WATTSTOCK LLC

THE DEPARTMENT OF ENERGY

NATIONAL POWER TRANSFORMER RESERVE

Request for Information

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National Power Transformer Reserve

I. Executive Summary

WATTSTOCK believes that strategies to mitigate the costs associated with LPT failures, regardless of the underlying cause, are necessary. Market realities inherent in our national electricity industry make private sector driven solutions the most effective means for addressing transformer recovery and resiliency challenges. The government does have a role to play in this process, particularly in guiding standards and crafting policies to enable and spur private sector participants to develop and deploy innovative solutions that enhance our national security.

WATTSTOCK's response aims to illuminate the innovative approaches and advances that have been made in the private sector to address the practical business challenges, as well as national security concerns, related to large power transformer ("LPT") reserves. This response does not directly respond to each question set forward by DOE, rather, it presents new perspectives for considering how our nation might improve the security and resiliency of our electricity infrastructure. There's no doubt that protecting our nation's electricity infrastructure is a shared public-private responsibility requiring cutting edge solutions that considers market forces, as well as national security requirements. WATTSTOCK thanks the Department of Energy for issuing this Request for Information (RFI) and providing a vehicle for engaging the private sector on this matter and remains committed to providing additional support in this important matter.

The ingenuity of the WATTSTOCK Transformer Recovery Inventory Program (TRIP) and recovery spare designs delivers a more dynamic and rapid response to LPT failures, regardless of the underlying causes.

From a security perspective, enhancing the recoverability speed and resiliency of LPT's:

- Diminishes the residual effects and costs of failures;
- Reduces the appeal of LPT's as targets by state and/or non-state actors;
- Eliminates the possibility of a cyber attack on recovery transformers, because, while stored, all connections remain planned, potential and unmade;
- Simplifies defense of LPT's by strategically storing modular recovery assets; and

- Extends time horizons for electricity generators to respond effectively in crisis situations and deliver long-term resolution (procuring permanent replacements).

From a private sector perspective, the WATTSTOCK program delivers:

- Cost savings;
- Flexibility; and
- Predictability to an increasingly important national security challenge.

From a public-private cooperation standpoint, WATTSTOCK addresses a critical need with a self-sustaining economic model.

- WATTSTOCK'S approach trades expensive and unique technical LPT designs for cost effective, rapidly deployable, standardized, modular designs that overcome significant cost, technical, and logistical challenges for responding to the broadest range of anticipated LPT failures.

II. Assessing National Exposure

In 2012, WATTSTOCK LLC ("WATTSTOCK") established priorities, processes to gather and protocols to quantify single point of failure vulnerabilities in the nation's electrical infrastructure. These findings validate and provide direction to WattStock's business model, but also serve as a compelling method for gathering and analyzing data for developing recovery protocols for other electrical grid components.

A. Priorities

Whether maliciously precipitated or normally occurring, LPT failures potentially cause complex and cascading electrical infrastructure degradation. Partly because the DHS RecoveryX Program was addressing transmission LPT's and swayed compellingly by the observation that electricity distribution cannot happen without electricity supply, WATTSTOCK focused its initial analysis on generator step up transformers ("GSU's"). We continue collecting data and plan to offer the same program for transmission transformers up to 600 MVA and 575kV.

Because the largest generators, typically nuclear and large coal-fired, maintain access or have especially unique transformer requirements, WATTSTOCK concentrated its resources on the next, or middle, third of US generators. Transformers for these power plants – the "journey-man power plants" of America – range in size from 20 MW to 300 MW. This prioritization does not obviate the need to study transmission LPT's or other single point of failure infrastructure components. It primarily reflects WATTSTOCK's initial focus and secondarily suggests an

empirical method to address, which would include gathering, organizing and analyzing data for, other important electrical grid components.

B. Process

Implementing a carefully designed data collection effort encouraged adaptations. The results, however, yielded some of the [highest integrity][most reliable] GSU operating data available in the US. For about 20% of the journey-man power plants in the US, WATTSTOCK's data bank includes capacity, or size, low voltage input, high voltage output and location. Similarly, WATTSTOCK compiled data on surplus GSU's. Analyzing WATTSTOCK's data identified groupings that support recovery GSU designs. Applying this process methodology would support recovery protocols for other vulnerable grid components.

C. Protocol

Understanding operating and surplus GSU specifications and locations buttresses both designs for recovery transformers and metrics for grading recovery plans for any transformer failure in the US.

III. Designing a Flexible Solution

Given selected recoverability goals, the data point to recovery plans and equipment designs for any single LPT or any group of operating LPT's can be expanded to apply to other grid components. *(Looking ahead, WATTSTOCK has developed an analytical tool set to grade the robustness of utilities' recovery plans.)*

Regardless of operator or regulator directed recoverability standards, WATTSTOCK designed recovery transformers (WATTSTOCK Recovery Flex Transformers) to accelerate return to service after any disruption. In terms of kilowatt-hours, WATTSTOCK accepts a 95% electrical efficiency to gain service resumption within weeks. This choice compels light weight modular designs that at least 4 major original equipment manufacturers (ABB, Alstom, GE, Siemens,) have either already provided or are scheduled to provide technical and financial bids to build. Cost considerations further compel operational flexibility. WATTSTOCK's Recovery Flex Transformers accommodate a range of both low voltage input and high voltage output that allow WATTSTOCK to standardize a flexible GSU design.

Based on its data, WATTSTOCK designed 9 GSU's to serve as recovery, not permanent replacement, transformers, covering 97% of the MVA in the WattStock market segment. WATTSTOCK'S modular designs effectively address serious logistical hurdles to delivering LPT's while accommodating a greater range of input and output voltages.

IV. Measured Recoverability – The WATTSTOCK Score

The WATTSTOCK SCORE is a set of analytical tools for grading the effectiveness of recovery plans, whether existing or recently modified. Expressed in terms of time and capacity—which one can easily convert into kilowatt-hours of cost or loss—The WATTSTOCK SCORE and the WATTSTOCK FLEET SCORES provide an objective, independent framework for evaluating the robustness of transformer failure recovery plans. WATTSTOCK SCORE DECAY CURVES reflect the stability, or reliability over time, of WATTSTOCK SCORES at normal failure rates.

Effectiveness: The WATTSTOCK SCORE provides a consistently and widely applicable methodology to compare relative strengths of individual transformer recovery plans that allows operators, their financial partners and other stakeholders to determine the overall resiliency of operating transformer fleets.

Criticality: The WATTSTOCK SCORE explicitly relies on operators, government agencies and regulators to set criticality levels. In other words, while the WATTSTOCK SCORE tool suite allows stakeholders to assess robustness of any recovery plan for any transformer (and how that plan degrades from normal to extraordinary failure rates), the SCORE does not rank the importance of designing a robust recovery plan for any grid asset or group of assets. Criticality may vary due to load serviced, security elements of load serviced, profitability of service use and other factors known to stakeholders.

Elements: WATTSTOCK SCORE components include:

- Electrical fit of spare;
- Proximity of spare (measured in time);
- Physical fit of spare;
    - Scaled 0 – 100, where 100 represents perfect recovery plan,
    - "Perfect" would indicate automatic and immediate replacement of a failed operating transformer, and
    - "Perfect" carries risk that damage to an operating transformer would also damage the spare.

Other components: WATTSTOCK **FLEET** SCORE combines the WATTSTOCK SCORE for any set of transformers. The WATTSTOCK SCORE DECAY CURVE:

- Anticipates the erosion of WATTSTOCK SCORES due to normal failure rates across the transformer population;
- Reveals the effects of removing spares due to normal or accelerated transformer failures; and
- Reflects the risk of existing recovery plans.

Utility: Appropriately used by government agencies, owners, operators, regulators, and insurers, the WATTSTOCK SCORE helps:

- Determine the number and placement of recovery transformers; and
- Evaluate the capital efficiency, or investment effectiveness, of recovery plans.

V. Quick Response

Passionate in its commitment to recovery speed, and unlike other programs, WATTSTOCK offers flexible recovery units on a temporary basis for any outage – whether statistically normal or calamitously caused. This dynamic involvement with operating assets and stakeholders offers several advantages:

- Recognizes failure trends – mechanically expected or maliciously created;
- Rebalances the recovery fleet with current data;
- Renews the recovery fleet's relevance and viability constantly.

VI. Design: Recovery Flex Transformer (RFT)

While challenging, designing transformers that can accommodate a range of both LV (low voltage) input and HV (high voltage) output allows WATTSTOCK to standardize a flexible and modular GSU design. Standardization, in turn, improves reliability, and creates cost and scale efficiencies across the industry instead of at single points or for single company transformer fleets. WATTSTOCK's nine RFT designs cover 85% of GSU's in units and 97% of the MVAs in the middle and most important power generating market in the United States – the transmission voltage class from 69 kilovolts to 525 kilovolts. These power generating units range from 20 to 300 megawatts.

The adaptable transformer design allows WATTSTOCK to cover more GSU's per customer with fewer transformers, reducing WATTSTOCK's inventory cost and, in turn, reducing the costs WATTSTOCK must recover from customers. Stated differently, the same level of investment in transformers should yield a higher reliability at a lower cost across multiple customers.

Critically, WATTSTOCK's design creates a smaller physical size and larger electrical capacity that allows WATTSTOCK transformers to fit in existing space-confined substations of old or existing transformers. Applying the smaller size, larger capacity innovations to single phase transformers makes a modular approach to replacing extra large transformers (over 230 mega volt amperes ("MVA")) possible. With this now feasible modular approach, WATTSTOCK can ship TRIP transformers by truck. Compared to existing choices, WATTSTOCK can mobilize recovery efforts sooner and drive recovery costs substantially lower. In practice, WATTSTOCK

should be able to return power plants to operation within 2-3 weeks of receiving a catastrophic failure notice.

WATTSTOCK's transformer design team focused on cost, speed, and flexibility:

- Cost: using a peak rating with Nomex insulation and reducing the complexity of the design lowers the cost of the transformer.
- Speed: physical size, the single most important criterion when trying to reduce down time, determines how quickly WATTSTOCK can transport and install the transformer.
- Flexibility: voltage range and design determines inventory size and cost.

Some features of WATTSTOCK's design include:

- Modularity: Off skid cooling systems reduce installation time and the footprint of the required space;
- Smaller size for the same voltage and capacity as a traditional transformer;
- Multiple low voltage capability;
- Multiple high voltage capability;
- Oil Directed Air Forced cooling system for increased output; and
- Single phase design for larger units, reducing component size and accelerating delivery speed.

Appendixes

A. LPT Market Trends

In addition to broader concerns over grid security and resiliency, WATTSTOCK has identified a number of current trends increasing the need for innovative approaches for responding to LPT failures. which are highlighted below.

1. Aging Infrastructure

Like all power generation systems, as transformers age, their failure rates increase. The Company has chosen to focus initially on this particularly vulnerable niche of the US aging infrastructure. Bill Bartley at Hartford Steam Boiler Inspection & Insurance Co. describes this problem. (Bartley, William H., PE, The Hartford Steam Boiler Inspection & Insurance Co, 2011)

WATTSTOCK built an age predictive failure rate model including the higher failure rate found in post 1987 transformers, this shows that those units start failing rapidly at ages over 25 years.

Both older and newer unit failure rates are accelerating resulting in an anticipated failure rate spike over the next 10 years, positioning WATTSTOCK very well to capture this opportunity.

2. Extraordinary Events

Low frequency, high impact events, whether attacks like at Metcalf, potential EMP attacks or GMD, and simple physical attacks

3. Bubble Unit Quality Concerns

Accelerated power plant additions during the "bubble" years of 1998 to 2002 resulted in manufacturing transformers at an unprecedented rate. In addition to manufacturing issues, sulfur contamination in transformer oil problems further degraded transformers from this period. These transformers are failing for different reasons at a faster rate.

4. Lack of Spare Assets Owned by Owner/Operators

Owners and operators have discussed their concerns with WATTSTOCK personnel, and they remain reluctant to make large investments in spare parts inventories. Without WATTSTOCK's adaptable transformer designs, operators would purchase unique spare transformers that specifically fit single power plants and not their fleets. By default, they rely on a used and dwindling surplus of spare high voltage equipment. Government and quasi-government agencies have written about their concerns. DHS and other project participants spent $17 million to sponsor an exercise to replace a transformer, and the North American Electricity Reliability Corporation has created a voluntary database of spare electrical components, including transformers. (Wald, 2012), (North American Electric Reliability Corporation, 2012) since 2007, only forty seven of seventy queried utilities responded.

5. Plant Upgrades

Power plant owners and operators are implementing upgrades to increase efficiency and output, often without replacing the old transformers, and putting extra stress on already aged transformers. As referred to earlier, some industry sources note results of up to 20% transformer failures within 3 years of the upgrades.

6. Aging Workforce

Workforce attrition contributes to implementing maintenance practices inconsistently and to outsourcing transformer maintenance for periodic review. The loss of daily, even cursory, supervision by experienced engineers results in missing critical indicators of pending failures. Inability to observe, understand or act upon such indicators will continue to produce preventable catastrophic failures.

B. An Innovative Approach: WATTSTOCK Solutions

After analyzing data on approximately 6,000 power plants with about 18,530 electricity generating units in the United States, WATTSTOCK's design team chose to focus on the roughly 6,000 high-value, middle market generating units. Each power generating unit produces 20 megawatts to 300 megawatts ("MW") for transmission onto the grid at voltages ranging from 69 kilovolts to 525 kilovolts ("kV"). To cover this market, WATTSTOCK created nine flexible GSU designs, which could allow WATTSTOCK to protect 97% of the middle market and roughly 53% of installed power plant capacity in the US. As noted above, WATTSTOCK's GSU designs and shared transformer redundancy reduce costs and enhance reliability.

1. Inventory Facilities and Technicians

Sited near the largest population of contracted transformers, WATTSTOCK anticipates a minimum of four regionally located warehouses. Each facility will have a service, installation, testing and monitoring team and will stock the necessary tools and testing equipment required to monitor, maintain and install transformers. Qualified technicians will be trained to respond to failures quickly and professionally.

2. Failure Ratio

Statistics indicate a failure rate of 0.5% to 2.5% of the entire operating transformer fleet every year. WATTSTOCK considers this approach conservative given that those units with a higher likelihood of failure should also have a higher customer acceptance rate than those with relatively new transformers that are operating without any problems or at very low utilization rates. Initial WATTSTOCK analysis show a rapid increase in expected failures and forecasted a failure rate of around 1.4% for 2014 in the WATTSTOCK targeted market segment.

3. Wind and Solar Farms (and Other Seasonal Generation Applications)

Renewable energy projects will soon need similar revenue and infrastructure protection programs. Typically, wind farm developers plan for only one transformer to reach required grid voltages. Because wind farms produce at full power capacities about 38% of the year, transformer failures matter little in non-windy months and matter materially more in windy seasons. Wind turbines, also, generate electricity at different voltages than traditional power plants.

For wind and solar farms, we have designed two Flex transformer models that will cover more than 450 GSU's with an input voltage of 34.5kV and output voltage of up to 525kV. The sizes range from 70 to 150 MVA.

C. Transformer Recovery Inventory Program ("TRIP")

Creating a supply of spare transformers and exploiting a standardized and flexible design captures financial efficiencies. By broadening transformer coverage ranges from geographically limited transformer clusters and limited company inventories to the much larger North American population of transformers, WATTSTOCK creates efficiencies for back up transformer inventory subscribers by reducing capital costs and increasing reliability ratios.

By standardizing models, WATTSTOCK seeks to provide recovery spare transformers for original transformers that fail or require maintenance, inspection or repair.

As transformers leave WATTSTOCK's inventory to replace failed units, WATTSTOCK will maintain coverage ratios by replacing inventory through multiple options. WATTSTOCK may buy back transformers, buy options on units or buy manufacturing slots to rebalance its inventory. Working with owners of "end of life" power plants may further improve market coverage.

D. Database

To support making the North American electrical grid, as others have called, "smart," WATTSTOCK began compiling a proprietary and comprehensive database that includes nameplate ratings of GSU's in the United States. The data include critical factors including age, input and output voltages, rating, operational description, and type of power plant. The data alone may provide important and competitively distinctive insights that help WATTSTOCK acquire "smart" inventories, target high value regions, design efficient technical solutions and keep inventory costs low.

As WATTSTOCK continues to enhance its database, it expects to utilize the data further by analyzing transformer operating condition trends. Using a description of Boeing's Airplane Health Monitoring capabilities, WATTSTOCK hopes to "deliver distinctly predictive … data to engineers and maintainers that will allow them to interdict incipient problems before they fully manifest themselves." (Chandler, 2012)

Exhibits

WATTSTOCK Market Segmentation – Design Matrix