

Transactive Control: An Approach for Widespread Coordination of Responsive Smart Grid Assets

Ron Melton & Don Hammerstrom Battelle, Pacific Northwest Division May 18, 2010



Overview

- Background on Pacific Northwest Smart Grid Demonstration
 Project
- Transactive Control Approach
- Transactive Control Nodes
- Implementation Challenges

Pacific Northwest Demonstration Project



What:

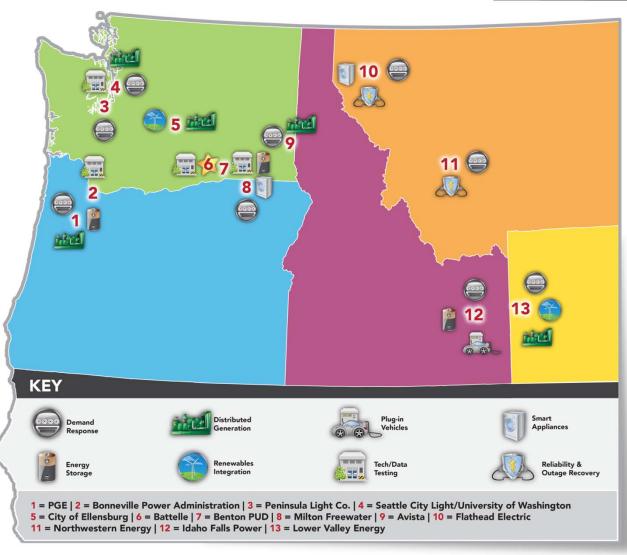
- \$178M, (\$89M private, \$89M ARRA-funded), 5-year demonstration
- 60,000 metered customers in 5 states

Why:

- Quantify costs and benefits
- Develop communications protocol
- Develop standards
- Facilitate integration of wind and other renewables

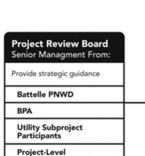
Who:

Led by Battelle and partners including BPA, 11 utilities, 2 universities, and 5 vendors





- Battelle Memorial Institute,
 Pacific Northwest Division
- Bonneville Power Administration
- 11 utilities (and UW) and their vendors
- 5 technology infrastructure partners



Infrastructure Participants



- · Federal funding authority
- Establishes federal assistance reporting and American Recovery and Reinvestment Act reporting requirements



Battelle Memorial Institute Pacific Northwest Division

- · Project management and integration
- · DOE reporting and financial tracking
- Federal funds management
- Lead research, analysis, and results presentation of test
- Administer contracts
- · Manage project level infrastructure team
- Administer project management plan and configuration management plan

Battelle

The Business of Innovation

Bonneville Power Administration

- · Coordinate with utilities
- Public outreach and communication
- Research and infrastructure design
- Integrate BPA operating units
- Coordinate with Battelle on cost-benefit analysis



Project-Level Infrastructure Participants

- Design and install project level infrastructure
- DOE reporting through Battelle





NETEZZA

QualityLogic.

Utility Subproject Participants

- Design and install utility site specific infrastructure
- Collect and share data
- DOE reporting through Battelle











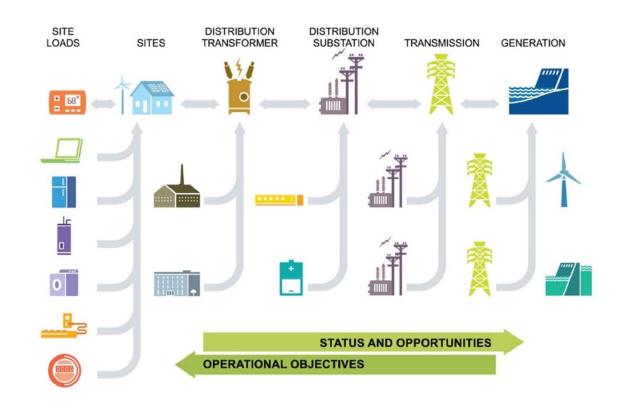
WASHINGTON

Project Basics



Operational objectives

- Manage peak demand
- Facilitate renewable resources
- Address constrained resources
- Improve system reliability and efficiency
- Select economical resources (optimize the system)



Aggregation of Power and Signals Occurs Through a Hierarchy of Interfaces



Some Definitions

Transactive Control

A single, integrated, smart grid incentive signaling approach utilizing an economic signal as the primary basis for communicating the desire to change the operational state of responsive assets.

Transactive node

A physical point within an electrical connectivity map of the system. Electrical energy flows through a transactive node.

Transactive Incentive Signal (TIS)

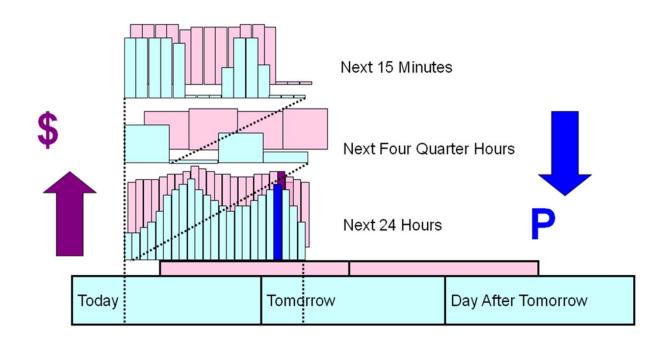
A representation of the actual delivered cost of electric energy at a specific system location (e.g., at a transactive node). Includes both the current value and a forecast of future values.

Transactive Feedback Signal (TFS)

A representation of the net electric load (responsive and unresponsive) at a specific system location (e.g., at a transactive node). Includes both the current value and a forecast of future values.



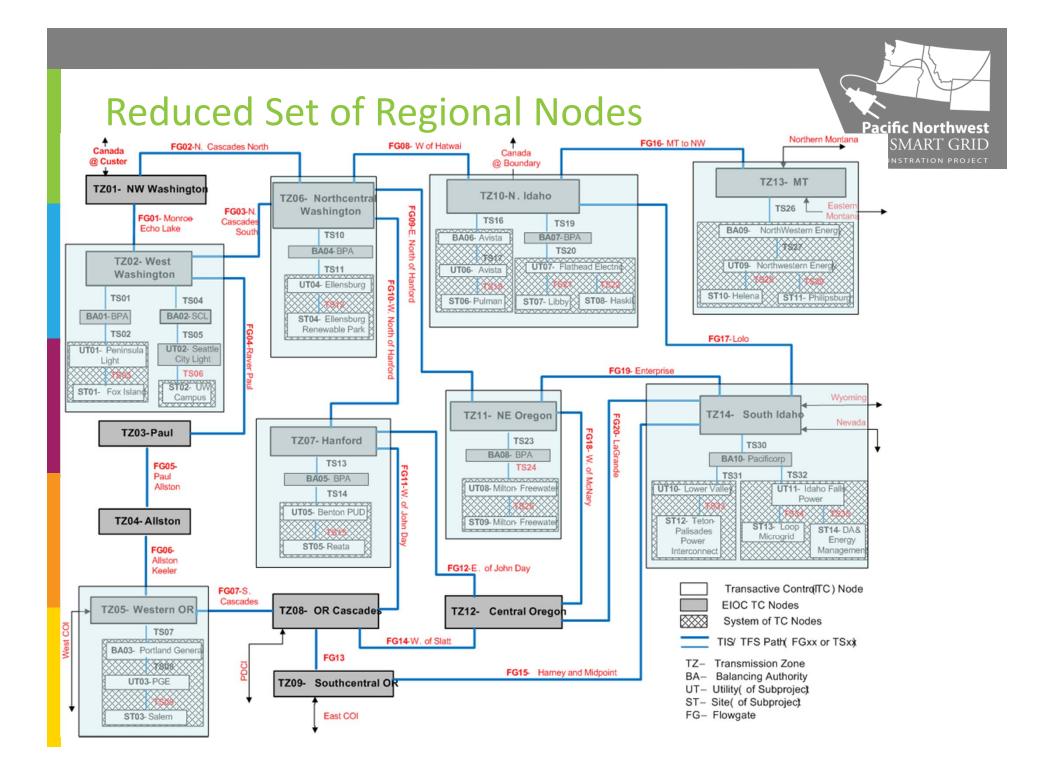
Multiscale Intervals for TIS & TFS



NW Region Influence Map West MT

17 August 2010

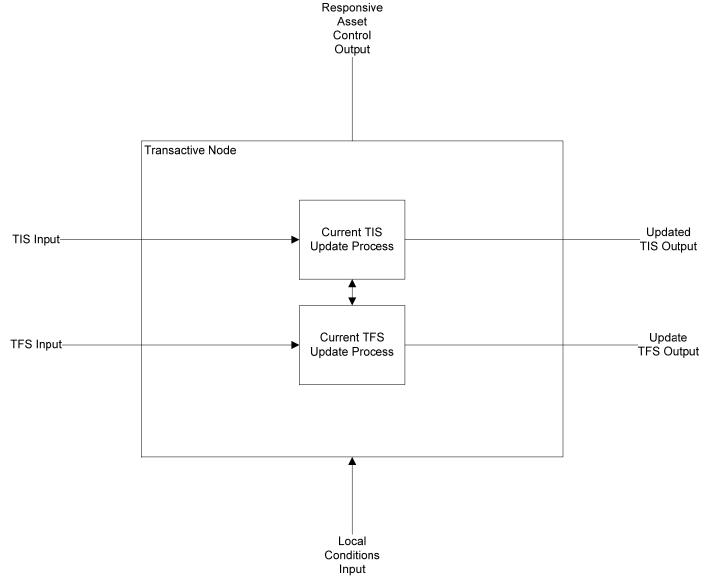
Regional and Subproject Transactive Control Nodes & Network Topology Northern Montanacific Northwest FG-MT to NW FG-W of Hatwai FG-N.Cascades North Canada Canada SMART GRID @ Custer @ Boundary TZ-13: MT TZ-1: NW Washington TZ-10: N. Idaho TZ-6: Northcentral Eastern FG-N. Washington FG-Monroe-Montana Cascades Echo Lake BA- NorthWestern Energy South North of Hanford BA-Avista BA-BPA BA- BPA TZ-2: West UT-Northwestern Energy UT-Flathead Electric Washington UT- Avista FG-W. UT-Ellensburg ST-Pulman ST-Helena ST-Philipsburg ST-Haskil ST-Libby BA-SCL BA-BPA ST-Ellensburg Renewable Park 으 FG-Lolo Hanford UT-Seattle UT-Peninsula City Light Light FG-Enterprise ST- UW ST- Fox Island Campus Wyoming TZ-14: South Idaho FG- LaGrande TZ-11: NE Oregon TZ-7: Hanford TZ-3: Paul · W. of McNary Nevada BA-Pacificorp FG-BA-BPA BA-BPA Paul Allston FG-W. UT-Idaho Falls UT-Lower Valley UT-Benton PUD UT-Milton-Freewater Power . 약 TZ-4: Allston ST- Teton-John Day ST- Loop ŠT-DA & Palisades ST-Milton-Freewater ST-Reata Microgrid Energy Power Management Interconnect Allston FG-E. of John Day Keeler FG-S. Cascades Transactive Control Node TZ-5: Western OR TZ-8: OR Cascades TZ-12: Central Oregon ← TIS Signal Ö FG-W. of Slatt ←→ TFS Signal West **BA-Portland General** TZ - Transmission Zone BA - Balancing Authority TZ-9: Southcentral UT – Utility (of Subproject) UT-PGE ST – Site (of Subproject) OR FG- Harney and Midpoint FG – Flowgate FG-East COI ST-Salem



Reduced set of Regional Nodes (2) **Pacific Northwest** SMART GRID Northern Montana FG16- MT to NW FG02-N. Cascades North FG08- W of Hatwai @ Custer @ Boundary TZ13- MT TZ01- NW Washington TZ10-N. Idaho TZ06- Northcentra (BA07-BPA) Washington Eastern FG09-E FG03-N (BA04-BPA) FG01- Monroe TS21 TS22 Cascade TS18 Echo Lake Sout ST11- Philipsburg ST10-Helena TS12 North of Hanford ST07-Libby ST08- Haskil (BA09- NorthWester (BA09- NorthWestern ST06- Pulman (UT07-(UT07-Energy) Energy) ST04- Ellensburg (BA06-Avista) Flathead Flathead (UT09- NorthWester (UT09- NorthWestern TZ02- West Washington Renewable Park (UT06-Avista) Electric Electrid Energy) Energy) (BA01-BPA) (BA02-SCL) (Ut04- Ellensburg) (UT02- Seattle City Ligh): TS03 TS06 FG17-Lolo ST01- Fox Island ST02- UW (UT01- Peninsula Light Campus FG19- Enterprise Wyoming TZ11- NE Oregon TZ14- South Idaho (BA08-BPA) Nevada (BA10- Pacificorp) TZ03-Paul TZ07- Hanford FG18- W. of McNan (BA05-BPA) **S33** TS34 UT08-Milton-Freewater FG05-FG11-W. Paul ST12- Teton-ST14-DA& Allston Palisades ST13- Loop ST05-Reata ST09- Milton- Freewater Energy Power Microgrid (UT05- Benton PUD) of John Managemen Interconnect (UT11- Idaho (UT11- Idaha (UT10- Lower TZ04- Allston Falls Power Falls Power Valley) Allston FG12-E. of John Day Keeler Transactive Contro(ITC) Node FG07-S Cascades **EIOC TC Nodes** TZ05- Western OR TZ08- OR Cascade TZ12- Central Oregon TS09 FG14-W. of Slatt TIS/ TFS Path(FGxx or TSxx ST03- Salem FG13 TZ- Transmission Zone (BA03- Portland General FG15- Harney and Midpoint (UT03-PGE) BA- Balancing Authority TZ09- Southcentral O UT- Utility(of Subproject ST- Site(of Subproject FG- Flowgate East COI

Generic Transactive Control Node



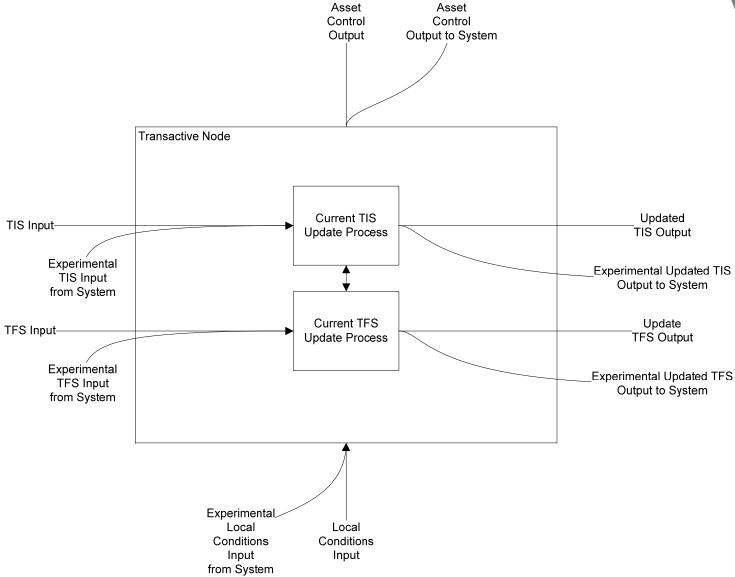


Generic Transactive Control Node +

Responsive

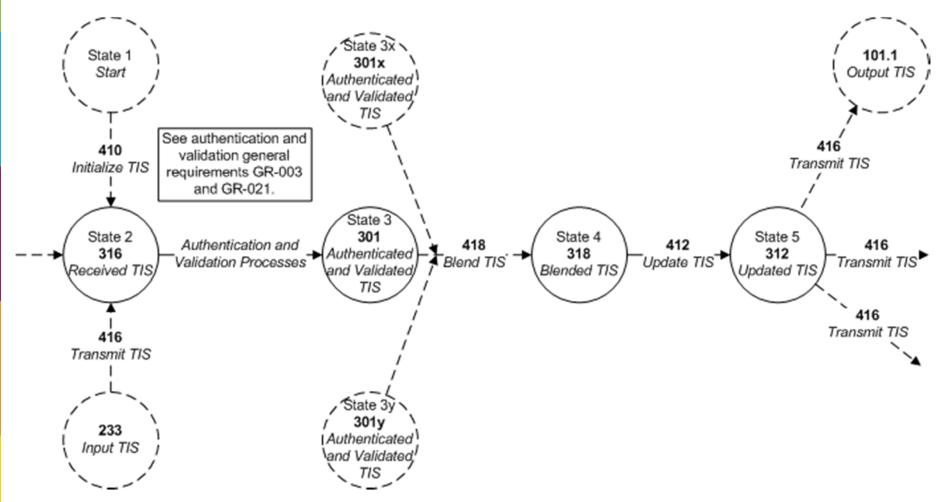
Experimental





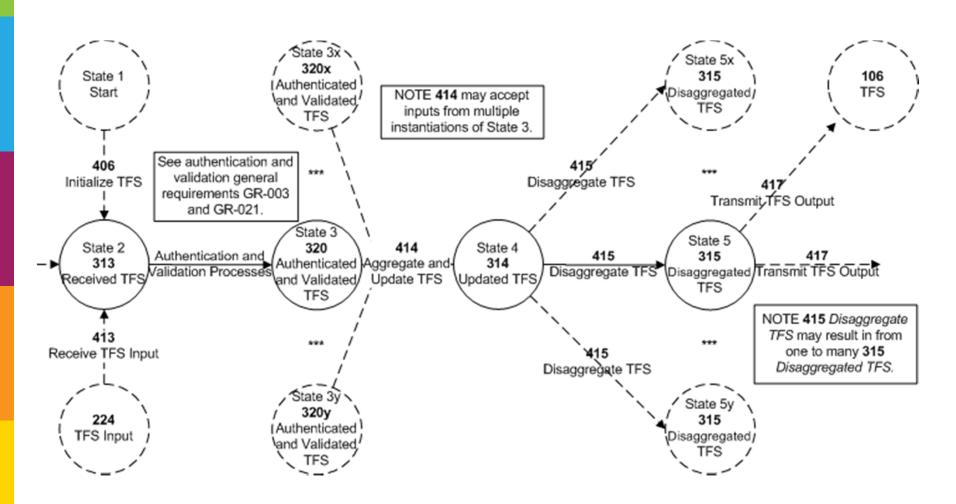






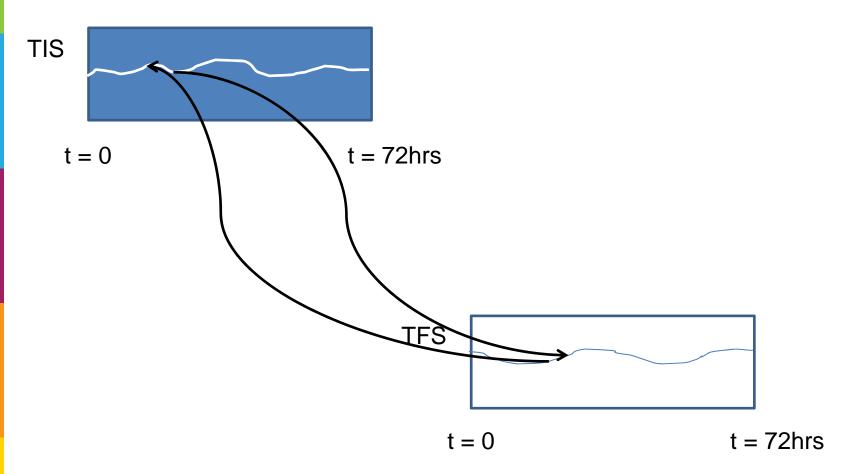






Pacific Northwest SMART GRID DEMONSTRATION PROJECT

TIS / TFS Interaction







- Approximately 40 TC test cases in project
- Examples include:
 - Voltage optimization
 - Load control commercial
 - Load control residential
 - Storage system control
 - Automated demand response
 - PHEV charging control





- Easy to say, difficult to do: apply the KISS principle
- The grid as a network
 - Bulk power nodes form a mesh
 - Distribution system nodes generally more hierarchical
 - How do we assure that a sudden change in bulk power is communicated to responsive assets in a timely manner?
- Cyber security
 - Signal integrity
 - System integrity, e.g., how to handle missing data, nodes that cease to operate, etc.



Questions and Discussion

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