



Appendix A

Technical Documents Generated by the Pacific Northwest Smart Grid Demonstration

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The following annotated list presents technical design documentation of the Pacific Northwest Smart Grid Demonstration (PNWSGD) transactive system that was developed during the project. Documents that are unpublished have a footnote with author information. Battelle Memorial Institute or the listed authoring organization must be contacted if the reader requires access to unpublished documentation.

Transactive Node Framework and Toolkit Library Functions¹ – functional specification of a transactive node’s computational framework. Includes a most general functional specification of toolkit functions and how they are integrated into this framework.

ALSTOM Toolkit Functional Description, Version 0.3² – as-built description of inputs requirements, available inputs, data assumptions, schedule formulation, operating limits, and modeling of the DC intertie by Alstom Grid’s informed simulation that emulated the behaviors (transmission power flow, monetization of energy resources, and incentives) in the PNWSGD transmission region.

Transactive Coordination Signals (Battelle Memorial Institute 2013) – PNWSGD report and deliverable to the U.S. Department of Energy that explains important features of the project’s transactive system. Two classes of transactive signals, the two types of system node sites in the project, signal timing, toolkit functions, and the nature of the system’s predictive time domain are all explained. Skeleton models of the transactive node object are presented and explained.

Smart Grid Project-Level Infrastructure: Functional Requirements Specification, Level 1, Version 1.0³ (unpublished) – specification of the transactive system that was produced through the project participants’ collaboration and using the system requirements and process modeling methodology (WISDM) process that was developed by H Blair Burner (WISDM Corporation 2003). This document includes the project’s justification for its mapping of transmission zones, an early interconnectivity map showing the initial connections between system nodes, and the functional requirement specifications for many system objects.

¹ DJ Hammerstrom. 2011. *Pacific Northwest Smart Grid Demonstration: Transactive Node Framework and Toolkit Library Functions, Version 1.0*. Unpublished specification, Battelle Memorial Institute, Pacific Northwest Division, Richland, Washington, March 3, 2012.

² Alstom Grid. 2014. *PNWSGD ALSTOM Toolkit Functional Description, Version 0.3*. Alstom Grid, 10865 Willows Road NE, Redmond, Washington 98033, September 9, 2014, unpublished.

³ Battelle Memorial Institute. 2014. *Smart Grid Project-Level Infrastructure: Functional Requirements Specification, Level 1, Version 1.0*. Unpublished specification, Battelle Memorial Institute, Pacific Northwest Division, Richland, Washington 99352, March 26, 2014.

Regional and Subproject Transactive Control Nodes and Network Topology, Version 1.2¹ – definitive map of transactive system nodes and their interconnectivity.

3TIER As-Built Documentation² – documents 3TIER wind data and data feeds that were made available to the project concerning predicted and actual wind generation in the region.

Design/As-Built Documentation BPA Data Feed for the Transactive Coordination System (TCS) of the Pacific Northwest Smart Grid Demonstration (PNWSGD) Project, Version 1.0³ – detailed descriptions of data that were made available to the project by Bonneville Power Administration (BPA). The data includes exemplary NETMOM (Alstom data set) files, up to 10 other files in csv format, and the data processes by which the data was securely made available to Alstom Grid for the purposes of the operating the transmission zones of the project’s transactive system. These files facilitated the project’s tracking of system load and resource scheduling.

PNW Certification Authority Design Document, Version 1.2⁴ – provides the design for the setup and operation of a common X509 Certification Authority for the trial period of the PNWSGD project.

Pacific Northwest Smart Grid Demonstration Project: Conceptual Design, Revision 1 (Hammerstrom 2010) – early conceptual design that guided development of the transactive system.

Pacific Northwest Smart Grid Demonstration Project: Interoperability and Cyber Security Plan, Revision 3 (Battelle 2011) – presents the interoperability and cyber security plan for the PNWSGD project. The interoperability and cyber security aspects of the demonstration are addressed in three areas: interoperability and cyber security of the project-level infrastructure, interoperability and cyber security of the utility subproject participants, and cyber security of the project collaboration environment and documents.

PNWSGD Project: Implementation Design of Transactive Node, Version 2.3¹ – includes system definitions at a level needed for runtime system design.

¹ M Yao. 2014. *Regional and Subproject Transactive Control Nodes and Network Topology, Version 1.2*. Unpublished design document, International Business Machines Corporation, TJ Watson Research Center, Yorktown Heights, New York 10598, 2014.

² A Vandervoort. 2013. *Design/As-Built Documentation, 3TIER System, Version 1.0*. Unpublished document, 3TIER, Inc., 2001 6th Avenue, Suite 2100, Seattle, Washington 98121, June 14, 2013.

³ Bonneville Power Administration (BPA). 2014. *Design/As-Built Documentation BPA Data Feed for the Transactive Coordination System (TCS) of the Pacific Northwest Smart Grid Demonstration (PNWSGD) Project, Version 1.0*. Unpublished document, Bonneville Power Administration, Portland, Oregon, 97218, 2015.

⁴ M Steiner. 2011. *PNW Certification Authority Design Document, Version 1.2*. Unpublished specification, International Business Machines Corporation, TJ Watson Research Center, Yorktown Heights, New York 10598, September 8, 2011.

Pacific Northwest Smart Grid Demonstration: Transactive Control System Data Collection, Version 1.1² – identifies five data buffers that should be maintained at system nodes and defines their contents that must be collected to conduct the analysis of the PNSGD.

PNW Smart Grid Demonstration Project: Conformance Test Specification, Version 2.7³ – documented conformance tests for project node software implementations.

PNW Smart Grid Demonstration Project: Interoperability Test Specification, Version 1.1⁴ – describes the methodology used for interoperability testing of nodes within the PNSGD project.

Pacific Northwest Smart Grid Demonstration: InfoSphere Streams Subsystem Integration Design Specification, Version 3.0⁵ – covers the usage of IBM’s product InfoSphere Streams within Release Cycle 1 of the PNWSGD. In particular, the current plan is for the use of Streams version 1.2.0.1.

Pacific Northwest Smart Grid Demonstration: InfoSphere Streams System Test Plan, Version 2.0⁶ – plan for system testing what will be the implementation of the design described in the PNWSGD InfoSphere Streams Subsystem Integration Design Specification. This document is a system test plan for the usage of IBM’s InfoSphere Streams version 1.2.0.1 product within Release Cycle 1 of the PNWSGD project.

Pacific Northwest Smart Grid Demonstration: InfoSphere Streams Unit Test Plan⁷ – plan for unit testing what was the implementation of the design described in the Pacific Northwest Smart Grid

¹ M Yao. 2012. *PNWSG Project: Implementation Design of Transactive Node, Version 2.3*. Unpublished design document, International Business Machines Corporation, TJ Watson Research Center, Yorktown Heights, New York 10598, May 2, 2012.

² DJ Hammerstrom. 2011. *Pacific Northwest Smart Grid Demonstration: Transactive Control System Data Collection, Version 1.1*. Unpublished specification, Battelle Memorial Institute, Pacific Northwest Division, Richland, Washington 99352, December 20, 2011.

³ L Rankin and G Cooper. 2011. *PNW Smart Grid Demonstration Project: Conformance Test Specification, Version 2.7*. Unpublished specification, QualityLogic, Inc., 5401 Tech Circle, Moorpark, California 93021.

⁴ G Cooper, S Kang, L Rankin. 2011. *PNW Smart Grid Demonstration Project: Interoperability Test Specification, Version 1.1*. Unpublished specification, QualityLogic, Inc., 5401 Tech Circle, Moorpark, California 93021.

⁵ MA Cohen. 2011. *Pacific Northwest Smart Grid Demonstration: InfoSphere Streams Subsystem Integration Design Specification, Version 3.0*. Unpublished design specification, International Business Machines Corporation, TJ Watson Research Center, Yorktown Heights, New York 10598, April 28, 2011.

⁶ MA Cohen. 2011. *Pacific Northwest Smart Grid Demonstration: InfoSphere Streams System Test Plan, Version 2.0*. Unpublished test plan, International Business Machines Corporation, TJ Watson Research Center, Yorktown Heights, New York 10598, April 28, 2011.

⁷ MA Cohen. 2011. *Pacific Northwest Smart Grid Demonstration: InfoSphere Streams Unit Test Plan*. Unpublished test plan, International Business Machines Corporation, TJ Watson Research Center, Yorktown Heights, New York 10598, October 11, 2011.

Demonstration Release Cycle 2 Real-Time Data Collection Management Design Specification. This document is a unit test plan for the usage of the data mediation from the Data Collection System to the Netezza data warehouse via IBM's InfoSphere Streams version 2.0 product within Release Cycle 2 of the PNWSGD project.

PNW Smart Grid Project Name Spaces, Revision 2¹ – sub-document of the subsystem specification that was maintained separately to better facilitate any change in software object name spaces.

Pacific Northwest Demonstration Project: Test Plan and Requirements, Version 1.0² – describes the plan, strategy and methods used for functional conformance and interoperability testing of transactive nodes that are the fundamental building blocks used in a hierarchical transactive control system. Based on this strategy, requirements such as software or system management capabilities are described.

Pacific Northwest Smart Grid Demonstration Project: Subproject Implementation User's Guide, Version 0.9³ – user's guide for project sites intending to implement an instantiation of one of the project's transactive nodes. Includes pointers to a reference node implementation, signal schema, system state model, and toolkit functions. Describes required conformance testing.

Toolkit Function Implementation User Guide, Version 0.11⁴ – provides major updates to three groups of toolkit functions for system implementers.

Resource or Incentive Toolkit Function 2.1: Wind Energy⁵ – as-built specification of how wind energy and its monetization were included in the PNWSGD transactive system.

Resource or Incentive Toolkit Function 2.3: Hydropower¹ – as-built specification of how hydropower energy and its monetization were included in the PNWSGD transactive system.

¹ A Webb. 2010. *PNW Smart Grid Project Name Spaces, Revision 2*. Unpublished specification, International Business Machines Corporation, TJ Watson Research Center, Yorktown Heights, New York 10598, December 2, 2010.

² G Cooper, S Kang, and L Rankin. 2011. *Pacific Northwest Demonstration Project: Test Plan and Requirements, Version 1.0*. Unpublished test plan, QualityLogic, Inc., 5401 Tech Circle, Moorpark, California 93021.

³ L Connell. 2012. *Pacific Northwest Smart Grid Demonstration Project: Subproject Implementation User's Guide, Version 0.9*. Unpublished user guide, Battelle Memorial Institute, Pacific Northwest Division, Richland, Washington 99352, November 11, 2012.

⁴ Battelle Memorial Institute (Battelle). 2013. *Toolkit Function Implementation User Guide, Version 0.11*. Unpublished user guide, Battelle Memorial Institute, Pacific Northwest Division, Richland, Washington 99352, October 20, 2013.

⁵ Battelle Memorial Institute (Battelle). 2014. *Resource or Incentive Toolkit Function 2.1: Wind Energy, Version 0.7*. Unpublished design specification of the Pacific Northwest Smart Grid Demonstration, Battelle Memorial Institute, Pacific Northwest Division, Richland, Washington 99352, April 9, 2014.

Resource or Incentive Toolkit Function 3.0: Fossil Generation² – as-built specification of how thermal energy and its monetization were included in the PNWSGD transactive system.

Resource or Incentive Toolkit Function 4.0: General Infrastructure Cost³ – as-built specification of how the costs of infrastructure were included in the PNWSGD transactive system.

Resource or Incentive Toolkit Function 5.1: Transmission Flowgate⁴ – specification of how the cost impacts of transmission load at flowgates were formulated for the PNWSGD transactive system. This toolkit function was never successfully deployed due to its unstable behaviors.

¹ Battelle Memorial Institute (Battelle). 2014. *Resource or Incentive Toolkit Function 2.3: Hydropower, Version 0.7*. Unpublished design specification of the Pacific Northwest Smart Grid Demonstration, Battelle Memorial Institute, Pacific Northwest Division, Richland, Washington 99352, April 1, 2014.

² Battelle Memorial Institute (Battelle). 2014. *Resource or Incentive Toolkit Function 3.0: Fossil Generation, Version 0.4*. Unpublished design specification of the Pacific Northwest Smart Grid Demonstration, Battelle Memorial Institute, Pacific Northwest Division, Richland, Washington 99352, April 3, 2014.

³ Battelle Memorial Institute (Battelle). 2014. *Resource or Incentive Toolkit Function 4.0: General Infrastructure Cost, Version 1.4*. Unpublished design specification of the Pacific Northwest Smart Grid Demonstration, Battelle Memorial Institute, Pacific Northwest Division, Richland, Washington 99352, April 2014.

⁴ Battelle Memorial Institute (Battelle). 2014. *Resource or Incentive Toolkit Function 5.1: Transmission Flowgate, Version 0.3*. Unpublished design specification of the Pacific Northwest Smart Grid Demonstration, Battelle Memorial Institute, Pacific Northwest Division, Richland, Washington 99352, April 4, 2014.