Comments on a National Power Transformer Reserve Program

Introduction

The Edison Electric Institute ("EEI"),[1] the National Rural Electric Cooperative Association ("NRECA"),[2] and American Public Power Association ("APPA")[3] ("Joint Trades") appreciate the opportunity to submit comments on the U.S. Department of Energy's ("DOE") Request for Information on a National Power Transformer Reserve.

Collectively, our members provide electric power to almost every home, business, and building in the nation. Doing so requires more than 6,000 power plants, nearly 160,000 miles of high voltage transmission lines, and hundreds of thousands of miles of overhead and underground distribution lines. Ensuring the reliability, safety, security, and resilience of the electric grid is of paramount concern to all stakeholders.

The Joint Trades' perspective on the questions presented in the RFI are grounded in our member utilities' many years of experience preparing for and responding to electric system threats associated with severe weather, natural disasters, critical equipment failures, vandalism, isolated physical attacks, and other issues. Additionally, our members participate in an ever-expanding set of programs and activities aimed at maintaining and improving grid reliability and resilience.

1. Program Need

Is there a need for a National Power Transformer Reserve? How would such a reserve affect the reliability and resiliency of the North American bulk power system? Are there alternatives to a power transformer reserve program that can help ensure the reliability, resiliency, and recovery of the bulk power system? Is there a need for a nationally-maintained inventory of large power transformers?

[1] EEI is the association that represents all U.S. investor-owned electric companies. Our members provide electricity for 220 million Americans, operate in all 50 states and the District of Columbia, and directly employ more than 500,000 workers. With $100 billion in annual capital expenditures, the electric power industry is responsible for millions of additional jobs. Reliable, affordable, and sustainable electricity powers the economy and enhances the lives of all Americans. EEI has 70 international electric companies as Affiliate Members, and 270 industry suppliers and related organizations as Associate Members.

[2] NRECA is the national service organization for more than 900 not-for-profit rural electric utilities that provide electric energy to over 42 million people in 47 states. Electric cooperatives own and maintain 2.5 million miles or 42 percent of the nation's electric distribution lines, covering 75 percent of the U.S. landmass. Power lines maintained by U.S. electric cooperative systems would stretch around the earth more than 100 times.

[3] APPA is the national service organization representing the interests of non-profit, state and locally-owned electric utilities. More than 2,000 public power systems provide over 15 percent of all kilowatt-hour sales to ultimate customers and operate in every state except Hawaii and provide electricity to U.S. territories such as Puerto Rico, Guam, and American Samoa. Collectively, public power utilities serve 48 million Americans.

Our industry has many years of experience dealing with threats to the electric system due to severe weather, such as hurricanes, tornados, and flooding. To address these and other operational needs (failures, vandalism, isolated physical attacks, etc.) utilities currently retain spare large power transformers (LPTs). A National Power Transformer Reserve could be an additional approach to strengthen the Bulk Power System (BPS); however, it is important to consider existing programs and arrangements that currently keep the BPS reliable and resilient even in the case of very significant potential threats. Any new efforts or programs should respect existing assets and programs the industry has put into place to protect the BPS, and any proposed programs, such as an additional National Power Transformer Reserve, should not displace or cause any current or planned investments to be negated.

Following the attacks on September 11, 2001, the industry initiated additional programs including the EEI Spare Transformer Equipment Program (STEP) to address certain physical threats. The industry also supports the SpareConnect Program and looks forward to the additional resilience capacity the recently announced Grid Assurance initiative can provide in terms of additional spare LPTs and other resources for catastrophic incidents.

The STEP program is a pool of LPTs in various voltage classes and sizes (Megavolt-amperes or MVA) located at member utilities throughout North America. STEP members[4] have predefined obligations and the ability to obtain LPTs from the STEP pool, or "call rights," under predefined conditions. While STEP has a defined activation criterion, the program also affords members an opportunity to provide mutual assistance to each other for emergency incidents that do not qualify as a triggering event. This type of support would be based on company to company agreements.

The SpareConnect Program[5] is less formal, but also provides utilities a mechanism to quickly and efficiently communicate with each other regarding the acquisition of spare LPTs and related equipment, including bushings, fans, and auxiliary components. Both STEP and SpareConnect require that utilities have physical assets in order to participate.

Additional benefits of these programs include, but are not limited to, the following: LPTs are not centralized but strategically located across North America; thus, the strategic locations provide the ability to turn over inventory and maintain modern equipment. For nearly 10 years, STEP members have continually networked with one another, conducted annual meetings, and

[4] As of August 1, 2015, more than 50 electric utilities are members of STEP. These companies directly serve over 98 million residential, industrial, and commercial customers which comprises approximately 67% of U.S. electricity customers.

[5] Over 120 utilities (investor-owned, municipal, cooperative) participate in SpareConnect, including 6 Canadian utilities and 7 joint action agencies that participate on behalf of themselves and their 176 municipally-owned utilities, and 14 cooperative utilities.

performed drills/exercises to test the resiliency and responsiveness of STEP and to identify gaps. Members of SpareConnect also drill and exercise to evaluate their protocols.

Furthermore, in June 2015 a new initiative proposed by several utilities, Grid Assurance, was announced which would (1) purchase an inventory of transformers based on the needs of utility subscribers; (2) pool the needs of the utility subscribers to provide the spare equipment at a reasonable cost; (3) ensure that warranties are transferred to utility subscribers when the equipment is needed; (4) store the equipment in secure facilities that are located in strategic and geographically diverse locations; and (5) assist in transportation and logistics.

Note that Grid Assurance plans to provide its service for other critical equipment in addition to LPTs, including some of the long lead-time supply chain items related to LPTs, such as bushings. Such a voluntary program can be used by utilities to supplement existing programs (such as utility-owned spares, STEP, SpareConnect, etc.), comply where necessary with North American Electric Reliability Corporation (NERC) Standard CIP-014, increase resiliency, and decrease recovery time if a high impact, low frequency incident occurs.

This layered approach to sparing provides a high degree of flexibility and security to the BPS. Both STEP and SpareConnect have established robust networks for communicating needs and responding to emergencies. Grid Assurance plans to establish strategic depots for transformers in support of participating utilities. The industry, working through the NERC Standards process, has developed enforceable reliability standards for physical security (CIP-014), cyber security (numerous CIP standards), and geomagnetic disturbances (TPL-007, EOP-010), and has taken other actions such as installation of the DOE-developed Cyber Security Risk Information Sharing Program (CRISP) technology to address cyber-attacks.

Additionally, utilities have other LPT resources available from original equipment manufacturers (OEMs), third party transformer vendors, and units harvested during ongoing system upgrades or expansions. The NERC Spare Equipment Database is also a tool used by some utilities.

An additional National Power Transformer Reserve program may bring a small improvement in terms of reliability or resiliency beyond existing programs; however, this will depend significantly on how the program is organized. Again, we reiterate the importance of structuring any new program so that it complements and supports existing industry programs and does not displace or negate any current or planned investments.

Because existing industry programs do help ensure reliability, resiliency, and recovery of the BPS, we do not see a significant need for a program that creates an additional nationally-maintained inventory of LPTs. If any such additional program is developed, it must support existing programs that have successful operational procedures and business models that

protect the BPS. It may be appropriate for the federal government to consider developing a transformer reserve program to specifically serve federal transmission and generation asset owners: Bonneville Power Administration, Southeastern Power Administration, Southwestern Power Administration, Western Area Power Administration, and the Tennessee Valley Authority.

The industry recognizes the need to ensure that the critical infrastructure and equipment that make up the BPS remains reliable and resilient. The background section of the RFI states that "LPTs have long been a concern for the U.S. electricity sector because the failure of a single unit can interrupt electricity service to a large number of customers and lead to collateral damage." This may overstate the impact of the loss of a single LPT. Pursuant to NERC standards, regional reliability criteria, and individual utility practices, the U.S. electric system is planned and designed to respond to the loss of individual elements on the system without compromising reliability. NERC standards require that the system be planned to remain stable following the loss of a large autotransformer with no non-consequential load loss and without exceeding applicable facility ratings.

NERC Regional Entities have similar planning requirements. In addition, in Texas the ERCOT regional planning criteria requires that the system be planned to remain stable with any single 345/138 kV transformer unavailable, followed by the loss of a second transmission element, which can also include the loss of another large autotransformer, with no non-consequential load loss and without exceeding applicable facility ratings.

Finally, as a part of its long term planning process, the industry is exploring options to potentially reduce the number of critical substations, which could reduce the number of LPTs that might be needed in any sparing program.

2. Power Transformer Criteria

What types and sizes of power transformers should be considered for inclusion in a transformer reserve program versus operational spare capacity? What are the design considerations for replacement transformers to support the bulk power system?

If an additional National Power Transformer Reserve were to be implemented, transformers in the most common and widely used voltage classes and MVA ratings (capacity) would be a good starting point. The focus should begin with large extra high voltage (EHV) transformers that tend to be larger and require greater care during transporting, assembly, commissioning, and testing.

There are various design considerations, with the most critical being voltage, MVA rating (capacity), physical size, and impedance. If the objective is only to develop specific

transformer(s) for "temporary" recovery from high impact, low frequency incidents and not for long term operation, then design flexibility may be desirable.

In addition, to support rapid deployment of spare transformers when needed, consideration should be given to a modular design (one for each phase) that can be assembled upon delivery to the substation. Careful study and analysis would need to be conducted in order to evaluate the voltages classes, capacity, and parameters for any transformers designed for an additional National Power Transformer Reserve.

Ultimately, the exact criteria for equipment required for spare transformers or in specifying or procuring spare equipment should be determined by subject matter experts from the electric utility industry.

3. Ownership and Economics

What would be an appropriate structure for procuring and inventorying power transformers? How, and by whom, should a program of this type be administered? How would a transformer reserve be funded?

To the extent that an additional National Power Transformer Reserve is developed, the electric utility industry should administer the program with input from appropriate governmental organizations. A program administered by the utilities could leverage existing utility procurement procedures and vendors, along with utility knowledge about LPT maintenance, storage, and transportation. It is also important that any proposed program allow utilities to leverage their current and planned investments in spare equipment in a manner that provides them with operational flexibility (e.g., the ability to rotate stock as needed or to utilize and replace spare LPTs based on operational needs).

Further, any proposed program should not displace current or planned industry-run sparing programs or agreements (which includes bi-lateral and multi-lateral transformer sharing arrangements between utilities). Utilities should retain ownership of LPT spares with the ability to receive full cost recovery for the procurement and ongoing maintenance under any required program(s) that create an additional national reserve of LPTs. Since utilities have both the operational and technical understanding of their LPTs, including loading, operations, maintenance, response time, etc., they should control these resources. Decentralized ownership and multiple, strategic storage locations reduces the likelihood that a single event would cause damage or loss to a significant number of the spare LPTs.

Industry-led programs, such as STEP and SpareConnect have developed criteria for deploying spare transformers, if a triggering event occurs. Grid Assurance will also develop criteria based on participant's needs. By having the users work cooperatively with the owners and consulting with federal and state authorities, sparing and deployment protocols can be developed in

advance of need, can be modified as needs and threats change, and are responsive to changes in policies and regulations.

Because existing programs and arrangements such as STEP and SpareConnect, are funded by the industry and new initiatives like Grid Assurance will be funded by participants, there is no demand for government funding. However, if the government believes that another tier of risk for extremely improbable incidents should be covered; industry programs and arrangements should be considered when determining that need. While regulatory mechanisms in most utility jurisdictions may allow rate recovery for costs incurred by utilities, the industry has concerns about the costs for additional programs to address extremely improbable incidents. It may be worthwhile to investigate whether governmental action may be needed to support such programs as a matter of national security.

Industry-led, customer driven programs result in an economic way to provide spare transformers for the U.S. and for North America. Fundamentally, any such programs would have to provide benefits to the local utilities' customers who ultimately bear the associated costs.

4. Technical Considerations

Is it technically feasible to develop a reserve of large power transformers when most are custom engineered? Is additional research and development (R&D) necessary to develop suitable replacement transformers that can be rapidly deployed from inventory in the event of an emergency?

It is feasible to have a fleet of spares that will allow the BPS to operate after an emergency incident that damages substations. While LPTs are engineered to provide optimal performance for a specific electric system, within a voltage class with comparable electrical properties and impedances, they can be in some instances interchanged. Further, customization of LPTs is generally standardized within a utility's fleet (not necessarily by substation); therefore, individual companies can (and regularly do) exchange transformers between substations. The ability to share transformers within voltage classes is the basis of STEP and SpareConnect as well as sparing programs run by individual utilities. These all are structured to help utilities recover from catastrophic damage to substations and transformers and keep the BPS operating.

If the application is being used for "temporary" recovery for high impact, low frequency incidents and not as the permanent replacement for a damaged LPT, it may be technically feasible to develop a more limited number of transformers specifically for selective applications. It is important to note that any such "temporary" transformers would have a very limited application, would be less efficient, have a shorter time of use, and result in sub-optimization of the BPS, may require a larger foot print, and be more costly to purchase, own, and operate.

The development of suitable replacement transformers requires further discussion on design, applications, transportation, expected recovery times, costs, and partnerships with the industry.

5. Procurement and Management

How should procurement, maintenance and management of the reserve power transformers be conducted? For example, should manufacturers be pre-qualified, and if so, according to what criteria?

If such a program were to be implemented, utilities need to receive full cost recovery for development and ongoing maintenance. Agreement among program member utilities is paramount in establishing standards and oversight. Existing industry programs and arrangements demonstrate that utilities are able to effectively develop resilience programs through a collaborative process.

Most utilities pre-qualify their vendors and have a large vendor base for various LPTs. Any such program should follow the same principles. LPT vendors are typically pre-qualified based on design knowledge, quality and capabilities of manufacturing facilities, as well as workmanship, delivery schedules, costs, and warranty.

6. Supply Chain

What are the critical supply chain components for the manufacture and delivery of large power transformers (e.g., electrical steel, copper, silicone, high voltage bushings, etc.)? Are there shortages or other considerations that could necessitate using the Defense Production Act Priority Ratings to ensure sufficient parts are available in a time of need? Are there related skilled workforce issues?

The critical components for transformer manufacture are core steel, mild and stainless plate steel, copper conductor, electrical grade paper and insulation, oil, and bushings. Presently, most utilities are not experiencing any critical supply chain issues with our LPT vendors or in developing and maintaining a skilled workforce. One area of concern, however, is the increase in demand for electric core steel, which is used not only for LPTs, but also in the small distribution and pole/pad mounted transformer markets.

7. Manufacturing

Is there adequate manufacturing capacity to support a transformer reserve program? What is the lead time for engineering, manufacture, and delivery of large power transformers? Are there approaches that could help to speed manufacture and delivery of large power transformers?

Under the vast majority of plausible scenarios, there is adequate manufacturing capacity both domestically and worldwide to support a reserve program. In fact, transformer manufacturing capacity in North and South America has grown over the past several years with new plants

opened in North America by Mitsubishi, Hyundai, SPX and EFACEC/Georgia Transformer. Additionally, manufacturers including ABB and Delta Star are expanding capacity. In the event of very large demand on an emergency basis, there may be a need to import transformers from off-shore manufacturers. And, while manufacturing capacity has increased in recent years, full implementation of an additional spare transformer program could take several years depending on the number of new transformers that must be manufactured.

Nominal lead times for LPTs range from 9 to 18 months dependent on voltage rating and size (MVA).

There may be some opportunities for programs or partnerships that improve manufacturing and delivery times of LPTs through increased standardization between and/or with transformer manufacturers and their suppliers as well as the railroads.

8. Transport and Deployment

What specialized transport infrastructure would be necessary to ship large power transformers from manufacturing site to storage locations, and from storage locations to field site in the event of an emergency? What should be the number and location of transformer storage sites? What are feasible delivery times for LPTs that reside in a reserve to an affected site?

Depressed rail cars, low boy trailers, Goldhofer modules, large capacity cranes, jacking/skidding rigs, and Schnabel cars are some of the specialized transportation equipment that is regularly used in transporting LPTs. Timely transportation-related permitting by state and local agencies and the aging infrastructure (roads and bridges) represent some of the biggest challenges when moving LPTs. Other challenges involve shipments by rail, especially when LPTs must be moved across multiple rail lines as well as the availability of specialized rail cars and viable rail sidings.

The industry has a transformer transportation initiative underway to strengthen our relationship with the transportation industry (especially with Class I railroads), in order to expedite movement of transformers in an emergency. This effort, under the auspices of the Electricity Subsector Coordinating Council, includes the development of communication and support protocols – at an operational and executive level – between the utility industry and the Class I railroads. Additionally, we are expanding information sharing between utilities and transportation entities, developing emergency playbooks and support guides, and performing exercises and drills.

The Joint Trades have asked their respective member utilities to review access (rail sidings/roads) to critical substations and to consider procuring the dimensional drawings necessary to move equipment on railroads. We have received significant support and cooperation from the railroad industry in this effort including evaluating the inventory and

availability of, and priority access to, specialized rail equipment needed to transport transformers.

In an emergency where multiple LPTs must be moved, industry will need strong support from federal, state, and local government bodies to quickly process and approve routes and permits for road transportation. The Joint Trades believe early engagement with government bodies through exercises may be useful for incident planning.

One way to address a transportation challenge is, when logistically and geographically feasible, to store spare LPTs within close proximity of their intended use and not at a distant location(s) or warehouse(s). During an emergency, spare LPTs stored within a utility's footprint can typically be delivered within 5 to 10 days, depending on location, size, weight and mode of transportation (truck vs rail and/or barge). LPTs at reserve sites and/or outside a utility's footprint could easily take 10 days or longer depending on origin, challenges associated with transportation and permitting, rail, or barge access, and general coordination and logistics between multiple parties/owners.

9. Field Engineering and Installation

Are there adequate domestic engineering and installation resources available throughout the United States to install multiple bulk power transformers simultaneously? What additional resources would be necessary?

While actual needs may be dependent on the circumstances and the severity of an incident, there are adequate domestic engineering and installation resources available throughout the United States to support the installation of multiple bulk power transformers simultaneously. Utilities have significant engineering resources in-house and have the ability to reach out to numerous engineering contractors should the need arise. By way of example, one EEI member noted they have the capacity to manage as many as 12 simultaneous bulk power transformer installations in each of their jurisdictions without resorting to outside firms. However, while utilities work on an ongoing basis to develop and maintain their engineering resources, in the case of extremely improbable incidents, there may be a need to prioritize resources.

10. Criteria for Deploying Transformers

What criteria should be used for activating and deploying transformers from the reserve? How would deployment be funded?

The specific criteria for deploying reserve transformers would need to be defined based on the structure of an additional National Power Transformer Reserve program and would be expected to address emergency, non-routine failures that, if not addressed, would jeopardize the BPS.

Transformers in any reserve locations or warehouses should have their inventory turned over periodically. However, if the spare inventories are specialty transformers designed for greater flexibility in an emergency, but not necessarily suitable for long term (permanent) use, inventory turning will be problematic and likely lead to the spares being less reliable when ultimately needed for the system in an emergency.

Funding for the deployment should be the responsibility of the receiving utility. Call rights (defined process for requesting LPTs) should be for pre-defined emergencies/incidents and restricted from supporting operational needs. The industry has significant experience in collaboratively developing appropriate procedures for deploying spares through existing and planned sparing programs and arrangements. Operational needs (mitigating equipment failures/forced outages, storm damage, vandalism, planned growth, etc.) can most often be addressed by existing utility-owned or jointly-owned spare LPTs. However, as discussed earlier, while an additional National Power Transformer Reserve program may bring an improvement in terms of reliability or resiliency beyond existing programs; this will depend significantly on how the program is structured. If any such program is developed, it should complement and support existing industry programs and arrangements, and it should not displace or negate any current or planned investments.

11. Additional Comments

Are there additional concerns regarding a National Power Transformer Reserve Program that need to be considered?

LPTs are critical components of the BPS. The utility industry has long standing experience in maintaining spare LPTs to ensure the reliability and resiliency of the BPS and to ensure recovery from single or multiple LPT failures/incidents. Additionally, the BPS is designed and operated conservatively and is capable of performing reliably even with the loss of one or more LPTs.

Not all LPTs within a voltage class or location have the same criticality. Utilities continually monitor, identify, and mitigate the potential risks associated with those critical assets to ensure grid reliability and resiliency. The NERC CIP-014 and GMD TPL-007-1 standards are programs that already address potential risks to LPTs. The Federal Energy Regulatory Commission (FERC) recently determined that a contract with Grid Assurance for access to spare critical transmission equipment is a permissible resiliency element of a physical security plan under Requirement 5 of Reliability Standard CIP-014-1. In addition, STEP and the SpareConnect Program and other arrangements address resiliency issues and concerns in addition to programs/policies/arrangements utilities already have in place.

The creation of an additional National Power Transformer Reserve could be duplicative of existing industry programs and may cause potential confusion regarding access to assets,

further delaying restoration and recovery times, and creating yet another expensive “non-standard” class of transformers with limited long-term application.

There may be some opportunities for programs or partnerships that explore: standardization of design and manufacturing, targeting voltage class and sizes at highest risk, R&D for new “temporary” or flexible rapid deployment high voltage transformers, and government support in addressing transportation and infrastructure deficiencies or challenges. However, any new program should respect existing assets and programs that the industry currently has in place to protect the BPS. Any proposed programs, such as an additional National Power Transformer Reserve, should not displace or cause any current or planned investments to be negated.

Finally, to the extent that an additional spare transformer program results in centralized collection and storage of information about utility infrastructure nationwide, that compilation of information would be a potential target of attack. Rigorous security measures are needed to ensure that such information is not compromised.