Grid-Interop™

Transactive Control of Distributed Energy Resources

Ron Melton & Don Hammerstrom
Pacific Northwest Smart Grid Demonstration
Battelle, Pacific Northwest Division

PNNL-SA-84354

Pacific Northwest Demonstration Project

What:

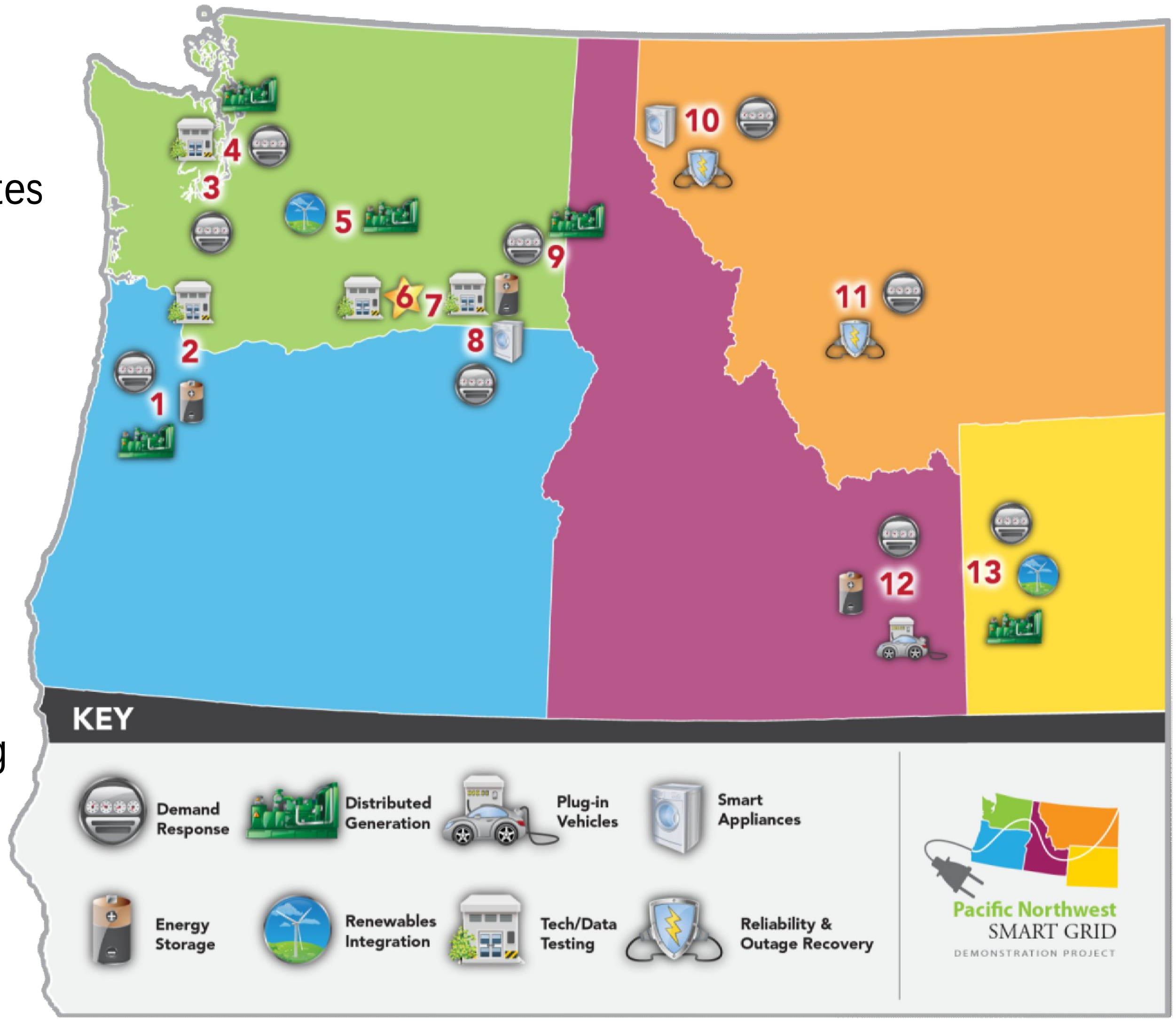
- $178M, ARRA-funded, 5-year demonstration
- 60,000 metered customers in 5 states

Why:

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

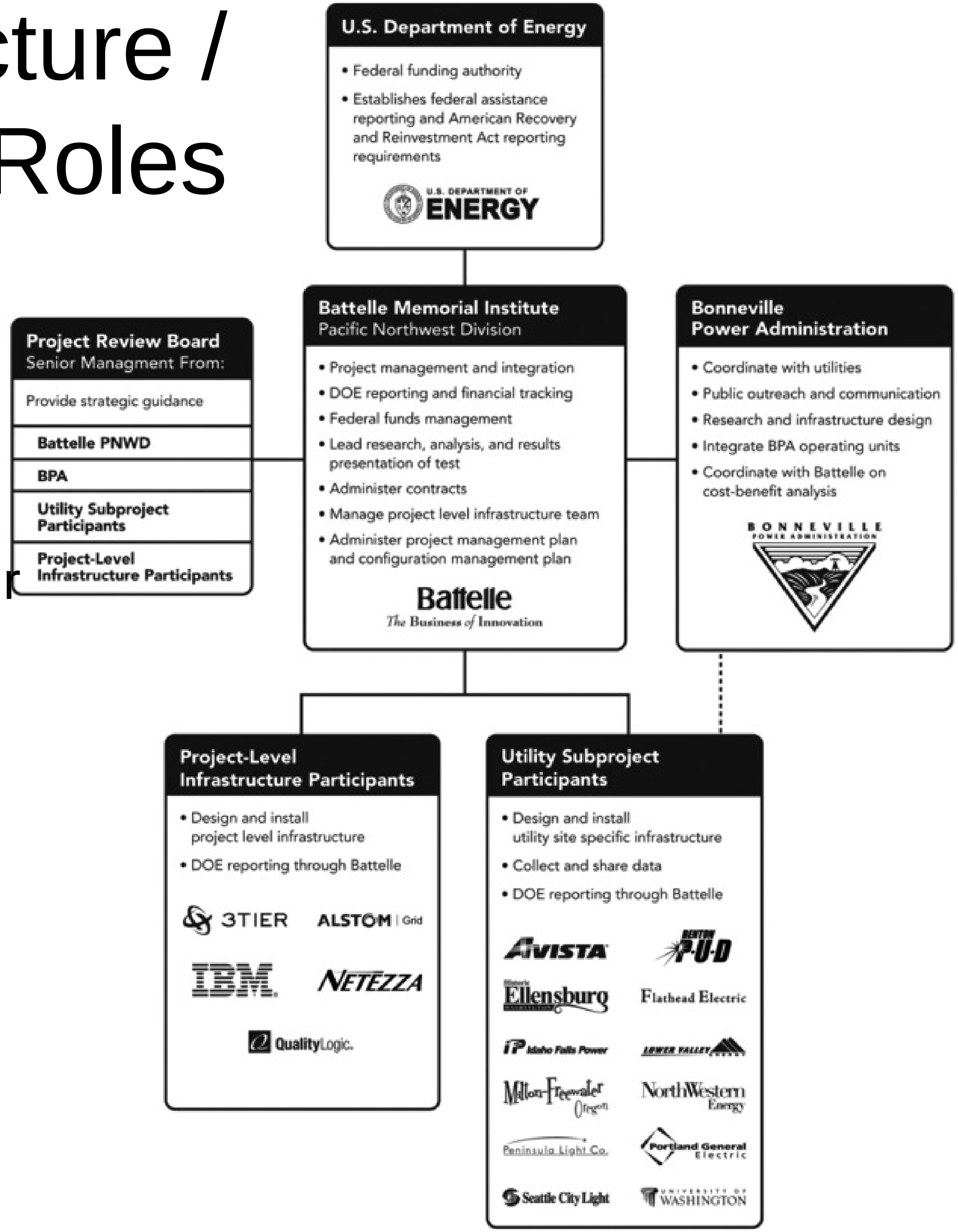
Who:

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



Project Structure / Roles

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



Demonstration Project Timeline

Phase Description	2010	2011	2012	2013	2014	2015
Phase 1 - Concept Design and Baseline Functionality	8 months (2/10 - 9/10)					
Phase 2 - Detailed Design; Subproject and Project-level Infrastructure Installation, Testing, and Implementation; and Test Case Design		23 months (10/10 - 8/12)				
Phase 3 - Test Case Execution, Data Collection and Analysis, and Enhanced Releases				24 months (9/12 - 8/14)		
Phase 4 - Cost-Benefit Analysis Reporting and Project Closeout					8 months (6/14 - 1/15)	

November 2011

- Complete contracts
- Design "system of systems" to connect subprojects to EIOC

- Install equipment at subproject
- Build 'system of systems'

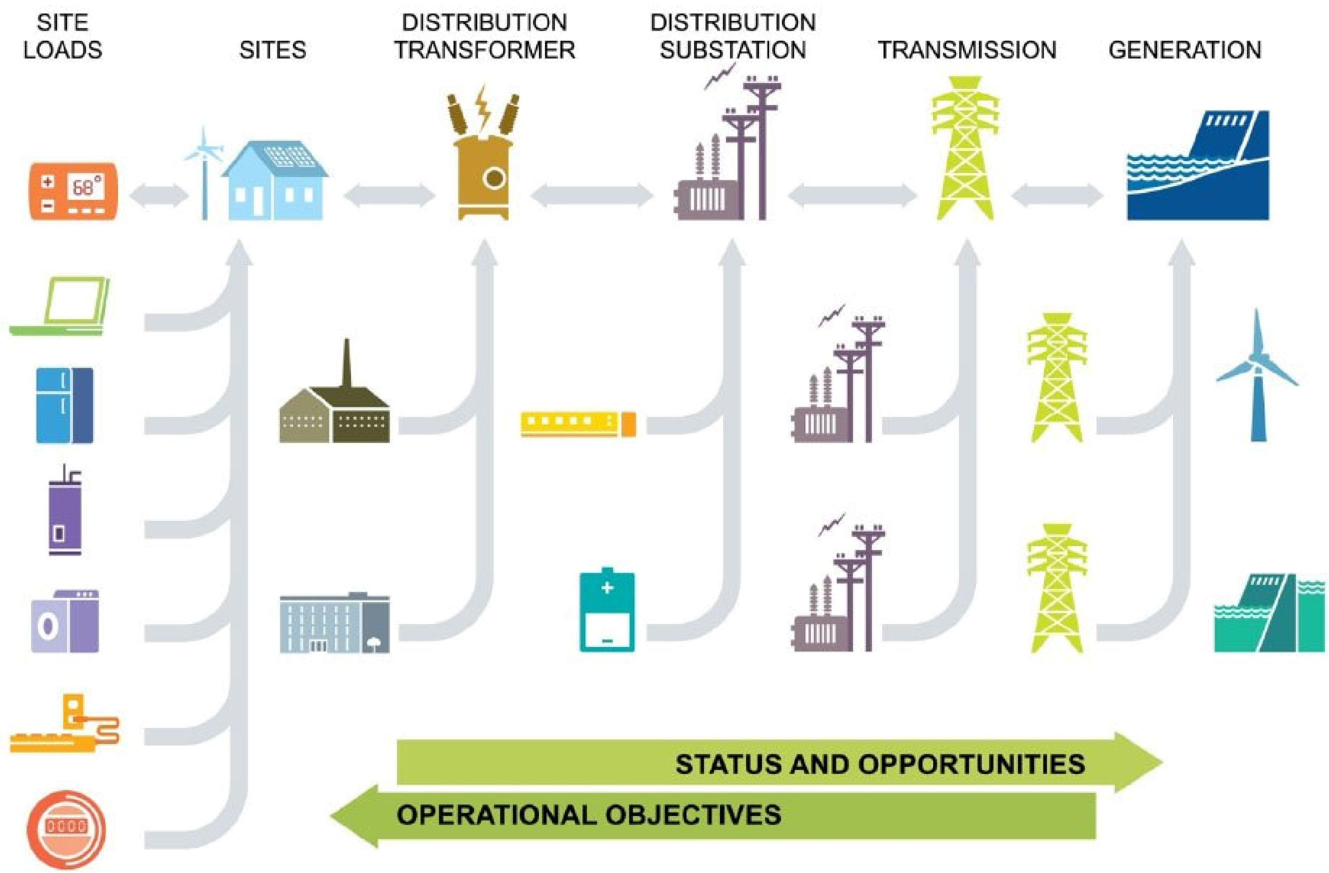
- Sites up and running
- Gather two years of data
- Perform data analysis

- Finalize cost/benefit
- Draft transition plan

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 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 at a specific system location (e.g., at a transactive node). Includes both the current value and a forecast of future values.

Role of a Transactive Node

- Respond to system conditions as represented by incoming Transactive Incentive Signals and Transactive Feedback Signals through
  - Decisions about behavior of local assets
  - Incorporation of local asset and other information
  - Updating both transactive incentive and feedback signals

- Inputs are needed from node-owners to calculate incentive and feedback signals
- Each signal is a sequence of forecasts for a time-series, so inputs will also be sequences of future (forecast/planned) values

Demonstration IST series definition

Table 1. Recommended Interval Time Series for use with *TIS* and *TFS*

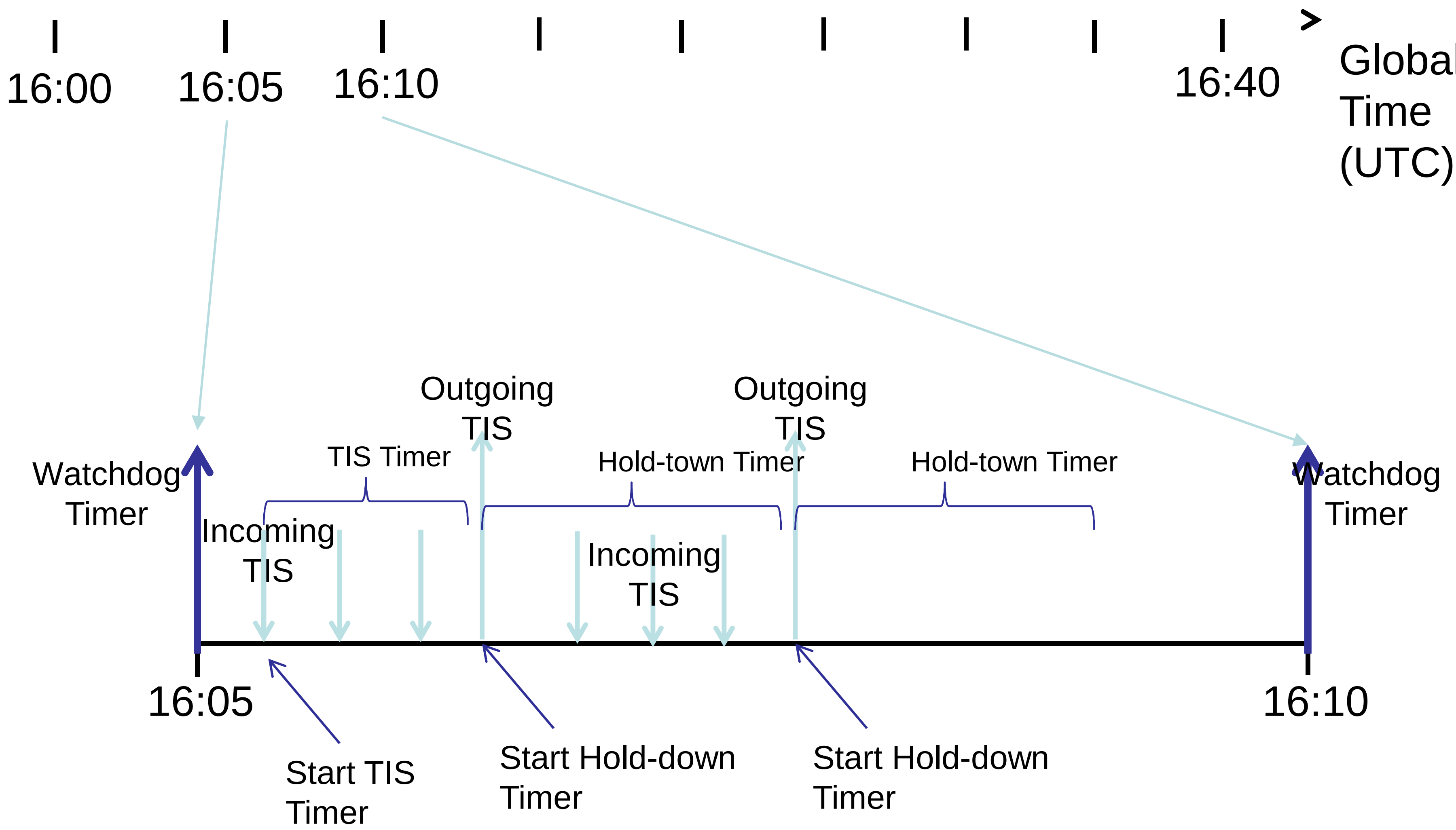
Duration	No. Intervals	Interval Start Times
5 minutes	12	IST_0, IST_0 + 0:05, ..., IST_{10} + 0:05
15 minutes	20	Round(IST_{11} + 0:15)*, IST_{12} + 0:15, ..., IST_{30} + 0:15
1 hour	18	Round(IST_{31} + 1:00)*, IST_{32} + 1:00, ..., IST_{48} + 1:00
6 hours	4	Round(IST_{49} + 6:00)*, IST_{50} + 6:00, ..., IST_{52} + 6:00
1 day	2	Round(IST_{53} + 1:00:00)*, IST_{54} + 1:00:00, IST_{55} + 1:00:00
> 3 days	56 intervals	57 interval start times (IST)

* This function "Round" indicates rounding down to the next 15-minute, 1-hour, 6-hour, or 1-day interval start time. Times are indicated as dd:hh:mm, i.e., days, hours, and minutes.

Extracted from Interval Start Time Series Definition, Version 1.1

Pacific Northwest SMART GRID DEMONSTRATION PROJECT

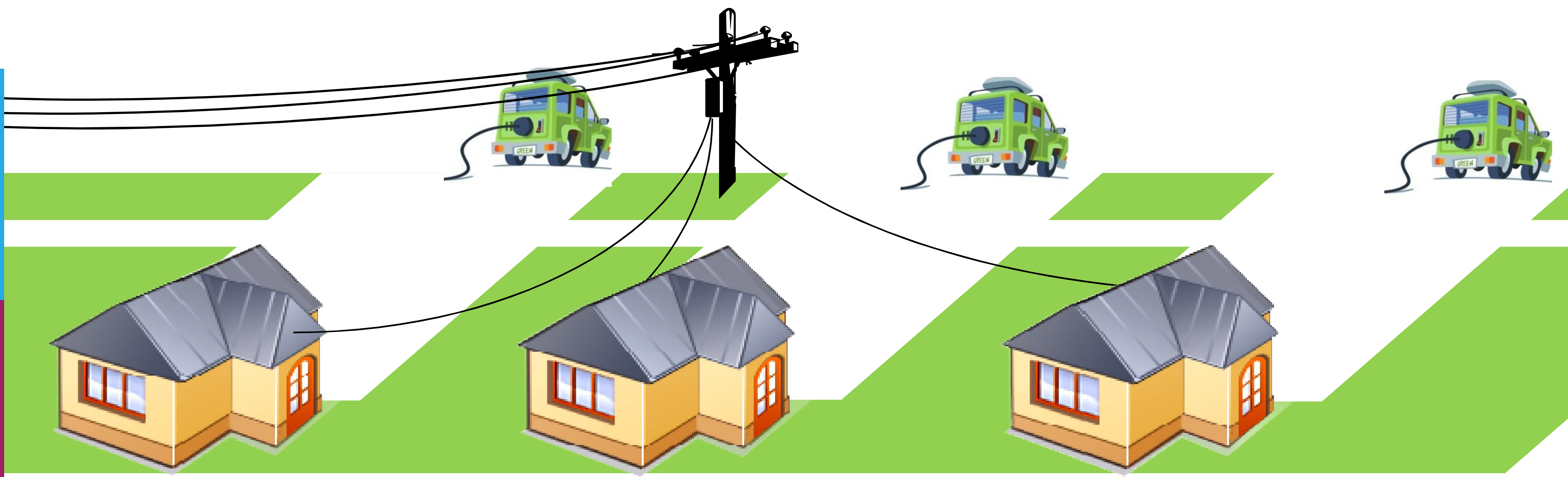
Transactive Incentive and Feedback Signal Timing

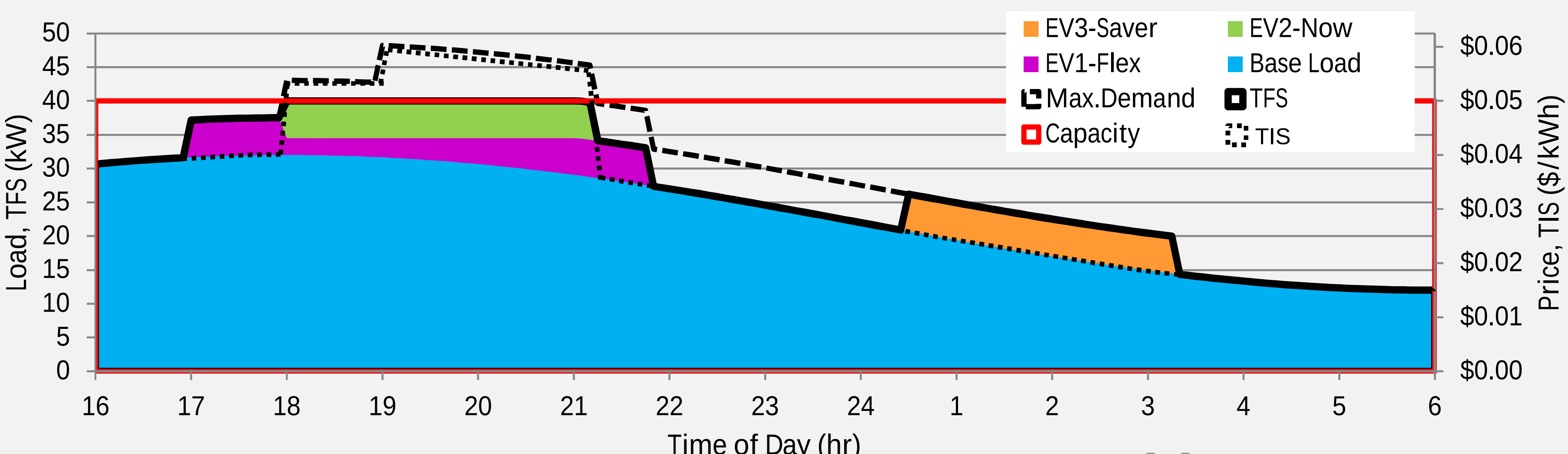


Simple Example – Local EV Charging

- Imagine the following situation:
  - Three neighbors with electric vehicles
  - All three fed by same distribution transformer
  - All three come home and want to do a fast charge at the same time!
- Problem – transformer is overloaded if all three fast charge at the same time
- Transactive control solution –
  - Transformer sees in feedback signal that all three plan to fast charge
  - Transformer raises value of incentive signal during planned charging time to reflect decreased transformer life
  - Smart chargers and transformer “negotiate” through TIS and TFS till an acceptable solution is found

Transactive Control – An Illustration





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Questions?

Ron Melton, Project Director
ron.melton@battelle.org
509-372-6777

Don Hammerstrom, Principal Investigator
donald.hammerstrom@battelle.org
509-372-4087

Project website: www.pnwsmartgrid.org