1.3.09 Smart Reconfiguration of Idaho Falls Power Distribution Network for Enhanced Quality of Service_FY18_Q2
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Project Start Date: *06/30/2016*
Project End Date: *12/31/2017*

1. Project Description

This proposal describes an 18-month effort (FY 16 – FY 17) that addresses core activities in the area of Pioneer Regional Partnerships. The principal goal of this activity is to accelerate grid modernization by providing technical assistance to northwestern states in the United States, utilities, and other stakeholders that are facing key emerging grid modernization challenges. The northwestern United States is rich in hydroelectric power generation, which primarily serves loads in a large geographical region that includes the states of Idaho, Washington, Oregon, and Montana. This proposed project - North Western Smart Reconfiguration and Protection System (NWSRPS) aims to demonstrate the use of such methods for enhancing the quality of power service for the Idaho Falls Power (IFP) distribution network, which is located in Idaho Falls.
Electromagnetic transient analysis tools like Digital Real-Time Simulation (DRTS) will be used to develop the Idaho Falls Power (IFP) utility model, to investigate and develop the reconfiguration algorithms and testing protection systems. DRTS is the chosen platform for this project because it offers following advantages–

hardware-in-the-loop (HIL) testing can be performed using DRTS, which is useful for fine-tune protection system settings and calibration of relays, breakers and switches. This capability of DRTS can be used to compare existing power system integrity protection (SIP) schemes with newly developed protection schemes.

DRTS provides the most accurate means of simulating and understanding the impacts of power system electromagnetic transients on the grid components, and the overall grid since it uses 50 microsecond time step for its computations.

Modeling, testing and validation done using DRTS can be easily adopted by mathematical machine dynamic models used by other utilities as more accurately validated models.

The methods developed under this project will be adoptable for other similar utilities in the northwestern states in the United States (or elsewhere) that have high hydro energy *resources and harsh winter weather. The protection and reconfiguration algorithms* *developed in this work can be universally adopted by other utilities with high confidence because they have been validated on a real power distribution network (IFP). The project will leverage ongoing Fuel-Cell Technology Office sponsored research on dynamic validation of hydrogen refueling station (electrolyzers) for ancillary grid services to investigate its applicability and potential benefits in IFP distribution systems (or other similar utilities) for providing energy storage or load curtailment.*

2. Total Planned Funding (for entire project)

	Funding Planned by Fiscal Year			
Entity	**FY16**	**FY17**	**FY18**	**Total**
INL	$600,000.00	$150,000.00	$0.00	$750,000.00
PNNL	$170,000.00	$80,000.00	$0.00	$250,000.00

3. Summary of Activities in This Quarter by Task and Lead Lab(s) per Task (Accomplishments/Highlights, worthy of comms)

The main activities in this quarter were collection of data from microPMUs in IFP grid. The data collected was extracted for the tests conducted in IFP on Dec 5th and 5th 2017. Currently the data is being used in RTDS for tuning governor controls.

Relay programming is under progress at INL. SEL RTAC controller communication settings are in progress and will be sent to SEL in this quarter for demonstration.

WSU has worked on including communication aspects in resiliency metrics.

PNNL has worked in developing a new approach for mathematical treatment of reconfiguration.

Final deliverable for the project is laboratory demonstration of the real-time reconfiguration using RTDS at INL. This is scheduled to be completed in this quarter.

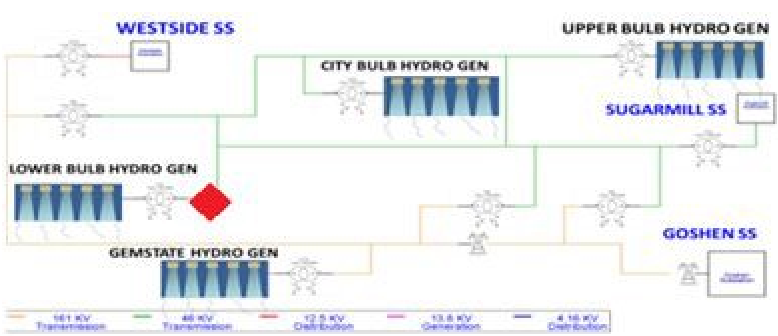

Figure 1: microPMU installation location on Idaho Falls Power regional distribution network

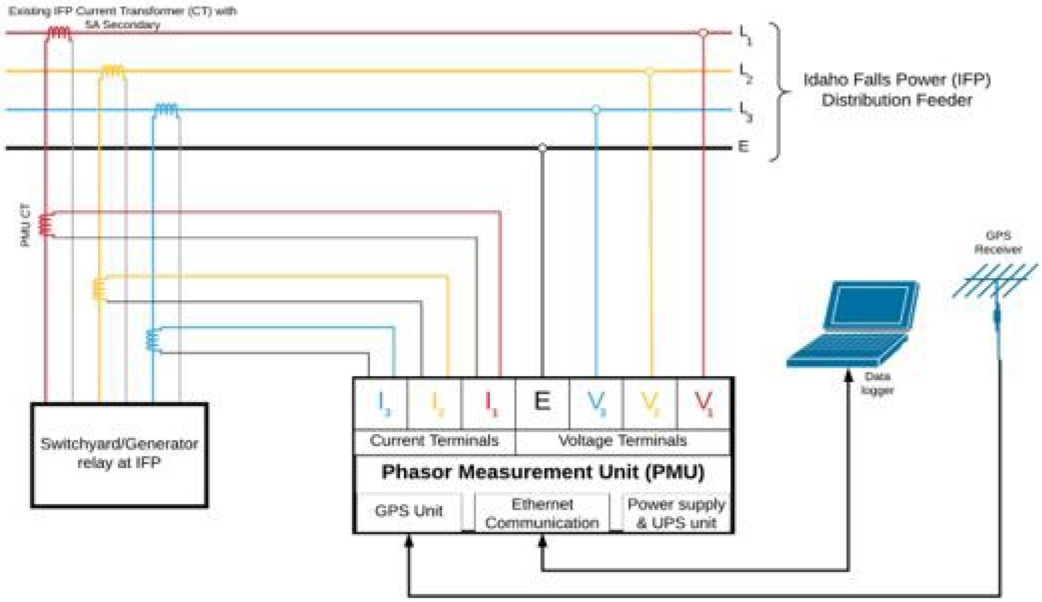

Figure 2: Three phase interconnection diagram for microPMUs at Idaho Falls Power.

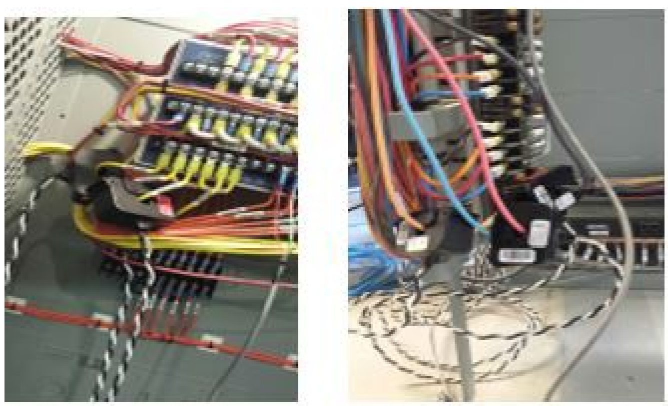

Figure 3: PMU CTs tapped from the CT secondary of generator and switchyard protection relay for recording current and voltage measurements.

Figure 4: microPMU with GPS synchronized timestamps installed at Generator substation at IFP

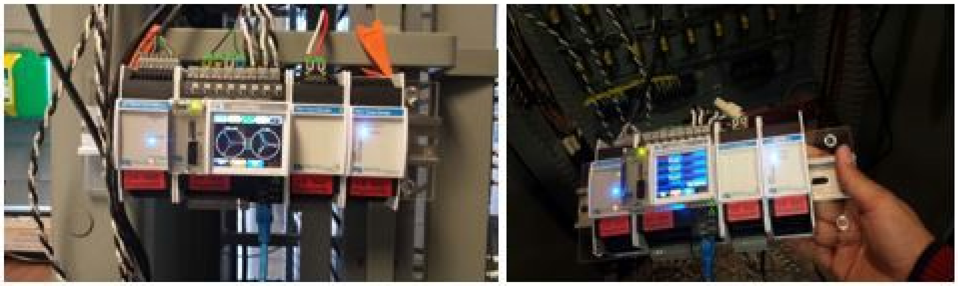

Figure 5: Current and Voltages in all three phases being displayed on the microPMU display

4. Summary of Issues and Concerns (Technical Approach, Interoperability, Cyber, Cost schedule, Risk)

Actual PMU data for events/faults were not available for transmission interconnections of Idaho Falls Power grid. No fault recorder data were also available at substations. So, with help from PNNL some realistic and synthetic data sets were developed using dynamic simulations at transmission level and imposing typical faults at transmission network close to IFP grid. The team will work with IFP and PNNL and try to obtain PMU data for other events from Rocky Mountain Power for transmission level equivalent modeling.

The technical challenge associated with the phase jumps in PMU signal generation (van de Pol problem) was identified and acknowledged by PNNL and a description is present in Section 1 of the Appendix.

To evaluate the reconfiguration and control algorithms on the Idaho Falls Power (IFP) system, information representing the larger transmission system must be provided to the Idaho Falls simulation. Two types of transmission-level data are being generated to assist with the evaluation: static loadflow data and dynamic simulation data. Both sets of data are based on a Western Electricity Coordinating Council (WECC) planning case for a particular grid configuration. For the simulations thus far, a “heavy summer 2018” case has been utilized, as it represents the most up-to-date planning model available. Other planning cases could be utilized, but the nature of the simulations thus far has not required the information specific to other operating conditions. This WECC model contains all of the generator information and a peak load condition for a summer month. The information contained in the model represents the level of detail needed to perform transmission-level planning studies on the western United States power grid. The static loadflow and dynamic simulation data are both generated using the GE/Concorda Positive Sequence Load Flow (PSLF) software package. The software is able to read in the model, allows for the manipulation for the two different types of model (detailed in the next subsections), and an export of the data into a more usable form. All WECC planning case models start as PSLF models, so PSLF represents the “most native” platform for generating transmission data for the IFP grid. More details about each data set are present in Section 2 of Appendix.

5. Milestone Schedule

Milestone Description	Schedule - Due date	Progress toward Completion	Completion date
Q1 (Apr-Jun 2016): 1. Data collection required for modeling from Idaho Falls Power and modeling the IFP grid and equivalent trasnmission interconnections2. Establish and capture the current baseline performance of IFP using known reliability metrics	6/30/2016	Data and information for the IFP grid has been provided by IFP staff. Completed 9/15/2016 PNNL has done preliminary work to generate data and run simulations for scenarios [due 11/25/16] PNNL has contacted IFP for obtaining transmission level PMU data from Rocky Mountain Power. Completed 9/30/2016INL is working closely with WSU to develop the baseline model for IFP grid. Later, a technical exchange meeting will be scheduled between INL, WSU, and SEL. SEL will be provided with the necessary information about the IFP grid. Enhancements over the baseline for smart reconfiguration will also be discussed.	9/30/2016
Q2 (Jul-Sep 2016): Validation of the IFP grid and equivalent transmission interconnections. Information and data for the optimal location of switches, PMUs, and DERs will be obtained.	9/30/2016	Realistic transmission grid PMU data at interconnections for event replay and validation is synthesized using dynamic simulations for typical events at transmission/sub-transmission level. Data and information about existing devices has been obtained.	12/31/2016
Q3 (Oct-Dec 2016):Identification of optimal locations for switches, PMUs, and DERs will be completed.	12/31/2016		12/31/2016
Q4 Annual (Jan-Mar 2017) Development and software simulation of reconfiguration and protection schemes will be completed. Comparison with existing baseline performance data using SAIDI, SAIFI indices	3/31/2017	06/30/17, Ongoing (expected September 2017)	6/30/2017

nnual Milestone/Tasks (Apr.'16-Mar.'17):Task1: Collecting all data needed for this project (i.e. the IFP existing grid, network parameters, transformer locations, existing switches and protection system, customer types, load profiles historical data, and previous outage scenario data and reliability metrics to establish a baseline in the next task.Task 2: Modeling and validation of IFP grid and equivalent transmission interconnections : Creating reduced-order real time models for Idaho Falls Power distribution grid. Establishing baseline for evaluating smart reconfiguration benefits.Task 3: Identifying optimal location for smart switches, PMUs, and DERs: Configuration assessment by evaluating distinct options to improve service reliability. Validation of the real time models for IFP using historical data and PMU data. Developing practical testing scenarios that require IFP smart reconfiguration to activate.	3/31/2017		3/31/2017
Annual Milestone/Tasks (Apr.'17-Dec.'17): Task 4.1: Development of reconfiguration schemes: Implementation of reconfiguration algorithms for achieving better quality of	12/31/2017	Interfacing of reconfiguration code with RTDS has been completed. An approach for microPMU placement in IFP distribution grid has been defined by PNNL, and will be	9/30/2017

serviceTask 4.2: Unit Testing HIL Unit testing for smart switches and controllers : Hardware-In-the-Loop Testing of SEL smart switches and controllers in the RT simulation environment Task 5: Development and testing of new protection schemes: Control schemes developed in real time and hardware implementation for testing. Integrated HIL testing of protection and control devices. Comparison of improved system performance with respect to established baseline in Y1. Benefit Analysis of hydrogen refueling station (electrolyzer) installation in IFP power distribution system.Task 6.1 Information Dissemination: Develop a technical report of the project which includes documentation of results, used algorithms, and expected performance improvements hydrogen refueling station (electrolyzer) installation benefit analysis with respect to baseline. Along with the technical report, research insights gained from this work will be published in leading journals and conference proceedings.		used to install microPMU in IFP grid in October 2017. Interfacing of protection relays and controller hardware obtained from SEL is under progress and testing is expected to be completed in November 2017 for HIL testing.(Ongoing expected December 2017)	

6. Spending Summary (Current FY)

1.3.9 FY18 Q2 Spending Summary							
Lab	FY17 Carryover	FY18 Funds Received	FYTD Funds Authorized	Q2 Spending	FYTD Spending	Committed	Balance Remaining
INL	$ 307,562	$ -	$ 307,562	$ 66,415	$ 199,488	$ -	$ 108,074
PNNL	$ 191,156	$ -	$ 191,156	$ 25,811	$ 43,318	$ -	$ 147,838

7. Products Developed

S/W interface models for power systems and reconfiguration algorithm.

8. Activities Planned for the Next Quarter (90 day look ahead)

Implement the smart reconfiguration scheme in distribution grid controller with protection relays, and distribution PMUs as hardware.

For performance improvement over the baseline, improvement will be measured using reliability metrics used by IFP and resiliency metrics developed by WSU.

9. Inter-project Relationships/Coordination

Coordination with GMLC 1.2.3 and 1.4.2 to contribute towards open library development and developing distributed energy resource standards.

Coordination will be established in next quarter with GMLC 1.4.10 and 1.4.15 for results from device testing activities with smart switches, advanced measurement-based protection and reconfiguration schemes with HIL and real-world transmission, distribution and communication issues for further investigation and improvement.

Communication layer development using NS3 for emulating realistic scenarios of latency, communication failures, and effects on smart reconfiguration etc.

Inter-project relationship also exists with two other INL projects from Fuel Cell Technologies Office (Dynamic modeling and validation of an electrolyzer in a real-time simulation environment), and Water Power Technologies Office (Hybrid energy storage for ROR hydroelectric power generation) for feasibility of Hydrogen refueling stations and operation of small hydroelectric generation in distribution grids. This coordination will be developed through information and data exchange in future stages of this project.

Additional project success worth reporting:

Based on the progress and reports from GMLC 1.3.9 project, SunValley Institute for Resilience (SVI) in Idaho approached INL and expressed interest for starting a project to improve the distribution grid and energy system resiliency for Blaine County, ID. A meeting was held on December 16, 2016 including representatives from INL, SVI, Idaho Power Company (IPC), Blaine County Office, and City of Ketchum, ID. The real-time digital modeling and simulation capabilities at INL will be used for this future project. An NDA is in progress between IPC and INL.