Appendix

b) Battery CEF Application

Avista Utilities Consortium

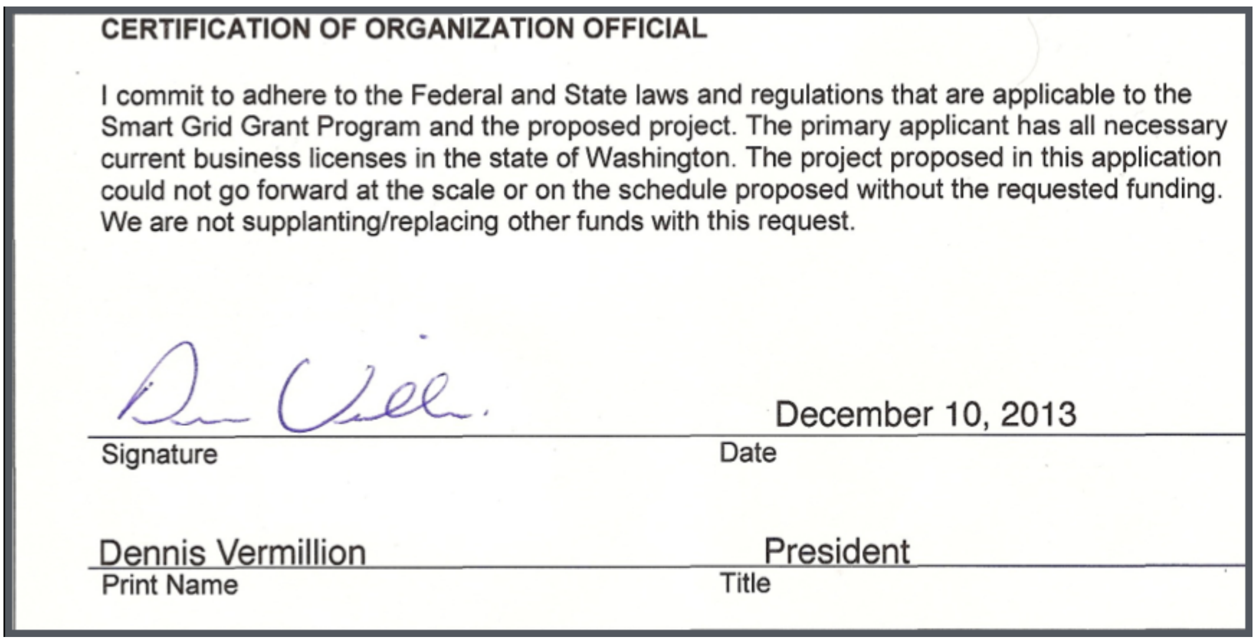
Proposal for:

Deployment and Evaluation of Energy Storage Integrated into the Pullman Smart Grid Community

Respectfully Submitted: December 11, 2013
By Avista Utilities

Contents

Signed Certification



CERTIFICATION OF ORGANIZATION OFFICIAL

I commit to adhere to the Federal and State laws and regulations that are applicable to the Smart Grid Grant Program and the proposed project. The primary applicant has all necessary current business licenses in the state of Washington. The project proposed in this application could not go forward at the scale or on the schedule proposed without the requested funding. We are not supplanting/replacing other funds with this request.

Signature: ______ Date: December 10, 2013

Print Name: Dennis Vermillion Title: President

A. Project Eligibility

1. Avista Credentials as Proposal Submitter

Avista Utilities, an electric and gas utility, serves 600,000 retail electric and gas customers. The energy storage technology the consortium intends to use is a Vanadium Flow Battery, made in the State of Washington, by UniEnergy Technologies (UET), located in Mukilteo, WA and is based on patents developed by UET Pacific Northwest National Laboratory (PNNL). PNNL (Richland, WA) is also a member of the consortium providing battery operation (charge/discharge) modeling, business case development/evaluation, and value stream assessment. Washington State University (Pullman, WA) will assist PNNL with valuation and control system development as well as provide assets and measurements as required to manage the local peaks associated with WSU on the target substation and feeder. Other Washington based companies upon which the consortium will draw are Itron, (Spokane, WA) for voltage alarms on the local circuit; Schweitzer Engineering Laboratories (SEL) located in Pullman, WA for phasor measurements and protective relaying; and Alstom which supplies the Energy Management System (EMS) used by Avista System Operations and Power Supply.

Avista is a company known for innovation. The world's tallest dam, longest transmission line, first electric stove, first automated meter (Itron created by Avista employees) , award winning bio-mass power plant, and patented fuel cell technology at Reli-On are but a few of these innovations. The employees at Avista are empowered to think broadly and envision future needs and solutions.

Avista received 3 smart grid grants and successfully completed each as a part of the 2009, ARRA smart grid grant program. The first grant, a smart grid investment grant (SGIG), involved 59 feeders in Spokane, WA. The second, the SGDP (smart grid demonstration project), involved 13 feeders in Pullman, WA. The third grant funded a workforce training facility and curriculum for smart grid. In total, Avista invested approximately $38M with partner funding of $4M and Department of Energy (DOE) funding of $40M. In total, 1/3 of Avista electric customers are supplied by the project feeders.

The ARRA smart grid projects leveraged numerous technologies to provide enhanced reliability, increased efficiency, and a specific customer experience. Technologies deployed in Spokane consist of smart devices; voltage regulators, switches and capacitor banks connected by fiber and 802.11 Wi-Fi mesh networks and controlled by a centralized distribution management system (DMS). The DMS provides for automated Fault Detection Isolation and Restoration (FDIR) and Integrated Volt-Var Compensation (IVVC).

The Pullman project leverages the same assets as Spokane with many additional technologies for increased benefit. Smart fault indicators provide outage locating and lateral loading. Smart meters provide outage notification, customer service via status and remote connect/disconnect, and power quality monitoring/alarming for use as an IVVC calibration mechanism. Smart transformers were co-developed with Howard industries that measure internal/ambient temperatures, kW, kVAr, voltage, and loss of life. These transformers also include an 802.11 Wi-Fi router allowing for build-out of the 802.11 network. Operators at WSU can respond to Avista communicated transactive energy requests to shed load or provide generation in 5 asset tiers. Customer thermostats have been installed in residences of volunteer customers and can be adjusted for additional load shed. Customers can view usage via the thermostat which is tied to the smart meter via ZigBEE or via automated meter infrastructure (AMI).

The centralized DMS that controls the Spokane and Pullman assets can be run in full automatic or supervisory mode and is fully functional. This is an accomplishment of significant proportion, especially when considering the breadth of deployment across 1/3 of the customer base. Many of the assets in Pullman were leading edge technologies that presented challenges with functional capability, interoperability, and scalability, however the challenges were met and now the technology can be deployed anywhere it is deemed appropriate.

The experience Avista brings in technology assessment application and deployment is top tier. Additionally the consortium team members are also top tier in their respective expertise areas. PNNL has extensive experience in energy storage research including battery technology and our storage partner UET brings advanced battery technology, decades of energy storage and business experience among its management, and leverages patents granted to PNNL to provide a leading edge, safe, reliable, energy storage system. WSU has a world renowned power program and has as recently as this past year supplied loaned expertise to the Department of Energy.

2. Target Categories

Avista Utilities and the project consortium intend the proposed project to provide value in the categories with checkmarks below:

✓ ***Integrate intermittent renewable energy projects through energy storage and information technology (IT)***

The energy storage battery will leverage 802.11 wireless and fiber communications, a DMS, EMS, battery management system (BMS), battery control system (BCS) tied to the EMS and DMS, building management systems at WSU, and data feeds from various internal and external sources including renewable output curves and predicted solar or wind effectiveness, to optimally charge and discharge the battery system to best capture value from intermittent renewable energy resources such as solar and wind. Negative pricing scenarios are of great importance as are large fluctuations of supply.

✓ ***Demonstrate dispatch of energy storage resources from utility energy control centers***

The energy storage battery will be dispatched from the Avista distribution operations center as well as from the Avista bulk power operations center. Scheduling priority will be established and maintained while acknowledging constraints in an automated system. The battery system may be direct connected to AGC, but only when under system operations control. This dual dispatch capability is not common, in fact may not exist in the industry as of yet. Leveraging the battery for all benefit streams increases the business value.

Use thermal properties and electric load of buildings and/or district energy systems to store energy

✓ ***Improve reliability and reduce cost of intermittent or distributed energy resources***

The energy storage battery will allow Avista to lower local peak conditions, increasing reliability and energy efficiency as well as reducing the cost of intermittent or distributed resources. Local conditions and constraints are processed in real time with power flow calculations occurring every 30 seconds. Fluctuations in resource availability can be mitigated by the battery system during non-committed bulk power system periods.

3. Assets

The asset systems installed for this project have an expected asset life of 20+ years The battery system, the most expensive component, is rated for a 20 year life by our consortium partner UniEnergy Technologies (UET). Upgrades both in hardware and software are anticipated as a part of normal maintenance. The energy storage technology the consortium intends to use is a Vanadium Flow Battery (VFB), made in the State of Washington, by UET. The battery uses technology similar to fuel cells whereby a Vandium electrolyte is pumped through a series of plates and membranes to extract protons. UET's form of advanced VFB uses an electrolyte developed at PNNL with funding by the U.S. Department of Energy. The advances in the PNNL-developed electrolyte used by UET enable higher power and energy density, and much wider allowable operating temperature. These attributes translate to specific project efficiencies: smaller system footprint and higher efficiency. In addition, there is no chemical reaction so the possibility of thermal runaway is eliminated. Vanadium electrolyte is also environmentally safe and green, and will be recovered and recycled by UET at the storage system's end of life.

Most equipment required to connect the battery system to the distribution electric grid has a 40 year asset life. The labor required to design, construct, test and energize this system is considered to be a part of the initial capital asset investment, therefore all costs are considered applicable as a 20 year asset.

4. Matching Funds

The total cost of the project is $7.6M. A match of $3.8M is requested. An "in-kind" match of $2.08M has been identified by UET. A letter from the Department Energy supporting an "in-kind" match of $250,000 towards PNNL efforts is provided in Section G.

While the consortium is not asking for in-kind treatment of past costs, it should be noted that the investments made in the smart grid projects Avista has already completed provide a sophisticated and reliable infrastructure which is not prevalent in the utility industry.

5. Smart Grid Grant Request

The consortium is requesting a match of $3.8M with a total project cost of $7.6M. The breakdown of these costs and the funding source is as follows:

	Before Share	Avista	DOE	State	In-kind
Cost	**$7,500,000**	**$3,500,000**	**$250,000**	**$3,750,000**	**$2,193,200**

6. Statement of Need

Avista has a strong interest in the use of battery technology as a means for augmenting the current portfolio of supply assets in addition to local load management (distributed resources/loads on feeders). Validation of the potential benefits singularly and coincidentally is essential to deployment and expansion in future years. The project as specified is only possible as a result of the matching funds made available by the Department of Commerce grant opportunity. At full cost the project is not cost effective and would not be funded. Even with Department of Commerce funding the project does not meet normal Avista funding requirements of 6.58% rate of return.

Successful completion of this project and validation of the anticipated as well as discovered benefit streams would help drive market sales within Washington state as well as provide validation for the lucrative California market as most of the benefit stream is directly applicable. The project has been designed for expansion adjacent to the installation site.

B. Business Case Analysis

The consortium has developed a detailed business case analysis of the different "use cases" the project will implement, test, and analyze. The below table shows anticipated benefits by specific use case. Each benefit has been conservatively estimated so as to allow for benefits to be achieved for each use case in simultaneous, sequential, or exclusive operational modes.

Year	Avoided Cost Capacity $/kW-Yr	Avoided Cost Risk $/kW-Yr	Balancing Ancillary $/kW-Yr	CVR On-Peak $/kW-Yr	CVR Off-Peak $/kW-Yr	Ramping Flex Market $/kW-Yr	Negative Pricing $/kW-Yr	O&M Operations $/kW-Yr	Energy Energy $/kW-Yr	Energy Capacity $/kW-Yr	Energy Risk $/kW-Yr	Totals
2014	$ -00	$ -00	$ 15.18	$ 9.46	$ 15.43	$ -00	$ 6.60	$ 2.06	$ 10.34	$ -00	$ -00	$ 59,061.60
2015	$ -00	$ -00	$ 15.46	$ 9.64	$ 15.71	$ -00	$ 6.60	$ 2.09	$ 11.02	$ -00	$ -00	$ 60,517.98
2016	$ -00	$ -00	$ 15.74	$ 9.81	$ 16.00	$ 14.93	$ 13.87	$ 2.13	$ 11.30	$ -00	$ -00	$ 83,794.73
2017	$ -00	$ -00	$ 16.02	$ 9.99	$ 16.28	$ 15.20	$ 14.11	$ 2.17	$ 11.38	$ -00	$ -00	$ 85,161.94
2018	$ -00	$ -00	$ 16.32	$ 10.17	$ 16.58	$ 15.48	$ 14.37	$ 2.21	$ 12.06	$ -00	$ -00	$ 87,181.86
2019	$ -00	$ -00	$ 16.62	$ 10.36	$ 16.89	$ 15.76	$ 14.64	$ 2.25	$ 12.76	$ -00	$ -00	$ 89,273.54
2020	$ 122.10	$ 4.60	$ 16.91	$ 10.54	$ 17.19	$ 16.04	$ 14.90	$ 2.29	$ 13.78	$ 5.05	$ 0.19	$ 223,591.79
2021	$ 127.10	$ 4.80	$ 17.22	$ 10.73	$ 17.50	$ 16.33	$ 15.17	$ 2.33	$ 14.57	$ 5.26	$ 0.20	$ 231,207.99
2022	$ 132.30	$ 5.00	$ 17.52	$ 10.92	$ 17.81	$ 16.62	$ 15.44	$ 2.37	$ 15.35	$ 5.47	$ 0.20	$ 239,019.28
2023	$ 137.70	$ 5.20	$ 17.83	$ 11.11	$ 18.12	$ 16.91	$ 15.70	$ 2.42	$ 16.28	$ 5.69	$ 0.21	$ 247,182.55
2024	$ 143.30	$ 5.40	$ 18.13	$ 11.30	$ 18.43	$ 17.20	$ 15.97	$ 2.46	$ 16.51	$ 5.93	$ 0.22	$ 254,849.62
2025	$ 149.10	$ 5.60	$ 18.44	$ 11.50	$ 18.74	$ 17.49	$ 16.25	$ 2.50	$ 16.45	$ 6.17	$ 0.23	$ 262,473.36
2026	$ 155.20	$ 5.80	$ 18.76	$ 11.70	$ 19.07	$ 17.80	$ 16.53	$ 2.54	$ 17.35	$ 6.42	$ 0.24	$ 271,394.13
2027	$ 161.50	$ 6.10	$ 19.09	$ 11.90	$ 19.40	$ 18.11	$ 16.82	$ 2.59	$ 17.79	$ 6.68	$ 0.25	$ 280,230.07
13 Year Totals												$ 2,474,940.44
2028	$ 168.10	$ 6.30	$ 19.44	$ 12.11	$ 19.75	$ 18.44	$ 17.12	$ 2.63	$ 18.55	$ 6.95	$ 0.26	$ 289,653.94
2029	$ 174.90	$ 6.60	$ 19.79	$ 12.34	$ 20.11	$ 18.77	$ 17.43	$ 2.68	$ 19.31	$ 7.24	$ 0.27	$ 299,440.74
2030	$ 182.10	$ 6.80	$ 20.15	$ 12.56	$ 20.48	$ 19.11	$ 17.75	$ 2.73	$ 20.46	$ 7.53	$ 0.28	$ 309,942.62
2031	$ 189.50	$ 7.10	$ 20.51	$ 12.78	$ 20.84	$ 19.45	$ 18.06	$ 2.78	$ 21.02	$ 7.84	$ 0.29	$ 320,162.02
2032	$ 197.20	$ 7.40	$ 20.87	$ 13.01	$ 21.21	$ 19.79	$ 18.38	$ 2.83	$ 21.88	$ 8.16	$ 0.30	$ 331,023.45
2033	$ 205.20	$ 7.70	$ 21.24	$ 13.24	$ 21.59	$ 20.15	$ 18.71	$ 2.88	$ 22.32	$ 8.49	$ 0.32	$ 341,836.24
IRP 20 Year Totals												$ 4,366,999.45

Anticipated benefits of use cases

The "use cases" assessed and evaluated include the following:

- **Avoided cost capacity** is the avoided cost of capacity for a gas combustion turbine
- **Balancing, ancillary services** are necessary to support the transmission of electric power from seller to purchaser given the obligations of control areas (balancing authorities) and transmitting utilities within those control areas (balancing areas) to maintain reliable operations of the interconnected transmission system. Typically ancillary services are for load balancing, reactive power and voltage control, loss compensation, energy imbalance, scheduling and dispatch.
- **Enhanced CVR, both on-peak and off-peak** is possible as the energy storage provide a peak flattening service, while correcting power factor which keeps voltage sags from limiting CVR operation during peak periods. Off peak is also affected as voltage rises during low load periods.
- **Ramping, Flex Rate market** is a market currently in place in the State of California intended to provide value for solutions that can provide ramping during large swigs in supply or load. This market is anticipated to be available for Avista participation in 2016.
- **Negative pricing** occurs when there is an over abundance of supply in the power system. Typically larger generation assets must be backed down to allow for renewable to be received. This has created negative pricing in the market as generators desire to continue supply rather than shutdown assets. Negative pricing has been a reality for brief periods in 2010, 2011, and 2012.
- **O&M cost reductions** can be realized if larger generation assets can remain in base mode operation. Large swing in output cause wear and tear and ultimately premature failure of components.
- **Avoided cost energy** is the avoided cost of energy for a gas combustion turbine.

The anticipated utility return on investment, including the cost match, is a negative 2.99%. That stated, there are a number of value streams which are difficult to determine and validate value without a demonstration installation.

Market opportunities will change over time, providing unique opportunities that may be best served by energy storage technology. This project can provide one of the most detailed energy storage assessment, valuation, and control system implementations in the industry.

The timing of this work will be beneficial to the State of Washington and its clean energy companies and workers, as the energy storage market space is ripe with opportunity. For example, the State of California has mandated that 200MW of energy storage be procured by the end of 2014 and a total of 1325MW installed by the end of 2020. This project addresses many if not all of the issues targeted in California, and also addresses distributed resource placement for load/peak management, power factor correction and power quality. Additionally, the novel approach to both distribution and power supply dispatch capability is not common in the utility industry. Distribution assets are not typically leveraged for bulk power system management other than through demand response programs, often provided by aggregators. The integration of the Avista DMS to the EMS will benefit as well another Washington State company, Alstom which provides the EMS in use by Avista System Operations.

With reference to the "Market Impact" and "Host Utility Benefit" criteria stated in the Department of Commerce's Application Guidelines, the Avista consortium would make the following observations:

Market Impact

The market potential for grid-scale energy storage and related control technologies generally can be viewed from at least three perspectives: (a) market size, (b) market segments, and (c) solutions to market problems. The market potential for the particular combination of grid-scale energy storage and control technologies proposed here by the Avista consortium including PNNL, WSU, and UET, is a matter of the technology combination's differentiated features and benefits as discussed above and throughout this application.

With respect to the market potential generally:

a) Market size – Estimates of the size of the global energy storage market all project a large market. One estimate by Lux Research is the global grid energy storage market will reach $10.4 billion in 2017. http://theenergycollective.com/joshshill/230661/global-grid-storage-market-reach-104-billion-2017, June 1, 2013. Another estimate by Pike Research (part of Navigant Research) is that energy storage on the grid will surpass $30 billion in annual market value by 2022. http://www.navigantresearch.com/newsroom/energy-storage-on-the-grid-will-surpass-30-billion-in-annual-market-value-by-2022, October 24, 2012 Pike Research further estimates nearly 56 gigawatts of new-long duration energy storage will be installed from 2012 to 2022. http://www.navigantresearch.com/newsroom/nearly-56-gigawatts-of-new-long-duration-energy-storage-to-be-installed-from-2012-to-2022, March 13, 2013.
b) Market segmentation – The grid-scale energy market should be segmented both by geography and application. For example, PNNL has estimated that for the western United States covered by the Western Electricity Coordinating Council (WECC), the requirement for balancing capacity assuming WECC attains its Renewable Portfolio Standard target of 20% by 2020, would be 6.32 gigawatts to balance 24 gigawatts of wind generation. http://energyenvironment.pnnl.gov/pdf/PNNL-21388_National_Assessment_Storage_Phase_1_final.pdf, June 2012. In California, the Public Utilities Commission has made final its decision to require the three largest utilities there (Southern California Edison, Pacific Gas & Electric, and San Diego Gas & Electric) to procure 1.325 gigawatts of energy storage by 2020. http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M078/K912/78912194.PDF. The following table from a Greentech Media Research study released on October 10, 2013 (http://www.greentechmedia.com/research/report/grid-scale-energy-storage-in-north-america-2013) shows the procurement targets by utility and year:

FIGURE 4-1: PROPOSED ENERGY STORAGE PROCUREMENT TARGETS (IN MW)

Storage Grid Domain Point of Interconnection	2014	2016	2018	2020	Total
Southern California Edison (SCE)					
Transmission	50	65	85	110	310
Distribution	30	40	50	65	185
Customer	10	15	25	35	85
Subtotal SCE	90	120	160	210	580
Pacific Gas & Electric (PG&E)					
Transmission	50	65	85	110	310
Distribution	30	40	50	65	185
Customer	10	15	25	35	85
Subtotal PG&E	90	120	160	210	580
San Diego Gas & Electric (SDG&E)					
Transmission	10	15	22	33	80
Distribution	7	10	15	23	55
Customer	3	5	8	14	30
Subtotal SDG&E	20	30	45	70	165
Total – all 3 utilities	**200**	**270**	**365**	**490**	**1,325**

SOURCE: CPUC

c) Solutions to market problems –As detailed below, this project will implement, test, and value multiple solutions for utilities and grid operators, including enhanced voltage regulation capability for increased CVR benefits made possible by localized peak management and fine-tuned power factor correction; localized operations to address imbalances between distribution and transmission networks; renewable integration (balancing); peak load shifting; ancillary services; ramping services; negative pricing opportunity capture; and decreased O&M expenditures for generation assets forced to constantly ramp.

A full discussion of all the market problems which energy storage will solve is an extensive subject beyond the scope of this application. We would note, however, that the solutions addressed by this project align well with the solutions that leading research organizations have stated are needed by the global market. For example:

"Long-duration or bulk energy storage on the grid (ESG) is by far the largest market for energy storage, and until recently was the only market. Advances in next-generation pumped storage, compressed air energy storage, and advanced batteries have multiplied the technology options available for ESG at the same time that the applications for ESG are also increasing. Pike Research has identified five key applications for ESG over the next 10 years: grid asset optimization, wind integration, solar integration, arbitrage, and the deferral of new transmission and distribution capacity additions."
Pike Research, **Energy Storage on the Grid**, Q4 2012, http://www.navigantresearch.com/research/energy-storage-on-the-grid

In terms of the project's economic impact on the Washington clean energy sector and the Washington economy as whole, Avista estimates the project will require the support of eleven (11) full-time equivalent (FTE) positions in the

Avista Utilities organization. PNNL estimates the project will require one (1) of its full-time positions. WSU estimates the time of four (4) graduate students will be required to support the project. UET estimates that to continue its scale-up and produce the 1MW Uni.System for this project and the additional Uni.Systems for the other Smart Grid Grant projects applied for by other Washington utilities (and for further purchasers of Uni.Systems in California and elsewhere for which the Washington Clean Energy Fund projects materially drive purchase decisions), UET will need to hire sixty-five (65) additional full-time technicians, engineers, and other personnel between January 1, 2014 and June 30, 2015. As of the filing of this application, UET has thirty-five (35) full-time employees.

Using the Office of Financial Management's input-output model (2012 update), the economic impact of the above hiring by Avista, PNNL, WSU, and UET (11 electric utility jobs, 1 engineering job, 4 educational service jobs, and 65 electrical equipment manufacturing jobs) is as follows:

$20.5M in labor income (in 2012 dollars), and

$81.9M in output (in 2012 dollars)

Host Utility Benefit

The proposed energy storage solution is a perfect fit for the infrastructure installed as a part of the Pullman smart grid project. That infrastructure enhanced reliability, increased efficiency and provided direct customer benefit. The addition of energy storage pushes the efficiency envelope much further and increases reliability in many different but important ways. Energy storage could be of sufficient size to act as a giant UPS in addition to the other benefits listed in the table at the beginning of this document. Avista believes that storage can be an important tool in the supply-demand equation.

Avista will test all of the supply side use cases as well as the load side and then dispatch for optimal operation while computing the benefits of all available opportunities. This concept could be applied to in-process storage, customer owned assets, electric vehicles; any distributed resource, the characteristics of which is known could be involved in a power system that is in optimal configuration mode at all times.

C. Project Plan

Detailed Project Description

The project proposes the use of energy storage to assess and value the use cases identified in the business case, which meets a number of utility objectives. One of the difficulties facing energy storage manufacturers and utility purchasers is the ability to accurately determine the value of the use uses cases offered by an energy storage system. It is critical, both to the utility industry and to the energy storage manufacturers, that value propositions can be easily understood, the methodology for calculation sound and the values captured during operation for validation. Consequently this consortium includes two recognized leaders in value quantification; Washington State University (WSU) and Pacific Northwest National Laboratory (PNNL). PNNL has conducted numerous research projects regarding energy storage and value quantification of these assets. A description of their capabilities is provided in section G-2. WSU has just completed a utility industry first; real-time savings quantification for the application of conservation voltage reduction (CVR). A description of their capabilities is provided in section G-3. Additionally personnel from UniEnergy Technologies have extensive experience in utility focused energy storage solutions and leverage or expand on storage patents developed by PNNL. A description of their capabilities is provided in section G-4

The project is presented as two distinct sets of project tasks; 1) the facility design, construction, integration and testing which employs 2) energy storage analytics and control system development.

The first set of tasks include permitting, contracting, design, construction, communications, security, and systems integration relies on the second set of tasks for definition and application of the control system and corresponding analytics and validation. These tasks are the primary responsibility of Avista in conjunction with delivery of the battery technology by UniEnergy Technologies.

PNNL with assistance from WSU will be responsible for the energy storage analytics and control system development. Avista and UET will assist as appropriate. This effort will provide assessment and identify valuation methodologies that are re-usable. Of specific importance is the valuation of the bulk power system needs and opportunities as well as the localized distribution operation with optimal solutions that honor schedule or constraints.

Energy Storage Project Objectives

The proposed project is designed to meet a number of objectives defined by use cases which are provided in the business case section. The use cases can be applied at the customer load, generalized to the distribution circuit/substation or anticipated on the bulk power system. The Pullman smart grid project focused on local objective fulfillment which can ultimately have a positive impact on the bulk power system. Optimizing delivery at the customer locale reduces losses throughout the system.

The project has another set of objectives for the energy storage installation that speak more to the long term value to the utility.

Objectives

1) Create design standards for installation of energy storage at substations, on feeders or on customer premise,
2) Establish protective relay standards for connection inside or outside substation facilities that maintain proper isolation of protection schemes for correct operation and adequate protection of the energy storage system and distribution feeder,
3) Assess use case values and develop control systems that can evaluate simultaneous use case opportunities for best mode of operation for the storage,
4) Integrate control of energy storage into the EMS,
5) Integrate control of energy storage into the DMS,
6) Develop system controls for dispatch of charge and recharge cycles from either the EMS or DMS systems optimized for best use,
7) Design control system to allow for scheduling of energy storage specific to power supply needs. Ideally tie the battery to AGC for designated periods of time to test viability as a precise ramping/ancillary services tool. Identify characteristics or predicted periods for bets fit operation,
8) Complete assessment of energy storage system operating characteristics for creation of accurate modeling tools,
9) Enhance/customize the EMS to leverage energy storage assets with better modeling, simulation and operation. Note these enhancements become available to all customer benefitting the Washington Clean Tech sector and specifically enhances Alstom product capabilities,
10) Enhance/customize the DMS to leverage energy storage assets with better modeling, simulation and operation. Note these enhancements become available to all customer benefitting the Washington Clean Tech sector and specifically enhances ACS product capabilities,
11) Understand maintenance obligations.

Project Tasks – Facility Design, Construction, Integration and Testing

The project is divided in two categories:

1) Contracting, Design & Construction (Sections 3.1 – 3.5)
2) Energy Storage Analytics and Control System Development (Sections 4.0 – 4.6)

The first project category includes early administrative tasks such as contracting and permitting; design; construction; and initial testing after which the energy storage system will be considered as an available asset controlled in remote/manual mode. This first set of tasks is primarily the responsibility of Avista and UniEnergy Technologies.

The second project category focuses on the valuation of benefit streams, or use cases, for which the energy storage system may be operated. This second category separates valuations into appropriate use case groups that can be valued against each other for incremental development and testing of the valuation methodologies. This second category of tasks is a coordinated effort of all consortium members after initial research and assessment by PNNL and control system development by WSU, followed by integration by Avista. The project is concluded with monitoring and validation of storage performance.

Task 1: Contracting (Complete 03/12/2014)

After award of the grant the first task and one of significant schedule importance, is contract development, negotiations, and signoff. Many other tasks cannot begin until this contract is in place, so the risk of delay impacts the end date of the project. The included project schedule anticipates 39 days from award to signature. It is recognized the Department of Commerce wishes to streamline the contract task. Avista will not submit any costs associated with this task for cost share.

Deliverables:

1) A signed contract with identified milestones, performance expectations, payment specifics, indemnification and liability clauses etc.

Task 2: Permitting (Complete 05/20/2014)

It is anticipated special environmental permitting requirements may be applicable for this installation. Whitman County and the Washington State Department of Ecology will both require environmental assessments for permitting. Avista completed two environmental assessments for the smart grid project in Pullman. It is expected the permitting process will take 90-120 days. The lead-time to receive permits has a direct impact on schedule. Avista and the consortium have little influence on the timeline for this process.

In order to minimize risk and shorten the timeline, Avista has already begun the environmental assessment and permit process.

Deliverables:

1) Whitman County permits
2) Washington Department of Ecology permits
3) Specific design/permit requirements

Task 3: Design (Complete 07/29/2014)

Avista routinely designs, constructs and modifies electrical transmission, distribution, and substation facilities serving 360,000 customers. This project proposal includes design work that is not in the current portfolio of design standards. New elements of design for an energy storage system are the interconnection, corresponding relay protection and control system for storage dispatch and charging. Avista will design for dispatch via both the EMS and DMS with coordinated use case evaluation for optimal energy storage utilization. The Avista staff is highly experienced in both the EMS and DMS technologies. The separate task for Energy Storage Analytics and Control System Development will provide solutions for all the use cases identified in the business case.

The design task also includes development of the general plan, ground plan, grading plan, fencing plan, electrical plans, structural plans, substation integration design, communication design, and specific requirements identified as necessary the battery system. The system design will be a first-of-a-kind for Avista. Much of the smart grid deployment in Pullman and Spokane was first-of-a-kind deployments which were successfully implemented. UniEnergy Technologies will provide a turn-key energy storage system that should speed design, installation, and testing. The turn-key product approach should make the solution very attractive in the clean technology market.

Design also includes protection, equipment integration, communications configuration, security assessment and configuration, and definition of analog/digital SCADA points. Additional capability may be required in the EMS and DMS software solutions Avista uses. The project plan includes funding for the EMS/DMS vendors to add appropriate functionality as identified by the project team in the analytics, controls and integration tasks.

Avista leverages design standards for maximum efficiency and cost effective equipment purchases. New design standards shall be a result of this project. These standards shall be developed in a manner that they can be reused for any type of distributed resource throughout the Avista service territory. The design concepts used in these standards could be leveraged by other electric utilities or communities, enhancing the market for Washington based energy storage solutions.

The efforts of the Avista DMS, EMS and Protection engineers will insure that all use cases identified in the business case can be achieved with the control and integration architecture. PNNL and WSU will provide the analytics and control methodologies that can be layered into the Avista design. Delivery of the design identifies the first use case as connection of the energy storage system for parallel operation with manual charge and discharge as executed through the DMS.

Currently Avista has fully automated FDIR and IVVC on circuits feeding 1/3 of the total customer base. The energy storage system design is able to take advantage of the systems as deployed.

Subtasks/Deliverables:

1) Foundations,
2) Site Plans,
3) Electrical Plans,
4) Structural Plans,
5) Digital Architecture,
6) Communications Plans,
7) Protection Scheme,
8) Substation Integration Plans,
9) Security Assessment & Mitigation Strategy

Task 4: Construction (Complete 10/21/2014)

Construction includes appropriate grading, grounding, trenching, structures, panel house modifications, equipment installation, wiring, and relay testing. Construction will be completed by Avista electrical, mechanical and relay personnel in conjunction with UET for battery installation. In the event Avista personnel are unavailable, contract resources will be assigned.

Sub Tasks/Deliverables:

1) Site preparation (includes all grading, fencing, foundations and trenching),
2) Structural installation (includes connection structure and bus work modifications),
3) Connection Equipment installation (includes disconnects, relays, ,circuit reclosers, communications, cables, substation integration package/modifications),
4) Battery Installation (turn-key delivery for connection of medium voltage output and communications,
5) All wiring,
6) Relay tests

Task 5: Initial Systems Integration Testing and Acceptance Test (Complete 11/24/2014)

Upon completion of installation and relay testing of the energy storage system and supporting connection equipment, initial testing for parallel operation shall commence. The energy storage system will be tested in sequence. Acceptance Testing will be the final key to on-line availability.

The team will develop an *acceptance test procedure* that validates each critical subcomponent of the energy storage system and its interconnection with the grid and the Avista communication infrastructure in a systematic way. After individual component testing, the UET storage device will be tested in a grid-connected mode to perform charging and discharging procedures followed by a set of performance test protocols that have been recently developed by the storage industry under PNNL leadership with U.S. DOE funding[1]. The published protocols are defined for 2 specific applications: 1) Frequency Regulation Services, and 2) Peak Shaving. These will be applied for the proposed acceptance testing. Two additional applications are currently being developed for microgrid and renewables integration applications. Based on the maturity of these protocol definitions at the time of the acceptance testing proposed, the team will evaluate if the new performance protocols will be incorporated into the acceptance testing.

[1]Protocol for Uniformly Measuring and Expressing the Performance of Energy Storage Systems. PNNL-22010, November 2012. Pacific Northwest National Laboratory, Richland, WA.

Subtasks/Deliverables:

1) Unit test, isolated from the distribution system. Simulate DMS command to energy storage and relay system function as appropriate,
2) Integration test of DMS and battery Management System (BMS), still isolated from distribution system but with DMS command issued and appropriate BMS and relay functions tested,
3) End-to-end test of DMS controls and BMS with parallel operation. Charge and discharge commands issued from the DMS to the BMS. Test for appropriate Energy storage and protective relay function,
4) Acceptance certificate

*** Success of all three tests and the Energy Management System is declared ready for manual remote operation and the acceptance certificate will be issued.

Project Tasks - Energy Storage Analytics and Control System Development

Introduction

Energy storage has the potential to provide many valuable grid functions ranging from load shifting to, power quality enhancement. The extremely rapid response time, high ramp rates, capacity to shape power (both during charging and discharging), and significant energy capacities, make it a flexible tool for utility operations, particularly when coupled with other variable generation and smart load system components.

However, this very range of grid functions creates new challenges to optimize design and operation of the energy storage unit, to maximize its grid contributions. When implemented at the distribution level, storage provides a dramatically new tool for grid operations, and most utilities have not had the opportunity to fully understand or appreciate the contributions that energy storage might make in grid distribution operations.

The first challenge to be addressed when considering storage in the distribution system, is to characterize, to the full extent possible, the values associated with the various functions storage can provide. It is expected that the values associated with these services vary with time. Furthermore it is anticipated that at times, multiple services can be provide simultaneously. Logically, the storage unit would be designed and operated to capture the highest value possible, including consideration of the compounding of values possible by providing multiple services. However, the design and operation of the storage unit depend to a considerable degree on the services that the storage unit is expected to provide.

Therefore, a complete and accurate characterization of the potential values that storage can provide is necessary in order to support an evaluation of design requirements, and optimization of operational strategies that would enable capturing maximum value. With the values determined, evaluation of optimal control strategies can be determined.

Once control strategies are determined (more likely to be methodologies and algorithms for optimization of storage unit operation), these need to be incorporated in to control software and integrated into grid operational software (e.g. the distribution management system), and potentially into the supervisory control of the storage unit itself.

Once implemented, monitoring of the performance of the control systems, and the storage unit is needed in order to evaluate whether the values derived earlier in the project, and incorporated into the control strategy and its implementation, were actually realized.

Approach

Four tasks are envisioned to accomplish the evaluation of value, the development of optimal control strategies, and the embodiment of the control strategies into an actual control system, the integration of that control system into the grid distribution management system, and evaluation of the performance of these systems in delivering the values estimated at the outset of the project. The team will collectively work to accomplish these tasks, with different team members taking the lead in various tasks, and with other team members in a supporting role. In general, concepts migrate to deployed systems, and team participation shifts from research providers and vendors to those with responsibility for grid operations. In this context, Pacific Northwest National Laboratory (PNNL) and Washington State University (WSU) will provide analytic and control system development efforts, which will be realized by UniEnergy Technologies (UET) and by Avista who will integrate and implement the development products into their operational systems.

Task 6: Refinement of Value and Business Case for the Deployment of Energy Storage

PNNL will work with Avista, WSU and UniEnergy Technologies to refine the set of potential value streams (already identified in this proposal) that can be provided by energy storage, and particularly at the site selected for deployment of the redox flow battery. PNNL will estimate the multiple values of the stationary energy storage individually and the potential for achieving multiple values simultaneously, by applying optimization techniques that seek optimal control strategies that maximize the total value of the storage device. Included in the value estimation will be benefits for the provision of capacity, balancing services, ramping and flexibility services, avoidance of negative energy pricing. PNNL will be working with WSU to explore strategies such that energy storage will coordinate Conservation Voltage Reductions (CVR) strategies in one selected feeder. PNNL will not develop the CVR strategy, but determine the impacts of CVR on the multiple value estimation.

PNNL will summarize the findings of the value assessment and explore the sensitivity of variables that affect the valuation, including deriving multiple simultaneous benefits. The outcome of this analysis will be a) a set of control strategies for the energy storage device with clear definition of distribution and transmission benefits and values, b) characterization of the sensitivity of the value streams to potential developments in the grid, markets, or storage, and c) an approach of how to implement the control strategies into an appropriate controller framework (either on the UniEnergy supervisory controller, or Avista's distribution management system.

PNNL will work closely with WSU faculty and staff to coordinate the consideration of optimal control strategies to enable effective transition from current feeder control toward more comprehensive strategies that incorporate some of the optimization approaches employed in the PNNL analyses in combination with other operational requirements as well as forecasting considerations that recognize uncertainties.

Deliverables:

1) Briefing material that summaries the value assessment and business case analysis of energy storage for a set of locations (Nov. 2014)
2) Briefing material that proposes the implementation of control strategies to extract maximum value from energy storage device. (December 2014)

Task 7: Development of Control System

The general control strategies derived by PNNL will be incorporated by WSU into a more comprehensive control system that recognizes other operational constraints and objectives beyond value maximization of the storage system. These could include safety and reliability considerations, or constraints associated with local operations within the Avista system and its control architecture. It is anticipated that the control system development by WSU will also address issues such as forecasting uncertainties, and multiple objective functions that may shift in priority as a function of system condition or Avista operational requirements (such as protection). Furthermore, loads served by the distribution system in which the storage system is interconnected, are managed by WSU, and may provide additional opportunities for examination of coordinated operation.

The objectives of the proposed control and optimization tools are for the batteries to perform the functions of energy management, demand response, and Conservation Voltage Reduction (CVR). Computer algorithms will be developed to enable the Battery Control System to determine and issue scheduling and control commands to the battery through the Battery Management System.

The battery serves multiple purposes, for example,

- Peak Shaving: Reducing the peak load by serving a portion of the load with the battery energy during the peak load condition,
- Storing the excess wind energy: Charging the battery rather than curtailing the wind power production during the low load condition.
- Reducing the curtailment of load: At a time when the transactive signal is to be sent for load curtailment, the available battery can be used to avoid or reduce the amount of load to be curtailed,
- Load management for CVR: Flatten the peak load for cyclical load to minimize voltage variations that reduce the benefits of CVR, and use battery as a resource with four quadrant operation for reactive power to optimize the system for maximum energy savings, and
- Participating in balancing ancillary service market: The battery can help generation suppliers to meet their commitment in production.

Since these functions rely on the available energy stored in the battery, a strategy is needed to schedule the battery charging and discharging and allocate the energy to perform based on the values created by the functions. As a result, the battery optimization problem is one with multiple objectives subject to the battery capacity and technical constraints associated with the distribution system such as voltage limits.

Several components are needed for the control and optimization tools. First, a model has to be established for each of the functions, including modeling of the problem, data needed, and the control model to perform the function and the outputs. Note that each function has different requirements of data and models. It will require an analysis of various functions to determine the feasibility and practicality of the models for this project. Next, load forecast data will be used to develop short term planning tool by multi-objective optimization. A multi-objective optimization method is needed to perform the optimization to perform tradeoffs based on different values of the functions. A coordinated set of real time control commands will be identified based on the results of the multiple-objective optimization. Finally, the technical feasibility of the control commands must be checked with respect to the operating constraints associated with the battery and the corresponding distribution feeder. It is expected that an unbalanced distribution power flow computational tool will be needed for the evaluation of the technical feasibility.

Based on the analysis, the development of control and optimization tools is organized into four subtasks.

WSU Task 1: To develop the model for each intended function for the battery application. WSU will develop a model of the Avista power system which can simulate different scenarios in which the battery applications can be exercised. The idea is that WSU will need some replica of the power system in which WSU can test the battery controls and this replica should have detailed models near the battery but the remaining of the system will be replaced by an appropriate equivalent model.

WSU Task 2: To develop the multiple objective bi-level optimization algorithm to search for the control commands corresponding to the Pareto optimal tradeoff.

WSU Task 3: To determine the technical feasibility of the optimization results for multiple objectives and enhance the solution when infeasibility is found.

WSU Task 4: To formulate and implement the computational environment of the Battery Control System and the interactions with other subsystems, including the Distribution Management System. The different applications of the batteries will be put into a single package for Avista to implement in their Distribution Management System environment.

PNNL will work with WSU, UET, and Avista to facilitate the incorporation of optimal strategies, methodologies and approaches developed in Task 1. PNNL has developed a tool to maximize the operational value of multiple value streams through an optimization based on day-ahead price forecasts for flow battery. The tool will be tailored for the UET device and the interested value streams at the selected location. The optimal control strategy (based on value) will be provided to WSU for their adaptation, extraction or merger with other control system development efforts for utilization in the storage energy supervisory management system and/or at distribution automation system. PNNL will provide assistance and support to WSU.

Deliverables:

1) Specification of the control strategies (February 2015)
2) Development of control strategies (May 2015)
3) Preliminary testing of control strategies (July 2015)

Task 8: Integration of Control System

The control system that is developed in Task 2, must be integrated with the control of the distribution system and the redox flow storage battery. Avista will lead this effort, with support from WSU, UET, and PNNL. The control architecture will be revised to incorporate the control system developed by WSU, and hierarchical control responsibilities will be determined. The UET control system will be modified to accommodate control requirements consistent with the Avista control system.

Integration efforts by Avista will focus on the EMS, DMS, BMS, control strategy and associated components. Business process definition layered with the control strategy shall dictate the specific integration effort. The vendors for the EMS and BMS may be requested to provide custom functionality. The integration design shall be such that the energy storage system can be requested or scheduled by either the EMS or DMS. As an example, the energy storage system may be included in the day-ahead resource schedule, which would be managed by the EMS. The control strategy should not only reserve the use but insure that the appropriate state, charged or discharged, is realized. The DMS must honor the EMS request, but is free to leverage the storage outside the EMS request in accordance with the valuation provided by the control strategy.

Test plans and a commissioning process shall be developed for each use case group to be implemented. Specifically commissioning shall validate the unit operation of each control component, integrated operation and end-to-end remote operation. Each use case will be placed in an advisory mode whereby an operator shall execute the final operation authorization. This approach provides two benefits. Distribution and system operators become familiar with energy storage assets in general and the applicable use cases. The modes of operation for commissioning will be manual-local, manual-remote, advisory-local, advisory-remote, auto-remote.

UET shall participate in commissioning such that performance of the energy storage system is maintained as each integration and associated use case is commissioned.

PNNL will provide assistance in evaluation of the control system, specifically focusing on the degree to which services which were valued in Task 1, are realizable in the developed control system.

Deliverables (use group specific for phased approach):

1) Definition of use case groups,
2) Identification of EMS/DMS customization required (2015)
3) Review and codification of WSU control systems designs
4) Test Plans for each use case group, unit, integration and end-to-end (2015)
5) Test and deploy use case groups 1-4 (2015)

Task 9: Monitoring and Validation of Storage Performance

The maximum value of this project will be realized not only by maximizing the values the energy storage system can provide, but also by gaining experience and insight into the performance of the storage system within the context of the utility operations. It is anticipated that the storage system will be operated both in a manner to maximize benefits within the distribution system as configured at the site selected for deployment, but also to evaluate the potential for contribution to addressing other grid operational challenges that may be most relevant at the transmission level or at other distribution sites having different challenges (e.g. reaching capacity, or experiencing other grid challenges such as excessive tap changing, or voltage sags).

Avista will be responsible for comprehensive monitoring of the performance of the system, including the storage components as well as its control and service within the distribution system. The monitoring will be focused not only in documenting performance but also in assessing the degree to which value propositions identified at the outset of the project are realized, and what additional measure might be needed to fully capture those values, potentially including policy issues (such as monetizing value streams not captured by present tariff or policy structures; an example might be the emerging flexibility market).

Avista will monitor the energy storage system using a set of DNP3 SCADA points that provide status, alarms and measures. These values will be stored for archival purposes in PI Historian (provided by OSISoft) and will be available to both the EMS and DMS. Avista has previously architected the smart grid assets such that both the EMS and DMS can access the desired points. The issuance of control command to the energy storage system may be limited to only the DMS, with the EMS system requesting through the DMS. This concept will be reviewed to maintain NERC/CIP compliance.

The valuation of use cases and the corresponding control system decisions will also be captured in PI Historian. Actual valuations observed will be calculated each hour. There will be a separate valuation point for each use case.

Sources required for the control strategy include but are but not limited to weather (wind, direction, temperature, solar irradiance), day-ahead schedules, ancillary services request, reserves request, capacity request, etc. Avista power supply personnel will request specific use cases. Initially Avista will give priority to these requests, but as valuations are validated and analyzed, the control system will provide feedback as to most optimal operation of the storage. This will be fully automated with business financials included for financial performance as well as operational performance.

WSU, PNNL and UET will support the Avista monitoring and evaluation of the performance of the project. PNNL, due to its role in identifying the original value propositions and control strategies to capture the various value streams will focus on comparative evaluation of the value projections before implementation and as deployed and operated, as part of its contribution to Avista monitoring and performance.

Deliverables:

1) Develop a plan for energy storage performance quantification
2) Create and deploy calculated tags in OSISoft PI Historian tags that quantify the energy storage system performance every hour
3) Create dashboards for executive monitoring of energy storage performance

Energy Storage Installation

The project places an energy storage battery at the South Pullman substation in Pullman, WA. The battery connects to the 13.8kV bus supplied by transformer no. 2 and can be utilized for all six South Pullman feeders via the transfer bus between transformers no.1 and no.2. A separate fenced area will isolate the battery installation from the substation area. In the event substation space is too limited for bus attachment, the battery will be connected to the feeder approximately 1000' from the station. The energy storage system shall be protected with a circuit recloser and SEL protective relays.

Energy Storage Operations Plan

The battery system includes a VFB, battery management system, power control system, and step-up transformation. A battery control system connects the battery system to the Avista DMS. The battery control system is responsible for managing charge and discharge cycles given input from the WSU asset systems, EMS, DMS, and transactive response system (TRS) and numerous data feeds such as weather, pricing, day-ahead schedule, etc. The battery control system is a key component and provides tremendous market potential as a means for managing distributed energy assets. The system must include a prioritization capability for multiple simultaneous objectives and must be able to operate in a fully automated manner. The architectural design is included in the diagram B-1.1a below.

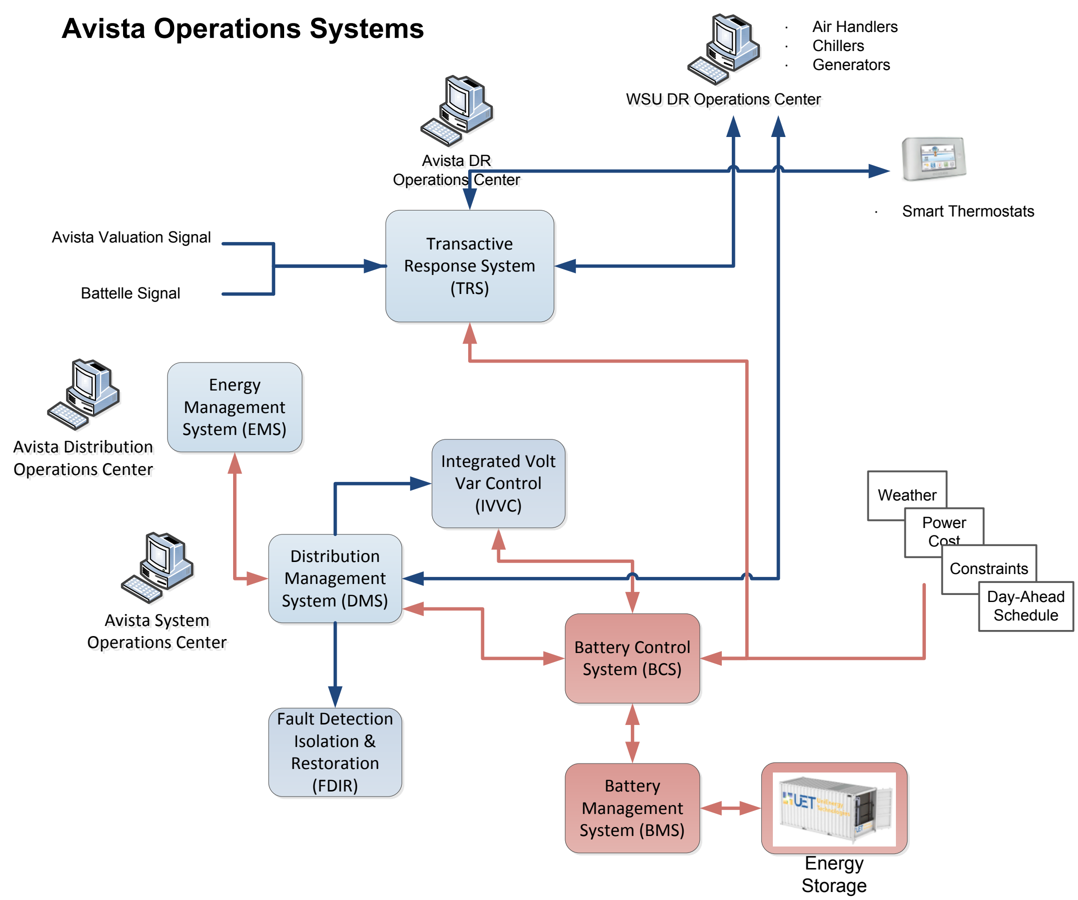


Diagram B-1.1a (note: all items shown in salmon, to be installed as a part of this project)

External data fed to the BCS is, but not limited to the list below:

- Weather including temperature, wind speed, wind direction, and solar irradiance,

- Day-ahead schedule as define by power supply schedulers which includes any needs for ancillary services, flex market, reserves, Var support, and potential negative pricing scenarios,
- Day-ahead pricing and near real-time pricing,
- Operational constraints,
- Cycle constraints

D. Project Innovation Category

1. Advanced Technology Discussion

The Avista consortium brings together a Washington retail electricity utility leading in the use of renewable, energy storage, and information technologies, with innovative companies and organizations in each of those technology areas, including Pacific Northwest National Laboratory, UniEnergy Technologies, and Washington State University.

Uni.System grid-scale batteries from UniEnergy Technologies

Specific to UET's advanced vanadium flow battery, the Uni.System™, a project funded under the WA CEF which utilizes this Made in Washington battery would demonstrate the use of a new and innovative product, whether in novel or conventional applications. The Uni.System™ batteries incorporate advances in four differentiated areas: (i) new generation vanadium-based electrolyte first developed and patented at Pacific Northwest National Laboratory with the support of the US DOE Office of Electricity, with double the energy density and much broader temperature range than conventional vanadium-based electrolyte; (ii) a containerized design derived from multiple decades of design experience among the UET engineering and manufacturing team, with a compact system footprint maximizing power and optimizing energy; (iii) mature large-scale electrode stacks with 7 years of field deployment and hundreds deployed in the field; and (iv) state of the art controls at each level of the Uni.System™ (cell, stack, container, string, site).

This bullet-list of technology advances incorporated into the UET battery, made in Mukilteo, Washington, has a large volume of supporting information behind each point. UET would be glad to provide such supporting information at the request of the Washington Department of Commerce.

More generally, project funding under the WA CEF to the Avista consortium including PNNL, UET, and WSU would bring to bear an advanced hardware/software technology solution which is differentiated in its safety, operational flexibility, reliability, long-life, and cost-effectiveness for utility and grid customers. Such a combination of advanced Made in Washington products will be highly competitive in the global market, including utilities and grid operators in Washington, California, New York, Texas, and Alaska in the U.S.; Germany, the U.K., and Italy in Europe; and other markets including Australia, Indonesia, and micro-grids around the world.

2. Novel Application

The Avista consortium has a detailed project plan to utilize, develop, assess, value and deploy multiple novel applications. Those novel applications, or “use cases”, include enhanced voltage regulation capability for increased CVR benefits made possible by localized peak management and fine-tuned power factor correction. These localized operations also address imbalances between distribution and transmission networks and allow for renewable integration (balancing), peak load shifting, ancillary services, ramping services, negative pricing opportunity capture and decreased O&M expenditures for generation assets forced to constantly ramp.

The project facilitates EMS or DMS control coordinated by an assessment of valuation that provides optimal dispatch for maximum utilization of the energy storage system to match one or more of the use cases. This approach, as stated previously is forward thinking and not prevalently available in the utility industry.

Specific to the UET Uni.System battery, though it incorporates the technology advances listed above, it is also a novel application of proven technologies, namely the flow battery first invented at NASA in the 1960’s utilizing an iron-chromium chemistry and then improved in the 1980’s in Australia utilizing an earlier generation of vanadium chemistry. See M. Skyllas-Kazacos, *Progress in Flow Battery Research and Development*, Journal of The Electrochemical Society, 158 (8) R55-R79 (2011).

Because of the new generation of vanadium chemistry invented at PNNL, which resulted in the doubling of energy density and much broader temperature range eliminating the need for much balance of plant equipment, it is now possible to apply and deploy grid-scale vanadium flow batteries in ISO standardized containers (whether 20’, 30’, or 40’). Such containerization of the vanadium flow battery was never before a practical application. Prior applications of the vanadium flow battery, which were already desirable for their safety, separation of power and energy, and design cycle life, have had the “downside” of having a large footprint, extensive balance of plant requirements, and an appearance akin to a “chemical plant.”

3. Balanced Application

The The Avista consortium’s detailed project plan to utilize, develop, and analyze a number of innovative energy storage and information products and novel applications of the same, within Avista’s infrastructure, is balanced with careful consideration of possible risks and extensive mitigation of the same.

Avista employs top tier EMS and DMS applications and supports the vendor products with highly trained technical support staff. Avista is more than capable to assist both Alstom and ACS with customizations necessary to make integration of the energy storage system seamless and reliable for all intended use case applications. Additionally Avista has established a beneficial relationship whereby control methodologies can be co-developed and deployed as real-world solutions. WSU provides the detailed technical methods and prototype code which is then implemented by Avista.

The UET advanced vanadium battery, is designed, engineered, and manufactured to address the broad set of possible risks associated with large-scale batteries in general, including fire (thermal runaway) and chemical spill. The flammability rating of the Uni.System is “0,” primarily because the vanadium electrolyte is water-based and if ever self-discharged, the temperature rise of the UET battery is no greater than 20°C with the large thermal mass of the water constituting most of the electrolyte absorbing the released energy. There are of course electronics incorporated into the UET battery. To fulfill those electronics requirements, UET has engaged in extensive sourcing efforts, selecting world-class components including from Washington companies whenever they qualify. To mitigate the risk of chemical spill, the UniSystem features double containment (tanks, containers with inner coatings and bulkheads), no penetrations of the tanks below the electrolyte level, no fluids flowing between containers, and vigorous simplification of the electrolyte flow system to eliminate as many potential failure points as possible. Manufacturing of UET's advanced vanadium battery at its Mukilteo facility is done by skilled mechanical, electrical, and other technicians, managed by expert engineers and scientists in all of the involved disciplines (mechanical, electrical, controls, electrochemical). This comprehensive mitigation of product risk at the design, engineering, and manufacturing levels by UET is part of UET's constant prioritization of safety and reliability.

In addition, the Uni.System battery will be subjected to rigorous third-party verification. UET will have witness testing in Washington in Q2 and Q3 2014 of a 500kW; 1.6MWh system by the leading institutions of Pacific Northwest National Laboratory, Sandia National Laboratory, and the Electric Power Research Institute (EPRI), and then on-site testing in Albuquerque, New Mexico at Sandia National Laboratory's test pad. Thereafter, the UET Uni.System will be tested in California, New York, and Europe at appropriate test centers with the credibility in the particular market to help foster positive channel development. Through such thorough third-party verification, the Uni.System will repeatedly demonstrate it provides an attractive balance of product innovation, novel applications, and risk management and mitigation.

4. Utility Fit

The installation of this energy storage system will allow Avista to complete proper assessment of the identified "use cases". Valuation and modeling also allow for optimal dispatch of charge and discharge cycles. Avista has not yet installed energy storage, but recognizes the many benefit streams that may be captured. What is not understood is the degree to which each benefit stream can be accomplished or how the storage should be modeled for simulation. This project will provide these and a long list of other objectives.

The project focuses on clean technology that can provide positive impacts for the customer, the environment, Washington based companies and the regional economy. The technology is safe and provides capabilities not yet available to Avista, specifically the four quadrant inverters of scale which can provide complete load shape possibilities on the distribution system.

The battery is a Vanadium Flow Battery provided by consortium partner UET, who will provide a full AC system with integrated inverter and medium voltage step up transformer. The inverter attributes include: MVA rating with real and reactive(VAR) capability, IEEE 519 (harmonics) compliance, and IEEE 1547 (anti islanding) compliance when required. The battery system has key specifications for Avista that are as follows:

- Single chemical, no possibility of thermal runaway
- Unlimited cycles ,
- 20 year life,
- >96% availability,
- Electrolyte remains stable between -40 and +70 degrees C,
- 50ms response time,
- Self contained for easy installation and turn-key marketability,
- Approximately 70% AC-AC efficiency

The battery is tied to the 13.8kV bus through a step-up transformer supplied as a part of the battery system and a utility supplied vacuum circuit recloser equipped with Schweitzer protective relays. This solution can be substation installed, line installed (with property), or community installed for maximum flexibility.

Avista is excited for this opportunity to add another key technology to its portfolio of assets.

E. Project Management Category

Project Management Category

Overall Task/Subtask List

Contracting, Design & Construction

1. **Contracting (3/12/2014)**
    1.1. Contract Award
    1.2. Negotiations
    1.3. Contract Signature (3/12/2014)
2. **Permitting (5/20/2014)**
    2.1. Whitman County
    2.2. WA Dept. Of Ecology
3. **Design (7/29/2014)**
    3.1. Foundations
    3.2. Site
    3.3. Electrical
    3.4. Structural
    3.5. Digital
    3.6. Communications
    3.7. Protection
    3.8. Substation Integration
    3.9. Security
4. **Construction (10/21/2014)**
    4.1. Site Preparation
    4.2. Structure installation
    4.3. Connection Equipment Installation
    4.4. Battery Subsystem installation
    4.5. Wiring
    4.6. Relay Testing
5. **Initial Systems Integration Testing (11/24/2014)**
    5.1. Battery Unit Test
    5.2. Battery Integration Test
    5.3. Battery Parallel Test
    5.4. Acceptance Certification

Energy Storage Analytics and Control System Development

6. **Refinement of Value and Business Case for the Deployment of Energy Storage (11/19/2014)**
    6.1. Summary of Value Assessment (11/19/2014)
    6.2. Proposal for Control Strategies (12/19/2014)
7. **Development of Control System (July 2015)**
    7.1. Specification of Control Strategies (February /2015)

7.2. Development of Control Strategies (Use Case Groups 1-4) (May 2015)
7.3. Preliminary Testing of Control Strategies (Use Case Groups 1-4) (July 2015)
7.3.1. Use Case Group 1 (6/23/ 2015)
7.3.2. Use Case Group 2 (7/23/ 2015)
7.3.3. Use Case Group 3 (8/24/ 2015)
7.3.4. Use Case Group 4 (9/23/ 2015)

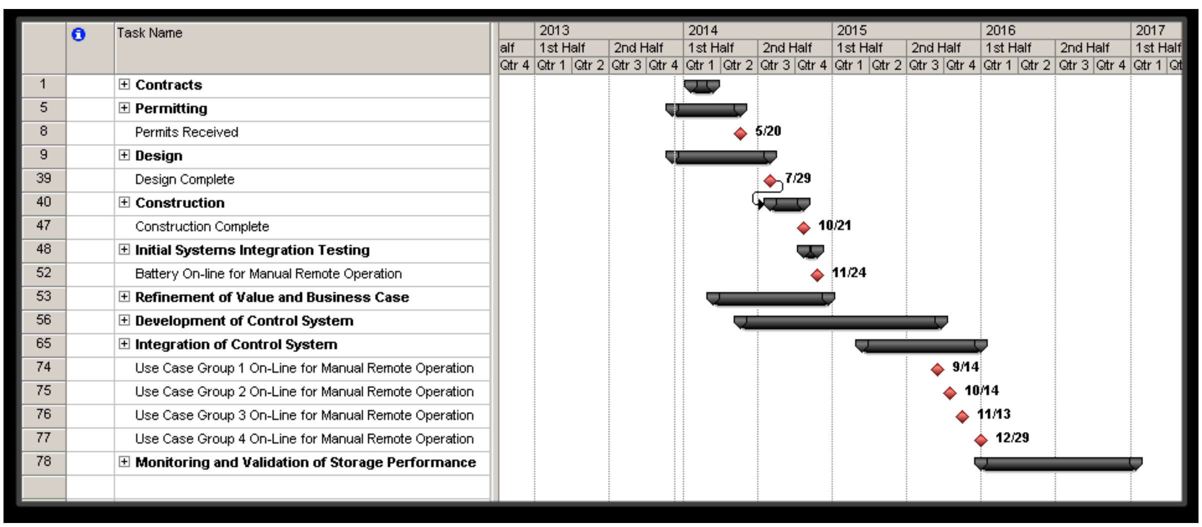
8. Integration of Control System (December 2015)

8.1. Definition of use case groups (4/13/2015)
8.2. Identification of EMS/DMS customization required (6/12/2015)
8.3. Review and codification of WSU control systems designs (8/13/2015)
8.4. Test Plans for each use case group, unit, integration and end-to-end (2015)
8.4.1. Integrate & Test Use Case Group 1 (9/14/2015)
8.4.2. Integrate & Test Use Case Group 2 (10/14/2015)
8.4.3. Integrate & Test Use Case Group 3 (11/13/2015)
8.4.4. Integrate & Test Use Case Group 4 (12/29/2015)

9. Monitoring and Validation of Storage Performance (2016)

9.1. Develop a plan for energy storage performance quantification (3/30/2016)
9.2. Create and deploy calculated PI tags for results (5/31/2016)
9.3. Create dashboards for executive monitoring of energy storage performance (7/15/2016)
9.4. Ongoing monitoring for expected results (2016)

Overall Schedule



Performance Milestones

Performance milestones coincide with the completion of tasks on the project schedule. Avista has engineering staff, mechanical, electrical, and relay crews, as well as a warehouse of materials. Avista builds millions of dollars of facility every year and as such is comfortable with performance milestones that match our normal mode of design, construction and testing. The performance milestones with anticipated dates are:

1) Contract signed with Washington State Department of Commerce (**March 2014**)
2) Permits Received from the Washington State Department of Ecology and Whitman County (**May 2014**)
3) Design Drawings complete and transmitted to crews (complete by **end of July 2014**)

4) Construction complete (this could be broken into a number of milestones, however the key milestone is the energy storage system installed and available for use (complete by **end of October 2014**)
5) Acceptance testing and initial integration testing complete (on-line in manual remote mode by **end of November 2014**)
6) Refinement of value and business case assessment for control system strategy proposal Complete by **end of 2014**)
7) Development of control system strategies (complete by end of **July 2015**)
8) Integration of control system with EMS and DMS. The number of "use cases" places a large amount of work on the integration team. This will be a phased approach that will be set based on the correct sequencing of "use cases" based on the assessment work (this work finished near the end of **2015** with first deliverables in **Sept. 2015**)
9) Monitoring and reporting for real time continuous calculation of performance. (note this task continues through the end of **2016** so that a demonstration period of adequate time is experienced)

Key Lead Times

The most significant lead times for the project are the contract negotiations, the environmental permitting process and the energy storage system.

- The Department of Commerce has indicated the contracting should go smoothly. In any case Avista has allowed for a 39 day process.
- The environmental permitting process is already underway at Avista so that the 90-120 anticipated lead-time has a month less impact. Some tasks can begin without the permits, however no sight work or final physical design.
- UET has assured the consortium that a unit will be available for testing in the first half of 2014. Installation takes place in the second half of the year.

Project Task Cost

Task 1 Title: Contracting	Grant	Cash Match	In-Kind Match	Total
Personnel – Inc. salaries, wages, fringe benefits	$-	$-	$-	$-
Contractual services	$-	$-	$-	$-
Goods and services – Inc. office costs, rent, communications	$-	$-	$-	$-
Other	$-	$-	$-	$-
Overhead/indirect	$-	$-	$-	$-
Total for Task	$-	$-	$-	$-

Task 2 Title: Permitting	Grant	Cash Match	In-Kind Match	Total

Personnel – Inc. salaries, wages, fringe benefits	$5,000	$5,000		$10,000
Contractual services	$-	$-	$-	$-
Goods and services – Inc. office costs, rent, communications	$-	$-	$-	$-
Other	$-	$-	$-	$-
Overhead/indirect	$-	$-	$-	$-
Total for Task	$5,000	$5,000	$-	$10,000

Task 3 Title: Design	**Grant**	**Cash Match**	**In-Kind Match**	**Total**
Personnel – Inc. salaries, wages, fringe benefits	$39,230	$39,230		$78,460
Contractual services	$-	$-	$-	$-
Goods and services – Inc. office costs, rent, communications	$-	$-	$1,200	$1,200
Other	$-	$-		$-
Overhead/indirect	$25,500	$25,500	$-	$50,999
Total for Task	$64,730	$64,730	$1,200	$129,459

Task 4 Title: Construction	**Grant**	**Cash Match**	**In-Kind Match**	**Total**
Personnel – Inc. salaries, wages, fringe benefits	$269,192	$269,192		$538,383
Contractual services	$-	$-	$-	$-
Goods and services – Inc. office costs, rent, communications	$2,060,470	$2,060,470	$2,180,000	$4,120,940
AFUDC	$6,250	$6,250		$12,500
Overhead/indirect	$174,974	$174,974	$-	$349,949
Total for Task	$2,510,886	$2,510,886	$2,180,000	$5,021,772

Task 5 Title: Initial System Integration and Testing	**Grant**	**Cash Match**	**In-Kind Match**	**Total**

Personnel – Inc. salaries, wages, fringe benefits	$18,240	$18,240		$36,480
Contractual services	$-	$-		$-
Goods and services – Inc. office costs, rent, communications	$-	$-	$3,000	$3,000
Other	$-	$-		$-
Overhead/indirect	$11,856	$11,856	$-	$23,712
Total for Task	$30,096	$30,096	$3,000	$60,192

Task 6 Title: Refinement of Valuation & Business Case	**Grant**	**Cash Match**	**In-Kind Match**	**Total**
Personnel – Inc. salaries, wages, fringe benefits	$18,240	$18,240		$36,480
Contractual services	$175,000	$175,000		$350,000
Goods and services – Inc. office costs, rent, communications	$-	$-	$3,000	$3,000
Other	$-	$-		$-
Overhead/indirect	$11,856	$11,856	$-	$23,712
Total for Task	$205,096	$205,096	$3,000	$410,192

Task 7 Title: Development of Control System	**Grant**	**Cash Match**	**In-Kind Match**	**Total**
Personnel – Inc. salaries, wages, fringe benefits	$27,360	$27,360		$54,720
Contractual services	$200,000	$200,000		$400,000
Goods and services – Inc. office costs, rent, communications	$350,000	$350,000	$3,000	$700,000
AFUDC	$13,500	$13,500		$27,000
Overhead/indirect	$17,784	$17,784	$-	$35,568
Total for Task	$608,644	$608,644	$3,000	$1,217,288

Task 8 Title: Integration of Control System	Grant	Cash Match	In-Kind Match	Total
Personnel – Inc. salaries, wages, fringe benefits	$60,800	$60,800		$121,600
Contractual services	$100,000	$100,000		$200,000
Goods and services – Inc. office costs, rent, communications	$-	$-	$3,000	$3,000
Other	$-	$-		$-
Overhead/indirect	$39,520	$39,520	$-	$79,040
Total for Task	$200,320	$200,320	$3,000	$400,640

Task 9 Title: Monitoring and Validation	Grant	Cash Match	In-Kind Match	Total
Personnel – Inc. salaries, wages, fringe benefits	$15,290	$15,290		$30,580
Contractual services	$125,000	$125,000		$250,000
Goods and services – Inc. office costs, rent, communications	$-	$-	$3,000	$3,000
Other	$-	$-		$-
Overhead/indirect	$9,939	$9,939	$-	$19,877
Total for Task	$150,229	$150,229	$3,000	$300,457

Smart Grid Proposal Budget

Please include all estimated costs. These estimates will be used to negotiate the budget for the agreement if you are awarded a grant. Please show how you developed your calculations and list each source of match funds and state if they are committed.

Summary - All Tasks	Grant	Cash Match	In-Kind Match	Total
Personnel – Inc. salaries, wages, fringe benefits	$453,352	$453,352	$-	$906,703
Contractual services	$500,000	$600,000	$3,000	$1,203,000
Goods and services – Inc. office costs, rent, communications	$2,435,470	$2,435,470	$2,216,200	$7,087,140
Other	$19,750	$19,750	$1,200	$40,700

Overhead/indirect	$291,428	$291,428	$-	$582,857
			$-	
Total for Task	$3,500,000	$3,800,000	$2,220,400	$7,600,000

F. Project Team

Individual Qualifications

1. Washington State University - WSU

Dr. Chen-Ching Liu

Chen-Ching Liu is Boeing Distinguished Professor at Washington State University (WSU), Pullman. At WSU, Professor Liu serves as Director of the Energy Systems Innovation (ESI) Center. During 1983-2005, he was a Professor of EE at University of Washington, Seattle. Dr. Liu was Palmer Chair Professor at Iowa State University from 2006 to 2008. From 2008-2011, he served as Acting/Deputy Principal of the College of Engineering, Mathematical and Physical Sciences at University College Dublin, Ireland. He was appointed by the Governor as a Member of the Board for Washington Technology Center. He served as Program Director of Power Systems at National Science Foundation. Dr. Liu received his BS and MS degrees from National Taiwan University and Ph.D. from the University of California, Berkeley. Professor Liu received an IEEE Third Millennium Medal in 2000 and the Power and Energy Society Outstanding Power Engineering Educator Award in 2004. In 2013, Dr. Liu was recognized with an Honorary Doctoral Degree by Polytechnic University of Bucharest, Romania. Chen-Ching chaired the IEEE Power and Energy Society Fellow Committee, Technical Committee on Power System Analysis, Computing and Economics, and Outstanding Power Engineering Educator Award Committee. He is a Member of the Board on Global Science and Technology, US National Academies. Professor Liu is a Fellow of the IEEE.

Dr. Liu has 30 years of experience in power engineering research and education with extensive collaborations with the power industry in US, Europe and Asia. His work in 1987* with colleagues on distribution feeder reconfiguration has been extended and implemented in all major cities in S. Korea. Similar feeder recovery technologies have been adopted by the power industry as a smart grid technology. The technology is the basis of on-going collaborative work with PNNL on resilient distribution systems sponsored by US Department of Energy. * C. C. Liu, S. J. Lee and S. S. Venkata, "An Expert System Operational Aid for Restoration and Loss Reduction of Distribution Systems," *IEEE Trans. on Power Systems*, Vol.3, May 1988, pp. 619-626.

Dr. Anjan Bose

Anjan Bose is a Regents Professor and the Distinguished Professor of Electric Power Engineering at Washington State University in Pullman, Washington, where he also served as the Dean of the College of Engineering & Architecture from 1998 to 2005. He served the US Department of Energy as a Senior Advisor on the electric power grid in the Obama administration. He is a leading researcher on the operation and control of the electric power grid. He received his BTech from the Indian Institute of Technology, Kharagpur, his MS from the Univ. of California, Berkeley and his PhD from Iowa State University, all in Electrical Engineering. He has worked in the electric power industry as well as academe for over 40 years.

Dr. Bose is a Member of the US National Academy of Engineering, a Foreign Fellow of the Indian National Academy of Engineering and a Fellow of the Institute of Electrical & Electronics Engineers (IEEE). He was the recipient of the Outstanding Power Engineering Educator Award, the Third Millennium Medal, and the Herman Halperin Electric Transmission & Distribution Award from the IEEE. He has been recognized by both Iowa State University and the Indian Institute of Technology with their distinguished alumnus awards. He has served on several editorial boards and on many national and international technical committees. He was appointed by the governor to the board of directors of the Washington Technology Center, and by the US Secretary of Energy on the committee to study the 1999 and 2003 power blackouts. He has served on several committees of the US National Academies including those for Engineering Education, Cybersecurity Research, Power Grid Security and America’s Energy Future. He has consulted for many electric power companies and advised government agencies throughout the world.

Dr. Anurag K. Srivastava

Anurag K. Srivastava is an Assistant Professor of electric power engineering and director of Smart Grid Demonstration and Research Investigation Lab (SGDRIL) within Energy System Innovation Center (ESIC) at Washington State University since August 2010. He received his Ph.D. degree in Electrical Engineering from the Illinois Institute of Technology, Chicago, USA in 2005. In the past, he worked as Assistant Research Professor at Mississippi State University during 2005-2010, as Senior Research Associate at the Indian Institute of Technology, Kanpur, India and as Research Fellow at Asian Institute of Technology, Bangkok, Thailand. His research interest includes power system operation and control. Dr. Srivastava is a senior member of IEEE and past-chair of IEEE PES career promotion subcommittee, chair of IEEE PES student activities and co-chair of microgrid working group within IEEE power and energy society generation and storage subcommittee. He is the recipient of best paper award form IEEE industry application society and is working closely with number of electric power companies. Dr. Srivastava is associate editor of the IEEE Transactions on Smart Grid and author of more than a hundred technical publications including a book on power system security.

2. Pacific Northwest National Laboratory - PNNL

Dr. Michael Kintner-Meyer

Dr. Kintner-Meyer is leading PNNL's grid analytics for energy storage and electrification of transportation for the DOE, Office of Electricity Delivery and Energy Reliability. The thrust of the energy storage activities is to establish methodologies and advanced approach for estimating the optimal size, placement, and operational requirements of energy storage system in local and regional power grids. In this function, he manages a grid analytics team, that provides services to grid operators (BPA, Energy Northwest), develops tool for the design engineering community for developing optimal control strategies to maximize the investment of stationary energy storage devices in both transmission and distribution systems. He is overseeing the development of a storage component cost modeling tools that reveals maximum cost reduction opportunities in the manufacturing and technology improvement for storage technology. Furthermore Michael’s team collaborated with the utility and vendor representatives to define protocols for performance measurement protocols and procedures. Michael has been with PNNL since April of 1998. He received his Ph.D. in Mechanical Engineering from the University of Washington, Seattle.

Mr. Patrick Balducci

Mr. Balducci is a Senior Economist at the Pacific Northwest National Laboratory where he has been employed since 2001. Mr. Balducci holds a BS in Economics from Lewis and Clark College, where he graduated with honors, and an MSc in Applied Environmental Economics from the University of London in Association with Imperial College London. He serves as an Adjunct Professor of Business at Marylhurst University where he was honored with the 2013 Excellence in Academic Service & Teaching Award. He also currently serves on the Board of Directors of the Pacific Northwest Regional Economics Conference. His areas of expertise include benefit-cost and return on investment analysis, economic impact analysis, economic modeling, environmental valuation, energy economics and utility financial analysis. Patrick has led economics analysis and modeling for recent energy storage valuation studies for the U.S. Department of Energy and for the BPA co-funded project led by Primus Power with Puget Sound Energy on grid energy storage.

Dr. Chunlian Jin

Dr. Chunlian Jin is an Electrical Engineer in the Electricity Infrastructure group within PNNL’s Energy and Environment Directorate. She has served as a PI or Key Contributor for multiple energy storage projects, including the PNNL Energy Storage sizing tool development, BPA/Primus/PSE/PNNL Zinc Bromide Battery Storage demonstration project, BPA/Powin/Energy Northwest/City of Richland/PNNL Li-ion Battery Storage demonstration project, Energy Storage National Assessment, PNNL Energy Storage Regional Case Study for the NWPP, and energy storage controller project. Her research interests include energy storage planning analysis, energy storage operation and control methods development, energy storage performance metrics development, modeling and assessment of power system operations and control performance, integration of renewable resources, climate change and smart grid study and distribution system power flow analysis. She received her bachelor's degree in Electrical Engineering from the Northwestern Polytechnical University (Xi'an, China) in 2000, her master's in Electrical Engineering from Tsinghua University in 2003, and her PhD from University of South Carolina in 2011.

3. UniEnergy Technologies

Z. Gary Yang
President & Chief Executive Officer UniEnergy Technologies
Dr. Yang is a leading scientist and now an entrepreneur in clean energy and energy storage. He co-founded UniEnergy Technologies, LLC in 2012, and currently serves as CEO and President of the company, with a mission to commercialize new generation vanadium flow batteries (VFB) and provideenergy storage solutions enabling the ever increasing adoption of renewable power from intermittent sources such as wind and solar and the implementation of smart, reliable grids.

Previously, Gary was a Lab Fellow, the highest science and technology rank at Pacific Northwest National Laboratory (PNNL) of the US Department of Energy (DOE), and served as the Lead Scientist of the Stationary Energy Storage Program at the lab. In that role, Dr. Yang led extensive efforts and managed a team of nearly 30 scientists and engineers at the lab in RD&D of vanadium and other redox flow, Na-halide, and Li-ion batteries, and new battery concepts for utility applications. As principal investigator and project manager, he led the DOE-OE storage project at PNNL which developed a new generation VFB. Earlier, Dr. Yang was a Senior Scientist and later a Chief Scientist leading efforts in RD&D of solid oxide fuel cells (SOFC) and hydrogen storage materials. He joined PNNL in early 2001, after over ten years of experience and training in materials science/engineering and electrochemistry including at Carnegie Mellon University and the University of Connecticut. Dr. Yang has organized 22 conferences and symposia on clean energy and advanced materials, and edited over 20 conference proceedings and special issues of journals. He has published over 200 research articles, 13 book chapters/editorials, and delivered numerous invited speeches. He is an inventor of over 50 US and foreign patents (including pending). His efforts in SOFC and VFB won him twice the Federal Laboratory Consortium's (FLC) Excellence in Technology Transfer Award, one of the most prestigious US government awards on technology development and commercialization.

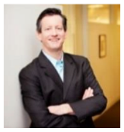
Liyu Li
Chief Technology Officer UniEnergy Technologies
Dr. Li has a solid background in chemistry, chemical engineering, and material sciences. He has broad experience in the fields of clean coal and biomass utilization, CO_2 capture, and redox flow batteries for grid-level electricity storage. He also has broad experience in developing inorganic absorbents, hydrogen storage materials, heterogeneous catalysts, inorganic ion exchangers, and glass and ceramic nuclear waste forms. He has published 70 peer-reviewed scientific papers with more than 1000 total citations,

and has given more than 100 presentations at national and international scientific conferences in these areas. He also holds nine patents, and has over a dozen patent applications on file. Dr. Li is the co-founder and Chief Technology Officer of UniEnergy Technologies, LLC. (UET), a company commercializing advanced large-scale energy storage solutions. Before co-founding UET, he was a chief scientist, a project manager and a lead principal investigator at Pacific Northwest National Laboratory. At this position, he had both research management and technical supervisory responsibilities for the execution of governmental and industrial projects. At PNNL, Dr. Li led/co-led different research projects developing new redox flow battery energy storage systems, and new CO_2 and impurity absorbents for clean coal and biomass application. Dr. Li's major scientific contributions to the energy storage area in a Leading Role include: (1) invented Mixed Acid All Vanadium Redox Flow Battery system which is under commercialization process by UET and two other US companies; (2) invented Fe-Vanadium Redox Flow Battery system which is under commercialization process by a Canadian company. Dr. Li received his Ph.D. degree in Chemical Engineering in 1995.

Rick Winter
Chief Operations Officer UniEnergy Technologies
Rick Winter earned his Bachelor of Engineering in Mechanical Engineering from the University of Queensland, Australia, and has 25 years' experience innovating and implementing grid storage technologies. He has been a driving force in the transition of the grid storage industry from its early stages, to the strategic imperative for grid flexibility and stability it is today. During this time, he has helped build the US Electricity Storage Association from its inception in 1991, serving twice as chairman and as a board member for 18 years. In 2011, Rick was awarded the Phil Symons award for his "*instrumental role in the evolution of storage technologies in both the utility and battery manufacturing industries*".

Mr. Winter's background ranges from managing the storage technologies program at Pacific Gas & Electric, America's largest investor-owned utility, to deploying remote area hybrid power systems in Australia's Torres Strait. He has led product development at four advanced battery companies, in the process creating the world's first flow battery product by leveraging advanced zinc-bromide technology from Austria (the 100kW/100kWh PowerBlock), and leading development of iron-chromium batteries for cell towers in India. Rick invented the single loop flow battery in his garage (Pat#8039161), going on to found Primus Power and raise $30M in capital. He holds 17 US patents and numerous abroad with a further 10 US patents pending. With a focus on productization, Mr. Winter has strong hands-on experience evaluating grid impacts of distributed generation systems including batteries, flywheels, microturbines, photovoltaics and diesel generators.

Rick is now Chief Operating Officer at UniEnergy Technologies (UET), a compact vanadium flow battery company bringing together a multinational supply chain of commodity components and materials; volume production; and next generation electrochemistry invented at PNNL with DOE funding. UET's focus is to commercialize its cycle and temperature-agnostic containerized storage solution. With full-scale product already under factory testing, field deployment begins in early 2014.



Russ Weed

VP Business Development & General Counsel UniEnergy Technologies

Russ Weed is a seasoned business executive and corporate lawyer with a track record of accomplishment at UET, GE, Labtec, and AV-rated Seattle and Portland law firms. He has 12 years of experience as the VP Business Development and company counsel at technology and industrial companies, as well as 10 years as a corporate attorney at law firms. He has led and teamed in the strategizing, preparation, negotiation, closing, and execution of a wide range of deals and business matters, including mergers and acquisitions, licensing, corporate financing, formations and fundings, intellectual property, and commercial contracts. With broad international experience, particularly in Asia and Europe, Russ also has expertise in government relations, employment, compliance, trade regulation, and risk management. He has managed corporate teams and cross-functional processes. Russ is personally committed to identify and accomplish the strategic and legal objectives of the business and its people, and to make large-scale clean energy a reality.

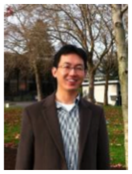
Charlie Vartanian Director of Marketing UniEnergy Technologies

Charlie Vartanian is Marketing Director for UniEnergy Technologies (UET), a manufacturer of advanced compact vanadium flow battery systems for grid-scale applications. Charlie has over 25 years of power industry experience including marketing advanced energy systems, leading and performing electric system planning studies, and contributing to technical standards development. At UET, Charlie focusses on matching client goals and market requirements with UET's novel solutions. His previous employers have included DNV KEMA, A123 Systems, Southern California Edison, the California Energy Commission, Enron Energy Services, and the U.S. Navy Civil Engineer Corps. Charlie received his MSEE from USC, and his BSEE from Cal Poly Pomona. Charlie is a licensed Professional Engineer in California, and is a senior member of the IEEE.

David Ridley

Director of Electrical Engineering & Controls UniEnergy Technologies

Dave has over 10 years of experience productizing and bringing to market a wide array of clean energy and enabling technologies, with the most recent 4 years dedicated to containerized flow battery development. With a background in Electrical Engineering, he specializes in the design and optimization of industrial and embedded control systems, as well as power conversion electronics. Dave's designs and innovations have been awarded numerous patents, and demonstrated many years of success in the field.



Chauncey Sun

Director of Testing UniEnergy Technologies

Chauncey Sun (Chenxi Sun) received his Ph.D. degree in Chemical Engineering from the Chinese Academy of Sciences. He has worked in the energy storage field for over 7 years, focusing on the vanadium flow battery (VFB) which is one of the most promising technologies for large-scale energy storage applications. Between 2010 and 2012, Chauncey worked as a leader in the R&D department at Dalian Rongke Power Co., Ltd., a leading advanced energy storage technologies company in China which was established in 2006 and has manufactured and delivered multiple megawatt VFB's, including the largest VFB system (5MW/10MWh) in the world. He came to the U.S. in 2012 with his first stop at University of Washington as a postdoctoral researcher, before joining UniEnergy Technologies (UET) in 2013. Currently, Chauncey works as the director of UET's testing department, in charge of product testing and evaluation.

Ted Volberding

Director of Manufacturing UniEnergy Technologies

An experienced, collaborative Operations leader and engineer in the industrial, electrical, telecom, networking, and medical device industries, with a proven ability to successfully manage projects, employees, and operations in a technically dynamic and worldwide environment, with a solid understanding of the legal, safety and regulatory, and financial responsibilities of management.

Nick MacDonald

Director of Mechanical Engineering & System Integration UniEnergy Technologies

Prior to joining UniEnergy Technologies, Niles "Nick" MacDonald was located in Silicon Valley where he served as Director of Tool Engineering at Enki Technologies, Senior Engineering Manager at Solyndra LLC, Senior Mechanical Engineer at KLA-Tencor, and Mechanical Design Manager atGaSonics International. In all of these roles, he was instrumental in specifying, developing, and building capital equipment to bring new and emerging technologies to market. His capital equipment experience ranges from semiconductor processing, solar panel manufacturing lines, chemical dispensing and automated systems, medical product development, and some consumer products. Mr. MacDonald received his Masters in Engineering Management from Santa Clara University, and his B.S. in Mechanical Engineering from California State Polytechnic University, Pomona.

Andreas Luczak

Managing Director Vanadis Power GmbH
Dr. Andreas Luczak joined Vanadis Power GmbH as General Manager in June 2013. In this role he is introducing the advanced version of the flow battery technology of UET in the European market. He joined this position as Head of Siemens Energy Storage Solutions where he managed all aspects of optimizing Energy Generation and Grid Stability Solutions. Prior to this, he managed the power electronics group within the Siemens photovoltaic division and held positions as R&D manager within the Automation&Control groups of Siemens Automotive and Siemens Power Generation and as Innovations Manager within the Siemens Industrial Service Business. Andreas Luczak is holding a PhD in Physics, is 44 years old and lives with his wife and two sons in Nuremberg, Germany.

Xuan Katheder
Deputy Managing Director Vanadis Power GmbH
Xuan Katheder has been working in the Vanadium chemical and metallurgical fields since 1998, after she graduated as Dipl.-Ing. (German academic title equivalent to MSc.) of Material Science and Technology in Germany. With her background of the technology and her language skill in Chinese, German and English, she was initially appointed to international marketing activity of GfE, a leading company in Vanadium chemical and metallurgical products and advanced coating materials. After two years, she changed to Innovation Centre of North Bavarian, a Branch office of Bavarian Ministry of Economy, as technical officer for assessment and approval of state funding of innovative projects. In 2004, she was reappointed by GfE to business development manager for vanadium sourcing and for Asian business. Later she joined an engineering company to start a project of establishing a Sino-German joint venture metallurgical plant and carried out this project as project manager in the following years. After completion of the project in 2012, she was authorized by the company group shareholder to establish Vanadium flow battery business in Germany as well as in Europe. The initial activity results in Vanadis Power GmbH where she holds now the position of deputy managing director.

Charles Toca
General Manager Utility Savings & Refund, LLC
Charles R. Toca is the General Manager for Utility Savings & Refund, LLC, (US&R) an energy services company that has advocated the vanadium redox flow battery since 2006 and has now partnered with UniEnergy Technologies (UET) to represent their advanced vanadium redox flow battery (VRFB) in the California energy market. US&R has previously been the sales affiliate and Strategic Partner for VRB Power and Prudent Energy, founding member of the BioEnergy Producers Association, and Board member for the California Electric Users Cooperative (CEUC). He is located in Southern California and has made numerous presentations before the California Public Utilities Commission (CPUC) and the California Independent System Operator (CAL-ISO) in support of VFB energy storage.
Carolina in 2011

4. Avista Utilities

Mr. Curtis Kirkeby, P.E.

Mr. Kirkeby holds a bachelor of science degree in electrical engineering (BSEE) from Montana State University and a Masters in Engineering Management from Washington State University. He is a registered professional engineer in the State of Washington and has extensive experience in the electric and gas utility industry; 6 years in substation design, 18 years in GIS, outage management, asset management, advanced metering systems, and engineering modeling, 6 years in research and development and 6 years of smart grid design and deployment. Mr. Kirkeby is currently responsible for applied research and development, focused on smart grid and emerging technologies. He also has the role of principal investigator for the Avista smart grid project in Pullman, WA which is a subproject of the Department of Energy sponsored Pacific Northwest Smart Grid Demonstration led by Battelle.

Mr. John Zachary Gibson, P.E.

Mr. Gibson holds a bachelor of science degree in electrical (BSEE) and civil engineering (BSCE) from Gonzaga University and a Masters in Engineering Management from Washington State University. He is a registered professional engineer in the State of Washington and has worked in the electric utility industry for over twenty years. Mr. Gibson's experience in the electric utility industry consists of Hydro Generation, Electric Facility Management Systems, System Efficiencies and Distribution Management Systems. Mr. Gibson was recently Avista's project manager for the Smart Grid Investment Grant project. Currently, Mr. Gibson is the manager of the Distribution System Operations group responsible for the day to day operations of the Distribution Management System.

Mr. Erik Lee, P.E.

Mr. Lee holds a bachelor of science degree in electrical engineering (BSEE) from Washington State University. He is a registered professional engineer in the State of Washington and has 6 years experience in the electric utility industry working with geographical information systems (GIS), automated metering systems (AMI/AMR), outage management systems (OMS), distribution management systems (DMS/IVVC/FDIR), distribution system analysis & modeling, building custom data analysis tools and other various prototypes. Mr. Lee is currently working on spatial load forecasting analysis, IVVC benefit analysis, and is responsible for maintenance of the DMS topology model.

Mr. Brad Calbick,

Mr. Calbick holds a bachelor of science degree in electrical engineering (BSEE) from Washington State University. He has extensive experience engineering, developing, and deploying management and control systems for the bulk electric system; 9 years at New York State Electric and Gas in Binghamton, New York, and 17 years at Avista. Mr. Calbick presently manages a team of 8 engineers and technicians who are responsible for engineering and operating Avista's primary and alternate control center computing and telecommunications systems. This includes Avista's smart grid distribution management system, which was deployed as part of Avista's DOE-funded Smart Grid Investment Grant project.

Timothy P. Olson, P.E.

Mr. Olson holds a bachelor of science degree in electrical engineering (BSEE) from the University of Portland. He has experience in Hydro-electric generator construction and rehabilitation, power equipment maintenance, substation design and construction, and distribution systems design and installation. Mr. Olson has worked for Portland General Electric Company from 1980 to 1985 and currently works as the South Region Operations Engineer for Avista Utilities. He is the Lead Distribution construction engineer for SGDP and the WSU partnership.

Reuben Arts

Mr. Arts holds a bachelor of science degree in electrical engineering (BSEE) from the University of Idaho. He has experience in power quality engineering, bulk electric system planning, smart grid Distribution Management System (DMS) support, and communications support for various metering systems; 3 years at PacifiCorp in Portland, Oregon, and 7 years at Avista. Mr. Arts presently works in the Distribution Operations Management group, supporting the DMS system and various other dispatch systems required to deliver actionable data to Avista's 24/7 distribution dispatch group.

G. Consortium Organizational Qualifications

1. Avista Utilities

Avista Utilities is an investor owned electric and gas utility that proudly provides electricity to nearly 340,000 customers and natural gas to about 300,000 customers. The primary market area covers more than 30,000 square miles and Avista operates and manages energy generation, transmission and distribution facilities in four western states.

The diverse generation portfolio allows Avista to produce energy that consistently ranks among the nation's most competitively priced. The system includes eight hydroelectric generating plants on two rivers, coal, natural gas and wood-waste combustion plants in five eastern Washington, northern Idaho, and eastern Montana locations.

Avista has some of the lowest electricity rates in the nation and is constantly working to minimize cost while improving, modernizing, and optimizing the electric system through comprehensive forward thinking planning efforts Emerging technology is routinely assessed for potential benefits.

Avista has been as an innovator since formation. Relevant to this project, Avista brings advanced technology infrastructure, balancing authority responsibilities, a proven track record deploying technology, and years of experience with personnel that has designed and deployed large scale smart grid solutions for 7+ years.

A review of the technology assessment section reveals the extent of the advanced infrastructure that can and will be leveraged for this project.

2. Pacific Northwest National Laboratory - PNNL

Pacific Northwest National Laboratory, located in Richland, WA, is a multi-program U.S. Department of Energy Laboratory operated by Battelle Memorial Institute since 1965. As a part of its mission for the US Department of energy, the over 4500 staff at PNNL has conducted research for the U.S. government and industry for more than 45 years.

PNNL has an extremely diverse set of scientific and technical skills ranging from fundamental sciences, to environmental, power generation, nuclear, biofuels, etc. Focusing on power systems, PNNL has broad expertise and experience in systems engineering with significant experience in renewables integration, energy storage and transmission planning. PNNL is applying our grid integration capabilities to pave the road for a wider penetration of renewables into national energy production without compromising reliability of power supply. Activities and capabilities include renewable integration tools & methods, power system transmission planning (power flow, stability, reliability, production cost optimization, etc.), operations (control performance criteria, quality, regulation, impacts of intermittent resources, etc.), and analysis. PNNL was a seminal force in establishment of smart grid architectures and analysis tools (e.g. GridLab-D), led the first smart grid field test (the Olympic Penninsula Study), and, as Battelle Pacific Northwest Division, leads the largest smart grid demonstration project in the U.S., the Pacific Northwest Smart Grid Demonstration Project.

PNNL conducts a wide range of energy storage research including technology development relying on fundamental scientific understanding and focused materials science and engineering. These capabilities are focused on redox flow batteries, sodium-based batteries, next-generation lithium-based and magnesium-based batteries. PNNL also develops analytic tools and conducts studies to guide cost reduction and realization of the full suite of benefits storage can provide in the electric enterprise. PNNL has conducted a number of studies examining the applications and market potential for grid energy storage. PNNL has completed, and will soon publish, a large DOE study evaluating the potential for energy storage for providing arbitrage and balancing services in various regions of the country including the Pacific Northwest, under assumptions of increased renewable deployments. Under BPA Technology Innovation projects with Primus Power and Puget Sound Energy, PNNL completed a value analysis that included evaluation of optimized multi-value grid service for storage at the distribution level; and with Powin Energy, Energy Northwest, and City of Richland, development of control strategies for firming wind power schedules, and providing substation reliability services. Analyses of storage for application in support of high penetrations of residential PV in Hawaii have also been conducted, utilizing GridLab-D (a tool for design and analysis of the smart grid). Finally, PNNL is active in development of performance test protocols for grid energy storage.

3. Washington State University - WSU

The WSU Energy Systems Innovation (ESI) Center builds on the existing excellence of the power engineering and related programs and broadens the scope and expertise to meet the grand challenges in energy and environment. The mission is to conduct research, educational, technology transfer, and outreach activities in the areas of smart grid in a societal context. The Center’s research is focused on important areas related to smart grid and energy systems. They include: (1) advanced monitoring, operation and control for the power grid, (2) cyber security of the power grid, (3) sociological, economic and environmental aspects, and (4) the integration of renewable energy resources into the power grid. The intellectual strengths of the Center include a core team of 8 power engineering faculty members and 18 other faculty members in allied fields, including control, computing, civil, environmental, chemical, mechanical, and materials engineering, economics, sociology, psychology, and public policy. The total research expenditures for the Center faculty are approximately $3.3M in 2013 from a variety of sources including the Department of Energy, National Science Foundation, Power Systems Engineering Research Center, Electric Power Research Institute, Avista, Puget Sound Energy, SEL, and Southern California Edison. A collaboration agreement allows industry and other organizations to participate in joint research, education, and training/development activities. The current Members are Alstom Grid, Avista, Itron, Pacific Northwest National Lab, Puget Sound Energy, Snohomish County PUD, and Wuhan University in China. The ESI Center receives STARs funding from the State of Washington through the Economic Development Commission. The Center has a strong program for international collaborations; visiting researchers and students from several countries participate in the Center's research and education projects. WSU is a leader in Smart Grid technology and a partner of the $178M DoE sponsored Northwest Smart Grid Demonstration Project with Avista, Battelle/PNNL and a team of utilities in the Northwest. As a result of the program, the City of Pullman is a Smart Grid with smart meters installed at all electricity customers and WSU is operating as a smart campus with Transactive signals.

WSU graduates about 40 BS degree students in power engineering and supports a pool of 80 Ph.D. and MS students in smart grid and related fields. The goal of the ESI Center is to increase BS power engineering enrollment by 50% over the next 5 years and increase the pool of graduate students in power engineering from 50 to 80 to address the need for power engineers in WA and nationwide. The ESI Center is awarded a new grant by National Science Foundation funding multi-year scholarships for 19 new students per year with 16 undergraduate and 3 Master's, especially women and minorities. WSU was part of a Department of Energy Workforce Training Grant that has developed power engineering courses for existing engineers in the workforce in collaboration with industry partners. The Workforce project has grown into a new WSU on-line Professional Master's degree in power engineering.

4. UniEnergy Technologies

UniEnergy Technologies (UET) produces and delivers large-scale energy storage systems for utility and grid, micro-grid, commercial and industrial, and other applications of value. The core technology is an advanced vanadium flow battery. The Uni.System™ is safe, operationally flexible, reliable, long-life, and cost-effective. Based in the Seattle area, UET has a 67,000 sqft facility scaling up to produce 100MW annually. UET's solution is differentiated by (i) new generation vanadium-based electrolyte first developed and patented at Pacific Northwest National Laboratory with the support of the US DOE Office of Electricity, with double the energy density and much broader temperature range than conventional electrolyte; (ii) a containerized design derived from multiple decades of design experience among the UET team, with a compact system footprint maximizing power and optimizing energy; (iii) mature large-scale electrode stacks with 7 years of field deployment and hundreds deployed in the field; and (iv) state of the art controls at each level of the Uni.System™ (from cell to site).

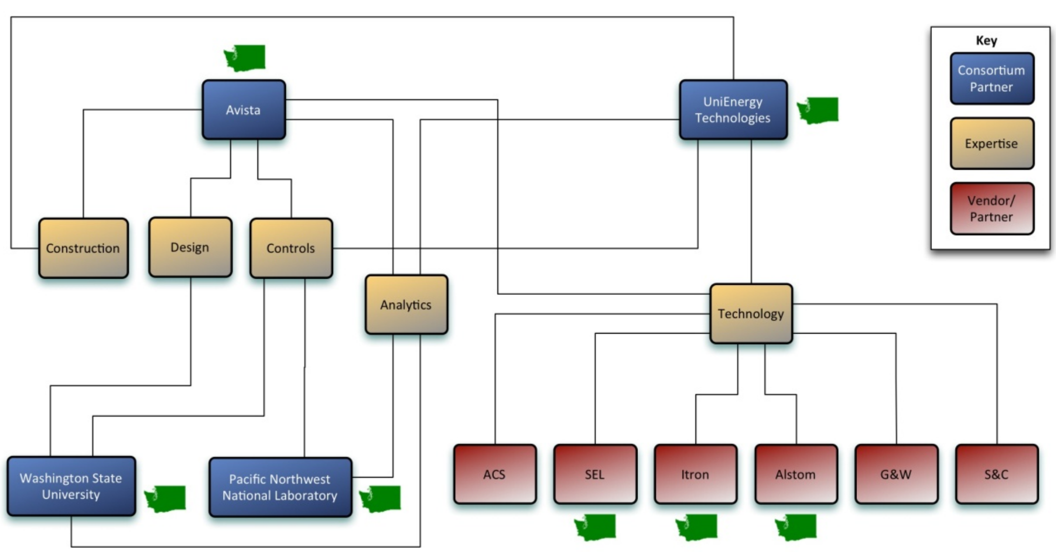
Team Balance

The Avista led consortium has been assembled purposely to balance the elements of Utility Operations, Innovative Solutions, Applied Research, Advanced Analytics and Controls coupled with Leading Edge Emerging Technology. Each consortium member brings expertise that complements the team as a whole. WSU, PNNL and Avista have successfully worked together on some very advanced projects in the recent past. UniEnergy Technologies has strong ties with PNNL, has some tremendous technology, and brings a wealth of market and technology expertise. The experience of the team members will allow for parallel efforts and a truly special implementation of dispatch capability of the energy storage system that allows for many benefit streams to be optimized in both the transmission and distribution operational worlds.

Consortium Structure

The consortium team members have responsibilities in numerous categories. The chart diagram below gives an idea of the integrated effort. PNNL and WSU are both involved in the development of analytics and controls which are integral to the solution design. Avista is responsible for the design and construction but leverages the efforts of all other partners. UET brings a wealth of capability in controls as well and will be heavily involved in the control system implementation. Additionally there are a number of top tier vendors whose equipment will be installed or whose software will be customized. It should be noted that Itron, SEL, and Alstom are all Washington based companies that will benefit from the selection of this project. Itron provides a data analytics software package, SEL provides relays and controls, Alstom provides the EMS. Non-Washington companies S&C, G&W, and ACS provide disconnects, circuit reclosers, and the DMS respectively.

Expertise - Responsibility Relationship Diagram



H. Matching Funds

Fund Source Table

	Cost Before Share	Avista	DOE	Commerce	In-Kind
Avista	$6,400,000	$3,200,000	$0	$3,200,000	$13,200
UET	$0	$0		$0	$2,180,000
PNNL	$500,000		$250,000	$250,000	$0
WSU	$600,000	$300,000		$300,000	$0
Totals	**$7,500,000**	**$3,500,000**	**$250,000**	**$3,750,000**	**$2,193,200**
Fund Ratio	**1.58**				

Requested Matching

In-Kind

The estimated in-kind contribution from UET to the Avista Utilities Consortium for a 1 MW Uni.System would be **$2.18M.**

This is based on WA CEF applications totaling 3.25 MW's from Avista and another WA utility proposed to be submitted tomorrow and also an earlier WA CEF proposal. In that case, UET's in-kind contribution to the WA clean energy ecosystem including fixed and variable costs less revenues through June 30, 2015 (not including pursued non-WA revenues in CA and elsewhere, which would provide true-up to WA) would by best estimate be approximately $7.08M (in addition to +$20M to date).

Avista anticipates using "in-kind" categorization for expenses related to crew lodging, travel, meals, etc. For our smart grid projects we set up a separate accounting. The total is estimated at $13,200.

So Avista's purchase of 1 MW from UET should under the Matching Category include proportionally $2.18M, which is 31% of UET's in-kind contribution ($7.08M*1 MW/3.25 MW).

I. Project Contact

The project contact is Mr. Curtis Kirkeby at Avista Utilities. Contact information is:

Curtis Kirkeby, P.E.
Sr. Electrical Engineer – Technology Strategy
Avista Utilities
Curt.kirkeby@avistacorp.com
(509) 495-4763 work
(509) 995-5099 cell

J. Utility Fiscal Calendar

The Avista fiscal calendar is coincident with the calendar year, January 1st – December 31st.

K. Supporting Documents (Not for Public Disclosure)

1. Avista Annual Report

Due to the size of the annual report a link is provided.

http://phx.corporate-ir.net/External.File?item=UGFyZW50SUQ9MTc3OTY1fENoaWxkSUQ9LTF8VHlwZT0z&t=1

2. Avista Balance Sheet

UNITED STATES
SECURITIES AND EXCHANGE COMMISSION
Washington, D.C. 20549

Form 10-Q

(Mark One)

☒ **QUARTERLY REPORT PURSUANT TO SECTION 13 OR 15(d) OF THE SECURITIES EXCHANGE ACT OF 1934**
FOR THE QUARTERLY PERIOD ENDED September 30, 2013 OR

☐ **TRANSITION REPORT PURSUANT TO SECTION 13 OR 15(d) OF THE SECURITIES EXCHANGE ACT OF 1934**
FOR THE TRANSITION PERIOD FROM TO

Commission file number 1-3701

AVISTA CORPORATION

(Exact name of Registrant as specified in its charter)

Washington	**91-0462470**
(State or other jurisdiction of incorporation or organization)	**(I.R.S. Employer Identification No.)**
1411 East Mission Avenue, Spokane, Washington	**99202-2600**
(Address of principal executive offices)	**(Zip Code)**

Registrant's telephone number, including area code: 509-489-0500
Web site: http://www.avistacorp.com

None
(Former name, former address and former fiscal year, if changed since last report)

Indicate by check mark whether the registrant (1) has filed all reports required to be filed by Section 13 or 15(d) of the Securities Exchange Act of 1934 during the preceding 12 months (or for such shorter period that the Registrant was required to file such reports), and (2) has been subject to such filing requirements for the past 90 days: Yes ☒ No ☐

Indicate by check mark whether the registrant has submitted electronically and posted on its corporate Web site, if any, every Interactive Data File required to be submitted and posted pursuant to Rule 405 of Regulation S-T (§232.405 of this chapter) during the preceding 12 months (or for such shorter period that the registrant was required to submit and post such files). Yes ☒ No ☐

Indicate by check mark whether the registrant is a large accelerated filer, accelerated filer, a non-accelerated filer, or a smaller reporting company. See the definitions of "large accelerated filer," "accelerated filer" and "smaller reporting company" in Rule 12b-2 of the Exchange Act. (Check one):

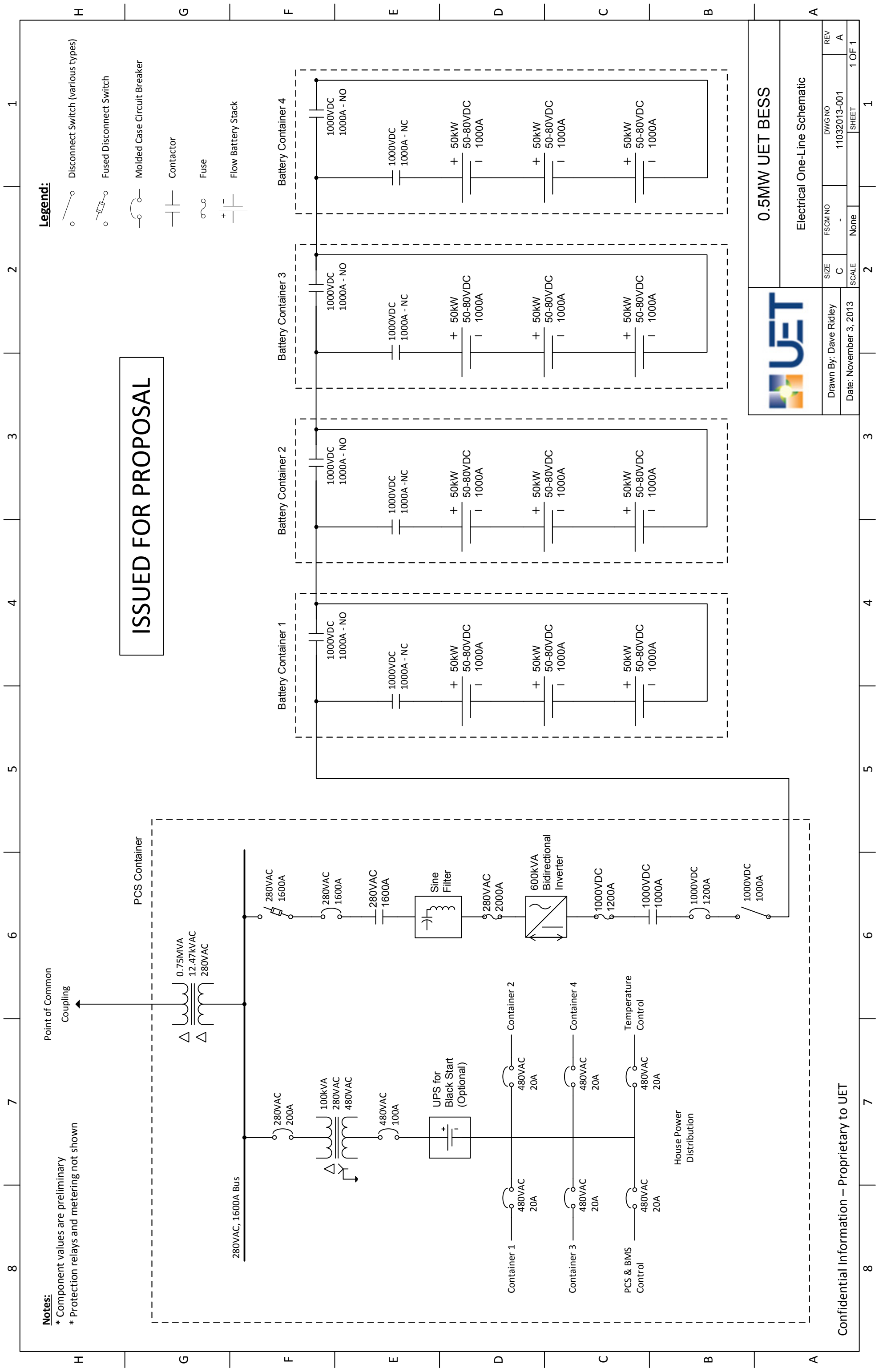
Large accelerated filer	☒	Accelerated filer	☐
Non-accelerated filer	☐ (Do not check if a smaller reporting company)	Smaller reporting company	☐

Indicate by check mark whether the Registrant is a shell company (as defined in Rule 12b-2 of the Exchange Act): Yes ☐ No ☒

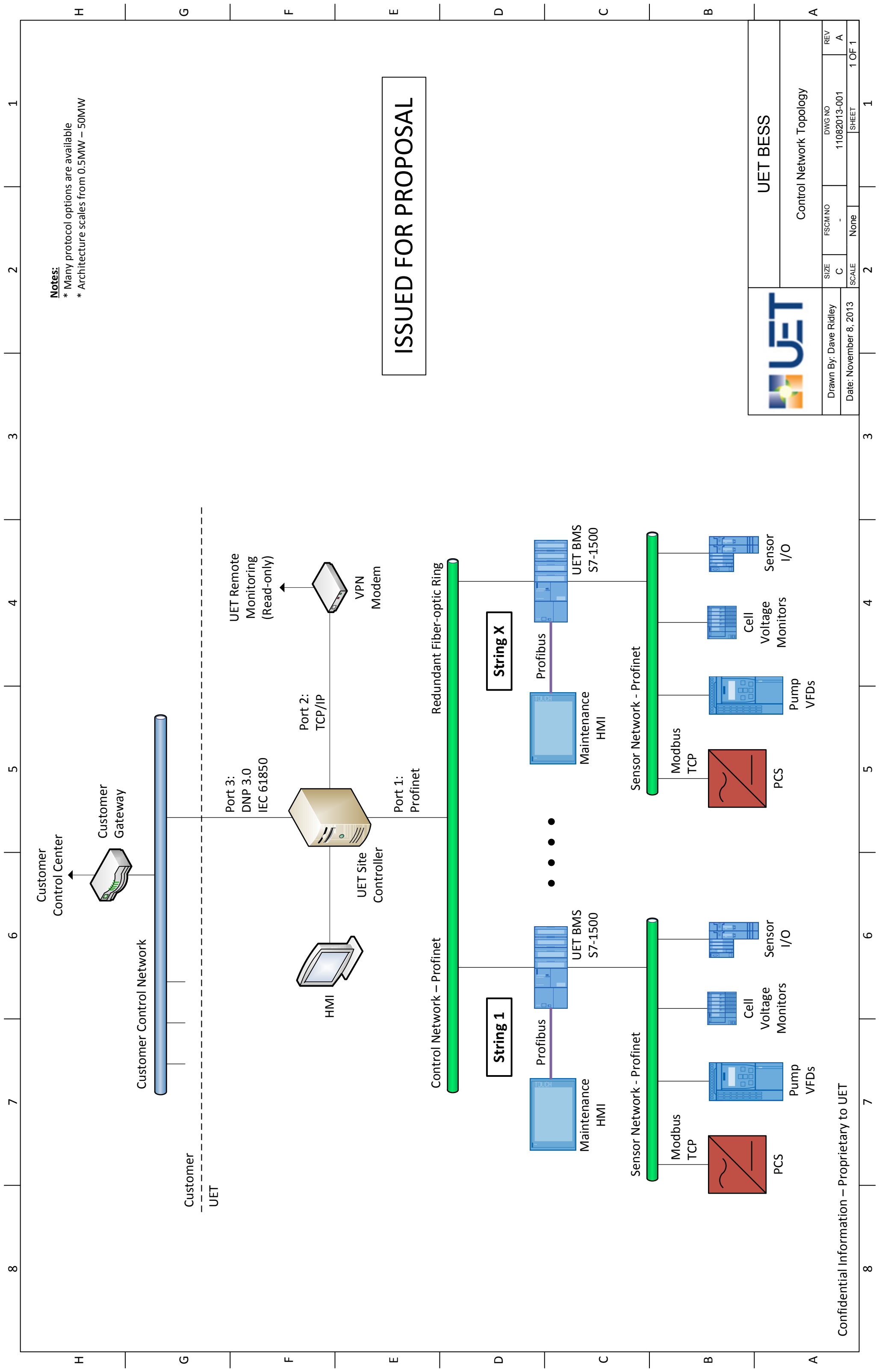
As of October 31, 2013, 60,036,179 shares of Registrant's Common Stock, no par value (the only class of common stock), were outstanding.

3. UET Site Layout

4. UET Electric One Line Schematic



5. UET Control Network Topology



6. UET MSDS Data Sheet

Safety Data Sheet

Version 1.1
Revision Date 10/11/2013

1. PRODUCT AND COMPANY IDENTIFICATION

Product name	:	Vanadium Electrolyte Solution
Supplier	:	UniEnergy Technologies, LLC 4333 Harbour Pointe Blvd SW Suite A, Mukilteo WA 98275 USA
Telephone	:	425-290-8898
Fax	:	425-740-9898
Emergency Phone # (Mon-Fri, 8 AM- 5 PM, PST)	:	425-290-8898

2. HAZARDS IDENTIFICATION

Emergency Overview

OSHA Hazards
Target Organ Effect, Harmful by ingestion, Corrosive

Target Organs

Teeth., Lungs, Blood, Brain.

GHS Classification
Acute toxicity, Oral (Category 4)
Skin corrosion (Category 1B)
Serious eye damage (Category 1)

GHS Label elements, including precautionary statements

Pictogram 

Signal word: Danger

Hazard statement(s)

H302	Harmful if swallowed.
H314	Causes severe skin burns and eye damage.

Precautionary statement(s)

P280	Wear protective gloves/ protective clothing/ eye protection/ face protection.
P305 + P351 + P338	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
P310	Immediately call a POISON CENTER or doctor/ physician.

HMIS Classification

Health	3*
Fire	0
Reactivity	0
Personal Protection	

NFPA Rating

Potential Health Effects

Inhalation	May be harmful if inhaled. Material is extremely destructive to the tissue of the mucous membranes and upper respiratory tract. Causes respiratory tract irritation.
Skin	May be harmful if absorbed through skin. Causes skin burns. Causes skin irritation.
Eyes	Causes eye burns. Causes eye irritation.
Ingestion	Harmful if swallowed.

3. COMPOSITION/INFORMATION ON INGREDIENTS

Component		Classification	Concentration
Vanadium trichloride			
CAS-No. EC-No.	7718-98-1 231-744-6	Acute Tox. 4; Skin Corr. 1B; H302, H314	0 - 20 %
Vanadyl Chloride			
CAS-No. EC-No.	10213-09-9 233-517-7	Acute Tox. 4; Skin Corr. 1B; H302, H314	0 - 20 %
Vanadium oxide sulphate			
CAS-No. EC-No.	27774-13-6 248-652-7	Acute Tox. 3; H301	0-10 %
Vanadium(III) sulphate			
CAS-No.	13701-70-7		0-10 %
Hydrochloric acid			
CAS-No. EC-No. Index-No.	7647-01-0 231-595-7 017-002-01-X	Skin Corr. 1B; STOT SE 3; H314, H335	0 - 10 %
Sulfuric acid			
CAS-No. EC-No. Index-No. Registration number	7664-93-9 231-639-5 016-020-00-8 01-2119458838-20-XXXX	Skin Corr. 1A; H314	0 - 5 %

For the full text of the H-Statements and R-Phrases mentioned in this Section, see Section 16

4. FIRST AID MEASURES

General advice
Consult a physician. Show this safety data sheet to the doctor in attendance. Move out of dangerous area.

If inhaled
If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.

In case of skin contact
Take off contaminated clothing and shoes immediately. Wash off with soap and plenty of water. Consult a physician.

In case of eye contact
Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician. Continue rinsing eyes during transport to hospital.

If swallowed
Do NOT induce vomiting. Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

5. FIREFIGHTING MEASURES

Conditions of flammability
Not flammable or combustible.

Suitable extinguishing media
Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

Special protective equipment for firefighters
Wear self contained breathing apparatus for fire fighting if necessary.

Hazardous combustion products
Hazardous decomposition products formed under fire conditions. - Sulphur oxides, Hydrogen chloride gas, Vanadium/vanadium oxides

6. ACCIDENTAL RELEASE MEASURES

Personal precautions
Use personal protective equipment. Avoid breathing vapours, mist or gas. Ensure adequate ventilation. Evacuate personnel to safe areas.

Environmental precautions
Do not let product enter drains.

Methods and materials for containment and cleaning up
Material is a corrosive liquid. Stop leak if without risk. Absorb with DRY earth, sand or other non-combustible material. Do not get water inside container. Do not touch spilled material. Prevent entry into sewers, basements or confined areas; dike if needed. Call for assistance on disposal.

7. HANDLING AND STORAGE

Precautions for safe handling
Avoid contact with skin and eyes. Avoid inhalation of vapour or mist.

Conditions for safe storage
Keep container tightly closed in a dry and well-ventilated place. Containers which are opened must be carefully resealed and kept upright to prevent leakage

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Components with workplace control parameters

Components	CAS-No.	Value	Control parameters	Basis
Vanadium trichloride	7718-98-1	C	0.05 mg/m3	USA. NIOSH Recommended Exposure Limits
Remarks	15 minute ceiling value			
vanadium dichloride oxide	10213-09-9	C	0.05 mg/m3	USA. NIOSH Recommended Exposure Limits
Remarks	15 minute ceiling value			
Vanadium oxide sulphate	27774-13-6	C	0.05 mg/m3	USA. NIOSH Recommended Exposure Limits
Remarks	15 minute ceiling value			

Vanadium(III) sulphate	13701-70-7	C	0.05 mg/m3	USA. NIOSH Recommended Exposure Limits
Remarks	15 minute ceiling value			
Hydrochloric acid	7647-01-0	C	2 ppm	USA. ACGIH Threshold Limit Values (TLV)
Remarks	Upper Respiratory Tract irritation Not classifiable as a human carcinogen			
		C	5 ppm 7 mg/m3	USA. Occupational Exposure Limits (OSHA) - Table Z-1 Limits for Air Contaminants
	The value in mg/m3 is approximate. Ceiling limit is to be determined from breathing-zone air samples.			
		C	5 ppm 7 mg/m3	USA. NIOSH Recommended Exposure Limits
	Often used in an aqueous solution.			
Sulfuric acid	7664-93-9	TWA	0.2 mg/m3	USA. ACGIH Threshold Limit Values (TLV)
		TWA	1 mg/m3	USA. Occupational Exposure Limits (OSHA) - Table Z-1 Limits for Air Contaminants

Personal protective equipment

Respiratory protection
Where risk assessment shows air-purifying respirators are appropriate use a full-face respirator with multi-purpose combination (US) or type ABEK (EN 14387) respirator cartridges as a backup to engineering controls. If the respirator is the sole means of protection, use a full-face supplied air respirator. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Hand protection
Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Eye protection
Tightly fitting safety goggles. Faceshield (8-inch minimum). Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Skin and body protection
Complete suit protecting against chemicals, The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

Hygiene measures
Handle in accordance with good industrial hygiene and safety practice. Wash hands before breaks and at the end of workday.

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance

Form	liquid
Colour	Greenish Blue

Safety data

pH	-0.5
Melting point/freezing point	< -40°C (-40°F)
Boiling point	>100°C (212°F (Water))
Flash point	not applicable
Ignition temperature	no data available

Auto-ignition temperature	no data available
Lower explosion limit	no data available
Upper explosion limit	no data available
Vapour pressure	< 2.3 kPa (@20°C) (water)
Density	1.35 g/ml
Water solubility	no data available
Partition coefficient: n-octanol/water	no data available
Relative vapour density	no data available
Odour	Pungent
Odour Threshold	no data available
Evapouration rate	no data available

10. STABILITY AND REACTIVITY

Chemical stability
Stable under recommended storage conditions.

Possibility of hazardous reactions
no data available

Conditions to avoid
no data available

Materials to avoid
Bases, Amines, Alkali metals, Metals, hexalithium disilicide, permanganates, e.g. potassium permanganate, Fluorine

Hazardous decomposition products
Hazardous decomposition products formed under fire conditions. - Sulphur oxides, Hydrogen chloride gas, Vanadium/vanadium oxides
Other decomposition products - no data available

11. TOXICOLOGICAL INFORMATION

Acute toxicity

Oral LD50
no data available

Inhalation LC50
no data available

Dermal LD50
no data available

Other information on acute toxicity
no data available

Skin corrosion/irritation
no data available

Serious eye damage/eye irritation
Eyes: no data available

Respiratory or skin sensitisation
no data available

Germ cell mutagenicity
no data available

Carcinogenicity

IARC:	1 - Group 1: Carcinogenic to humans (Sulfuric acid)
IARC:	3 - Group 3: Not classifiable as to its carcinogenicity to humans (Hydrochloric acid)
NTP:	Known to be human carcinogen (Sulfuric acid)
OSHA:	No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

Reproductive toxicity

no data available

Teratogenicity

no data available

Specific target organ toxicity - single exposure (Globally Harmonized System)
no data available

Specific target organ toxicity - repeated exposure (Globally Harmonized System)
no data available

Aspiration hazard
no data available

Potential health effects

Inhalation	May be harmful if inhaled. Material is extremely destructive to the tissue of the mucous membranes and upper respiratory tract. Causes respiratory tract irritation.
Ingestion	Harmful if swallowed.
Skin	May be harmful if absorbed through skin. Causes skin burns. Causes skin irritation.
Eyes	Causes eye burns. Causes eye irritation.

Signs and Symptoms of Exposure
Burning sensation, Cough, wheezing, laryngitis, Shortness of breath, spasm, inflammation and edema of the larynx, spasm, inflammation and edema of the bronchi, pneumonitis, pulmonary edema, Material is extremely destructive to tissue of the mucous membranes and upper respiratory tract, eyes, and skin.

Synergistic effects
no data available

Additional Information
RTECS: Not available

12. ECOLOGICAL INFORMATION

Toxicity

no data available

Persistence and degradability
no data available

Bioaccumulative potential
no data available

Mobility in soil
no data available

PBT and vPvB assessment
no data available

Other adverse effects

no data available

13. DISPOSAL CONSIDERATIONS

Product
Offer surplus and non-recyclable solutions to a licensed disposal company. Contact a licensed professional waste disposal service to dispose of this material. Dissolve or mix the material with a combustible solvent and burn in a chemical incinerator equipped with an afterburner and scrubber.

Contaminated packaging
Dispose of as unused product.

14. TRANSPORT INFORMATION

DOT (US)
UN number: 3264 Class: 8 Packing group: III
Proper shipping name: Corrosive liquid, acidic, inorganic, n.o.s. (Vanadyl Chloride, Vanadium trichloride, Hydrochloric acid, Vanadium(III) sulphate, Vanadium oxide sulphate, Sulfuric acid)
Reportable Quantity (RQ): 2000 lbs
Marine pollutant: No
Poison Inhalation Hazard: No

IMDG
UN number: 3264 Class: 8 Packing group: III EMS-No: F-A, S-B
Proper shipping name: CORROSIVE LIQUID, ACIDIC, INORGANIC, N.O.S. (Vanadyl Chloride, Vanadium trichloride, Hydrochloric acid, Vanadium(III) sulphate, Vanadium oxide sulphate, Sulfuric acid)
Marine pollutant: No

IATA
UN number: 3264 Class: 8 Packing group: III
Proper shipping name: Corrosive liquid, acidic, inorganic, n.o.s. (Vanadyl Chloride, Vanadium trichloride, Hydrochloric acid, Vanadium(III) sulphate, Vanadium oxide sulphate, Sulfuric acid)

15. REGULATORY INFORMATION

OSHA Hazards
Target Organ Effect, Harmful by ingestion, Corrosive

SARA 302 Components
The following components are subject to reporting levels established by SARA Title III, Section 302:

	CAS-No.	Revision Date
Sulfuric acid	7664-93-9	2007-07-01

SARA 313 Components
The following components are subject to reporting levels established by SARA Title III, Section 313:

	CAS-No.	Revision Date
Hydrochloric acid	7647-01-0	1993-04-24
Sulfuric acid	7664-93-9	2007-07-01
Vanadium trichloride	7718-98-1	2007-03-01
Vanadyl Chloride	10213-09-9	2007-07-01
Vanadium oxide sulphate	27774-13-6	1993-04-24
Vanadium(III) sulphate	13701-70-7	2007-07-01

SARA 311/312 Hazards
Acute Health Hazard, Chronic Health Hazard

Massachusetts Right To Know Components

	CAS-No.	Revision Date
Hydrochloric acid	7647-01-0	1993-04-24
Sulfuric acid	7664-93-9	2007-07-01
Vanadium oxide sulphate	27774-13-6	1993-04-24

Pennsylvania Right To Know Components

	CAS-No.	Revision Date
Water	7732-18-5	
Vanadium trichloride	7718-98-1	2007-03-01
Vanadyl Chloride	10213-09-9	2007-07-01

Hydrochloric acid	7647-01-0	1993-04-24
Sulfuric acid	7664-93-9	2007-07-01
Vanadium oxide sulphate	27774-13-6	1993-04-24
Vanadium(III) sulphate	13701-70-7	2007-07-01

New Jersey Right To Know Components

	CAS-No.	Revision Date
Water	7732-18-5	
Vanadium trichloride	7718-98-1	2007-03-01
Vanadyl Chloride	10213-09-9	2007-07-01
Hydrochloric acid	7647-01-0	1993-04-24
Sulfuric acid	7664-93-9	2007-07-01
Vanadium oxide sulphate	27774-13-6	1993-04-24
Vanadium(III) sulphate	13701-70-7	2007-07-01

California Prop. 65 Components

	CAS-No.	Revision Date
WARNING! This product contains a chemical known to the State of California to cause cancer. Sulfuric acid	7664-93-9	2007-09-28

16. OTHER INFORMATION

Text of H-code(s) and R-phrase(s) mentioned in Section 3

Acute Tox.	Acute toxicity
H302	Harmful if swallowed.
H314	Causes severe skin burns and eye damage.
H335	May cause respiratory irritation.
Skin Corr.	Skin corrosion
STOT SE	Specific target organ toxicity - single exposure

Further information

UniEnergy Techologies, LLC provides the information contained herein in good faith but makes no representation as to its comprehensiveness or accuracy. For further information regarding the hazards listed on this document please consult 29CFR1910.1200 (Hazard Communication Standard). This document is intended only as a guide to the appropriate precautionary handling of the material by a properly trained person using this product. Individuals receiving the information must exercise their independent judgment in determining its appropriateness for a particular purpose. UniEnergy Technologies, LLC and its Affiliates shall not be held liable for any damage resulting from handling or from contact with the above product. If have any questions, please call us at 1-425-290-8898.

7. PNNL – DOE Letter of ‘In-Kind” Support

Department of Energy

Washington, DC 20585

Mr. Curtis Kirkeby
Sr. Electrical Engineer – Technology Strategy
AVISTA Utilities
1411 East Mission Avenue
P.O. Box 3727
Spokane, WA 99220-3727

December 10, 2013

Dear Mr. Kirkeby:

The U.S. Department of Energy, Office of Electricity Delivery and Energy Reliability (Office of Electricity), Energy Storage Program is pleased to make a commitment of $250,000 of in-kind participation by Pacific Northwest National Laboratory, over a three year period, as contribution to your proposed study entitled “Deployment and Evaluation of Energy Storage Integrated into the Pullman Smart Grid Community”. PNNL will contribute to this project primarily through identification of the system and site-specific benefits, development of optimal control strategies, and evaluating system performance and the monitoring of system performance to validate benefits. PNNL will work closely with AVISTA, Washington State University, and other technology providers in this project. The project is particularly of interest because of its leverage of investments made by AVISTA under the Pacific Northwest Smart Grid Demonstration project. The Office of Electricity supports the exploration of storage as a technology that facilitates deployment of renewables, energy efficiency and reduced GHG emissions. Furthermore, we believe that energy storage will be a critical technology for facilitating such deployment, in combination with provision of many other grid support services. Understanding the role that storage can play, and the requirements for greater utilization of energy storage, are important contributions to helping us guide energy storage development and deployment.

We anticipate PNNL and AVISTA will implement a Cooperative Research and Development Agreement (CRADA) for this project. The commitment of DOE is subject to available funding resources enabled through appropriation by the U.S. Congress, and successful implementation of the CRADA.

We wish you success in your proposed study, and look forward to collaborating on this, and future, efforts to facilitate the deployment of clean energy and energy storage technologies.

With best greetings,

Dr. Imre Gyuk
Program Manager, Energy Storage Research
Office of Electricity Delivery and Energy Reliability
U.S. Department of Energy