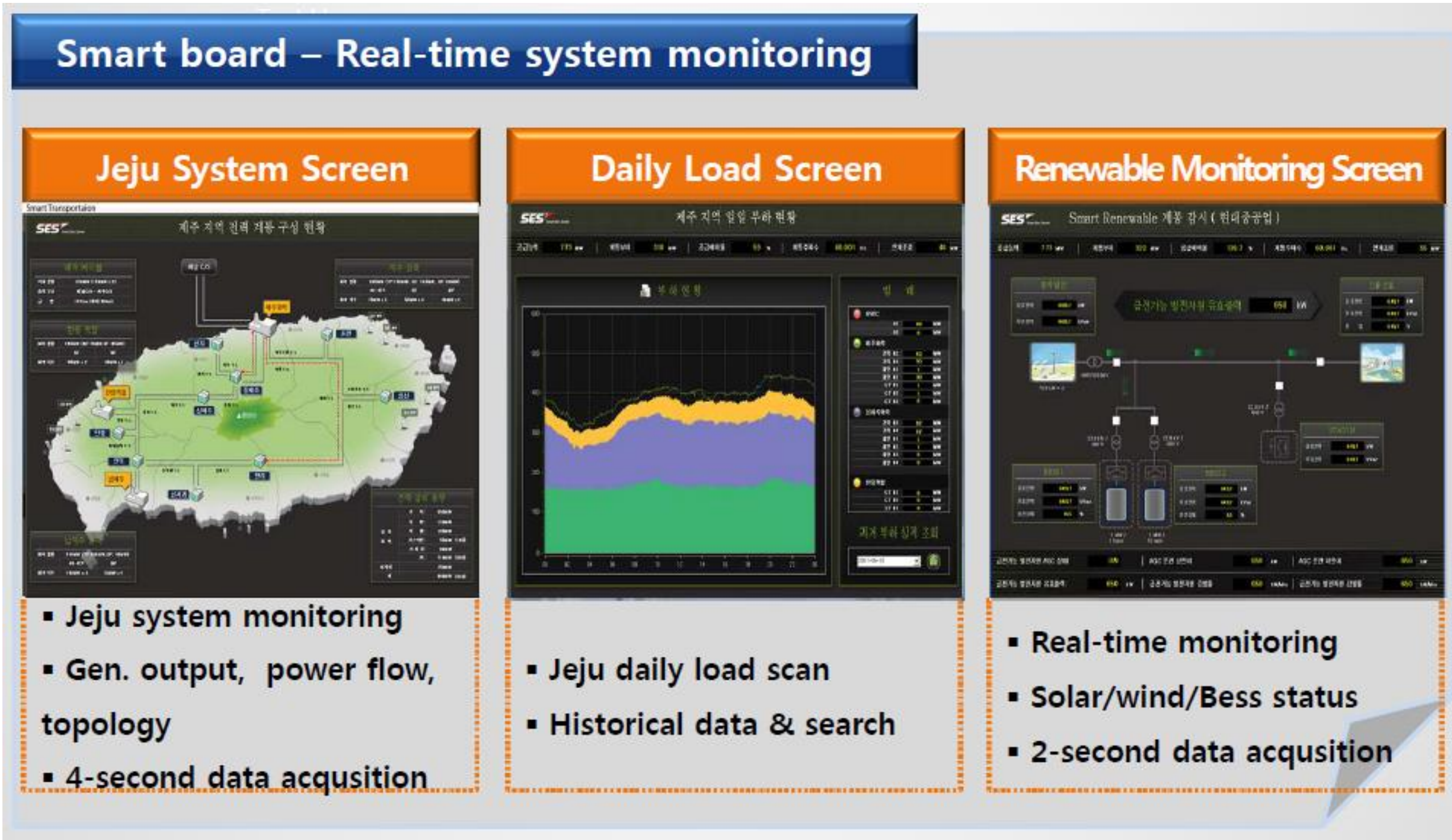
Distribution – Northwest Region/US Example

Northwest Energy Efficiency Alliance Distribution Efficiency Initiative

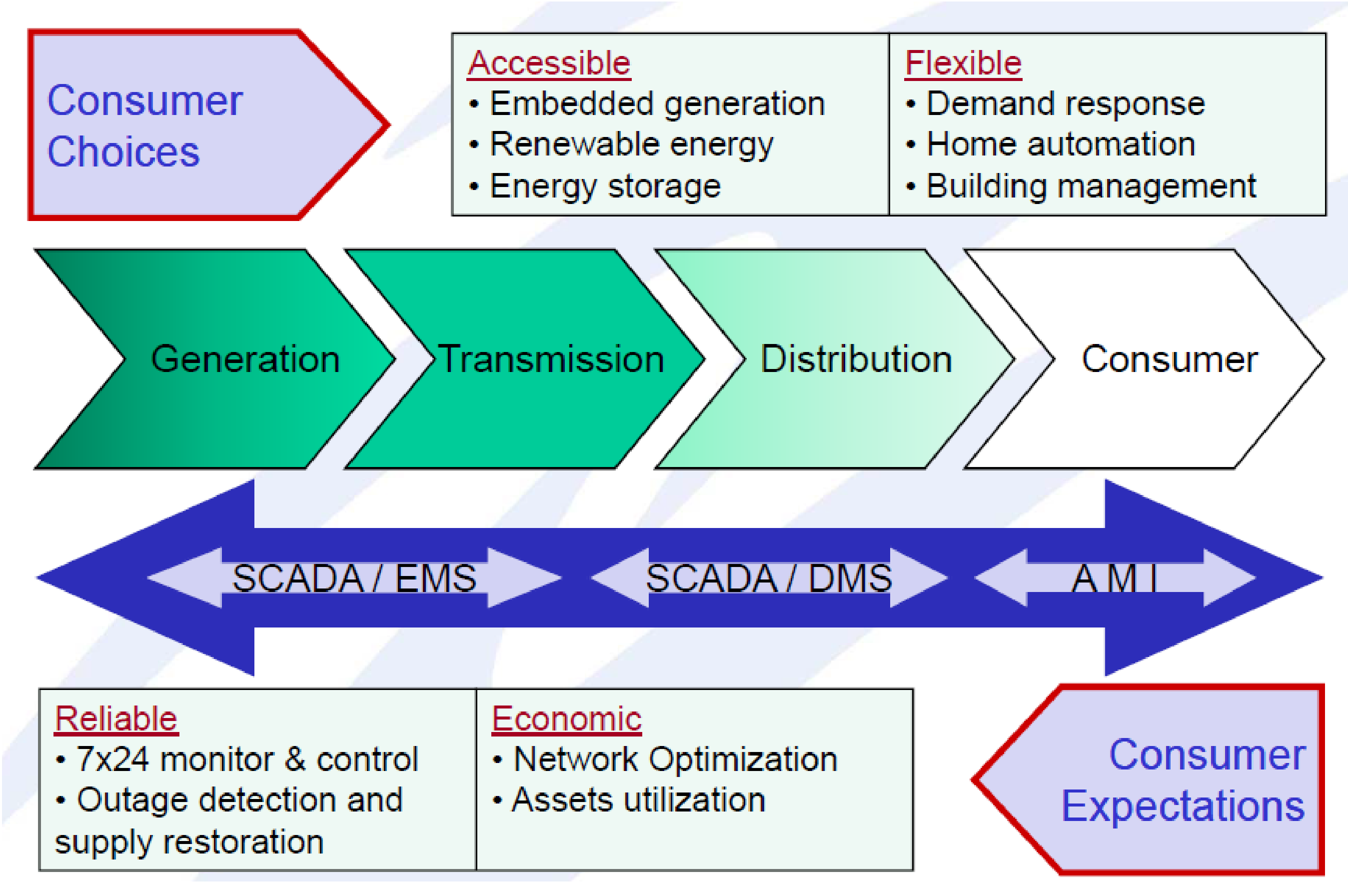
Utility	kWh Saved	kWh Saved per House	Annualized kWh Saved	Annualized kWh Saved per House	Percentage Savings
Douglas PUD	14,262	303	22,696	483	1.79%
Eugene W & EB	3,134	92	6,302	185	1.14%
Franklin PUD	5,471	219	8,385	335	1.87%
Hood River	9,231	401	14,402	626	2.31%
Idaho Falls Power	2,608	137	6,631	349	2.04%
Idaho Power	12,151	190	18,654	291	2.36%
PacifiCorp	4,999	151	8,755	265	1.84%
Portland General Elec.	8,996	219	14,270	348	2.77%
Puget Sound Energy	9,827	234	13,732	327	2.87%
Skamania PUD	3,324	158	4,856	231	1.39%
Snohomish PUD	12,651	275	17,981	391	2.86%
TOTAL	86,655	219	1,36,661	346	2.15%



Case Study – South Korea Jeju Smart Grid Test Bed



Case Study – Singapore's Intelligent Energy System



Discussion

What are the implications of smart grids for the electricity sector programs that you work with in developing countries?

- Participant examples