The Distribution Grid of the Future

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Agenda

- Recognizing Future Needs
- Vision of a Smart Grid
- Distribution vision in the Smart Grid
- Distribution Smart Grid technologies / characteristics
- Example of dynamic islanding
- Seek real solutions to achieve benefits
- Impacts for suppliers and users

Recognizing the Future Power Needs

- By 2010, the Consumer Electronics (CE) sector will be represent 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.

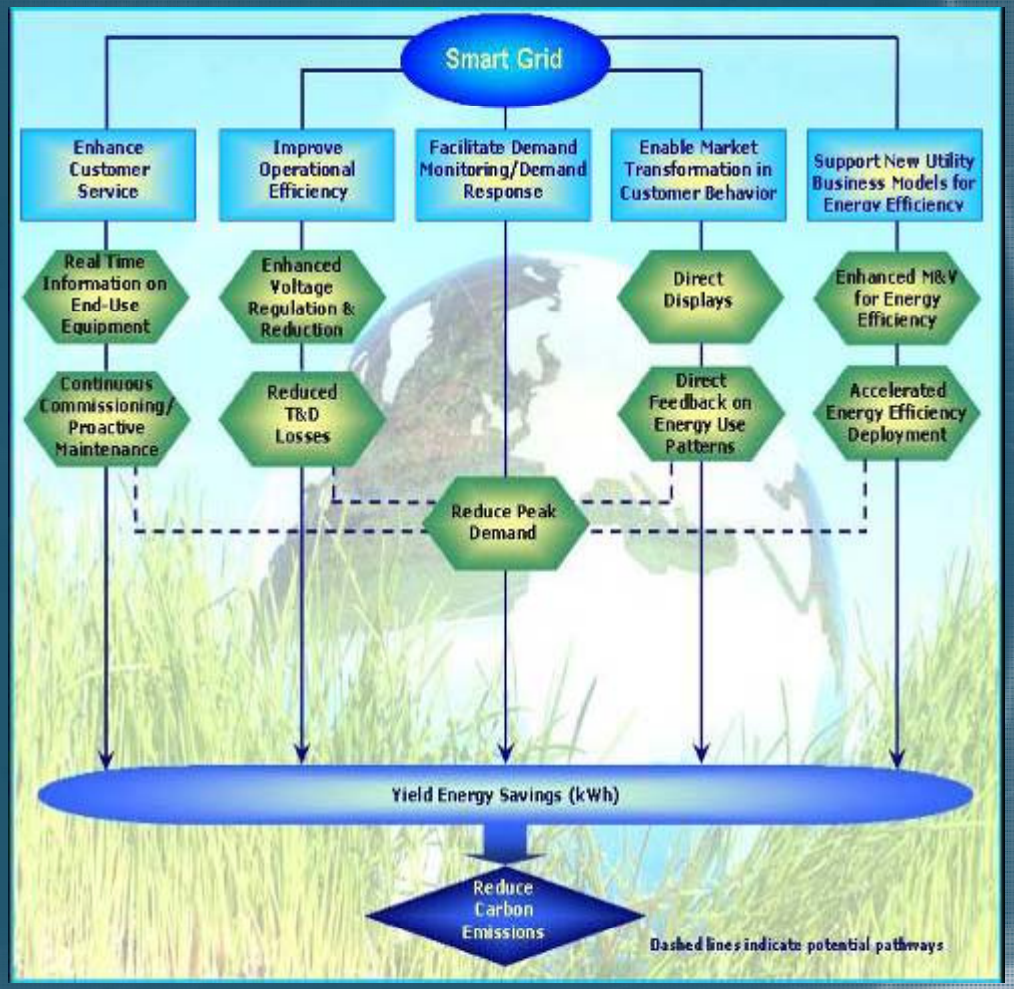
The average US household owns 26 consumer electronic products

Further increases in dependency on electronic devices drives 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.

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



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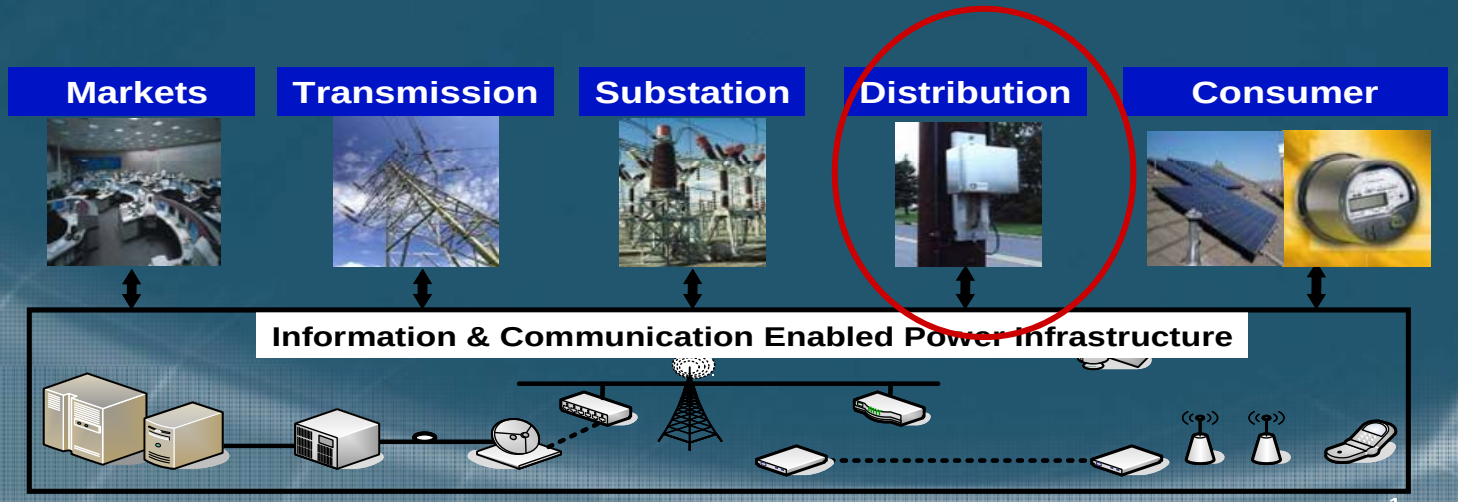
Vision of a Smart Grid

- Enable active participation by consumers
- Accommodate all generation & storage
- Enable new products, services, markets
- Provide power quality for digital economy
- Optimize asset utilization, operate efficiently
- Anticipate & respond to system disturbances
- Operate resiliently against attack & natural disasters



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Distribution Vision in the Smart Grid

- Performs real-time simulation and contingency analysis
- Automatically adjusts
- Interacts between distribution devices, meters, home area networks, DG sources and substations
- Readily accommodates renewables, distributed generation, storage, plug-in-vehicles
- Supports islanding and re-established interconnection
- Provides diagnostics / statistics

- phase balancing
- self-healing
- peak reduction
- loss management
- congestion management
- curtailment / price signals

Distribution Smart Grid Technologies

- Distribution Grid Management
  - distribution automation
  - advanced metering infrastructure
- Distributed Resources
  - energy storage
  - distributed generation
  - electric vehicles
  - wind generation
  - solar generation
- Integration with meters, home area networks and substations

Smart Meters

Intelligent Distribution Devices

Renewables

Energy Storage

Technology Characteristics

- Capable of being updated dynamically
- Supports present and future protocols, DNP compatible
- Uses the most secure technologies
- Deployable in stages, scaleable
- Utilizes integrated communications:
  - Adequate bandwidth – for AMI, DA,DG,PHEV
  - Capable of prioritizing traffic - minimal latency
  - Avoids interference and is redundant
  - Supports peer-to-peer and peer-to-master communications

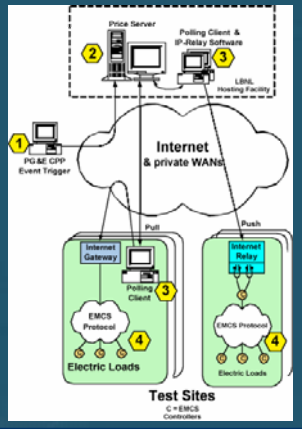
EPRI Smart Grid Demonstration

Communication Media: BPL, Wi-Max, Satellite, Fiber, DSL, Wi-Fi, RF Mesh, etc.

Smart Grid Infrastructure: Software/database, network communication and monitoring, and control architecture

Substation/Feeder DER Integration

C&I Customer Demand Response & DER Integration



Residential Customer Demand Response & DER Integration

Reduce Peak Demand, Enable Energy Efficiency, and Reduce CO_2 Footprint Through Dynamic Pricing & DER Integration

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Energy Storage

- Energy Storage Benefits
  - Cost deferral of new substations
  - Improved service reliability
  - Less stress on aging infrastructure
  - Integration of renewable energy
  - Energy market value
  - Frequency regulation

Energy Storage

- Have installed several 1 MW -- 7.2 MWh NaS Batteries
  - Peak shaving for a station transformer
  - Dynamic islanding with distribution automation integration
  - Facilitating more dispatchable wind generation

2008 NaS Storage Project Overviews

AEP - Balls Gap, West Virginia

AEP - Churubusco, Indiana

AEP - Bluffton, Ohio

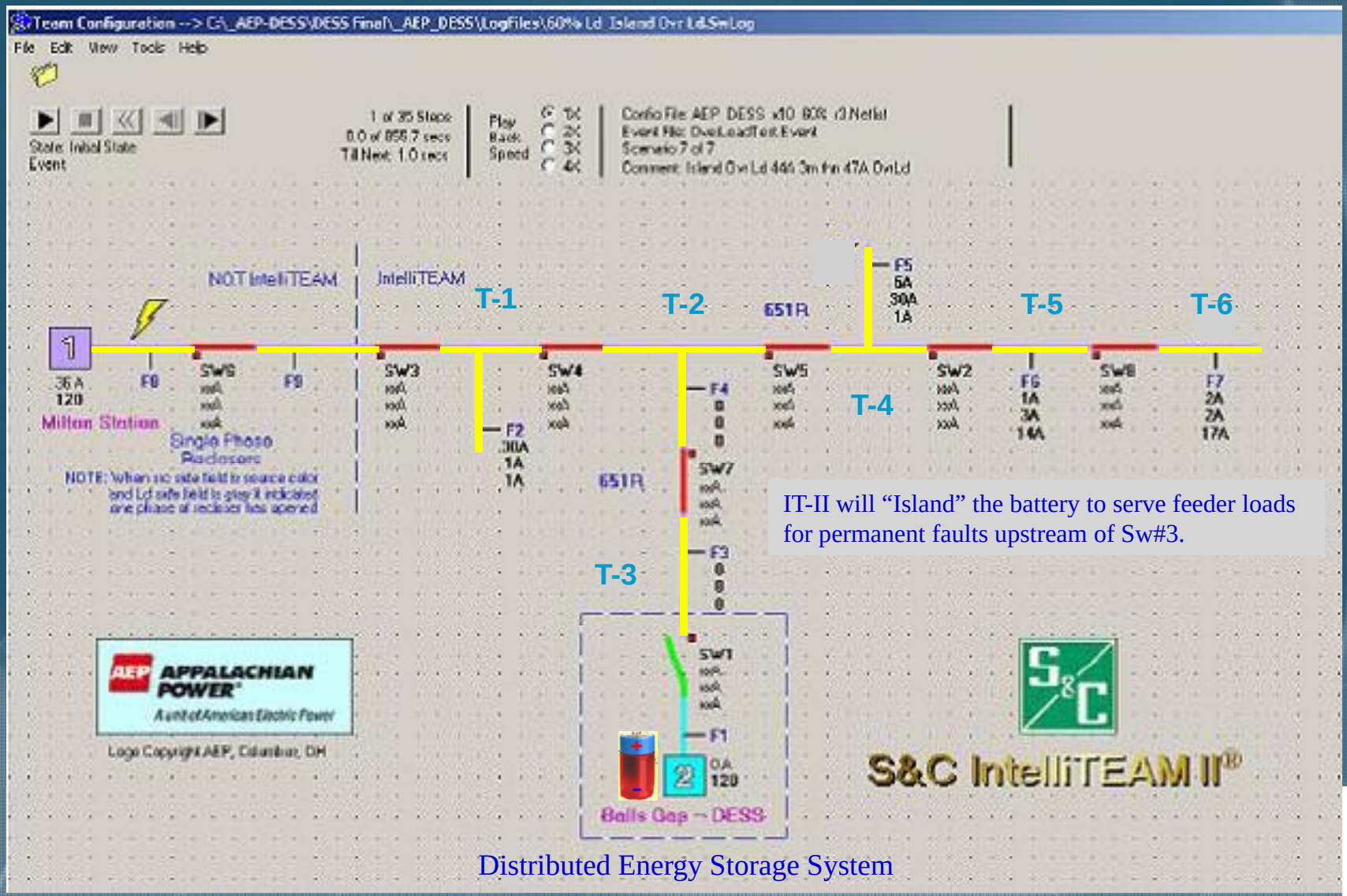
Xcel – Beaver Creek, Minnesota

Dynamic Islanding from Storage and DA

- Load information is captured by Intelliteam II devices
- Dynamic islanding activated upon loss of power
- The maximum number of customers are restored serviced by the battery based upon:
  - Last load information
  - Energy in the battery
- The island can be minimized as the battery depletes
- Customer load served until battery is exhausted or power is restored

Using a NaS Battery to Mitigate Outages

A Fault Occurs Locking Out the Balls Gap Feeder

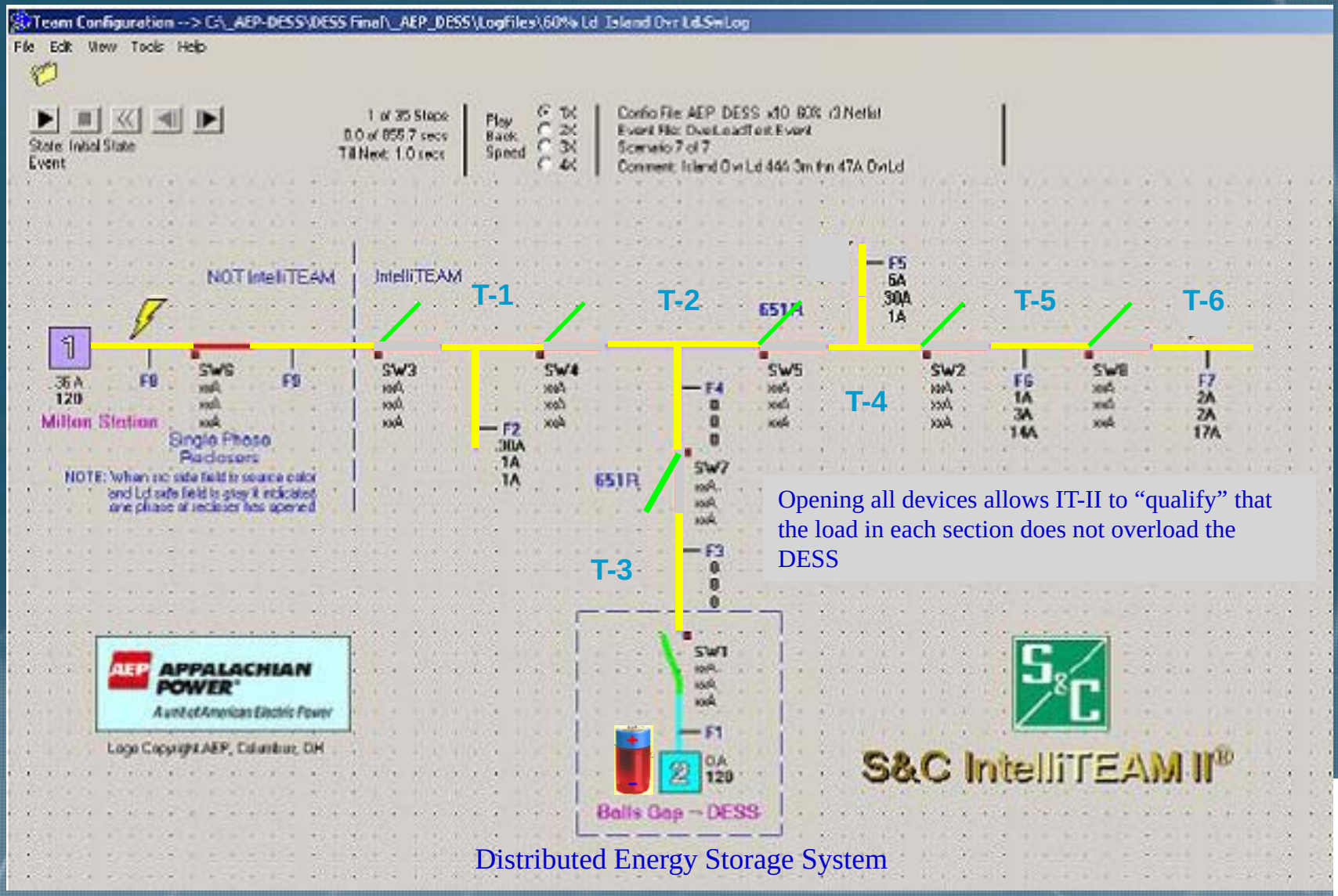


IT-II will "Island" the battery to serve feeder loads for permanent faults upstream of Sw#3.

Distributed Energy Storage System

Using a NaS Battery to Mitigate Outages

All IT-II Devices Open (on Loss Of Voltage)

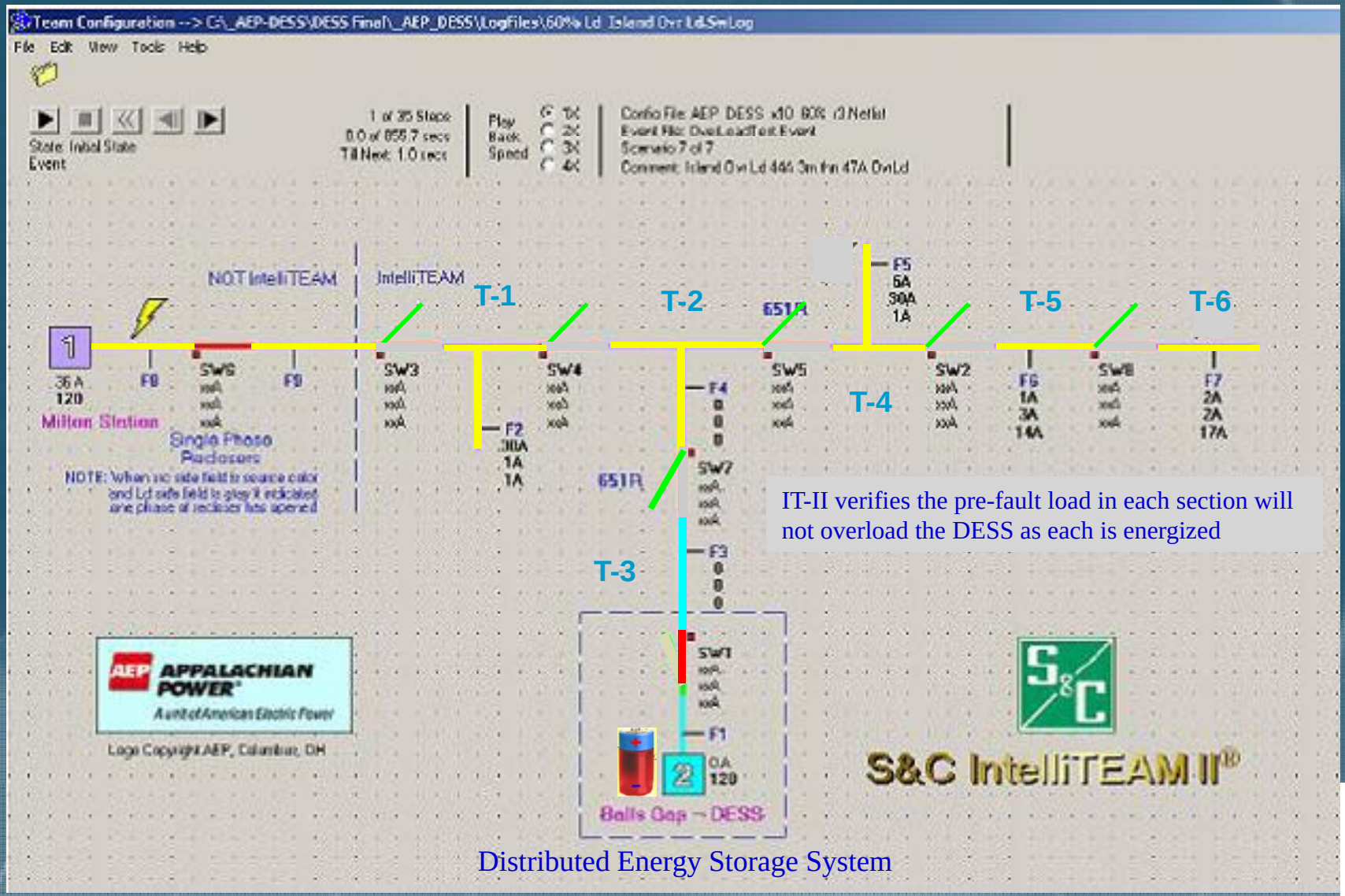


Opening all devices allows IT-II to "qualify" that the load in each section does not overload the DESS

Distributed Energy Storage System

Using a NaS Battery to Mitigate Outages

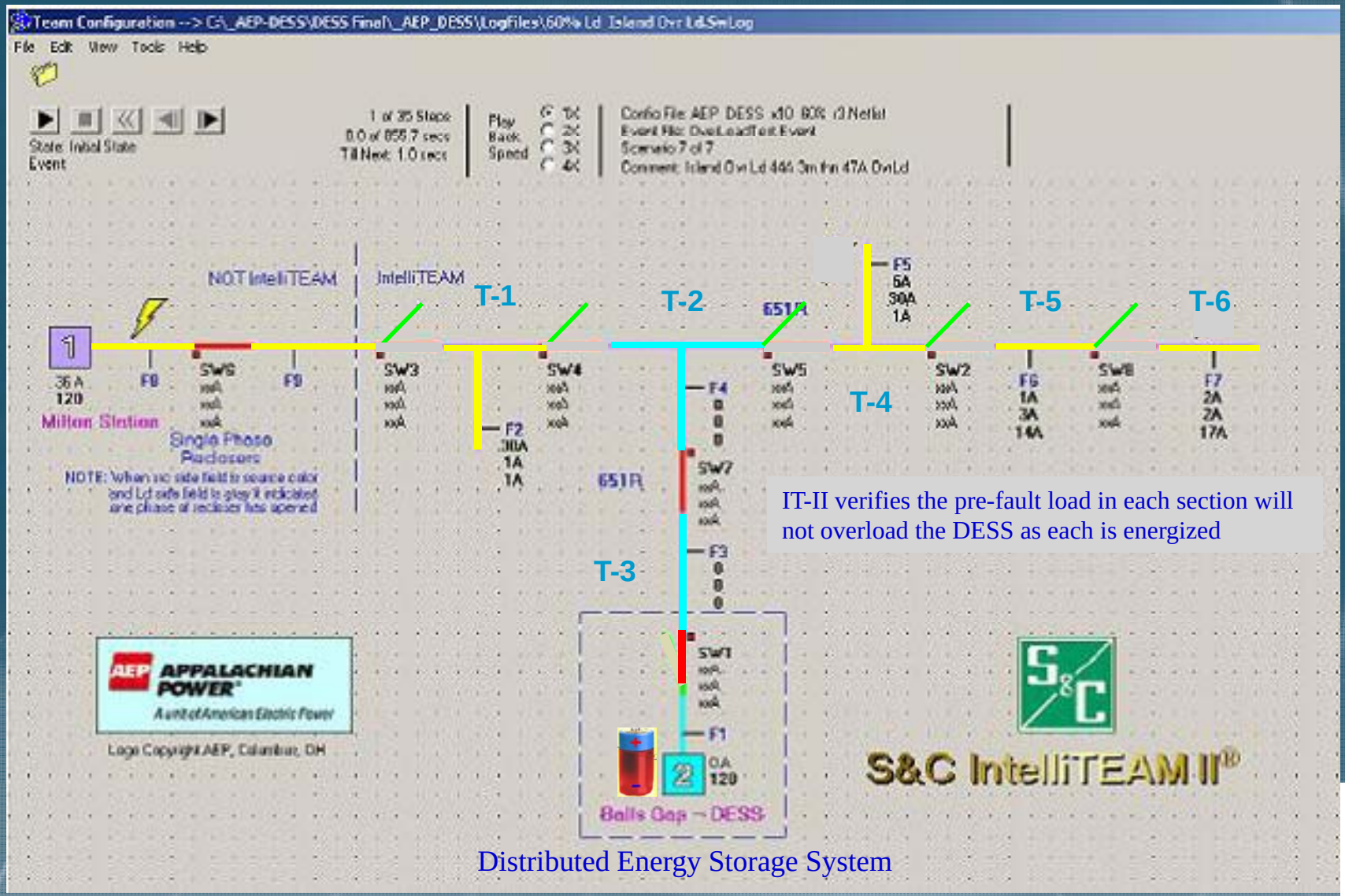
IT-II Closes SW-1 to Energize Team 3



Distributed Energy Storage System

Using a NaS Battery to Mitigate Outages

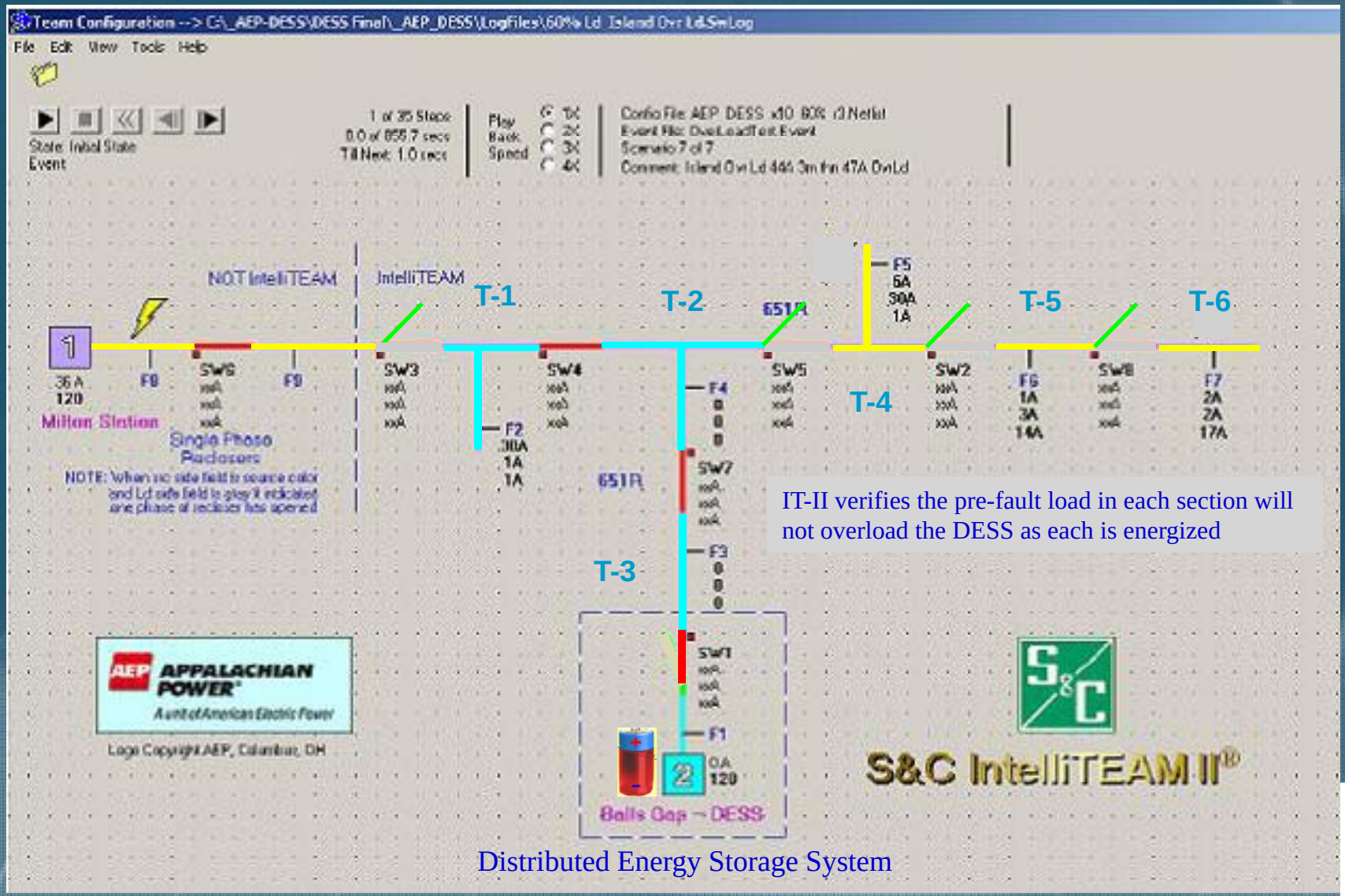
IT-II Closes SW-7 to Energize Team 2



Distributed Energy Storage System

Using a NaS Battery to Mitigate Outages

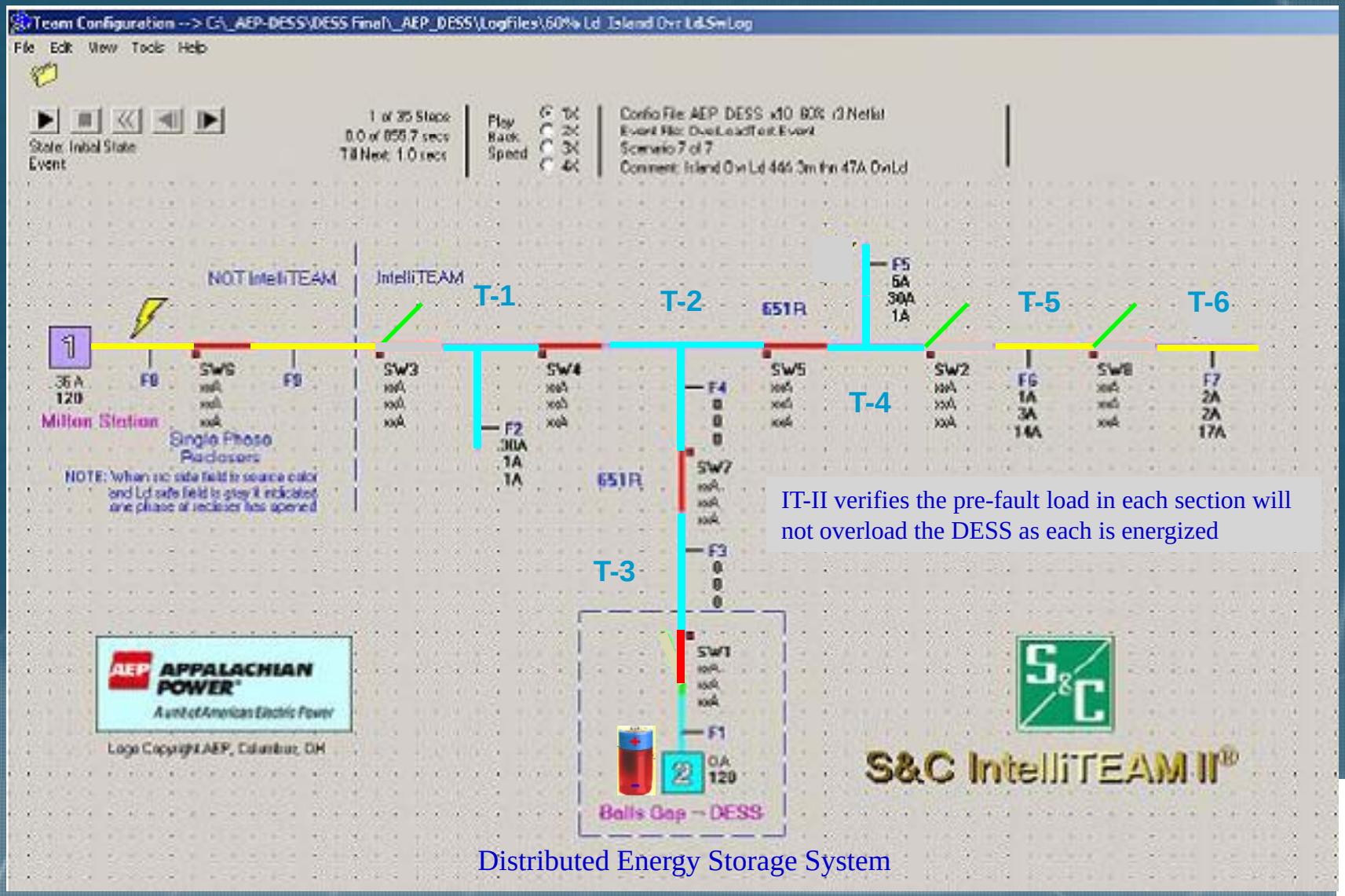
IT-II Closes SW-4 to Energize Team 1



Distributed Energy Storage System

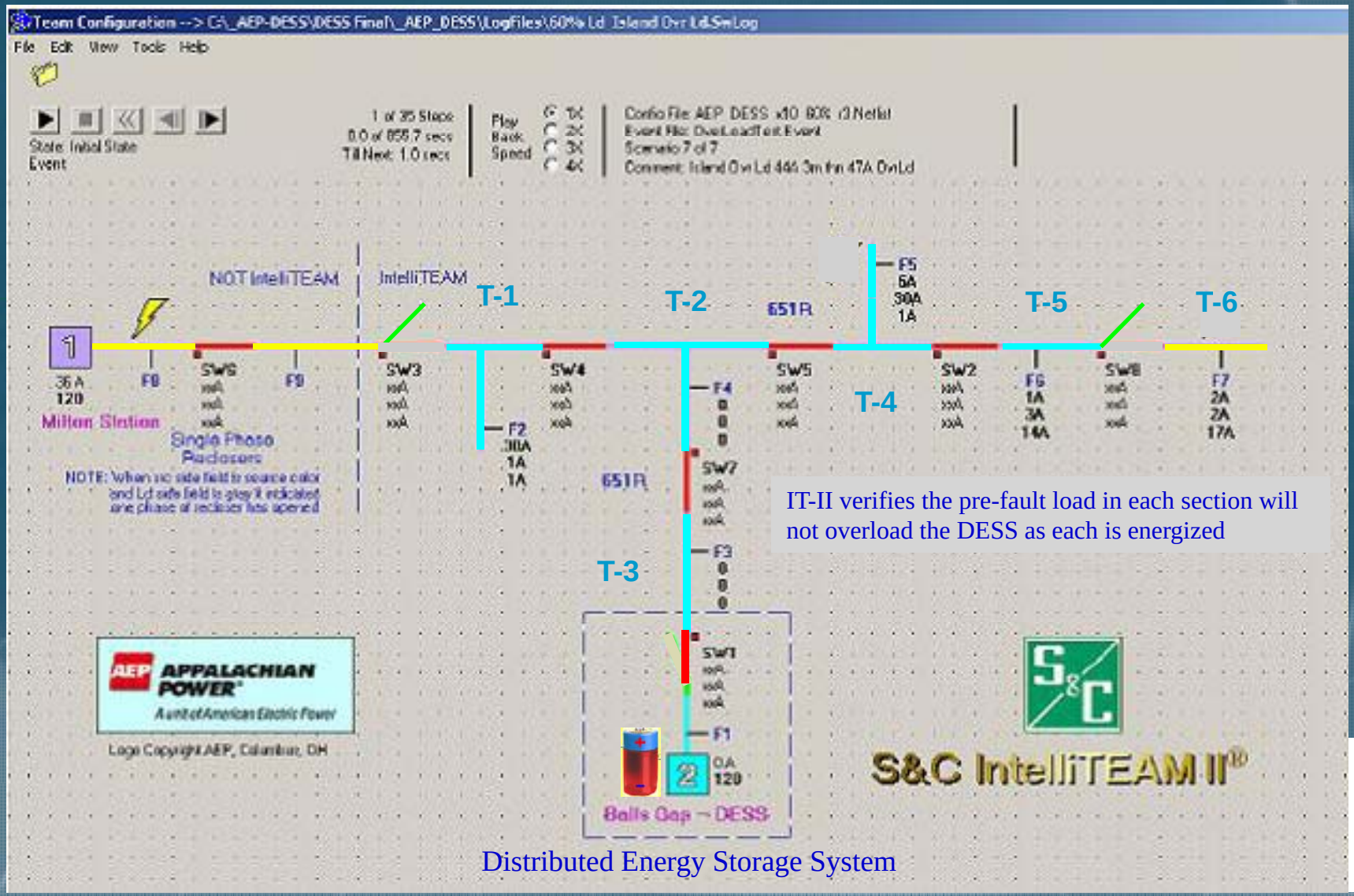
Using a NaS Battery to Mitigate Outages

IT-II Closes SW-5 to Energize Team 4



Using a NaS Battery to Mitigate Outages

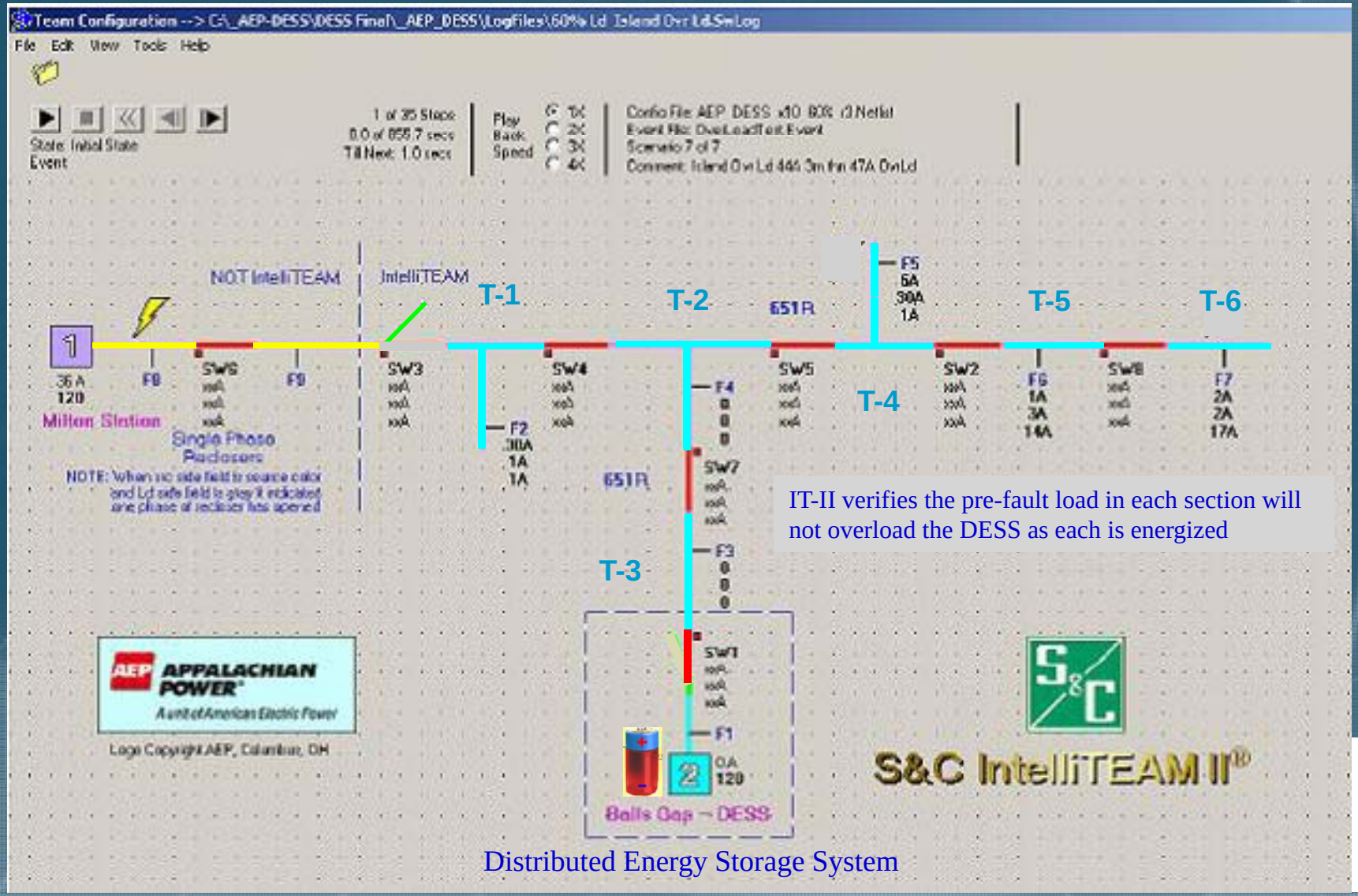
IT-II Closes SW-2 to Energize Team 5



Distributed Energy Storage System

Using a NaS Battery to Mitigate Outages

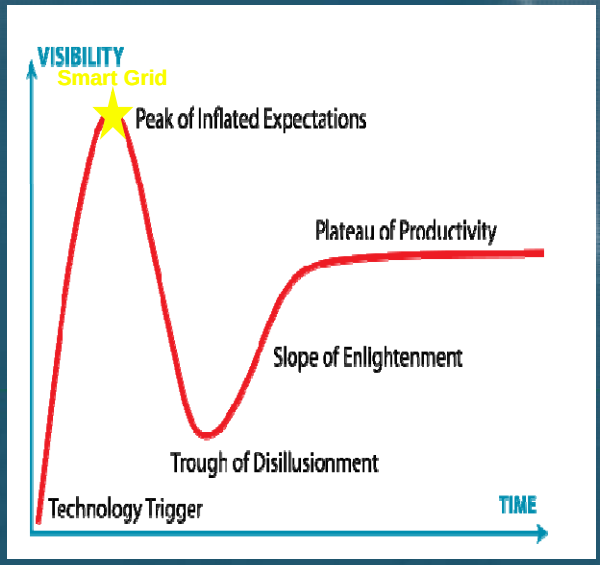
IT-II Closes SW-8 to Energize Team 6



Distributed Energy Storage System

Real Solutions Achieve Benefits Today

- S&C innovates upon proven technology
  - Expanding existing automation functionality
  - Using Universal Interface Module for inter-operability
  - Installing IntelliRupter — NEW self powered, self contained, fault-interrupting switch
    - fast communication, priority messaging
    - remote control/communication
    - low-energy pulse senses fault and reduces energy pushed through circuit
    - mimics any fuse curve
    - can be fuse saving AND fuse blowing without intervention
    - selects the right speed based on the fault current



IntelliRupter

Impacts for Suppliers

- Suppliers
  - need to collaborate with other suppliers
  - consider backward / forward compatibility
  - support interoperability standards
  - stay abreast of security requirements, policies and technologies
  - seek technologies from non-traditional sources

Impact for Utilities

- Think through the macro smart grid roadmap
- Work with others for technology assessments
- Gain experience with large-scale integrated deployments
- Validate business case assumptions
- Get started!

Conclusion

- Smart Grid is critical to maintaining reliability
- The industry is on the cusp of a wave of change presenting a growing opportunity for innovation and collaboration
- Requires:
  - Awareness of smart grid initiatives
  - Long range planning
  - Innovative technologies
  - Deployments: scaleable, interoperable, and secure
  - Willingness to explore new thinking, manage expectations