Keeping the Lights On - Today and Tomorrow

Jay Giri

IEEE Power & Energy Society (PES)
Governing Board Member

EEA, Wellington, New Zealand June 26th 2015





- 2

Grid Management LANDSCAPE

COMMONPLATFORM



Grid Challenges

- Demand for energy is growing
- Greater risk of blackouts
- Increasing energy costs & price volatility
- Increasing renewable generation



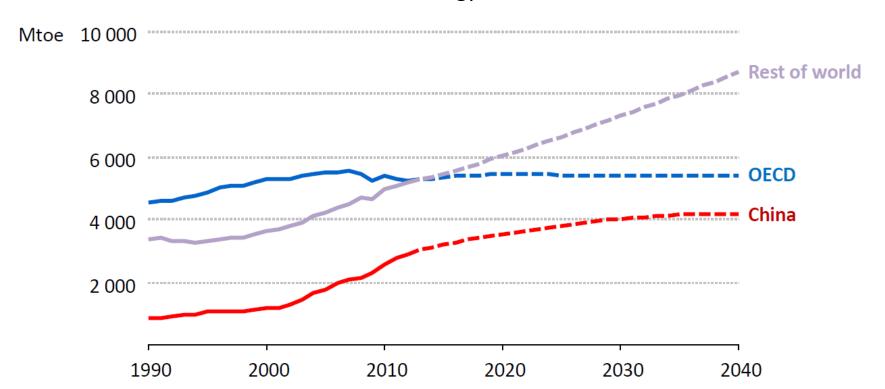




Global Energy Demand

Projected to grow by 80% from 2012 to 2040

IEA World Energy Outlook 2014

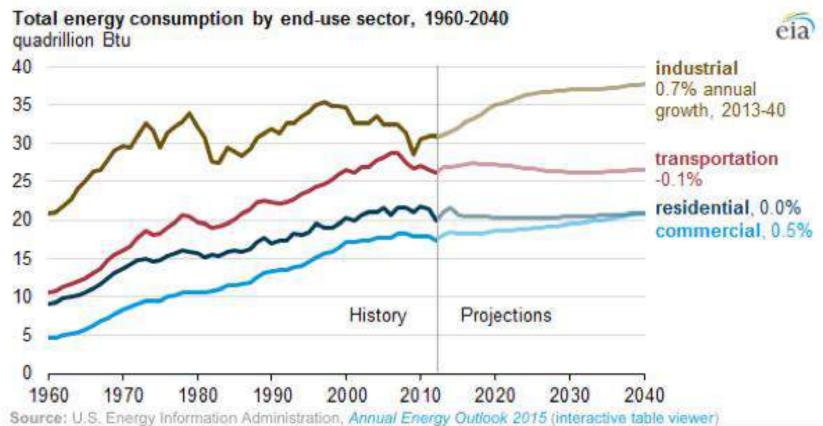






Energy Demand

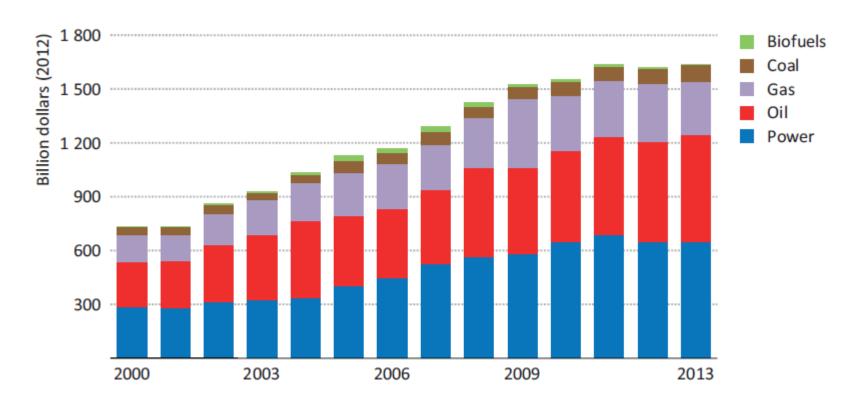
US Energy Demand Slows





Global Energy Supply Investments

Doubled since 2000







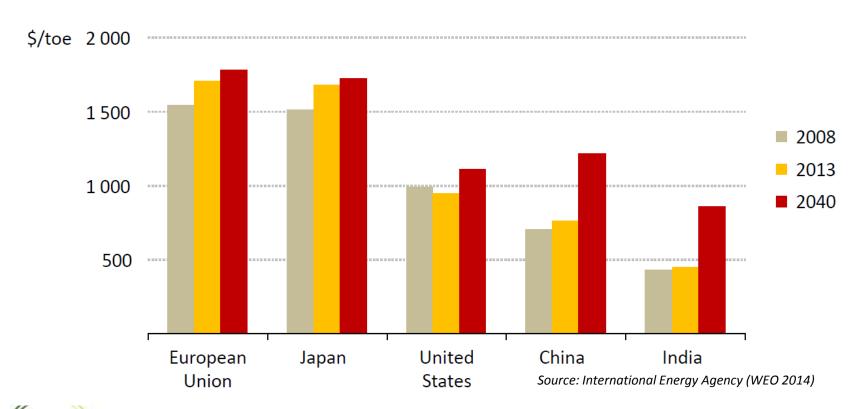
Blackouts are increasing worldwide

History of Blackouts	Region	Duration	People affected	Initiating Event
9-Nov-65	NE US, NYC	14 hours	25M	Faulty substation relay
13-Jul-77	NYC	25 hours	8M	Lightning
1-Mar-89	Quebec & NY State	9 hours	6M	Geomagnetic storm
11-Mar-99	Sao Paolo, Brazil	5 hours	97M	Lightning
14-Aug-03	NE US (8 states), Canada	upto a day	50M	Line overload problems
28-Sep-03	95% of Italy, Switzerland	18 hours	55M	Line fault
12-Jul-04	Greece	varied	7M	Heavy Load conditions
1-Aug-05	Indonesia	5 hours	100M	Grid imbalance
1-Nov-06	Germany, France, Italy, Spain	varied	10M	Line switching error
1-Feb-08	Chenzou, China	2 weeks	4M	Winter storms
10-Nov-09	Brazil & Paraguay	3 hours	67M	Storms
10-Jul-12	India North	24 hours	370M	Over-withdrawals, line overloads
31-Jul-12	India - 3 regions	several hours	620M	Over-withdrawals, line overloads



Global increase of energy costs Price Volatility Increasing

Weighted average customer cost

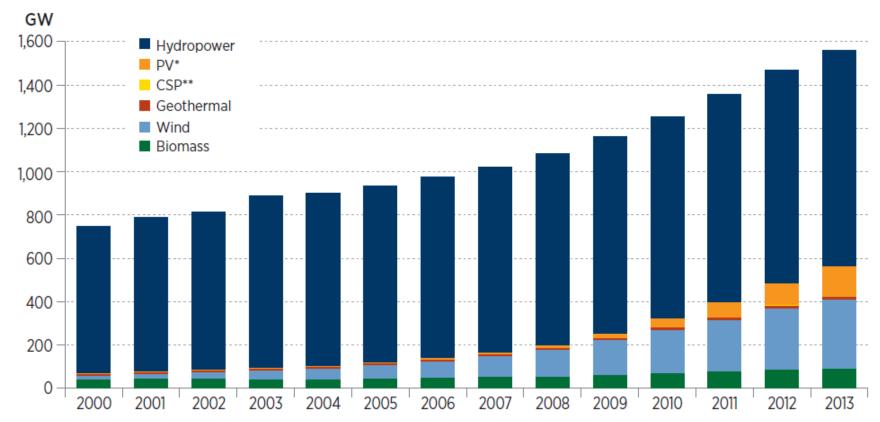






Renewable generation growth Global

source: DOE NREL

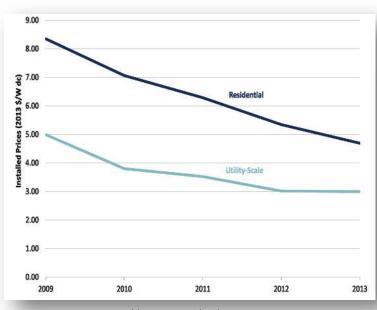




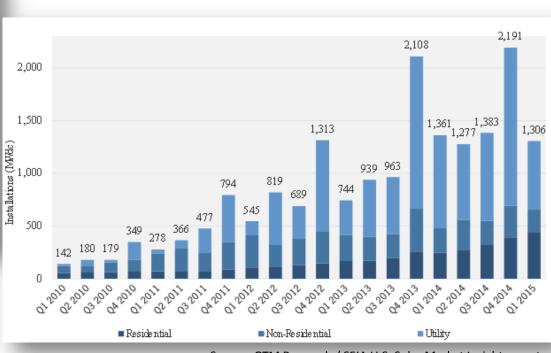


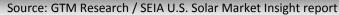
Solar generation growth US

As Solar Costs decrease, Installations increase



Source: Lawrence Berkley National Laboratory

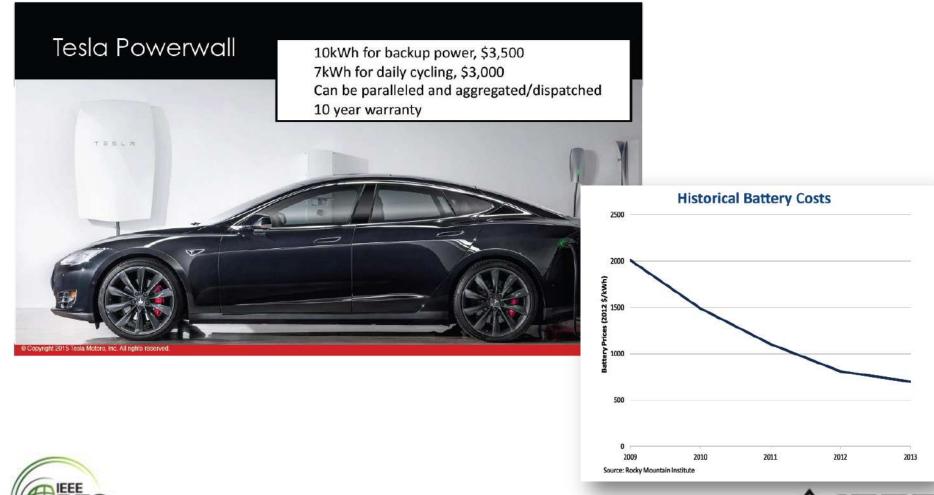








Also, Battery costs are decreasing



Power & Energy Society®

Our imperatives

Reliable power

Affordable power

Renewable power

for a stable grid

for an efficient grid

for a clean grid



Today's grid management challenges

Plan, Model, Measure, Monitor, Mitigate



Meters, PMU, ... **Big Data**



Critical mission

Communication

Environment

Public Safety Storm Restoration GHG





Retiring

Workforce





Sustainability

Renewable
Deployment
& CO2 free energy
New Generation Mix



New Electrical Equipment (FACTS, HVDC, ...)



Business Model
Change
New regulation

DynamicsOperating near to True real Time Limits

System

System Scalability

From energy cluster to large Interconnected Grids













The Future Aint What it Used to Be

Long-Term Research Needs vs. Near-Term Trends

Avoid gas-fired plants; fuel prices high, volatile

Nuclear power poised for a renaissance

Digital tech driving more powerful processors & hard drives

Boring. Just run it safely and reliably CCS grabs global focus and investment

Not in long-range plans or capital budgets

Natural Gas



Gas is king

2015

Nuclear Power



Nuclear renaissance stalled in US

Digital **Technology**



Digital tech focusing on batteries and energy

Distribution



Distribution system platform is the key enabler

Carbon Capture



CCS research funding and interest on the decline

Wind and Solar



Lion's share of new plants; front and center in planning

Keep all options open in the long term; maintain a balanced portfolio

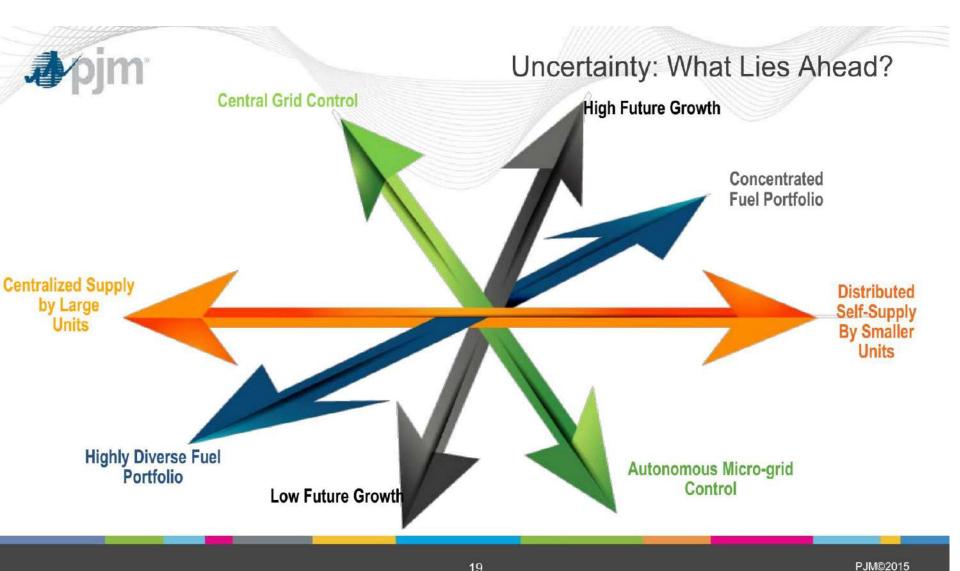
© 2015 Electric Power Researcf Institute – EPRI

PJM©2015



14

Courtesy - Terry Boston, CEO PJM





Power & Energy Society®

Future Projections Monitor Trends...Hard and Soft

Book Reference: Daniel Burrus,

"Flash Foresight: How To See The Invisible and Do

The Impossible"







Smart Grid TECHNOLOGY & SOLUTIONS

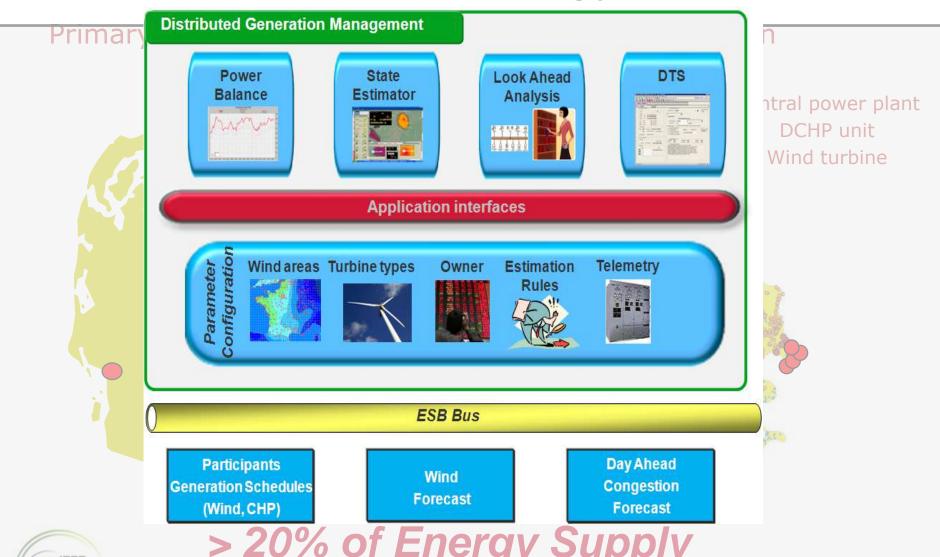


Smart Grid Technology & Solutions Enhancing the 'brain and the nervous system' of the grid





Denmark Renewable Energy 1980 vs 2008

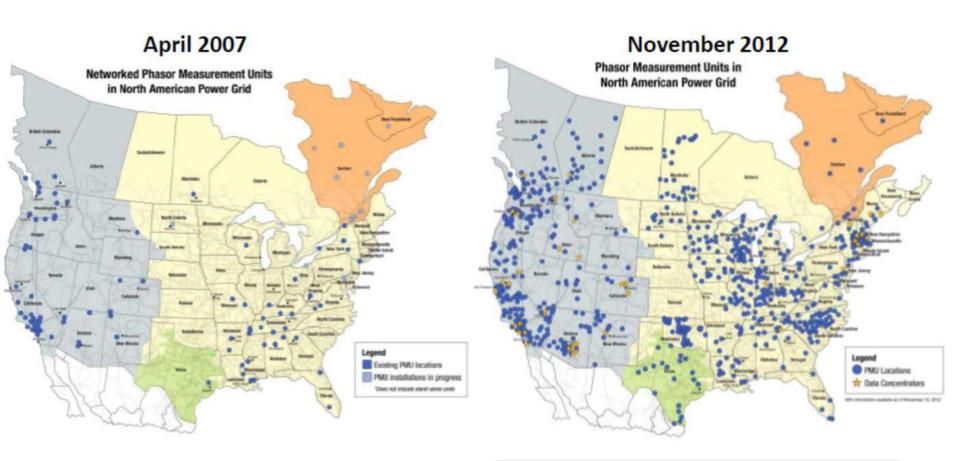


Power & Energy Society®

Synchrophasor Deployment in North America

Source: NASPI Website (www.naspi.org)

A Rapidly Changing Landscape



Approx. 200 PMUs in 2007

Over 1700 PMU deployed as of 2015 (over 10TB/Month of "raw" PMU data)





Indian Synchrophasor project



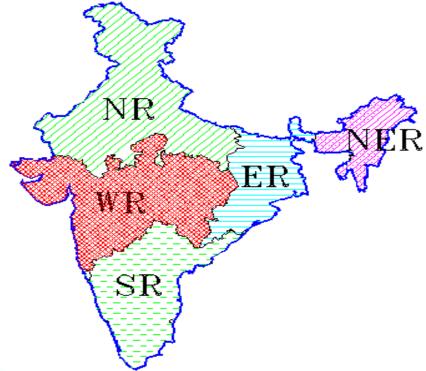
Full observability of the Indian Power system in real time

Serving over a Billion people

The world largest WAMS for a single interconnection

Local, Regional and National System

1800 PMUs in 351 substations, 34 control centers at 5ms resolution

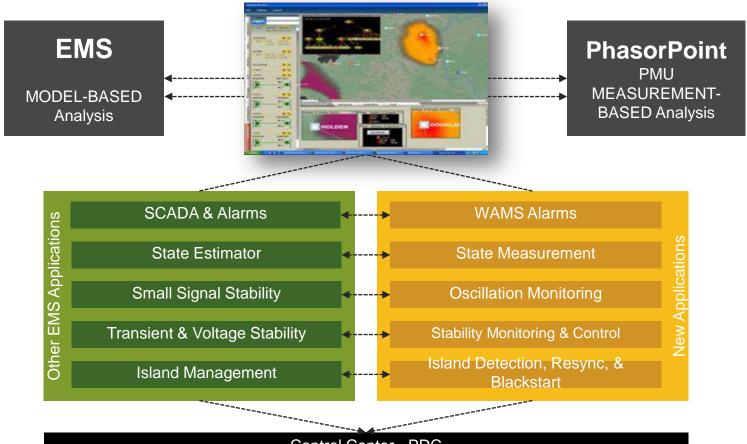






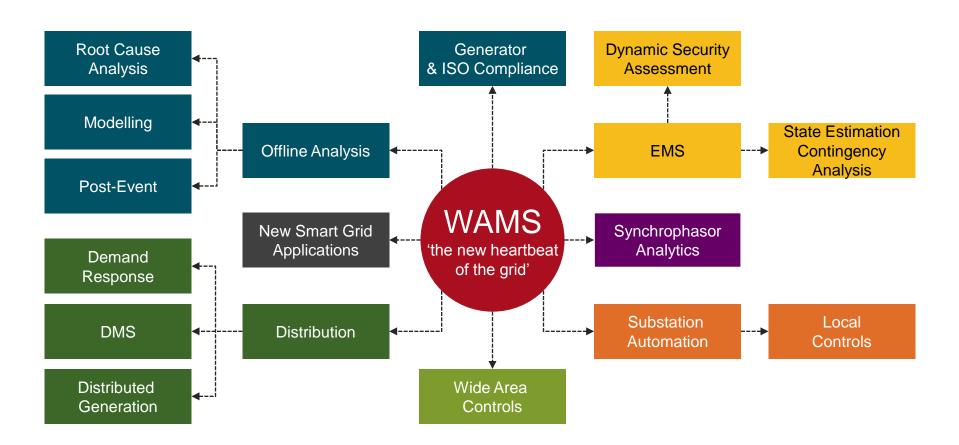
Control Room Operations Are Changing

Transitioning from traditional "steady-state" view to enhanced "dynamic" situational awareness.





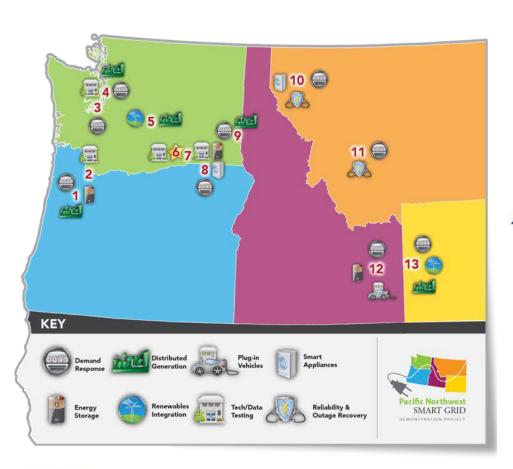
Wide Area Monitoring Systems (WAMS)







Pacific Northwest Smart Grid Demonstration Project











QualityLogic.



STIER.

NorthWestern

N NETEZZA





Future Grid Management

Examples of practical nascent solutions

- Evolve from a Reactive paradigm to a Proactive paradigm!
 - From 'Load Following' to 'Generation Following'
- Dispatch transmission MW using FACTS devices

$$P = \frac{V_1.V_2.\sin(\delta)}{X_{line}} + P \text{ (HVDC/FACTS)}$$

- Develop new Grid Automation control schemes
 - Integrate sub-second synchrophasors with FACTS





Keeping the Lights On..

Some Final Takeaways..

- Uncertainty is increasing..
 - Challenges & Opportunities!
- Monitor trends continually...
 - Past not always a good indicator of the future
- Develop creative solutions to innovate & leverage technology advances







Jay Giri

jay.giri@alstom.com



