# AC 2012-4240: USING PUBLIC POLICY THEORY TO IMPROVE POWER ENGINEERING EDUCATION

**Dr. Timothy R.B. Taylor P.E., University of Kentucky**
**Prof. Johne' M. Parker, University of Kentucky**

Johne' M. Parker is an Associate Professor of mechanical engineering.

# Using Public Policy Theory to improve Power Engineering Education

## Introduction

As society continually increases its reliance on complex, highly integrated technological systems to function, engineering education must evolve to include not only traditional engineering subjects, but also topics including business, economics, and public policy. As Dr. Bernard Amadei, Civil Engineering professor and the distinguished founding president of Engineers Without Borders - USA and co-founder of Engineers Without Borders International, has stated "if [our] problems were merely technical, they would have been solved by now." The American Society of Civil Engineers state in the *Civil Engineering Body of Knowledge for the 21st Century* that the next generation of "engineers need to understand the engineering/public policy interface" to successfully operate in the new millennium[1]. Other professional societies, such as ASME and IEEE, have made similar statements and consider public policy as a high-priority area.

Furthermore, *policymaker*s have identified a gap in the type of information that Congress receives on science and technology (S&T) matters and recognize the importance of including those with *technical expertise* in the conversations surrounding science and technology policy. Policymakers have found that a lack of information is not the problem; rather, the difficulty most legislative branch decision-makers have in fully understanding the large amounts of information and advice received on a daily basis and appropriately assessing the validity, credibility and usefulness of that information. The follow policy maker quotes illustrate this point:

> "If we want good public policy, it has to be made by those who understand the issues ... sadly, few elected officials have technical or scientific backgrounds ... and have to rely on others to provide independent, nonpartisan review of the scientific and technological implications of legislation ..."
>
> -John E. Sununu, Former Governor (R-NH)

> "It has become increasingly important for Congress to include technical expertise [in policy making]"
>
> -Senator Dianne Feinstein (D-CA)

> "The [ASME Federal Fellows Program] provides an invaluable resource ... in areas such as energy, environment, national security ... that require some understanding of very technical subjects in order to make informed decisions that are good for our county"
>
> -Rep. Heather Wilson (R-NM)

The need for a bridge between policy makers and technology developers is certainly apparent in the energy sector where advanced technology is developed with an evolving energy policy environment. The need for a multidisciplinary approach is especially true in the electric power industry. Historically, engineering programs have focused only on developing technical expertise; however, current power generation, transmission and distribution technologies are also challenged by evolving electricity markets, regulations and the societal pressure to develop and implement sustainable sources of energy. This requires the incorporation of non-traditional engineering topics from areas such as business and public policy. While incorporating conventional business and economic theory into engineering education is challenging, these fields are similar to engineering in that their foundation is often found in mathematics. However, the more fluid and seemingly chaotic nature of public policy can be challenging to engineering students.

The Department of Energy funded Power and Energy Institute of Kentucky (PEIK) was recently established to improve the undergraduate and graduate engineer training across engineering divisions in power engineering. One of the core classes of the PEIK program focuses on the incorporation of public policy into engineering decision making, EGR-540 *Power Economics and Public Policy*. As part of this new course undergraduate and graduate students from electrical, mechanical, biosystems, mining and civil engineering receive training in public policy theories including institutional rational choice, multiple stream framework, punctuated-equilibrium, and innovation-diffusion. The instructors present these theories as a means to structure the public policy process in a manner that would be familiar to engineers. The students were then asked to use the public policy theories in engineering decision making in homework, exam, and term project problems related to electric market regulation, renewable energy, nuclear energy, and generation selection decisions. The public policy theories allowed the student a structured method to evaluate policy risks associated with their technical solutions. Student performance on exam, homework, term project problems and course evaluation from the first offering of the course (discussed later) indicate that the theories may be a useful method for incorporating public policy into engineering education.

**Class overview**

The University of Kentucky follows the traditional two-semester, 9-month curriculum format. EGR-540 is a three credit-hour course taught in the spring semester with bi-weekly, 75 minute lectures resulting in 28 class meetings (including exams) for a total of 35 contact hours during the semester. The current course objectives are as follows:

1) Introduce students to the economics of the power industry
2) Introduce students to public policy theory
3) Prepare students to work in the power industry
4) Prepare students to include economic analysis and public policy elements in their engineering decision processes
5) Prepare student to participate in the policy making process

The course objectives are achieved through the learning outcomes shown below. Each outcome is tied to the specific course objective by the dual number system (e.g. 3.1 is linked to objective 3 above). Students completing the course are expected to be able to:

1.1) Describe the basic structure of power markets in a regulated and deregulated utility environment
1.2) Describe how utility business regulations impact electricity utility operation and decision making

1.3) Plan the selection of new electric generation facilities within the power market structure of the utility

2.1) Apply public policy theory to engineering system policy issues
2.2) Plan the selection of new electric generation facilities within the current and future environmental regulatory environment.
2.3) Identify the unintended consequences of public policies

3.1) Communicate professionally within the utility industry
3.2) Describe issues within the utility industry using the general vocabulary of the industry

4.1) Understand how current and potential future market and environmental regulations affect the feasibility of engineering decisions and assumptions
4.2) Apply engineering economic analysis to engineering decision making

5.1) Explain how professional engineering organizations influence the public policy process
5.2) Explain how engineering professionals can influence public policy process

The learning objectives fall on the lower levels of the cognitive domain of Bloom's taxonomy[2] since the course is intended to be a broad-based introduction to topic within public policy, economic analysis, and the power industry. The general schedule for the course is shown in Table 1. The course schedule includes lectures set aside for guest speakers from the power industry and the public policy and economic sector and can be moved throughout the course to accommodate the guest speaker. For the Spring 2012 semester, invited speakers include a retired utility industry CEO, an expert on synthetic fuels, a public policy professor specializing in energy policy, and a compliance officer from the Tennessee Valley Authority. In addition to class time, students can earn extra credit points for attending PEIK-sponsored University wide seminars offered during the semester (outside of class time) on subjects related to the course.

**Table 1: Class session schedule for EGR-540**

| Week | Tuesday Class Session | Thursday Class Session |
|---|---|---|
| **1** | -- | Course introduction and overview |
| **2** | Power industry overview | Power industry overview |
| **3** | U.S. political process | U.S. political process |
| **4** | Mock senate hearing | Public policy theory (3 stream) |
| **5** | Public policy theory (IAD Framework) | Public policy theory (Punctuated EQ) |
| **6** | Public policy theory (AC & Diffusion) | Exam #1 |
| **7** | Engineering economic analysis* | Engineering economic analysis * |
| **8** | Engineering economic analysis* | Engineering economic analysis* |
| **9** | Engineering economic analysis* | Term project introduction |
| **10** | Spring Break | |
| **11** | Facility siting | Exam #2 |
| **12** | Guest speaker | Generation fuel issues |
| **13** | Generation planning | Power conservation |
| **14** | Guest speaker | Lobbying |
| **15** | Power generation development presentations (Teams) | Power generation development presentations (Student Teams) |
| **16** | Power generation development presentations (Teams) | Power generation development presentations (Student Teams) |

The organization of the topics is intended to facilitate an understanding of the interrelational complexities of power industry public policy and economics. For example the “power industry overview” provided during the second week of the course (Table 1) focuses on the current make up of the U.S. power industry (e.g. an overview of the power generation fleet, the grid system, utility business models, important utility legislation). The political process lectures and mock Senate hearing (described later) during the third week of the course (Table 1) allows students to experience funding allocation decisions for generation development. For example, why would a Senator from Arizona favor solar power investment over investment in wind power? The discussion of public policy theory (weeks 4-6, Table 1) helps students better understand how U.S. public policy over the past 100 years has shaped the power industry. For example, why did U.S. utilities begin building civilian nuclear reactors in the 1950’s Why did the U.S. utilities stop ordering new nuclear reactors after 1979? The engineering economic analysis lectures (weeks 7 – 9, Table 1) provide the students a tool to analyze the impact of policy decisions on the power economics. These themes culminate in the term project (described later) which requires the student to develop a generation plan to meet a specific states future electricity needs.

Student learning in the course is evaluated using homework assignments, in-class exercises, daily oral quizzes, exams, and a term project during the second half of the semester. Each exam and the term project account for 25% (each) of the course grade To encourage class discussion, class participation is weighed as 15% of the final course grade (compared to 10% for homework assignments). Class participation is measured by informal instructor observation and randomly distributed in-class exercises which are collected and reviewed.

Two required textbooks are used for the course. *Theories of the Policy Process, 2$^{nd}$ Edition* by Paul A. Sabatier provides an overview and description of current public policy theories.

*Schaum's Outlines: Engineering Economics* by Jose A. Sepulveda, William E. Sounder, and Byron S. Gottfried is used during the engineering economic analysis portion of the course. These texts are supplemented by additional reading assignments provided by the instructor including state and federal government reports, the Energy Information Administration, the Department of Energy, U.S. Congressional websites, popular press (e.g. the *Wall Street Journal* and the *Engineering News Record*), and power industry specific publications. As part of homework assignments and term projects students are expected to search for and incorporate additional references into their assignments.

The student demographics for the first offering of the class included 25 total students comprised of 7 undergraduate seniors, 16 graduate masters, and 2 graduate doctoral students. Of these students, 17 were focused in electrical engineering, 3 were focused in mechanical engineering, 3 were focused in biosystems engineering, 1 was focused in mining engineering, and 1 was focused in civil engineering. Thirteen students were U.S. citizens and [State] residents with the remaining twelve international students from China (majority), Europe, India, and Africa. While the course was offered as an elective for any graduate or undergraduate student enrolled in the College of Engineering the majority of the students in the class (23) were required to take the course to earn their PEIK power and energy certificate.

**Policy theory descriptions**

The focus of the current work is on the use of public policy theory in engineering education. The instructors covered five current theories of public policy in the course including institutional-rational choice, the multi-stream framework, punctuated-equilibrium theory, the advocacy-coalition framework, and the innovation diffusion model. These theories were selected based upon their current use in policy analysis and research, their advanced level of development compared to other policy theories, and the applicability of the theories to power public policy.

A brief description of each theory quoted[3] from Chapter 1 of *Theories of the Policy Process, 2nd Edition* is offered next.

> **Institutional Rational Choice**: "Institutional rational choice is a family of framework focusing on how institutional rules alter the behavior of intendedly rational individuals motivated by material self-interest. Although much of the literature on institutional rational choice focuses on rather specific sets of institutions, such as the relationships between Congress and administrative agencies in the United States (Moe 1984; Shepsle 1989; Miller 1992), the general framework is extremely broad in scope and has been applied to important policy problems in the United States and the other countries (Ostrom 1986, 1990; Ostrum, Schroeder, and Wynne 1993; Ostrum, Gardner, and Walker 1994; Twombley, and Headrick 1991; Chubb and Moe 1990; Dowding 1995; Scharpf 1997). It is clearly the most developed of all the frameworks in the this volume and is arguably the most utilized in the United States and perhaps in Germany."
>
> **Multiple-Streams**: "The multiple-streams framework was developed by John Kingdon (1984) based upon "garbage can" model of organization behavior (Cohen, March, and Olsen 1972). It views the policy process as composed of three streams of actors and processes: a problem stream consisting of data about various problems and the proponents

of solutions to policy problems; and a politics streams consisting of elections and elected officials. In Kingdon's view, the streams normally operate independently of each other, except when a "window of opportunity" permits policy entrepreneurs to couple the various streams. If the entrepreneurs are successful, the result is major policy change. Although the multiple-streams framework is not always as clear and internally consistent as one might like, it appears to be applicable to a wide variety of policy arenas and was cited about eighty times annually in the Social Science Citation Index."

**Punctuated-Equilibrium Framework**: "Originally developed by Baumgartner and Jones (1993), the punctuated-equilibrium (PE) framework argues that policymaking in the United States is characterized by long periods of major policy change. The latter come about when opponents mange to fashion new "policy images" and exploit the multiple policy venues characteristics of the United States. Originally developed to explain changes in legislation, this framework has been expanded to include some very sophisticated analyses of long-term changes in the budgets of the federal government (Jones, Baumgartner, and True 1998)."

**The Advocacy Coalition Framework**: "Developed by Sabatier and Jenkins-Smith (1988,1993), the advocacy coalitions-each consisting of actors from a variety of institutions who share a set of policy beliefs-within a policy subsystem. Policy change is a function of both competition within the subsystem and events outside the subsystem. The framework spends a lot of time mapping the belief systems of policy elites and analyzing the conditions under which policy-oriented learning across coalitions can occur. It has stimulated considerable interest throughout the countries of the Organization of Economic Cooperation and Development (OECD)-including some very constructive criticism (Schlager 1995)."

**Policy Diffusion Framework**: "The policy diffusion framework was developed by Berry and Berry (1990, 1992) to explain variation in the adoption of specific policy innovations, such as a lottery, across a large number of states (or localities). It argues that adoption is a function of both the characteristics of the specific political systems and a variety of diffusion processes. Recently, Mintrom and Verfari (1998) integrated this framework with literature on policy networks. The diffusion framework has thus far been utilized almost exclusively in the United States. It should, however, apply to variation among countries or regions within the European Union, the OECD, or any other set of political systems."

The methods used to instruct engineering students in these policy theories is described in the next section.

**Policy theory use in class and results**

Prior to discussing policy theory the instructors used a mock Senate hearing to allow students to experience a simulated piece of the policy process. The students held a Renewable Energy Policy Hearing (of the Energy and Water Subcommittee of the Senate Appropriations Committee) to 1) develop an understanding of the creation of policy in the legislative branch and 2) secondarily explore the link between the executive and legislative branches in policy creation. The primary goal of the hearing was to gather information that would help the subcommittee appropriate the

$10 billion in additional funding authorized for specific renewable energy technologies. It was serendipitous that, in the State of the Union Address (held after the assignment was made, but before the hearing was held), the President mentioned a request (from the Executive Branch) for $15 billion for renewable and clean energy technologies in the FY 2012 budget, so the assignment was very timely. Key deliverables of this activity were the oral presentations (testimony) by the witnesses and question/answer session between the witnesses and the Members of the subcommittee (witness testimony and anticipated questions were also submitted to the instructors in hardcopy). The students worked in groups comprised of five students each; each student in the group had a distinct and specific role: one student served as a Senator on the Energy and Water Appropriations Subcommittee; two students served as staffers to the Member and the remaining two students served as witnesses. Each group drew a) their state affiliation, b) whether they were members of the minority or majority party and c) their seniority on the committee). Each group had two witnesses with one witness invited to provide up to 3 minutes of testimony and both witnesses available to answer questions. Each senator had up to eight minutes to question witnesses. States were selected for the exercise based on their specific energy characteristics identified below:

- Arizona (Minority Party) – high potential for solar energy
- California (Majority Party) – aggressive renewable energy portfolio standards and large energy demand
- Kansas (Majority Party) – high potential for wind energy
- Montana (Minority Party) – diversified energy potential
- New Mexico (Majority Party) – high potential for solar energy

The instructors represented the Chair and Ranking Member of the Energy and Water Appropriations Subcommittee Instructors and also assumed the roles of the Chair and Ranking Member of the full Appropriations Committee as necessary.

The mock hearing was well received by the students and they actively participated in the discussion. Prior to the exercise the instructors were concerned that the students would require heavy instructor involvement to achieve success. However, as the exercise progressed there was very little input required from the instructors to facilitate student discussion.

After experiencing the mock senate hearing, students received instruction on the policy theories through assigned readings, lectures, oral quizzes, in-class exercises, exams, and a term project. Students were assigned readings from specific chapters in *Theories of the Policy Process, 2nd Edition* that discussed a specific policy theory prior to the lecture on that topic. To encourage students to complete the reading, students were then given oral quizzes prior to the lecture covering the reading assignment. Oral quizzes would ask questions of random students that were designed to determine whether the student completed the assigned readings. Example oral quiz questions are shown below.

- The multiple streams framework describes three steams in the policy process. Name 2 of the 3 streams.
- What is the basic underlying assumption of the Institutional Analysis and Development Framework?

- In the advocacy coalition framework, what is meant by the devil shift?

Of the 15 questions asked to randomly selected students throughout the four lectures on policy theory, 80% of the questions were answered correctly. However, prior to the beginning of the first class lecture on policy theory covering Kingdon's multiple stream policy framework one of the students with a history of high academic performance stated, "I did not understand a word of that chapter. I couldn't follow the organization of the chapter and I did not know the definitions of many of the words used." Several other students agreed with the student's assessment. The instructor encouraged the students to focus on that day's lecture to see if it would provide a clearer picture of the theory.

Lectures were administered using Microsoft Powerpoint slides to summarize and explain the specific policy theory. The instructors framed the policy theory as a tool to help organize the seeming chaotic and random policy process into a form that allows the process to be better understood. The instructors illustrated this approach using a theory familiar to all engineering students: Newton's second law of motion (Force = mass*acceleration). Newton's second law allows engineers to model complex relationships in physical system. More importantly, it allows engineers to understand, design, and manipulate physical systems to achieve desired behavior. Policy theories in a similar manner provide a mechanism to understand, design, and manipulate a policy system.

Each policy theory was described in detail to the class by the instructors with examples being used to illustrate how the theory could be applied. For example, Kingdon's multi-stream model was used to analyze the policies at the beginning of the U.S. nuclear age. The example was presented as shown below:

- The civilian nuclear age began in the U.S. in the 1950's
- How can we model the birth of the nuclear age in the U.S. with the multi-stream model?

The diagram shown in Figure 1 was used to demonstrate how the multi-stream model could be used to describe the beginning of civilian nuclear power in the U.S. The diagram shows how the growing post-World War II economy required the development of electricity, the country had faith in the government and a spirit of optimizing, and one of the policy solutions to the growing energy demand was civilian nuclear power. These three streams "merged" due to policy entrepreneurs and produced the Atomic Energy Act of 1946 and 1954 (which encouraged civilian nuclear power development) and the Price-Anderson Act of 1957 which limited utility liability for nuclear accidents. After discussing this example, the students were asked how this policy scenario relates to the current planned restart in U.S. nuclear plant construction. The students responded with statements such as, "most people do not currently trust the government" and "the economy is currently either not growing or growing very slowly." The students felt that this model shows that large scale nuclear construction will be difficult in the current environment. Similar examples were used to illustrate the use of the remaining policy theories.

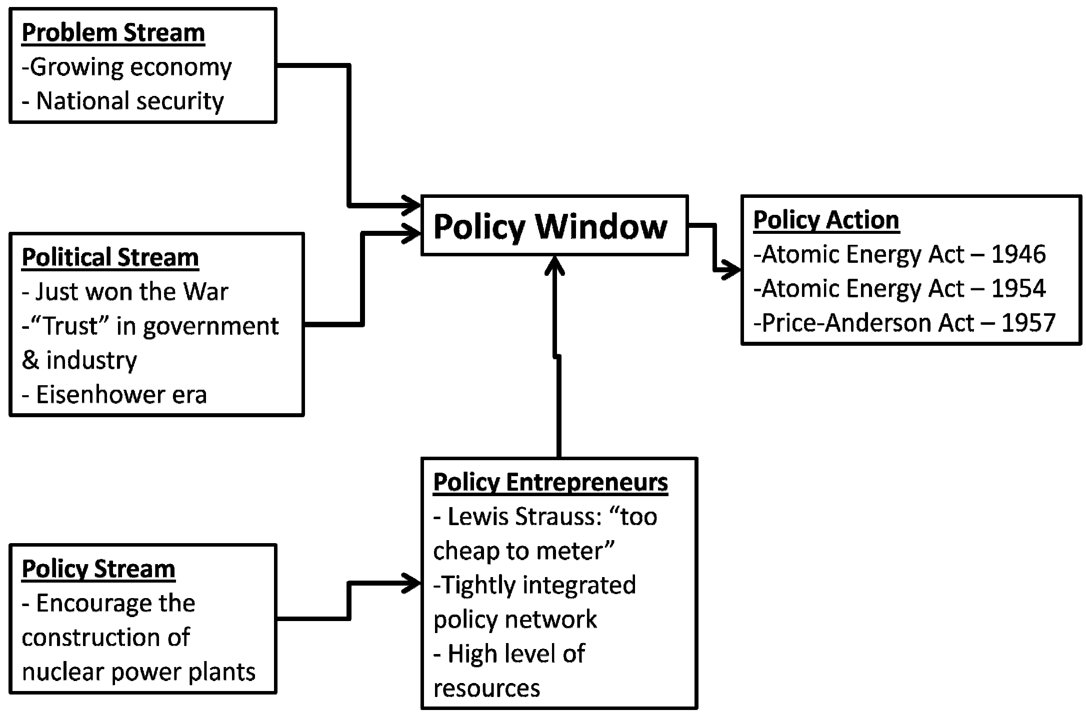


**Figure 1: Start of U.S. civilian nuclear power industry described using the multi-stream policy theory**

At the end of the lecture discussing the three stream-framework the instructors discussed the topic with the student (described earlier) who had expressed frustration with the understanding of the reading. The student indicated that the explanation and example helped them to better understand what they had read. Other students echoed this student's sentiments.

To test the student's understanding of the three stream framework the student's were assigned the following individual homework assignment:

> "Thanks to your excellent policy briefing State Senator Boone made the right call on power market deregulation in [State] [a reference to an earlier assignment]. This decision propelled him to be elected to represent [State] in the U.S. Senate. Of course he has brought you along as a staff member to Washington, D.C. Senator Boone has been placed on the Senate Energy and Water Committee and now needs to get up to speed on energy issues in the U.S. He wants to learn more about the growth of wind power generation in the U.S. He asks you to prepare a 6 page memo to him summarizing the U.S. wind industry and U.S. wind power public policy in general. You think John Kingdon's multi-stream policy framework provides an excellent foundation for this analysis. In your memo:
>
> 1) Provide a description of wind power policy in the U.S. using Kingdon's three stream policy framework (discuss the streams in relation to wind power energy, identify coupling points, indicators, etc.). Support your descriptions with references.

2) Use your framework to predict how U.S. wind energy policy will evolve over the next 20 years. What are the key issues U.S. wind power generation faces in the next 20 years? Describe using the three stream framework (i.e. how will it affect the coupling of the streams)?"

The class performed well on the assignment with a class average on the assignment being 92% with a high of 100% and a low of 63%. Some of the common point deductions for this assignment were for not adequately relating U.S. wind policy to the three streams, not addressing the idea of streams coupling, and not incorporating the three stream framework in making future predictions.

Students were also assessed on their understanding of the multi-stream framework in a multi-part exam question shown below:

*Problems 5-6 (25 total points)*
Recall the Multi-Stream (Three) Stream framework we discussed in class. Below is a list of potential problems and solutions related to energy in the U.S. that are currently "floating" around in the policy arena. These lists are certainly not exhaustive and you may add to them if need be to answer questions 5 – 6.

<u>Problem Stream</u>
Climate Change
Air Pollution
Fossil Fuel Production Consequences
Foreign Fossil Fuel Dependence
National Security
Growth in Energy Demand
Deepwater Horizon Incident and Aftermath
Increased Energy Prices
Decreased Agricultural Land Availability
Limited R&D funding for new energy research
Electric Transmission Distribution Challenges

<u>Solution Stream</u>
Increased Nuclear Power Generation
Increased Hydro Power Generation
"Clean Coal" Generation
Increased Wind Power Generation
Increased Solar Power Generation
Increase Biofuels Production
Hybrid/Alternative Fuel Vehicles
Increased Energy Efficiency
Increased Energy Conservation
$CO_2$ Emission Limiting Legislation

*Problem 5 (10 points)*
Based on the state you were assigned for the Senate hearing exercise (Arizona, California, Kansas, Montana or New Mexico), list five (5) elements of the solution stream for energy in the U.S. Explain how each of the element impacts your state's view on U.S. energy policy.

*Problem 6 (15 points)*
Based on the state you were assigned for the Senate hearing exercise (Arizona, California, Kansas, Montana or New Mexico) and using your understanding of the three-stream policy framework, describe a scenario where the three streams couple in a manner favorable to your state. Be sure to describe the scenario in terms of the three stream framework (indicators, focusing events, policy entrepreneurs, etc.)

The class average for problem 5 was 95% and the average for problem 6 was 85%. Common errors on problem 5 were not listing 5 elements of the solution stream or listing elements that were actually part of the problem stream or political stream. Common errors on problem 6 were failing to use the multi-stream theory to answer the question and failing to adequately describe the coupling of the streams. The results of student performance on problem 5 appears to indicate that the students understand the basic multi-stream theory but the results of problem 6 indicates that the students were less proficient at applying the theory to a given situation.

The final assessment for student understanding of how the policy theories could be used in engineering decision making was in the term project. The term project assignment was presented to the students in the following form:

> "You are employees of a newly formed power generation company (*[Your state here]* Generating Company). Your company has acquired all electric utilities and independent power producers in your respective states (see the team assignments, next page). As the sole power producer in your state, it now the responsibility of your company to provide your state with the electricity it needs to meet the current and future demand. Your company has assembled a team to estimate the future electricity needs of your state and to determine how the projected growth in electricity demand will be met by your company.
>
> Your team has been asked to make a recommendation to the upper management of your company of how the company will meet the energy demands of your state in the year 2025. This recommendation will be in the form of a generation portfolio that offers a view of the generation fleet in the year 2025. Your team may consider both supply side solutions (e.g. build new plants) and demand side solutions (e.g. increased energy conservation).
>
> Your recommendation to your upper management will be in the form of a written memo and an oral presentation. Your analysis should include:

1) An overview of your current generation fleet (e.g. composition, electricity price, electricity production cost, renewable energy portfolio requirements, etc)
2) Strategies you recommend for your state (e.g. how much will your plant construction generation strategies cost your company?). These should include cost and schedule estimates (e.g. will a new plant come on-line, when will conservation measures be implemented). The Sandia GenSim model will help you estimate plant costs.
3) An identification and analysis of the risks associated with your strategy. For example, if you propose to build a coal plant to meet generation demand what would happen if a "carbon tax" was imposed on fossil fuel generation? How would this impact the cost of your solution? What is the likelihood of the carbon tax being imposed? Again, the GenSim model can be used to perform a sensitivity analysis on your generation costs.

The memo should summarize your analysis and make recommendations to your management team. The body of your memo is limited to 5-pages. However, you may use appendices to support your analysis (i.e. show your sensitivity results in the appendices) and there is no limit to the length of your appendices. We expect that you will have to perform different analyses to develop your solution so be sure to show all the good work you do here. The presentation will summarize your analysis results and recommendations. The presentation will be on behalf of your entire team but it does not have to be given by all team members."

It is important to note that the term project does not explicitly require the students to use one of the policy theories as part of the project. However, the policy theories could be used as part of the required analysis (number 3 above) to assess the potential policy risks of their selected generation strategy. While all five teams included some basic elements of policy risks in their generation plan (i.e. a carbon tax would decrease the competitiveness of coal plants) only one team used one of the policy theories discussed (the multi-stream framework) in class to analyze the policy situation. This appears to indicate that the students either did not view the policy theories as useful analysis tools or they did not understand how the theories could be used in their analysis.

The course was well received by the students. In anonymous course evaluations the students' average rating for the "overall value of the course" was 3.8 on a 4.0 scale (0.5 greater than the average value of courses in the College of Engineering). The students were also asked to rate the "overall quality of teaching" for the course with the average rating for the instructors of 3.9 on a 4.0 scale (0.6 greater than the average quality of teaching for the College of Engineering). The instructors also asked student to answer the following questions on a 1 – 5 scale (1 – I am not familiar with this concept, 3 – I am somewhat familiar with this concept, 5 – I fully understand this concept and how it is applied).

- Basic understanding of the public policy theories discussed in class – 4.7/5.0
- Understand how politics and public policy impact engineering decisions – 4.8/5.0

- How to integrate public policy and economics in engineering decision making related to power infrastructure – 4.6/5.0

Written anonymous student comments on the course were also positive:

- "Surprisingly interesting course on a subject that was somewhat far from my concerns. Thank you very much!"
- "Great class, I wish there was a part II."

**Conclusions and future work**

The current work presents the results of the first offering of a course at the University of Kentucky to incorporate public policy theory into engineering analysis and decision making. As part of the PEIK program the course focused on applying public policy theory to engineering decision making. Students were presented five established public policy theories and given assignments that required these theories to be applied to power engineering situations. The course was well received by the students and is currently being offered in the Spring 2012 semester.

After reflecting on the progression of the course, it is the instructors' observation that students found the discussion of policy theory uninspiring. However, they were actively engaged with class exercises and homework problems that allowed the students to apply the theories to "real world" situations (e.g. renewable energy, nuclear power, the Keystone XL pipeline). In future course offerings the instructors may consider covering only one public policy theory (likely the Kingdon multi-stream theory) but cover the theory in more detail and apply the theory to a more diverse set of power and energy related issues.

The current work offers several areas for improvement in both the class and the dissemination of the results. First, the assessment of student learning is largely qualitative and is based on course assignments and anonymous student evaluations. The instructors are currently developing a pretest/post-test set of questions that will be presented to the student prior to receiving instruction on the policy theories and again after the students have received instruction on the policy theories. This type of test will provide insight into the usefulness of the policy theories in developing student understanding of policy issues related to power systems. Students also expressed a desire to see more "real life" examples of the use of the policy frameworks in analyzing policy situation. The instructors provide a copy of their own use of the policy framework to analyze U.S. civilian nuclear power regulation[4]. Future course offerings will identify additional uses of the policy theories in analyze policy scenarios.

Despite these limitations, the current work demonstrates that incorporating public policy theory into the engineering curriculum is well received by the students and could offer a useful means of incorporating public policy into engineering decision making. As the purpose of this paper is to disseminate the results of their experience with the course and to encourage the incorporation of public policy theories into engineering course work the authors are happy to share course material with other instructors. Please contact the authors for additional details.

**References**

[1] American Society of Civil Engineers (ASCE). (2008). *Civil engineering body of knowledge for the 21st century*. American Society of Civil Engineers, Reston, VA.

[2] Bloom, B. (1984). *Taxonomy of educational objectives book 1: Cognitive Domain, 2nd edition*. Addison Wesley Publishing Company, Boston.

[3] Sabatier, P. (2007). *Theories of the policy process, 2nd edition*. Westview Press, Cambridge, MA.

[4] Taylor, T., Ford, D., and Reinschmidt, K. The impact of public policy and societal risk perception on U.S. civilian nuclear power plant construction. *ASCE Journal of Construction Engineering and Management*. In press.