



Future History of the Grid

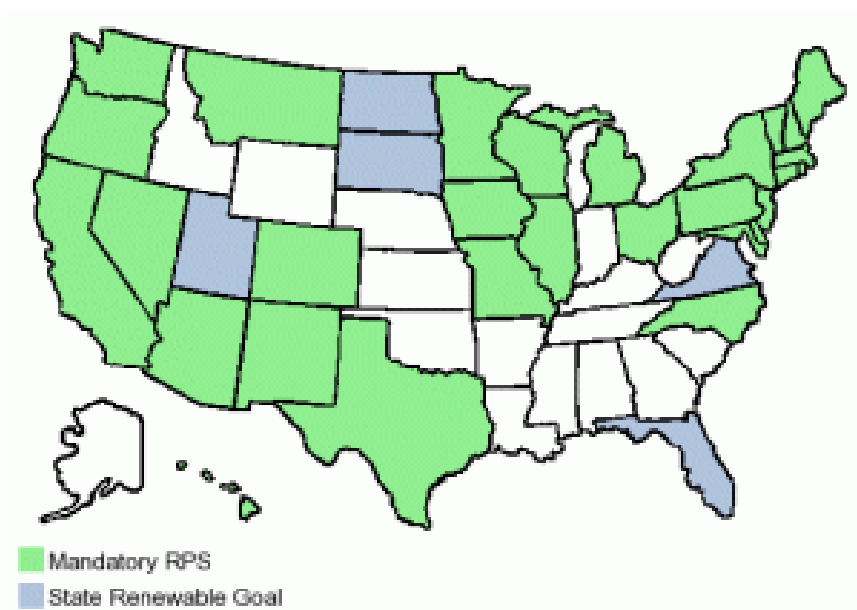
Paul De Martini

December 3, 2012

Grid-Interop 2012

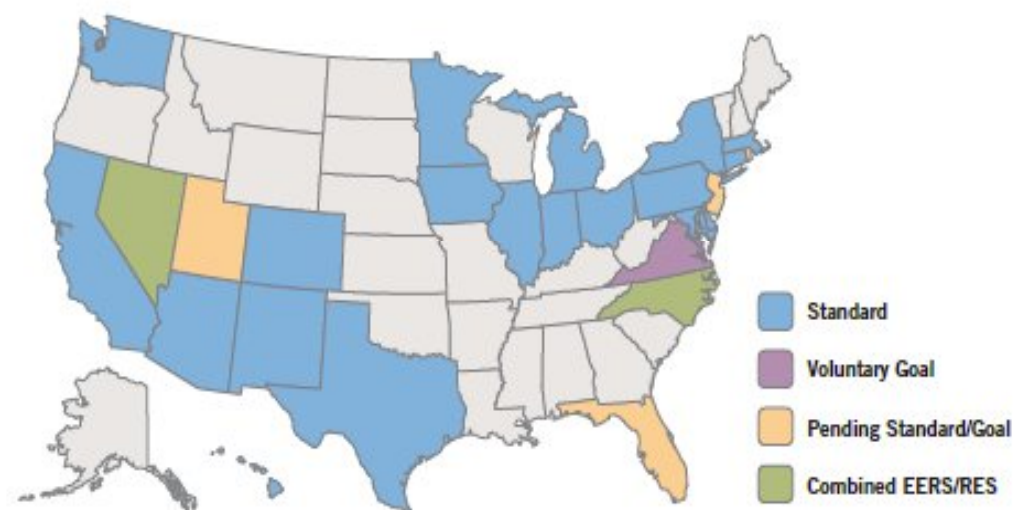
Policy is Spurring Renewable & DER

2011 US State Renewable Policy



Source: EIA

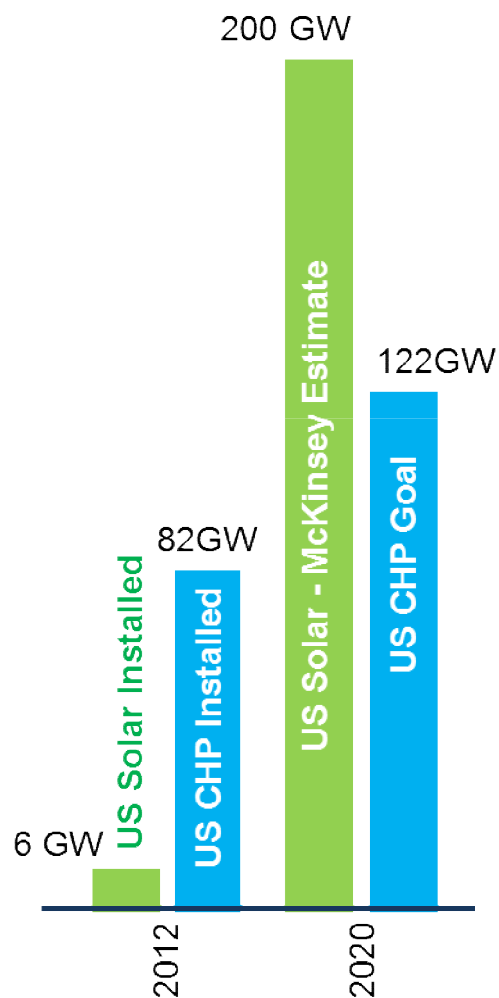
2010 US State EE Policy



Source: ACEEE

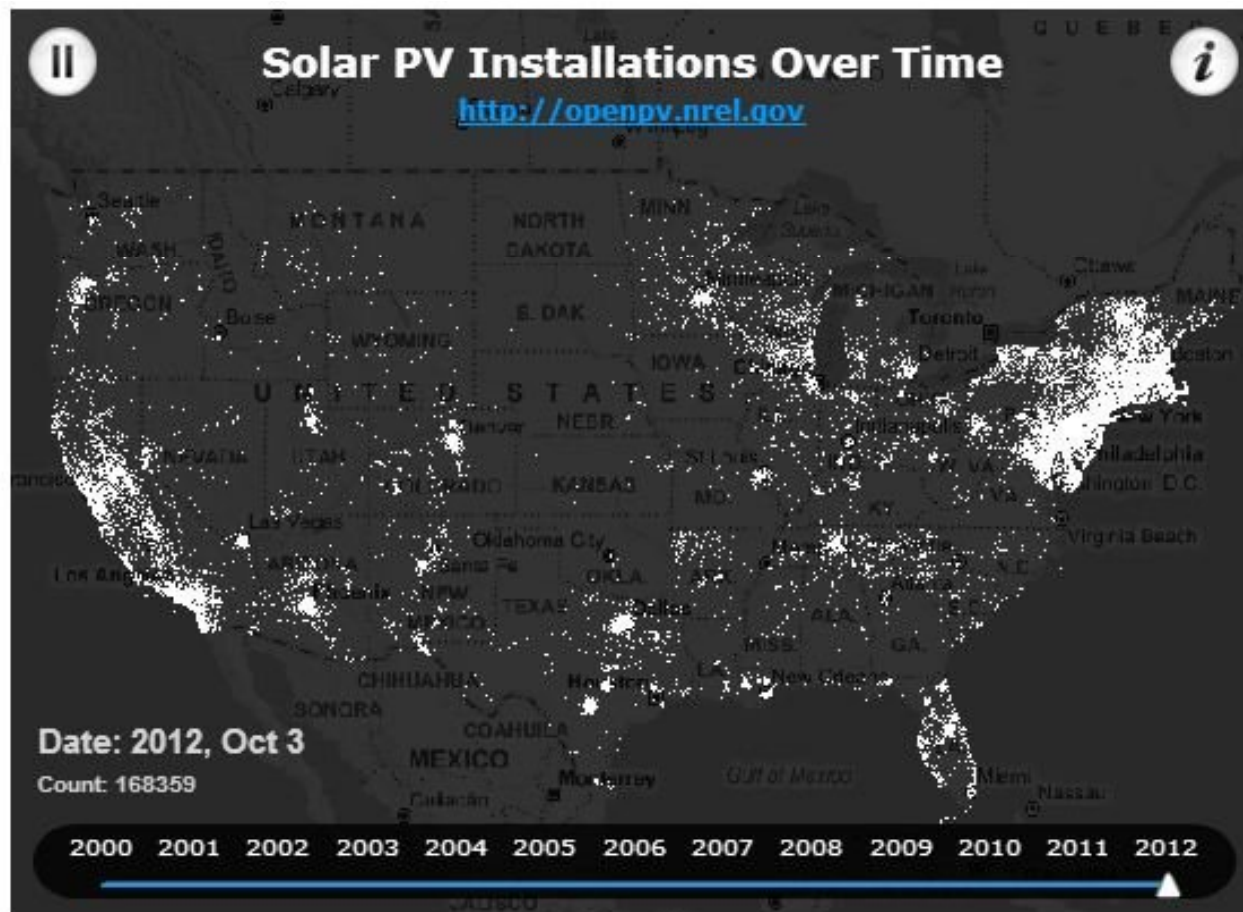
80% of US population under the equivalent of EU's 20/20/20 Plan

DER will change distribution design + operations



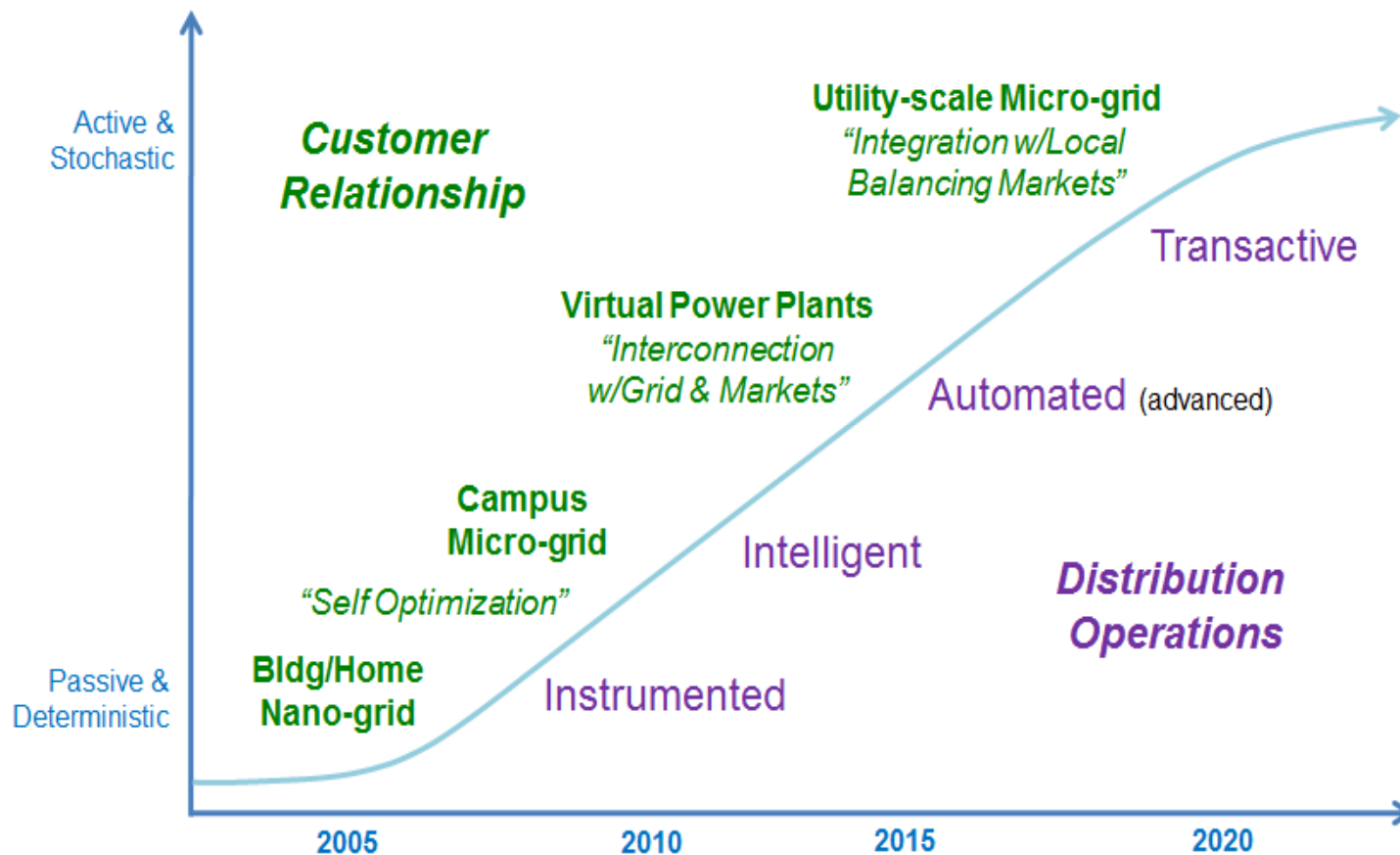
Sources: SEPA, DoE, USCHP

$$\frac{322 \text{ GWs Solar + CHP}}{100,000 \text{ Distribution circuits (20\% of US total)}} = 3.2 \text{ MWs/circuit}$$



Customer-Grid Evolution

Customer DER driven by resilience, economics & environmental objectives

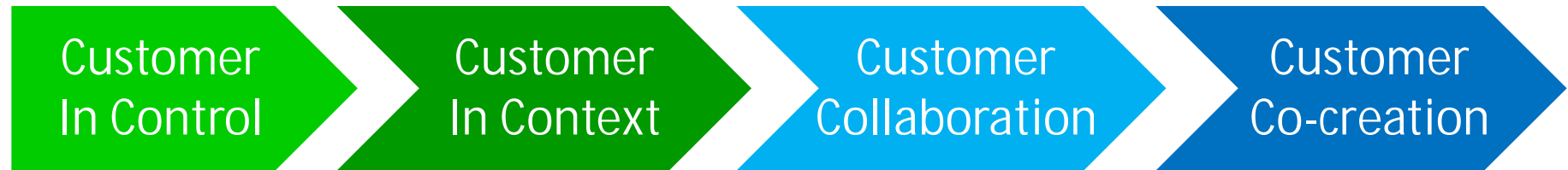


- More than 1.2 million solar PV panels were installed by the top 20 corporate solar users in US
- Walmart and Costco combined have more solar PV on their store rooftops than all of the PV capacity deployed in the state of Florida

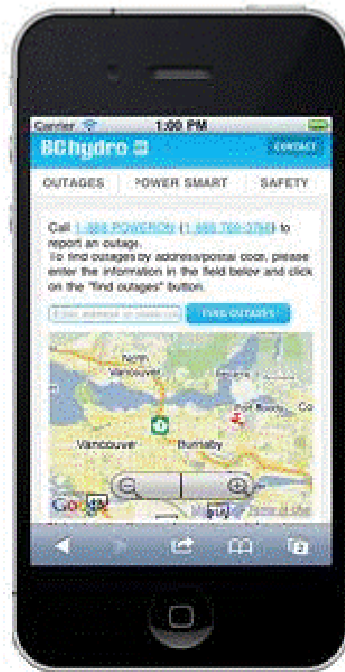
Source: SEPA

Consumer-Prosumer Evolution

Linking Smart Grid with Web 2.0 Enables Customer Partnerships



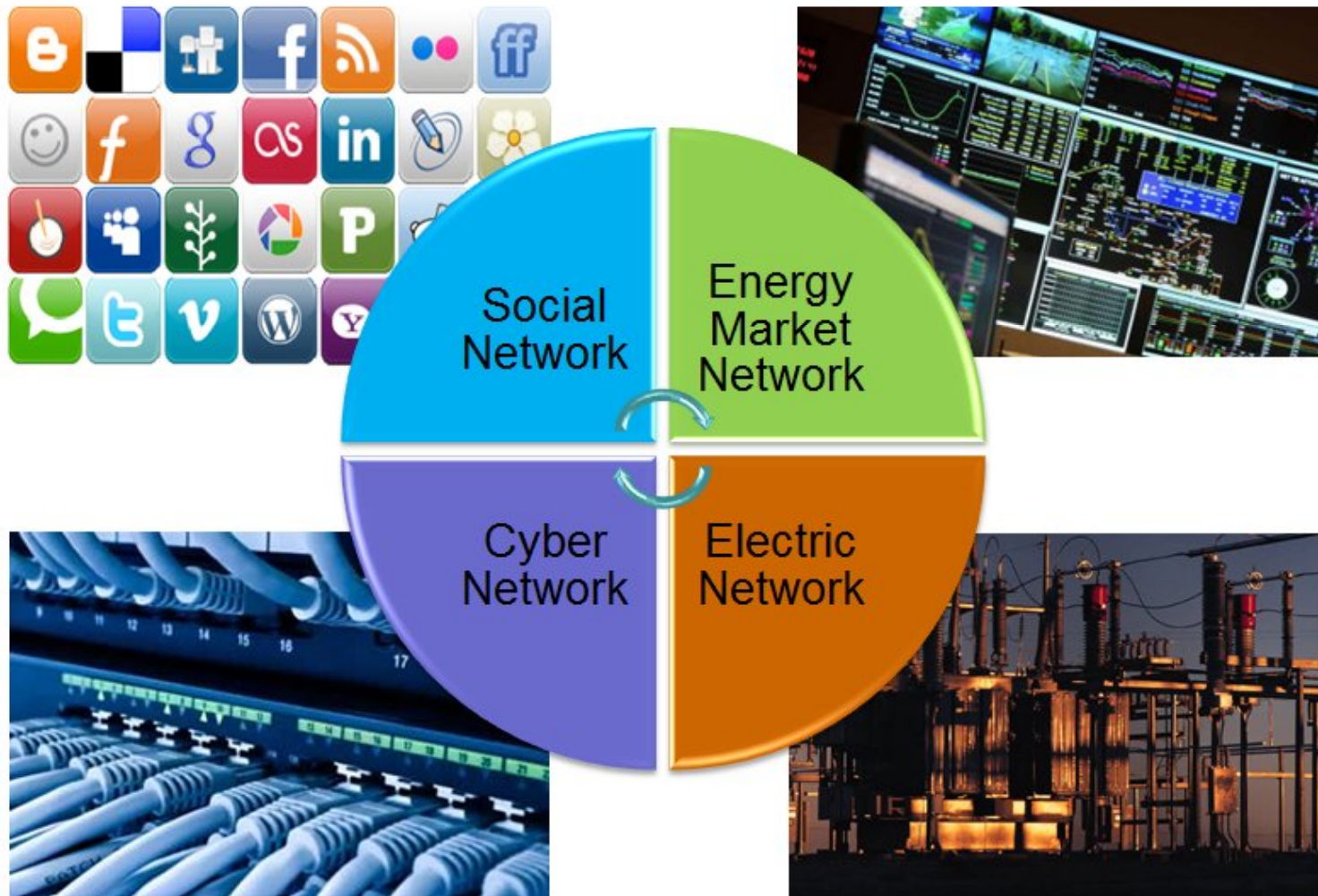
Green Button



Zero Net Energy

Evolving Energy Ecosystem

Convergence of Four Key Networks



Resilience & Reliability

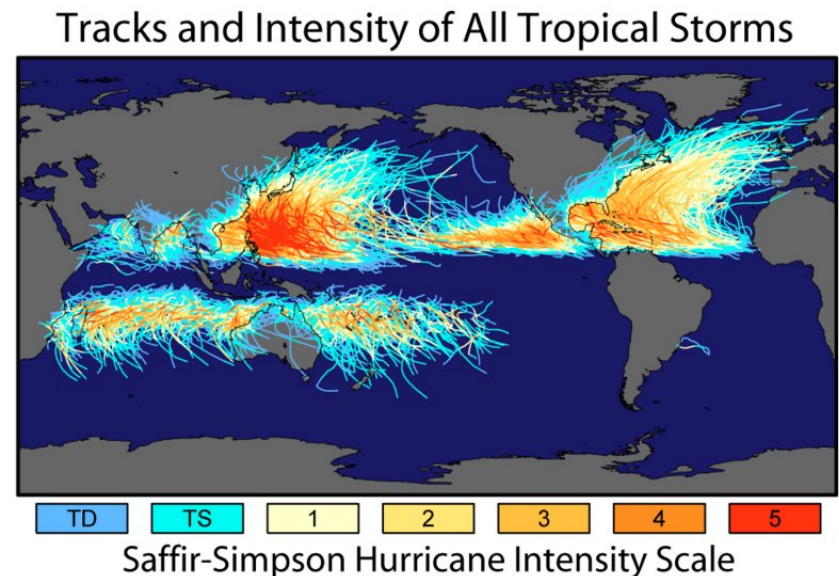
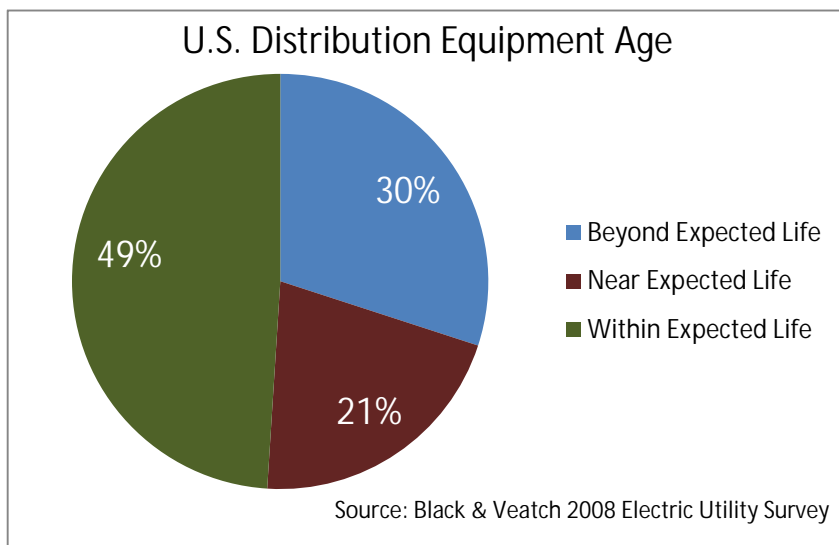
\$675 billion in distribution investment thru 2030 provides opportunity for grid modernization to improve reliability and resiliency – challenge is rate impact

Utilities reported average duration and average frequency of power interruptions has been increasing over the past 10 years at a rate of approximately 2% annually.

LBNL 2012

We conclude that it is likely that greenhouse warming will cause hurricanes in the coming century to be more intense globally and have higher rainfall rates than present-day hurricanes

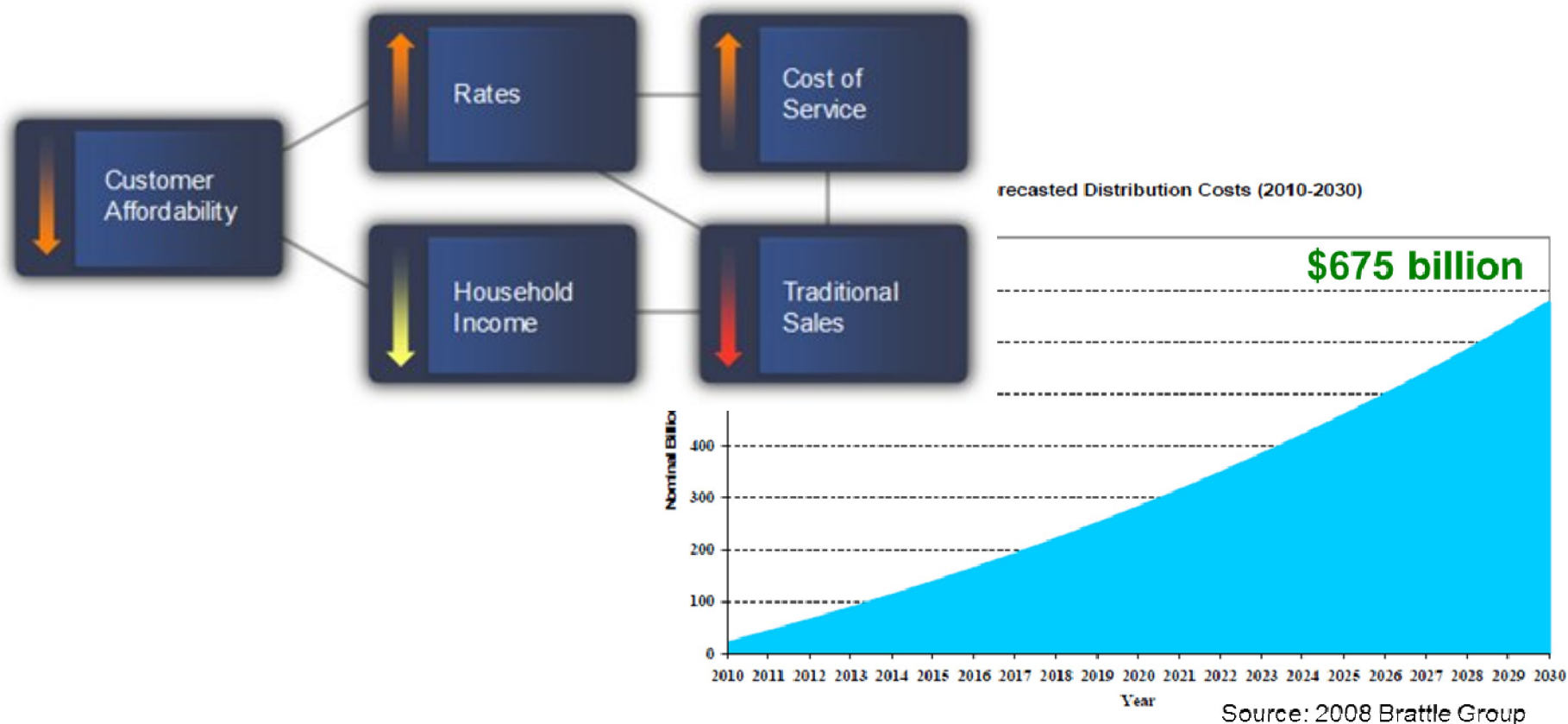
Nov 28, 2012



Balancing Objectives: Opportunities & Challenges

Electricity that is...

- costs less
- greener
- more reliable and of higher quality



A Future History of the Grid

“The future is already here, it’s just not evenly distributed.”

William Gibson

Sensing & Automation	Clean & Distributed Generation	Resiliency & Response	Super Grid
<ul style="list-style-type: none">▪ Smart Monitoring: sensor networks▪ Analytics & Automation: substation, distribution, decision support and operational systems	<ul style="list-style-type: none">▪ Solar / Wind: clean generation integration and transmission▪ Distributed Generation: integration of customer DG used for economic optimization & self-reliance	<ul style="list-style-type: none">▪ Self-Healing Grid: advanced protection, automation, and circuit designs▪ Situational Intelligence: integration of advanced cyber-physical systems with workforce automation & mobility	<ul style="list-style-type: none">▪ Virtual Power Plants/Micro-grids: integrated distributed generation and smart endpoints for market economics and increased reliability▪ N-Way Smart Grids: any-to-any smart grid enabling optimized power flows and additional resiliency