DEVELOPMENT OF AN ENERGY ASSURANCE PLAN FACILITATED BY STUDENT PROJECT TEAMS

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Abstract

The U.S. Department of Energy (DOE) has recently mandated that each state create or update their energy assurance plan (EAP), which describes how the state intends to respond to a variety of possible disruptions to their energy supplies. During the fall of 2010, the New Jersey Board of Public Utilities engaged Rowan University to help draft the state's EAP. To accomplish this, we integrated the development of the plan as part of our Junior/Senior Engineering Clinic program. An initial team of five students developed a draft EAP within the 14-week semester constraints. Key aspects of the Clinic that facilitate projects such as the EAP development include: formation of multidisciplinary teams, emphasis on project-based learning, and a client and deliverable focus. The paper describes the project requirements, formation of the clinic team, conduct of the project, and an evaluation of the results. From a pedagogical viewpoint, this clinic project provided an opportunity for students to learn about important emergent technologies, such as the Smart Grid, which was a topic that was included in the EAP. A second clinic team is continuing the EAP work during the spring 2011 semester, which emphasizes the need for continuity and methods to exchange information between student teams.

Background

The Rowan University engineering program is singularly characterized by the Clinic program, which consists of an eight semester sequence of courses that must be taken from freshman to senior year[1]. The purpose of clinics is to provide students the opportunity to interact and play a key role in the development of an actual project while applying their current engineering abilities and developing new skills beyond the standard curricular offering they receive in their core engineering discipline[2]. Most junior and senior clinic projects feature a mixture of projects sponsored by related industry partners and faculty research interests[3]. Sponsored projects have included research and design on sustainability, biomedicine, food processing and robotics among others. Clinic teams are typically multidisciplinary, giving students the opportunity to develop and improve their teamwork and communication skills. The typical sequence of a clinic project includes: information search and review; development of a clear and concise problem statement; research and/or design and testing activities; and presentation of results via written report and oral presentation[2].

In June of 2009, DOE, through the National Association of State Energy Officials (NASEO) and the State Energy Program (SEP), announced a Funding Opportunity to provide federal grants to every state in order to prepare and develop a State Energy Assurance Plan (EAP)[4]. These grants ranged from $205,257 to $3,572,526[4]. In July, 2010, the New Jersey Board of Public Utilities (NJBPU) Division of Reliability & Security sponsored the development of the EAP through the engineering clinic program. This project was integrated into the Rowan University's Engineering clinic program as a multidisciplinary project available to junior and senior clinic students from

diverse engineering disciplines (chemical, civil and environmental, electrical and computer and mechanical).

The NJBPU is a governmental authority that regulates the rates and services of public utility companies that operate in the State of New Jersey. The NJBPU Division of Reliability & Security is responsible for executing ongoing strategies for preparedness, reliability and security of the energy system's infrastructure in the event of an energy emergency[5]. Energy assurance consists in the comprehensive study of a state's energy profile and the interdependencies across the different energy sectors (electrical, petroleum and natural gas). This study provides a basis for developing a plan, which purpose is to assess energy supply vulnerabilities and risks in order to mitigate the devastating consequences that these events can have on the economy, the health and safety of the public[6]. This plan also includes the development of processes and methods for tracking energy emergencies and supply disruptions. The EAP project provided engineering clinic students with the opportunity to understand the complexity, performance and vulnerabilities of the diverse energy systems. Moreover, students had the opportunity to research cutting-edge technologies, such as Smart Grid, and their importance to energy assurance planning.

Project Requirements

The NJBPU assigned Rowan University a series of tasks to develop and complete the New Jersey Energy Assurance Program. The tasks required to be performed include:

1) Energy Assurance Planning (EAP). Rowan University was assigned to prepare an Energy Assurance Plan following the Energy Assurance Guidelines developed by NASEO under DOE's direction. These guidelines were prepared in order to facilitate the design process of the EAP. The guidelines document comprises valuable information regarding state actions that should be taken in case of energy emergencies, in order to ease the impacts of short-term energy disruptions and describes how states could improve energy emergency and critical infrastructure plans[6].

2) Energy Supply Disruption Display and Reporting System (ESRS). The design of a process or mechanism for tracking the duration, response, restoration and recovery time of energy supply disruption events was incorporated into the project.

3) Table Top Exercises. Once the EAP draft is developed, several table-top exercises will be performed in order to evaluate the effectiveness of the plan. These exercises consist in the simulation of energy emergency and disruptions, both within the state and on a multi-state or regional scale, incorporating local, state and federal agencies and industries. Table-top exercises serve as an important tool in reviewing and revising the EAP.

4) Technical Training. Several areas of emerging technologies need to be presented in focused training modules. Topics include Smart Grid, cybersecurity, supervisory control and data acquisition (SCADA) systems.

Semester Project Progress

During the fall semester of 2011, a team consisting of junior and senior engineering clinic students was assigned to work on the development of the EAP. A kick-off meeting held with representatives from the NJBPU's Division of Reliability and Security marked the commencement of the development of the EAP. A brief introduction to the project's requirements, deliverables and tasks were discussed during this meeting. The NJBPU provided information in the form of other states' EAPs, federal and state agency emergency response plans, contact information, and documents related to energy emergency planning. Students reviewed EAPs from over 20 different states in order to familiarize themselves with the concept and nature of the document. This was intended to identify some of the similarities that New Jersey shares with other states in terms of the state's energy profile. Once the concept and purpose of the EAP was understood, students continued to perform an exhaustive study of New Jersey's energy sectors using the NASEO's guidelines as a framework. This analysis consisted in the identification of the different energy sources used for electricity generation and petroleum refining as well as the energy assets that conforms the New Jersey's energy system. Energy infrastructure includes power generation plants, transmission and distribution substations, transmission lines, petroleum products refineries, crude oil terminal and storage sites, docks, petroleum and natural gas pipelines and pumping substations among others. Students also revised various state documents such as emergency support functions, planning response strategies, and other appropriate state policies, procedures and practices.

When developing an EAP, it is very important to understand the interdependencies across the diverse energy sectors in order to recognize the vulnerabilities of the different energy systems. Figure 1 presents the interdependencies within the energy infrastructure. Furthermore, it is very important to recognize and comprehend the functions and responsibilities of the various state and federal agencies during an energy emergency. Clinic students had the opportunity to participate in meetings with the utility companies and representatives from three different energy sectors in order to acquire information concerning energy emergency planning procedures, infrastructure and annual reports regarding energy systems performance. This project also gave students the chance to research the potential roles of renewable energy resources in energy assurance planning. Renewable energies, such as solar photovoltaic generation, can be one practical method for enhancing resiliency and reliability of the energy system. Renewable energy systems have been found to be extremely useful in energy and supply restoration efforts [6].

Students analyzed data comprised in the Energy Information Administration (EIA) reports for the state of New Jersey[7]. These reports are available to the public and they provide substantial information on the three energy sectors under study. This information includes:

- Monthly and annual consumption of petroleum based products (diesel, gasoline, naphtha, asphalt and others).
- Crude oil supply and disposition (monthly and annual).
- Petroleum based products prices, sales volume and stocks.
- Annual refining capacity by state.
- Petroleum net imports by country.
- Monthly and annual consumption of natural gas.

- Natural gas supply and disposition (monthly and annual).
- Natural gas prices.
- Natural gas imports and exports.
- Natural gas storage capacity.
- Natural gas monthly and annual consumption.
- Monthly and annual electricity consumption.
- State's generating capacity.
- Consumption of fuels used to generate electricity.
- Electricity costs.
- Electricity demand, capability resources and capability margins.

Relevant information was also extracted and analyzed from annual reports from the different electrical and natural gas utility companies (electricity: PSE&G, JCP&L, Atlantic City Electric Co, Orange and Rockland Co; natural gas: PSE&G, NJNG, SJG and Elizabethtown Gas) and from the Pennsylvania-Jersey-Maryland (PJM) Interconnection. These reports contain abundant information on the energy system's assets and the capacities.

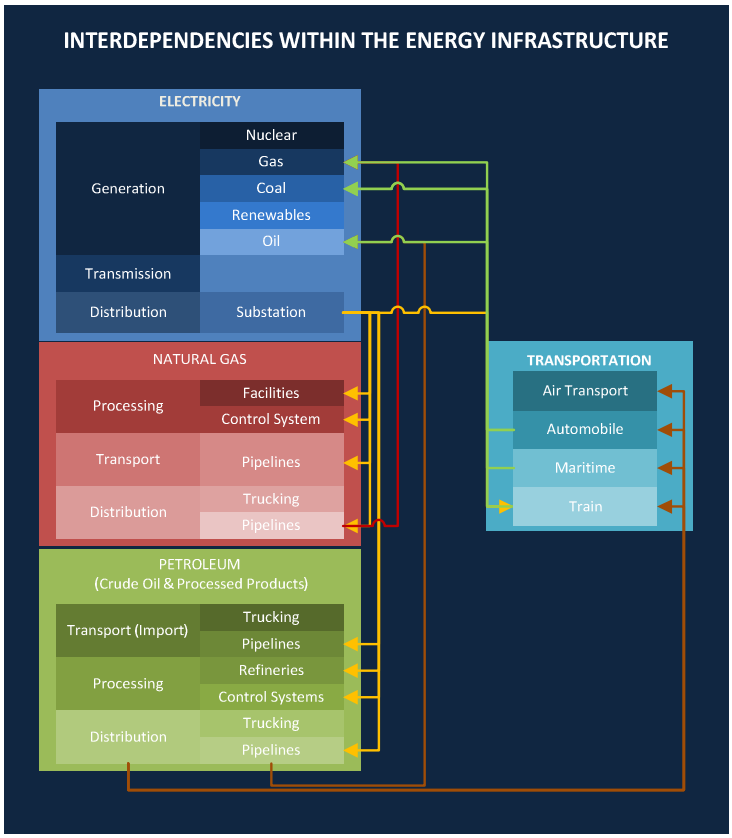

Figure 1. Interdependencies within the Energy Infrastructure.

Students also studied the impacts of Smart Grid technologies and its importance in energy assurance planning. The Smart Grid is considered a key technology to improve the reliability, quality and resiliency of power systems. These technologies bring numerous benefits such as continuous monitoring of power system and energy efficiency among others. Hence, it represents an important tool for supervising and assessing vulnerable or unsafe situations that could jeopardize the reliability of the power system[8].

At the conclusion of the semester, a draft EAP was finalized and delivered to the NJBPU. It addressed significant portions of the NASEO guideline requirements and included a substantial number of supporting appendices.

Future Work

The EAP is a living document that requires frequent updating to reflect changes in best practices, to reflect experience gained through exercising the plan, and to better fit the current energy posture of the State of New Jersey[9]. During the spring semester of 2011, a new team of Engineering Clinic students was formed to work on updating of the EAP as well as on the development of the Energy Supply Disruption Display and Reporting System (ESRS). A second team of Clinic students undertook the design of a training module for the NJBPU staff with the aim of introducing Smart Grid concepts, case studies, and to provide a venue for strategic planning. The first table-top exercise is scheduled to take place during the summer of 2011, with the objective of evaluating the executability of the most recent EAP version that will have been delivered at the end of the spring semester. These table-top exercises will provide the opportunity to revise, update and shape the EAP draft according to the necessities of the state. The alpha version of the ESRS will have been completed; further work during the summer will extend the functional capabilities of the tool and begin the process of porting the software from a web-based application to a tablet-based platform.

Lessons Learned

The type of project described in this paper clearly provides students with the opportunity to develop the ability to work effectively in multidisciplinary teams and to improve their communication skills, both oral and written. Students also learn about professionalism, problem solving, safety and ethics and most important, they foster their knowledge in diverse engineering aspects.

The development of a state energy assurance plan is, without a doubt, an opportunity that cannot be found in any curricular program. Students found this project to be a practical exercise to understand the interdependencies within the diverse energy sectors and as well as the vulnerabilities of the energy systems infrastructure. Moreover, they were able to analyze the importance of reliable and resilient systems and its importance over energy assurance planning.

The project also afforded a valuable opportunity to research new emerging technologies that are currently being developed to enhance reliability and resiliency of energy systems. Smart Grid is

one example of these technologies. The use of Smart Grid can be very valuable to mitigate and lessen the impacts of an energy emergency.

Finally, the Engineering Clinic program has been found to significantly impact student preparation for professional practice and for matriculation into graduate programs. For example, that a high percentage of Rowan's engineering students pursue graduate degrees is evidence of how Clinic projects awaken interest in research and help lower the perceived barrier between undergraduate and graduate work[1].

Acknowledgements

The support of the New Jersey Board of Public Utilities is gratefully acknowledged as well as the effort of all the students that worked on the development of this project.

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