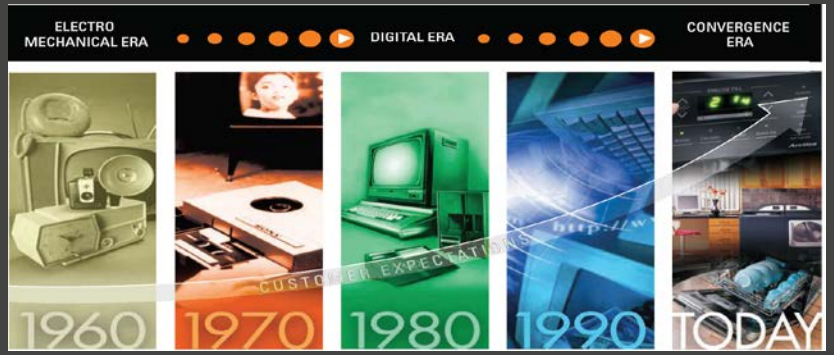
Smart Grid- The Big Picture

Recognizing Future Power Needs

- In 2010, the consumer electronics sector represented the largest single usage category for domestic electricity
- By 2020, entertainment, computers and gadgets will account for 45% of electricity used in the home and need the equivalent of 14 average-sized power stations to power them



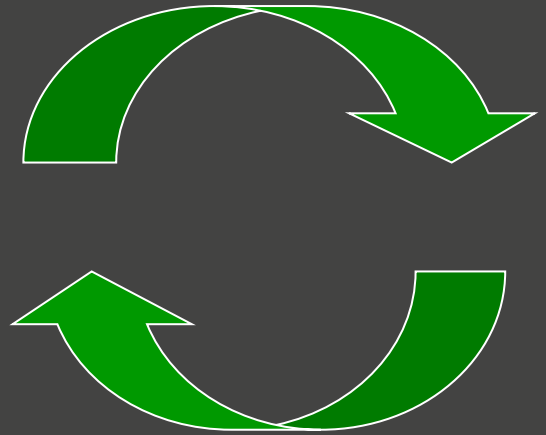
The average US household owns 26 consumer electronic products

Further increases in dependency on electronic devices drive demand for near-perfect power quality and uninterrupted power availability

Sources: "The Ampere Strikes Back: How Consumer Electronics Are Taking Over The World," Energy Saving Trust, June 2007; "The Rise of The Machines: A Review of Energy Using Products In The Home From The 1970s to Today" Energy Saving Trust, June 2006; "Electric Power – The Next Generation: The Intelligent Grid," CenterPoint Energy, April 2007

What's in the Future for the Smart Grid?

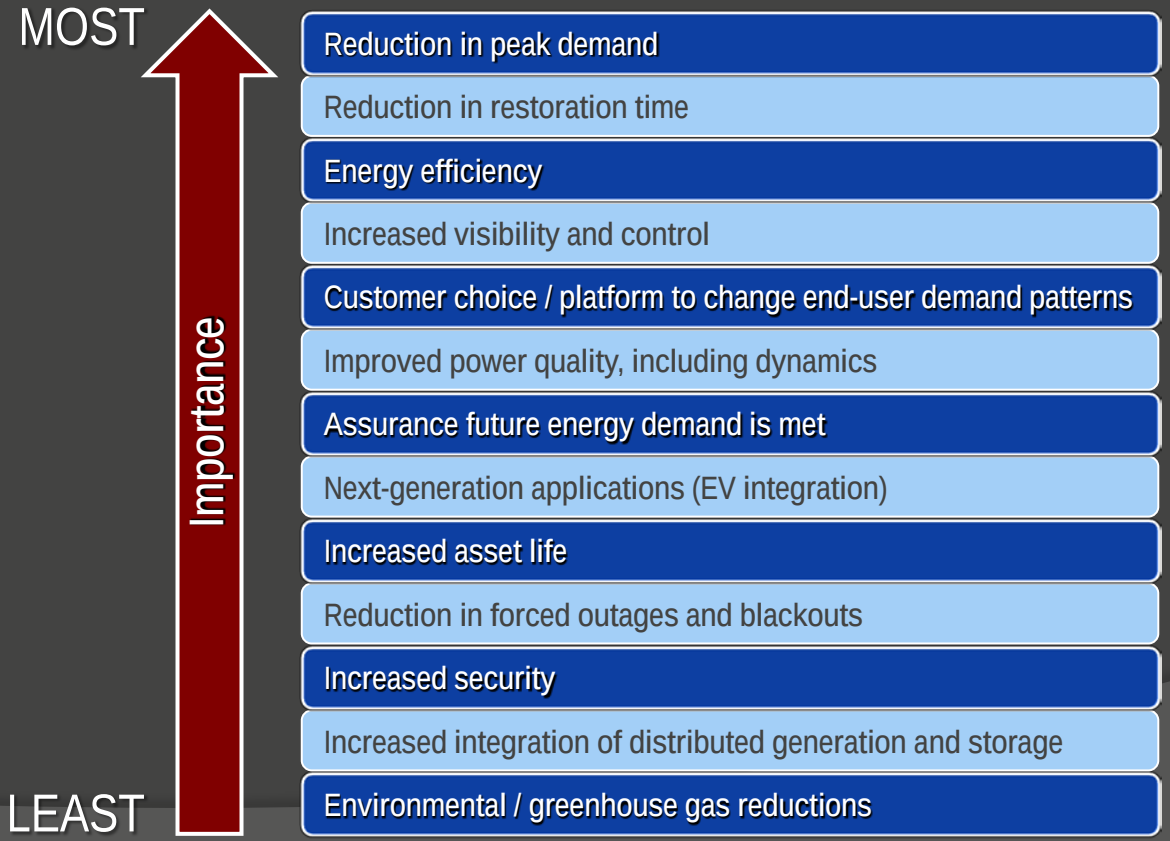
Emerging grid drivers
- Electric vehicles
- Consumer generation
- Consumer response
- Variable renewables
- Transmission constraints



Emerging grid impacts
- Multidirectional power flows
- Grid instability
- Increasing peaking factors
- Increasing reliability demands

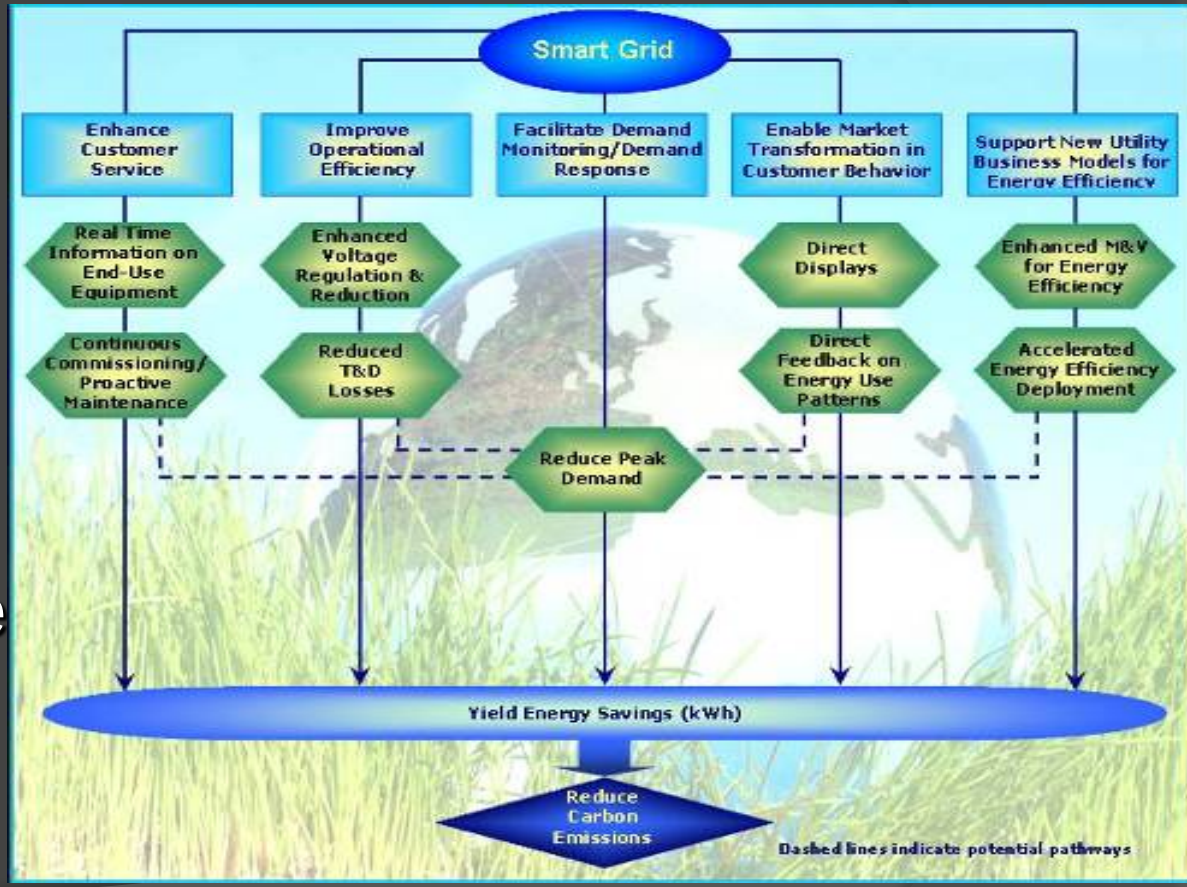
Emerging grid requirements
- Automatic sensing
- Dynamic activity
- Distributed intelligence and control

What Are the Expectations for the Smart Grid?



Is a Smart Grid a Green Grid?

- Initial estimated annual energy savings are 37 – 194 billion kWh
  - equivalent to reducing 24 126 million metric tons of CO2
  - equivalent to removing 4 to 20 million cars off the road

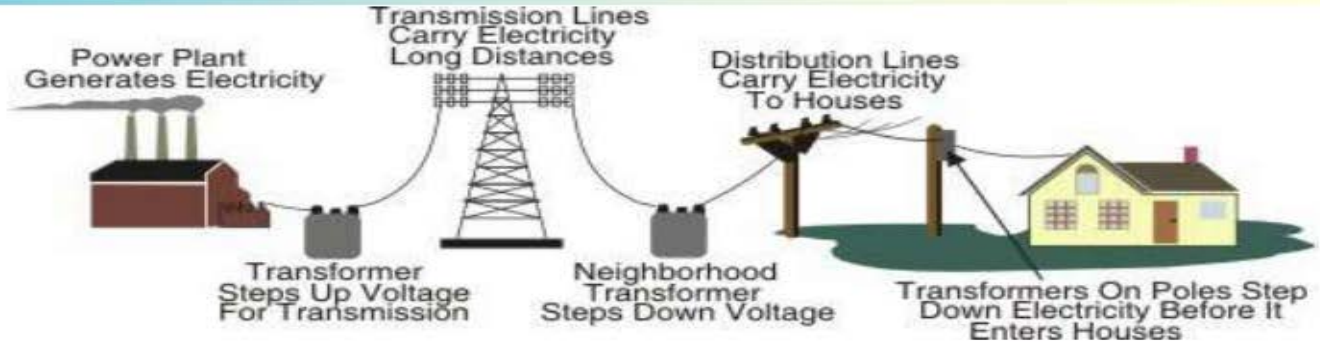


Courtesy of EPRI ELECTRIC POWER RESEARCH INSTITUTE

The Evolution of the Electric Utility System

Before Smart Grid:

One-way power flow, simple interactions



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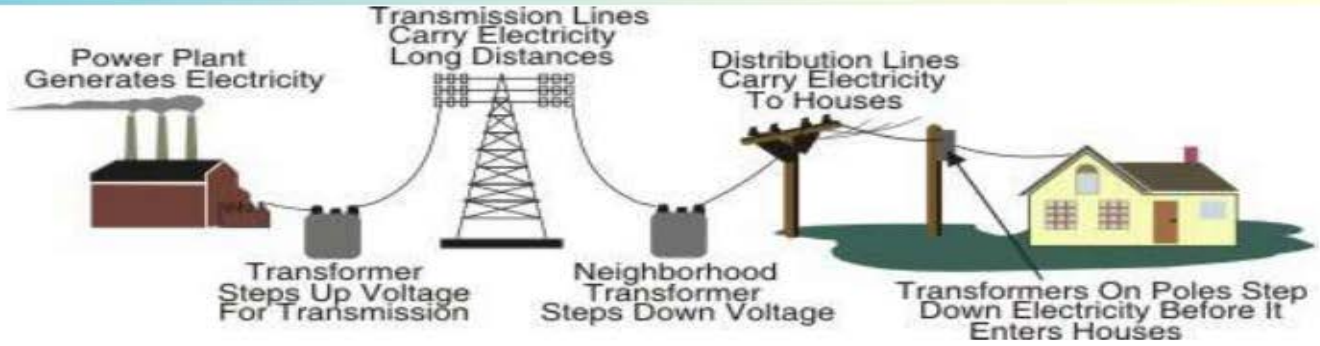
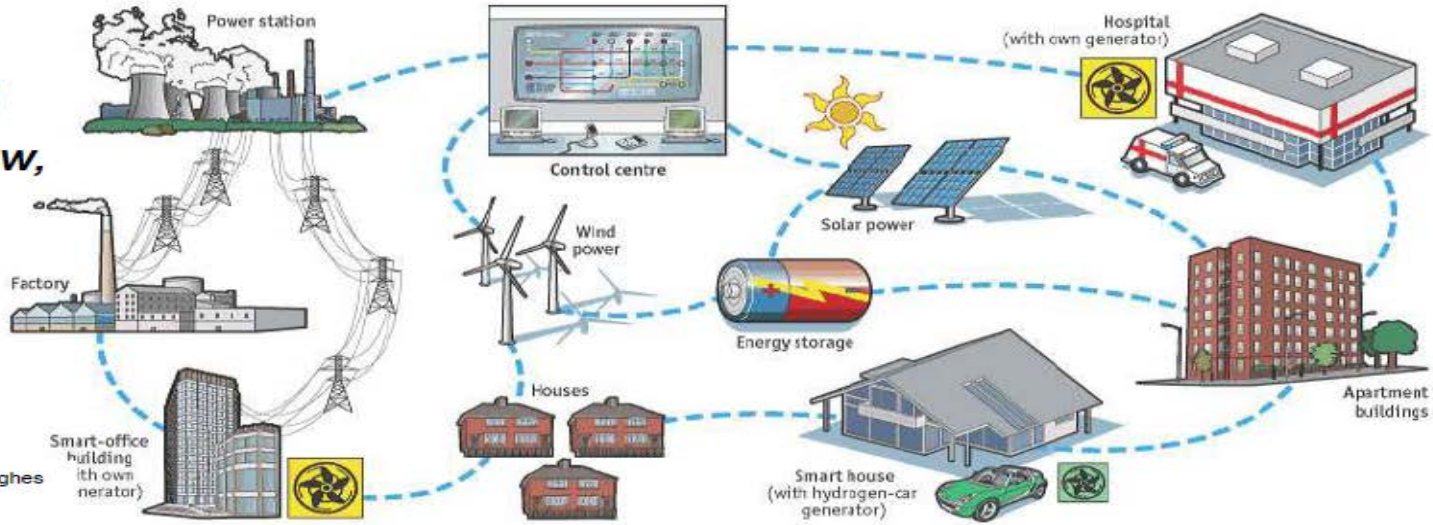


After Smart Grid:

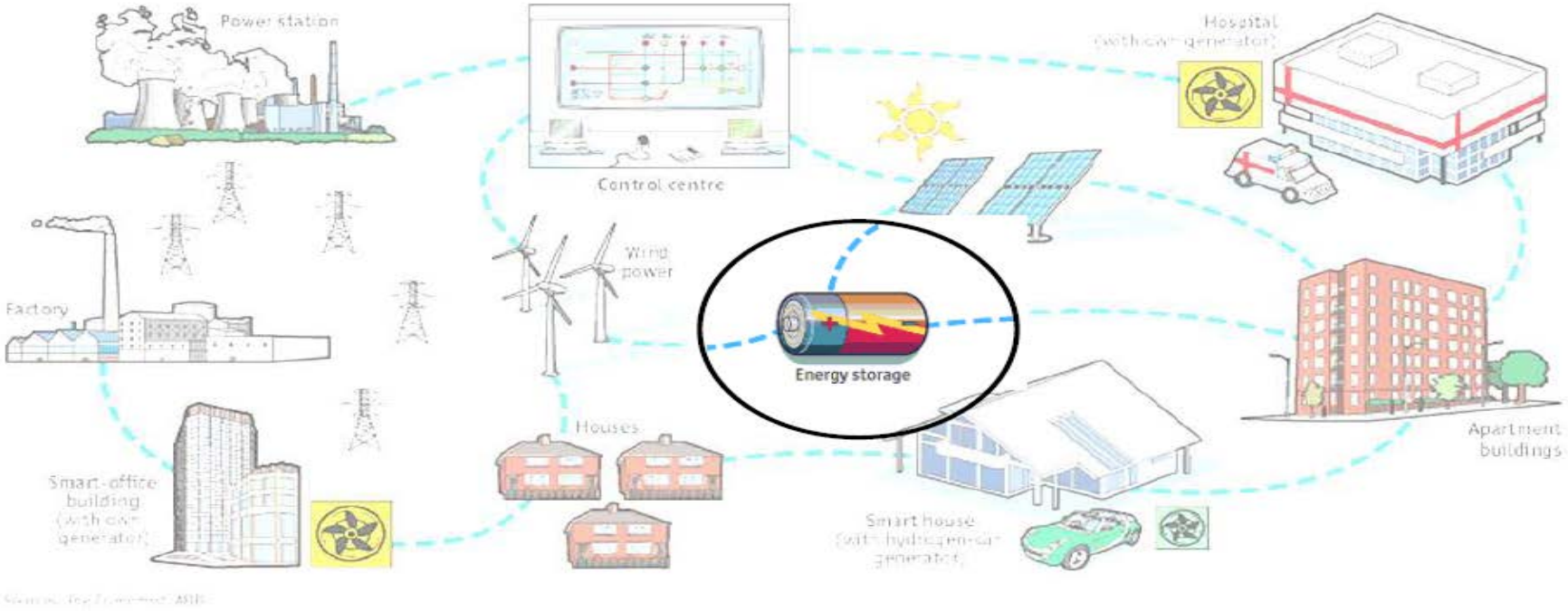
Two-way power flow, multi-stakeholder interactions



Adapted from EPRI Presentation by Joe Hughes
NIST Standards Workshop
April 28, 2008

Sources: *The Economist*; ABB

Energy Storage is a central component...



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...in the success of the Smart Grid!

Potential benefits of energy storage

- Improve capacity utilization
  - Storage for peak loads
- Time shift renewable energy
  - Use power as needed not as generated
- Defer capital investments
  - Defer new substation by using storage for peaks
- Reliability enhancement
  - Provide back up power during down circuits
- Voltage and frequency grid support

Substation scale Energy Storage

- Multiple MegaWatt output
- Hours of support
- Black start
- Frequency support
- Smooth wind output

www.xcelenergy.com/SiteCollectionDocuments/docs/W2BMilestone5Report_Public.pdf

Smaller scale
Community Energy Storage Applications

- Provides local backup power for consumers
- Provides voltage control along the feeder
- Integrates renewable power resources into the microgrid
- Multiple 25 kW units
- Distributed and scalable

CES – A Virtual Substation Battery

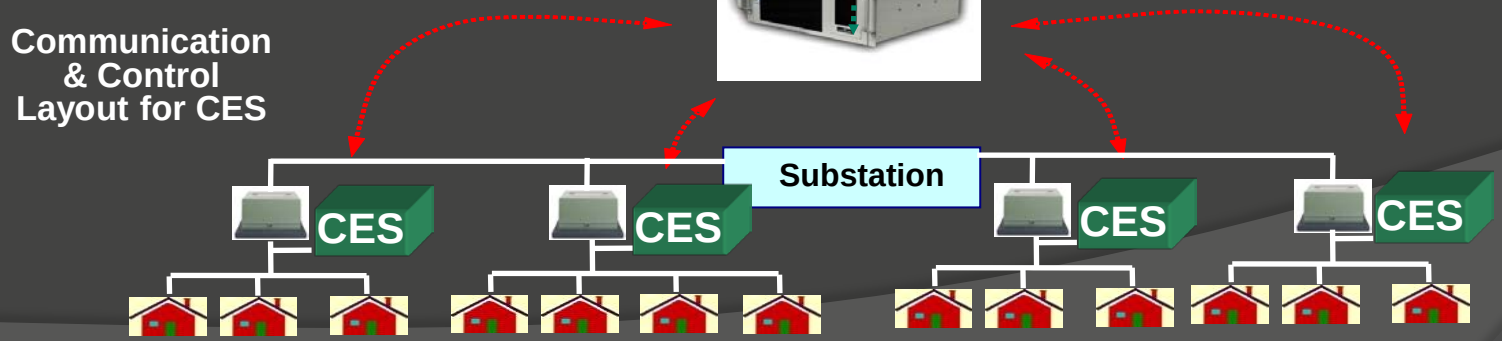
CES is Operated as a Fleet offering a Multi-MW, Multi-hour Storage

Local Benefits:

1) Backup power
2) Voltage correction
3) Renewable Integration

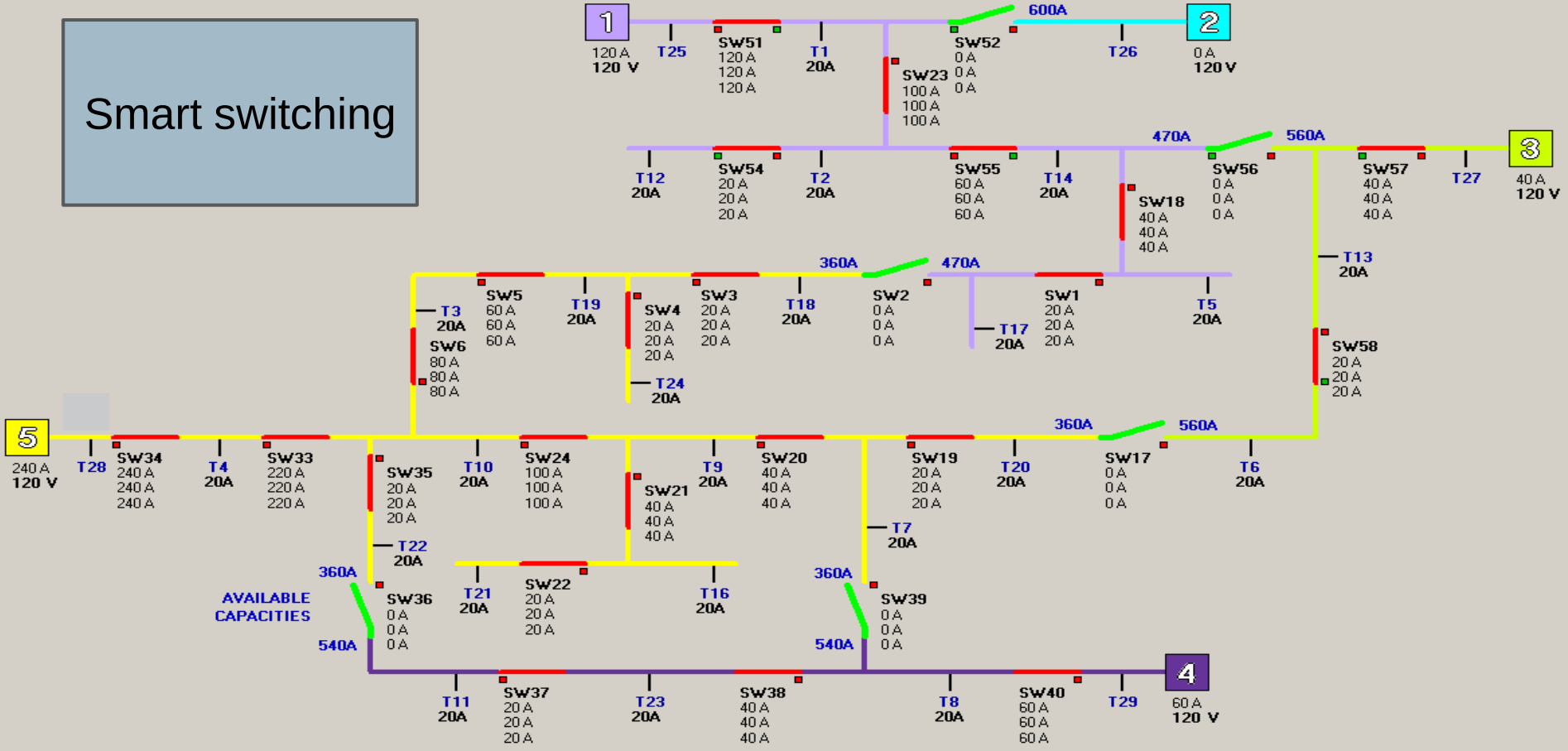
Grid Benefits:

4) Load Leveling at substation
5) Substation Power Factor Correction
6) Ancillary services



Smart Switching
Self-healing systems

Smart switching



Action:
Event: Circuit State Change

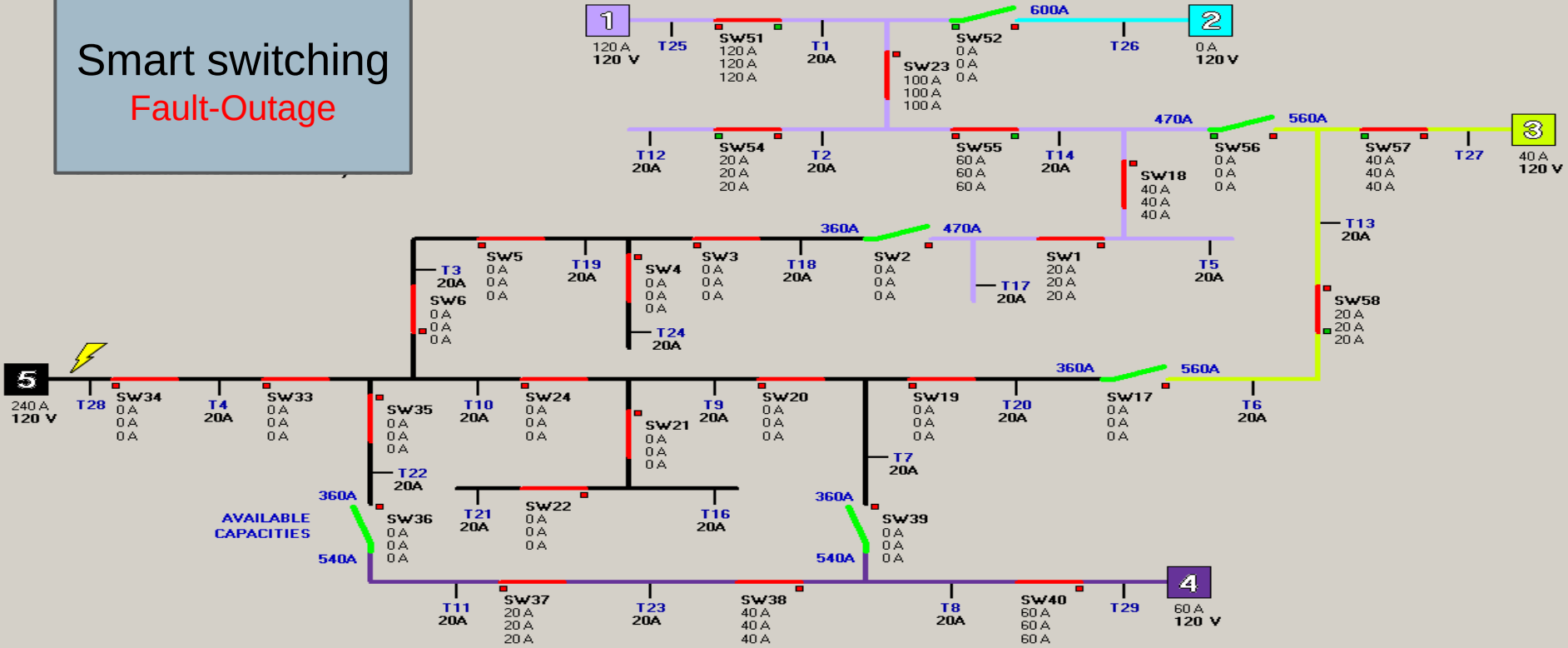
2 of 7 Steps
1.1 of 85.6 secs
Till Next: 3.9 secs

Play
Back
Speed
1X
2X
3X
4X

Event File: DrpSrc 20s.Event
Scenario 15 of 15
Comment: DrpSrc 5

Smart switching

Fault-Outage



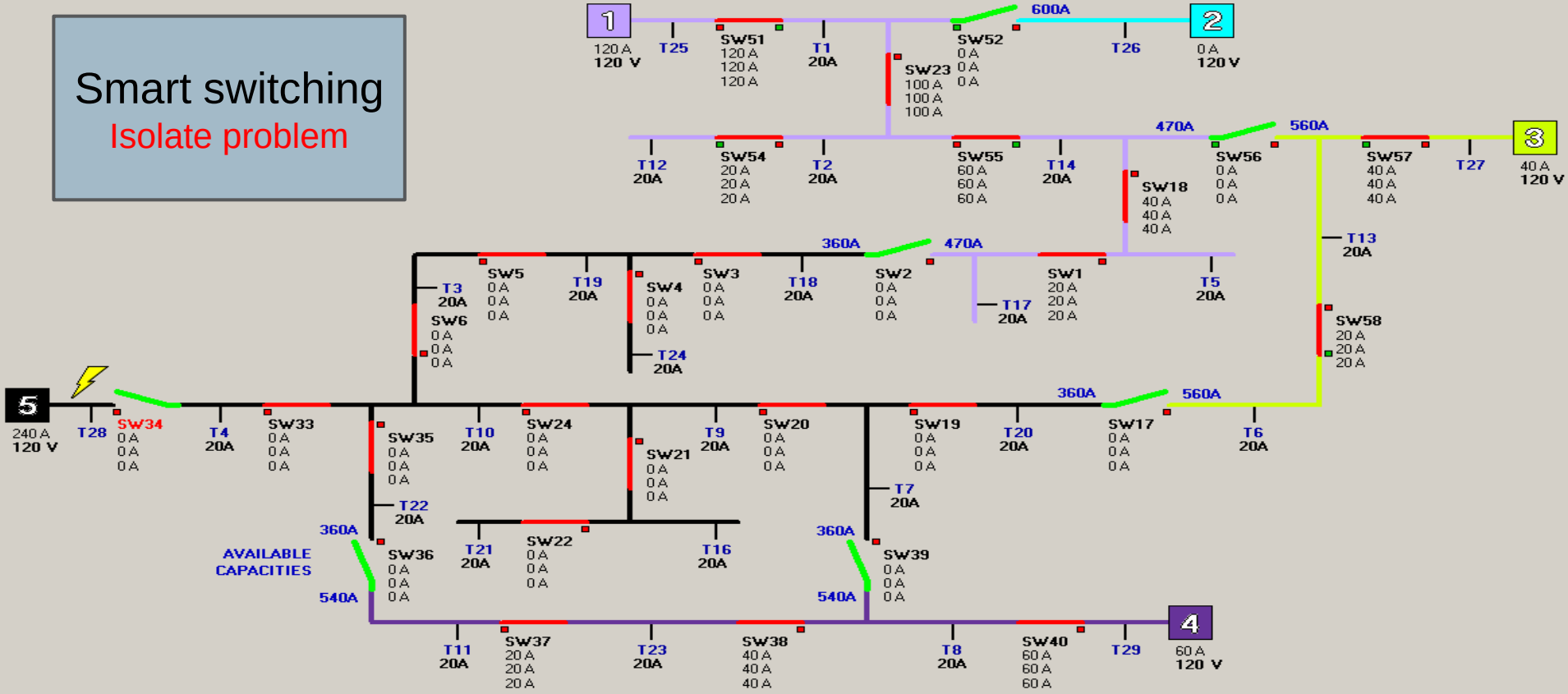
Time = 0

X=2880, Y=1440

1/28/2012

Smart switching

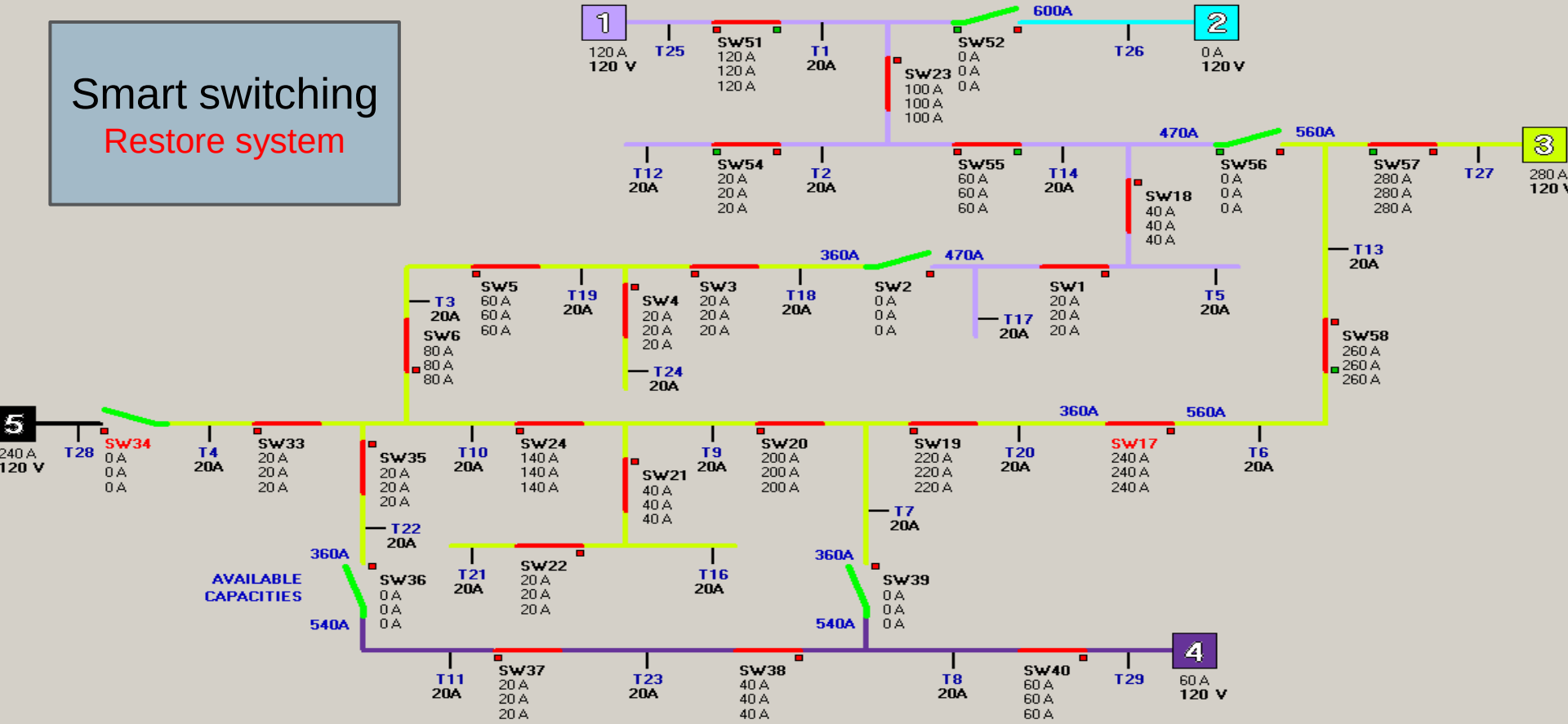
Isolate problem



Time = 5 sec

Smart switching

Restore system

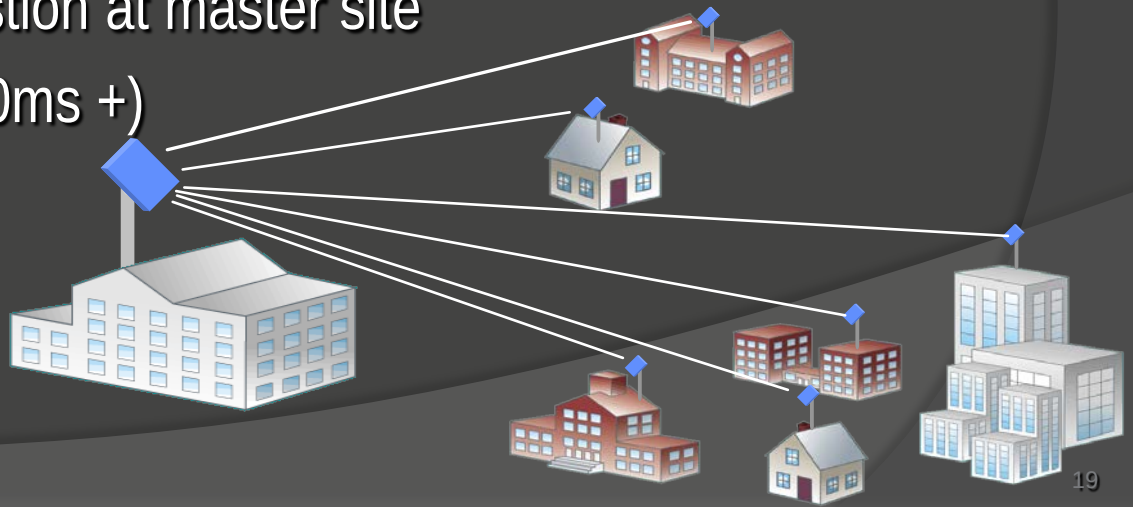


Time = 9.4 sec

Communications

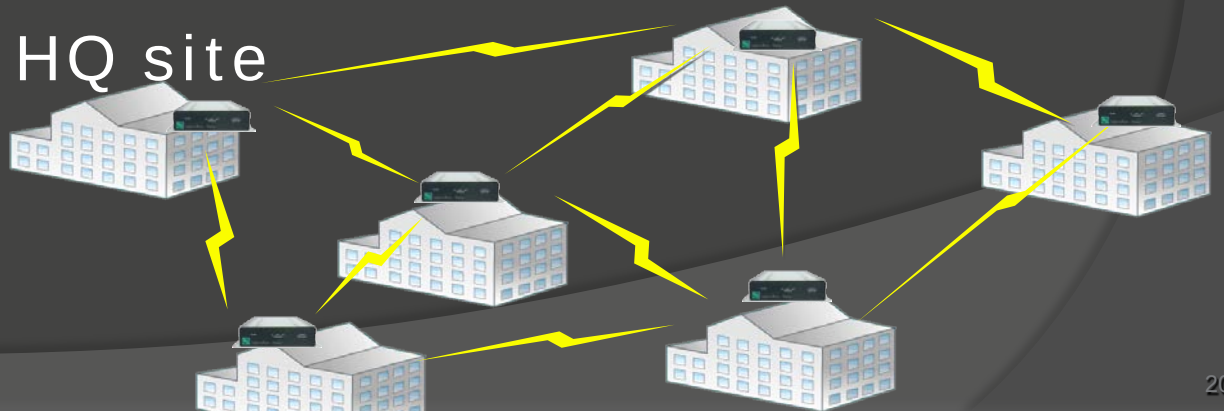
Architecture : Point-to-Multipoint

- Connects multiple remote sites to a single location
- Typically Requires line of site (LoS)
- Throughput typically limited to 50 Mbps per master
- Subject to single point outage at master site
- Prone to network congestion at master site
- Typically high latency (50ms +)



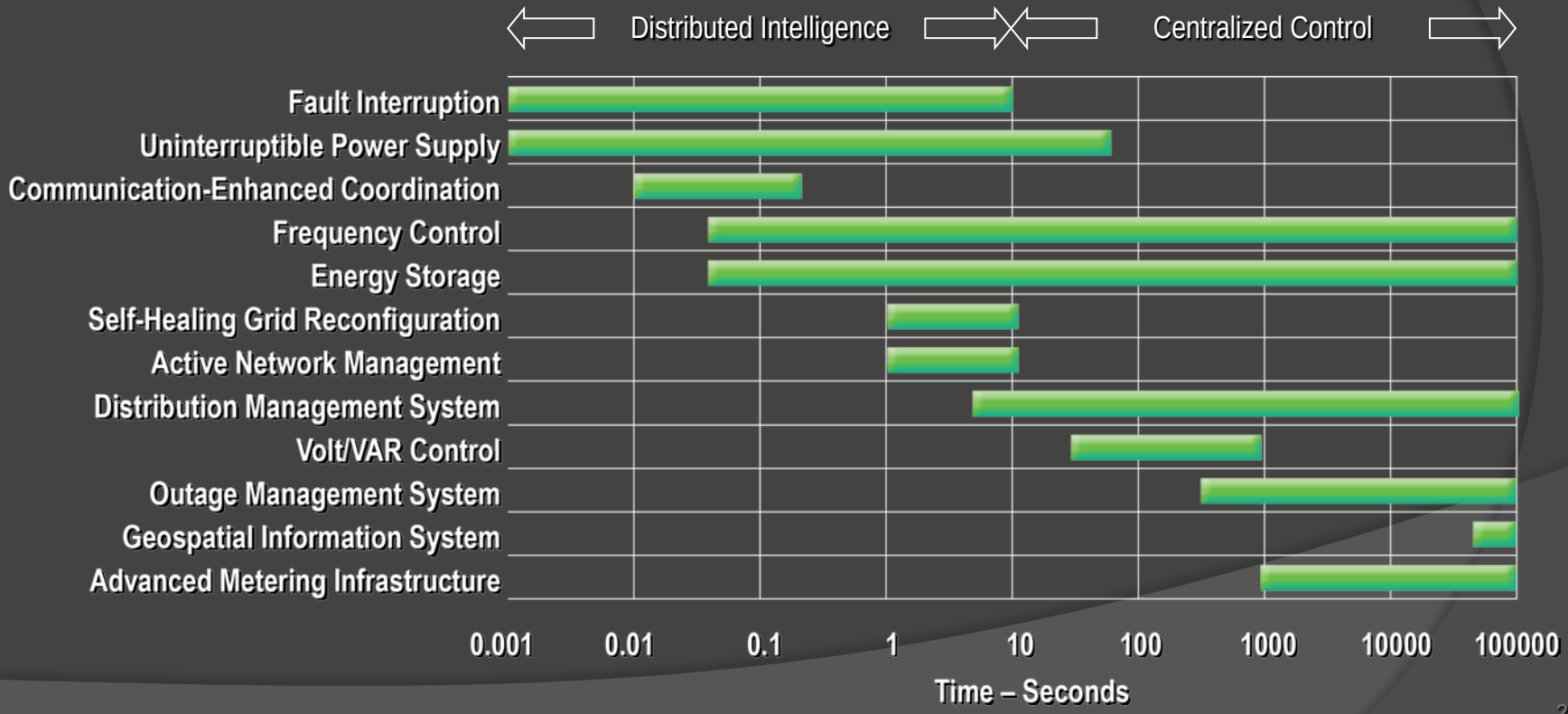
Architecture : Mesh

- No single point congestion
- Highest possible reliability
- No single point of failure
- Networks continually evaluate and select best path
- Throughputs are path dependent, not master site dependent



Layered Intelligence™

Operational Timeframes for Smart Grid Functions



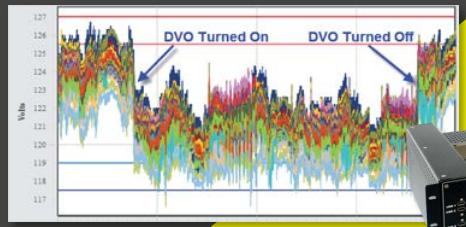
Advantages of Layered Intelligence™

- Fulfills multitude of Smart Grid requirements
- Uses distributed intelligence for many functions
  - makes faster, more reliable decisions
  - easier to integrate distributed resources
  - makes system more dynamic
  - offers better cyber security protection

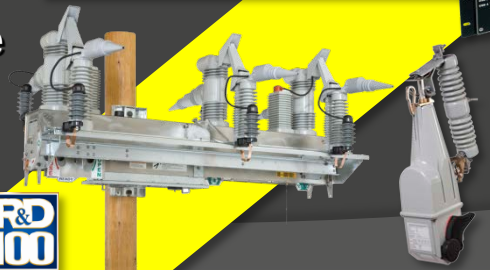
Layered Intelligence™

Integrated into control room

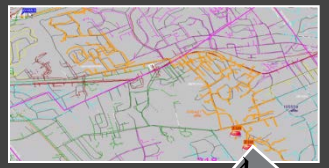
Substation-based



Distributed intelligence



Smart grid Components



Geospatial Information System

Existing Switching Devices: upgrade to distributed intelligence

Smart Switching

Network Data

Communications

Substation based

Self-healing

Device based

Energy Storage – MV and LV

Status & Data

SCADA switches

Renewables

Pad Mounted Switches

Grid Control Center

Questions?