

Technology Management and Policy Graduate Consortium

June 26-28, 2011

The Pennsylvania State University

University Park, Pennsylvania

PRESENTATION ABSTRACTS

SESSION 1: Innovation and Policy

Monday, June 27, 2011 – 8:30 a.m.

SESSION CHAIR: Seth Blumsack, Assistant Professor of Energy Policy Economics

ABSTRACT

Gaining from Other's Losses: Technology Trajectories and the Global Division of Firms

Chia-Hsuan Yang, Carnegie Mellon University

After the burst of the telecommunications bubble in March 2000, the majority of U.S. optoelectronic component firms moved manufacturing offshore. Mainstream economists have claimed offshoring will benefit firms and their home countries by freeing up resources to put into higher value-added activities. However, other intellectuals have argued that offshoring can hurt firm and national innovation. Recently, Fuchs et al. have added that offshoring can reduce the economic viability of emerging technologies. In the case of the optoelectronics industry, these emerging technologies are “monolithic integration” – a capability critical not only to the future of telecommunications (the locus of innovation at the time of the study) but also to advance in energy, health, computing, and military applications. Following up on Fuchs et al.'s findings, this research explores (1) whether due to different offshore production economics, optoelectronic firms who move manufacturing offshore stop or slow U.S.- based R&D activities in emerging “integrated” technologies and (2) whether inventors originally within these offshoring firms, leave, and continue to innovate in emerging “integrated” technologies at different institutions.

We focus on the 28 leading small- or medium-sized U.S. firms that manufacture optoelectronic components for telecommunications (18 offshore, 10 not) and the 81 inventors who have three or more integrated patents at these firms. We triangulate USPTO patents, firm SEC filings, inventor CVs, and survey data we collect from the firms. Our regression results show that offshoring is associated with a decrease in the emerging monolithically integrated patents but an increase in non-integrated patenting. Our in-depth case studies of these firms also suggest that there may, indeed, be a relationship between firms' resources, offshoring strategies and their type of integrated innovation. One firm, Infinera, stays onshore and dominates in the most advanced (monolithic) integrated technologies, while the firms that move offshore either from the start lack or move out of the most advanced technologies. The exception is the large-resource firms with split production strategies (fabrication in the U.S., assembly offshore),

for whom it remains to be seen how their advanced (monolithic) integration activities will fare in the long term. In the case of the inventors, we observe that the majority of inventors who ever worked at offshoring firms eventually leave. Notably, 90% of those who left offshoring firms to non-offshoring firms go to Infinera, which during the same period as the offshoring waves of other firms, shifts to focus on and become a powerhouse in monolithic integration.

ABSTRACT

Impacts of Offshoring on Down-Stream Innovations—A Case Study of U.S. Rare Earth Industry

Zhi Li, Penn State University

Rare earth elements (REE) are essential for high-tech, renewable-energy, and defense-related technologies. Before 1990s, the United States used to be the leader in both production and innovations related to rare earth elements. Since 1990s, there has been a significant offshoring in rare earth industry, including a gradual phase-out of REE production and , moving abroad of REE-related manufacturing. , as firms seek locations to maximize their efficiency and competitiveness. However, such offshoring activities could influence the balance of the domestic innovation system and negatively impact the down-stream innovations in the supply chain of REEs.

We examine the effect of such offshoring on innovation of U.S rare earth industry, particularly in the downstream of the supply chain. Using the patents dataset from the Chinese Patent Office (SIPO) and the US Patent Office (USPTO) from year 1985 to 2007, we investigate the change in patenting by U.S. entities after such offshoring, in comparison to that of Japanese entities and European entities. We find that offshoring has a substantial negative impact on innovation in U.S. rare earth industry. The results hold for both patenting in both REE-containing components and REE-related end-use applications. In addition, patenting activities have declined more in end-use applications than in the relatively upstream technologies of the supply chain, indicating that U.S. innovation capacity related to various end-use fields are more likely to be weakened when the innovation system is disturbed.

ABSTRACT

Competition and Technological Innovation in the Telecom Sector: Entry, Exit and Market Structure in the UK

Claire Weiller, University of Cambridge

Until liberalization and privatization policies throughout the 1980s opened the market to competition, the telecommunications sector in the UK was dominated by a government-owned monopolist, British Telecommunications. Thirty years later, hundreds of suppliers compete in the sector on the basis of different product offerings, service bundles, and customer segments. This paper explores the drivers of entry in response to technological innovation in the UK telecoms sector and how regulatory policy can promote new companies entering in the retail telecoms market. Other than the prospects of a profitable market opportunity, factors inherent

to the nature and history of certain firms determine their likeliness to invest in innovative technologies.

A hazard model is presented to test the effects of firm size, CEO's years of experience within a company and past experience in the telecoms industry, on the timing of the strategic decision to enter the market. We hypothesize that firm size is positively correlated with the probability of entry, as larger firms are less risk averse and have more resources for R&D. As a result of the econometric analysis, we expect to find that the CEOs of new telecom companies or subsidiaries are likely to have previous experience in the telecommunications sector. We assess which entrepreneurial backgrounds help predict "willingness to innovate" in new markets for mobile, broadband or fixed-line telecommunications.

The analysis provides an understanding of the competencies that enabled *de novo* entrepreneurs with little or no experience in the telecom industry to challenge the incumbent companies' market share. Finally, parallels are drawn between the telecoms experience and another network industry with a history of liberalization in the UK: the energy supply sector. Once seen as offering little scope for innovations and technological change, electricity markets are currently undergoing potentially radical transformations with the adoption of new technologies such as smart metering and electric vehicles. Understanding the drivers and barriers to entry in the telecoms history will help devise and adapt regulation policy to create an efficient and innovative market of energy services.

ABSTRACT

Infrastructure Dependent Technologies: Escaping Lock-In and Role of Policy

Alexander van der Vooren, Utrecht University

The lock-in of a dominant technology is one of the main barriers to the diffusion of new technologies (Unruh, 2000, 2002). When the dominant technology is considered undesirable, governments may want to stimulate the escape from the existing lock-in. Such government intervention is more likely for infrastructure dependent technologies (Gomez-Ibanez, 2003), which are those technologies that depend on the availability of a physical infrastructure in order to function e.g., cars depend on fuel stations. A policy measure that is often used to escape lock-in is the stimulation of technological diversity. While the existence of technological diversity is a prerequisite for the escape of lock-in (Arthur, 1989; van den Bergh, 2003; Metcalfe, 1994), less is known about the adequate level of diversity especially in situations where a limited budget for the creation and (long term) support of technological options is available.

Policymakers that seek to influence technological change can apply a wide range of instruments when trying to influence these processes. R&D subsidies for example may lead to increased variety whereas other measures such as the development of infrastructure and price subsidies target the selection and diffusion process. Choosing the optimal strategy for intervention is a difficult task for several reasons. First, the 'budget' for government intervention is often limited. Second, the effects of intervention in one part of the process influences the success of

intervention in other parts, that is, the process is characterized by feedback mechanisms. Third, the optimal level of variety is unknown: while variety is necessary to escape lock-in too much variety may lead to increased uncertainty and delayed adoption by end consumers (Geroski, 2000). For a policymaker finding the optimal strategy is thus not straightforward. The main issue that we will address in this paper therefore concerns the effects of and interactions between different strategies to influence the substitution process of infrastructure dependent technologies. We address this question by building a simulation model. In our model we consider the strategy of the government in a multistage problem. In the first stage the government has to decide how much to invest in variety creation, for example through R&D subsidies. In the second stage the government decides whether to support some of the new technological options. Our model provides insights in the general trade-offs between the different aspects of variety creation and selection and the interdependencies between the different stages of the substitution process.

ABSTRACT

Local Content Requirement Policy and Innovation: A Case Study of Wind Power in China

Yuxi Meng, Penn State University

China is well established as a powerhouse in renewable energy technologies. It produced nearly half of the world's wind turbines in 2010, and passed the United States last year as the world's largest wind turbine market. It also produce more than half the world's solar panels last year, and more than 95 percent of them will be exported to countries like the United States and Germany. More importantly, commentators have claimed that an important shift, from "Made in China" to "Created in China", is taking place - China is not just a manufacturer and exporter, but is becoming a source of innovation in renewable technologies. This shift is driven primarily through a web of industrial policies that aim to promote China's indigenous innovation and leadership in renewable technology. China is now 4th in the world in patent origin in technologies such as wind power.

This paper studies the impact on China's indigenous innovation in wind power of a particular industrial policy (Notice 1204), that required a 70% local content for wind power. This local content requirement policy was implemented in 2006, has since been intensively debated and discussed, and and that was eventually revoked due to the pressure from the U.S. Using patenting in solar PV as a comparison and a Dif-in-Dif (D-D) strategy, we find that the number of patent filings in wind power by Chinese, particularly by non-academic (firms and individuals), has significantly increased and the quality of the filings remained the same after 2006. The results hold when we use as a further control patenting in wind power and solar PV by foreigners that involves a D-D-D strategy. Our results suggest that the local content requirement had significantly advanced China's innovation in wind power.

SESSION 2: Energy Environment and Decision-Making (Part 1)

Monday, June 27, 2011 – 10:15 a.m.

SESSION CHAIR: Andrew Kleit, Professor of Energy and Environmental Economics

ABSTRACT

Green Infrastructure: Evaluating a Novel Approach to Reducing Urban Flood and Pollution Susceptibility

Seth Wilberding, Penn State University

The United States faces a looming water infrastructure crisis. Nationwide, conventional urban and exurban storm water management systems increasingly require extensive replacement and repair, leaving residents susceptible to flood, infrastructure breakdown, and contamination risks. However, estimated U.S. storm water system rehabilitation costs run in the billions, an expense that many municipalities are unable to afford. To address this problem, officials in several U.S. and international cities are turning to an urban design-based alternative, termed green infrastructure, to supplement conventional surface and subsurface drainage systems. Based on core principles from landscape ecology, urban planning, landscape architecture, and civil engineering, this green infrastructure approach purports to reduce flood susceptibility and reduce drainage infrastructure costs by decoupling runoff from existing storm water management systems. However, relatively little scholarship has investigated these claims, and more thorough investigation of this novel strategy is required to advance its capabilities. To address this gap, this research will employ both empirical observation and modeling approaches – the Environmental Protection Agency-funded WinSLAMM (Source Loading and Management Model for Windows) model and the Natural Capital Project's InVEST (Integrated Valuation System of Ecosystem Services and Tradeoffs) model – at three scales to predict current and future flood hydrology of several Pennsylvania sub-watersheds, quantify the infiltration capacity of pilot green infrastructure projects, and develop a comprehensive theoretical green infrastructure plan for an urban area to optimize runoff capture and infiltration. Results will guide municipal officials, urban planners, engineers, and ecologists in implementing future planning and design policy for urban runoff and pollution management.

ABSTRACT

Burn or Export: The Impact of an International Climate Treaty on South African Coal Utilization

Brennan Hodkinson, University of Cambridge

South Africa has one of the world's most coal intensive electricity generation mixes. The chief reason for South Africa's high use of coal fired power plants is the easily available and cheap domestic coal reserves. South Africa is also a major coal exporter, serving both the Atlantic and Pacific markets owing to its unique geographic location. For these two reasons, coal holds a

significant position in South Africa's current development trajectory. Given some form of an international climate treaty may be signed within the next several years, its contents could greatly affect the current structure of South Africa's coal use with respect to domestic consumption and/or exports. The contents of a possible treaty will greatly affect South Africa's coal landscape and hence development, and this paper investigates what these effects may be. It does so by constructing four scenarios that consider the combinations of stringent and loose emission constraints and high and no restrictions on coal exports. The performance of three metrics – namely private returns, global welfare and economic growth – are then analysed under each scenario and from that, optimal strategies for the utilisation of South Africa's coal are suggested.

ABSTRACT

Enhanced Geothermal and Earthquake: Implication for Siting and Resource

Enes Hosgor, Carnegie Mellon University

Induced seismicity concerns have halted Enhanced Geothermal Systems (EGS) projects in Switzerland and Germany. This paper refines the EGS resource base in the US to include only areas with lower seismicity damage potential and establishes a framework for permitting and site-selection that accounts for a socially acceptable EGS deployment.

ABSTRACT

Measuring Public Preference for Energy Alternatives Using Choice Experiments

Allard van Mossel, Utrecht University

The public acceptance of energy technologies is an increasingly important topic in the energy transition debate. A wide variety of studies employ public preferences as a measure of acceptance of energy technologies, yet many limit themselves to a specific technology. Moreover, the issue of how to arrive at a valid and reliable measure of public preferences remains subject to considerable scientific debate.

Choice experiments are particularly promising and have a track record of being a reliable tool in measuring preferences in various scientific disciplines. Applying this method on a sample of 900 Dutch citizens, this study compares public preferences for nine of the most prominent energy alternatives that could attribute significantly to our energy system in the foreseeable future. Furthermore, we assess to what extent reputation, technology specific attributes (price per kWh, long term risks, energy security, spatial impact, individual effort to obtain energy) and various respondent characteristics can explain preferences for these alternatives.

Employing a fractional factorial design, respondents were asked to choose between two alternatives, in a series of six choice tasks with systematically varying attributes among the alternatives. Furthermore, to measure reputation effects respondents were randomly distributed amongst two equally sized groups, whereby only one group was provided with the

name of the technology represented by the alternatives. The data was analyzed in a multinomial logit model with choice for an alternative as dependent variable.

Our results signify a marked contrast between preferences based solely on technology attributes and those that include reputation effects. While the former indicate a strong support for nuclear energy and coal with CCS, the latter greatly favor off-shore wind and biomass technologies. Overall, off-shore wind appears to be the most supported alternative.

In terms of the influence of technology attributes, price per kWh and long term risks take prominence over the other attributes. Their influence, however, is dramatically reduced by reputation effects. This leads to the conclusion that reputation effects are dominant over technology attributes in preference formation. Similar effects could well play a role in the context of other studies, suggesting that great caution should be employed in interpreting stated preferences. Furthermore, differences are found between groups of respondents based on individual characteristics. This leads to the conclusion that no energy system will satisfy all segments of the population. However, the identification of these segments gives stakeholders the opportunity to formulate communication strategies that target these segments in an optimal manner, which can induce a change in public preferences.

ABSTRACT

Designing the Governance Framework for Public-Service Infrastructure Delivery

Vivek Sakhrani, MIT

Many novel approaches involving the private sector have been suggested and used for the delivery of large engineering projects in heavily regulated infrastructure sectors in regions such as Asia or Africa. Governments in these circumstances have had limited success in the procurement of large scale infrastructure, and the state owned operating companies have had little incentive for its efficient operation and maintenance. There have been a few successes at best, but most projects have typically resulted in cost overruns, schedule delays, asset value loss over the project's lifetime, and in some cases, the inability to produce and deliver the very service for which they were built.

Public bodies have therefore looked to the private sector's expertise in construction, operation and maintenance. However, the design of project delivery frameworks such as public private partnerships (PPPs) and the embedded incentive structures have also been prone to failure. Projects have fared well on simplistic metrics such as total project costs or schedule, for which budgets and timelines could easily have been inflated, but there is no clear indication of whether project value was improved or maximized in aggregate or for a subset of the participants. This phenomenon is noted across various sectors – energy, transportation, healthcare, and others. Although the literature on both project design and governance frameworks is prolific, the fundamental question that is yet to be studied formally and adequately is how the design and governance frameworks interact to affect underlying project value.

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also indicate that most managers in the field are not conversant with advanced valuation and risk-management techniques [9]. In my own work, I therefore propose to combine and formalize the analysis suggested by the two bodies of literature, project design and risk management, applied to energy projects. The central tasks of this effort are (i) developing a more sophisticated approach to project design in the face of uncertainty; for example, identifying appropriate decision options by understanding the impact of uncertainties on the specifications for design today, (ii) using modern valuation techniques to assess underlying project value with the various decision options, and (iii) designing the project governance contracts and agreements with explicit consideration of the strategic interests of the participants. I will thus employ the methodologies of flexibility in design, real options valuation, and investment and game theory in studying the sustainable delivery of energy infrastructure.

SESSION 3: Risk, Security and Policy

Monday, June 27, 2011 – 1:30 p.m.

SESSION CHAIR: Darryl Farber, Assistant Professor of Science, Technology and Society

ABSTRACT

Uncertainty Analysis of Storage Resource Estimates for CO₂ Sequestration in Saline Formations

Olga Popova, Carnegie Mellon University

This study focuses on the geologic CO₂ sequestration resource in deep saline-filled formations because this class of repositories is believed to make up the bulk of the sequestration resource. The goals of this research are (1) to better understand the sources of uncertainty in deep saline-filled formation (DSF) resource estimates by developing a sequestration resource model and (2) using this model to probabilistically quantify the sequestration resource for the Pennsylvania part of the Appalachian sedimentary basin. The geologic framework of the model is based on data provided by the Bureau of Topographic & Geologic Survey of the Pennsylvania State Department of Conservation and Natural Resources (DCNR). The results of statistical studies of reservoir and structural properties of the Oriskany sandstone suggest the best fit distribution for average formation depth. Regression models developed here allow prediction of (1) porosity as a function of depth and (2) formation temperature and pressure as functions of depth. The equation of state developed by Span and Wagner is used for calculation of density as a function of temperature and pressure. Storage resource estimates are developed using Monte Carlo simulations. Four parameters are treated as uncertain: average formation depth and regression model parameter estimates for porosity, pressure, and temperature. The results of the simulation for storage resource show that there is a large variation in storage resource estimates and that a point estimate using mean values of input parameters does not result in the same capacity as the mean of the simulated storage resource distribution. Results suggest that depending on scenario we can store in the Oriskany formation 0.2 (Less storage scenario, which assumes an efficiency factor (E) of 1%), 0.4 (Typical storage scenario, E=2%), or 0.8 Gt of CO₂ (More storage scenario, E=4%) respectively. Sensitivity analysis indicates that the two parameters that contribute the most to the uncertainty in estimates are porosity and temperature. The majority of the uncertainty of the model results derives from the heterogeneity of reservoir properties. This suggests the importance of further research into rock properties to understand these parameters better.

ABSTRACT***Risk Perception for Natural Disasters: The Gap Between What Scientists Say, and What the Public Hears***

Katherine Thompson, Columbia University

The Working Group on California Earthquake Probabilities (WGCEP) includes, in its introduction to earthquake rupture forecast maps, the assertion that "In daily living, people are used to making decisions based on probabilities—from the flip of a coin (50% probability of heads) to weather forecasts (such as a 30% chance of rain) to the annual chance of being killed by lightning (about 0.0003%)." [3] However, psychology research identifies a large gap between lay and expert perception of risk for various hazards [2], and cognitive psychologists have shown in numerous studies [1,4-6] that people neglect, distort, misjudge, or misuse probabilities, even when given strong guidelines about the meaning of numerical or verbally stated probabilities [7]. The gap between lay and expert use of probability could be recognized more clearly by the WGCEP and other scientific bodies that communicate information to the public.

When presented with earthquake hazard information in graphical map form, laypeople produce a much more varied and inaccurate estimate of earthquake probability than do earth scientists. Even when hazard maps present an explicit probability for specified earthquake events, people tend to underestimate that risk. Their error is partially mediated by their past experience with and level of knowledge about earthquakes, but even well-informed subjects showed high variance in their judgments. This persistent misinterpretation of hazard information, when coupled with the existing research on the ways people distort probabilities even when they have calculated them accurately, has important implications for scientists seeking to distribute information to the public. I discuss these implications, both in the specific context of the WGCEP's laudable attempts to help people prepare themselves and their communities for seismic hazards, and in the broader realm of science communication.

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[2] Fischhoff, B, Slovic, P, Lichtenstein, S, Read, S & Combs, B (1978). How safe is safe enough? A psychometric study of attitudes towards technological risks and benefits. *Pol Sci*, 9, 127-152.

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[4] Hau, R, Pleskac, TJ, Kiefer, J & Hertwig, R (2008). The Description–Experience Gap in Risky Choice: The Role of Sample Size and Experienced Probabilities. *J Behav Decis Making*, 21:493-518.

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[6] Hertwig, R, Barron, G, Weber, EU & Erev, I (2006). The role of information sampling in risky choice. In K Fiedler & P Juslin (Eds), *Information sampling and adaptive cognition*. Pp 75–91. New York: Cambridge University Press.

[7] Budescu, DV, Broomell, S & Por HH (2009). Improving communication of uncertainty in thereports of the intergovernmental panel on climate change. *Psychol Sci*, 20(3), 299-308.

ABSTRACT***Planning Through Complexity: Employing Scenario Analysis to Facilitate Climate Change Adaptation and Security Policy*****Mark Read**, Penn State University

Planning effective climate change adaptation policy is complicated by a wide range of social and environmental factors, as well as high levels of uncertainty. Scenario analysis, a method used extensively by the business community and gaining recognition by the policy and research communities, is well suited to studying plausible futures in complex problems that are highly uncertain and uncontrollable, including challenges associated with national and international security policy. By bringing together interdisciplinary groups of experts and stakeholders, scenarios can be used to examine policy impacts, identify areas for future research, and anticipate the effects of different surprises. Scenarios may be qualitative (e.g., narratives or storylines), quantitative (e.g., models), or both. Additionally, scenarios may be developed for any temporal, spatial, or institutional level, but relatively few attempts have been made to build multilevel scenarios. This paper outlines recent developments in socio-environmental scenario analysis, exploring two major threads--an inquiry-driven thread that caters to the research community, and a strategy-driven thread that caters to the policy community--as well as attempts to combine these two threads. Next, the paper examines attempts to and challenges associated with creating multiscale and multilevel scenarios, and scenarios that incorporate surprise. Finally, the paper proposes a scenario analysis framework that might be used to focus research or develop policy related to climate change adaptation and national or international security, including advantages and limitations of such an approach.

ABSTRACT***Managing Misbehavior in Cyberspace: An Application-Level Approach to Creating Costly Virtual Identities*****Josephine Wolff**, MIT

Every Internet application is host to a variety of ill-mannered and misbehaving users. E-mail is plagued by spammers who send out unsolicited advertisements, malware, or phishing messages; online gaming applications are home to numerous "griefers" who seek explicitly to ruin the gaming experience of other players by sabotaging team members or otherwise disrupting the environment; Facebook has been host to several harassment cases and cyber-bullying attacks in recent years; and online communities like SecondLife and LambdaMOO have seen countless instances of virtual harassment and attack, dating back to the infamous 1993 cyber rape in LambdaMOO. My current research focuses on methods for managing these (and other) types of misbehavior at the application-level and formulating specific recommendations for application designers to permit for more effective, realistic approaches to regulating and reducing bad behavior in cyberspace than tackling it on a larger scale of the Internet as a whole. In particular, dealing with various types of bad behavior in cyberspace requires a means of moderating people's virtual interactions and, in turn, their virtual identities within each of these applications.

The early part of my research focused on identifying different types of applications that require different modes of managing misbehavior, ranging from allowing end-users complete control over their application experience, to engaging the involvement of an all-powerful moderator who alone has the authority to punish or remove individual users. Most online applications fall somewhere on the spectrum between individual end-user empowerment and centralized authority or control from a moderator or master programmer. Applications centered on bilateral relationships (like e-mail and Facebook) tend to rely more heavily on end-user control, while community-based applications (like World of Warcraft and Second Life) are more likely to emphasize the role of centralized authority and application moderators. However, all of these applications suffer from the same weakness of online identities: it is incredibly easy, and in most cases costless, to create new ones. Thus, blocking or deleting an account — the last line of defense for end-users or moderators wishing to moderate online misbehavior — is a largely useless exercise. Blacklist a spam address and the spammer will likely just create a new one; delete a griefer's World of Warcraft account or Second Life avatar and that same user can be back, wreaking havoc with a new identity in minutes. The only way to achieve effective and sustainable models of managing and mitigating bad behavior in online applications is to associate some cost — either an investment of money or time — with the creation of new virtual identities for these applications.

While some online applications do charge their users joining fees, many remain entirely free, and given the democratic ethos surrounding much of the Internet rhetoric, as well as the obvious advantages of attracting large user groups by removing all entry fees, it may also be instructive to consider the possibility of investing identities with costs paid in time, rather than money. Two simple models for time-investment costs are requiring new users to wait through an "initiation period" of some duration before allowing them full access to all the privileges of their accounts, and publishing public "reputation data" about every account to allow other users to assess the value and trustworthiness of a given identity. As with the fee model, both the initiation and reputation cost models favor richer users, who will be more able to pay other people to create new identities for them and invest the time needed to wait through the initiation period or build up positive reputations. However, unlike the fee model, poorer users will still have access to applications that rely on time investment costs, and so long as they do not wish to behave in ways that would result in their accounts being terminated, they would be at no great disadvantage. Currently, my research is focused on different ways of implementing these models and evaluating their pros and cons as a means for managing misbehavior in cyberspace. None of these mechanisms provides a perfect "silver bullet" solution for solving the problems of identity facing online application developers and moderators. Each, in their way, leaves the door open for some forms of misbehavior, especially on the part of richer users who can afford to spend more money creating new identities and building up their reputations (in some cases, simply by paying other people to build these identities for them). However, imposing even small costs on virtual identities could play an important role in mitigating the amount of malicious behavior in online applications.

ABSTRACT

Why We Need Standards for Breaking the Smart Grid

Stephen McLaughlin, Penn State University

Numerous standards are being established for the construction of smart electric grids that are secured against cyber-attacks. While good design principals are essential for a secure system, history has shown that even the best designs ultimately fail under vulnerability analysis. Yet, there are currently no standards for analyzing smart grids for security vulnerabilities. In this talk, we describe one possible route for standardizing the vulnerability analysis of smart grid

infrastructure based on two years of experiences in penetration testing smart metering equipment from multiple vendors. Through the use of archetypal attack trees, it is possible to both form a generic vulnerability analysis plan, and to accumulate the knowledge of expert penetration testers. We explain how attack trees were used to capture and instantiate attacks leading to energy theft and targeted disconnect, and make the case that standards bodies should strive towards codifying vulnerability analysis using similar methods.

SESSION 4: Energy and Markets

Monday, June 27, 2011 – 3:30 p.m.

SESSION CHAIR: Anastasia Shcherbakova, Assistant Professor of Energy Economics, Risk, and Policy

ABSTRACT

Competitive Markets and Investment in New Generating Capacity – Evidence from the U.S. Nuclear Energy Industry

Chen –Hao Tsai, Penn State University During 1991 to 2010, U.S. Nuclear Regulatory

Commission had approved 121 power uprate applications from 104 commercial power reactors in United States. These power uprates added around 5,300 MW generation capacities to existing nuclear power plants, which was equivalent to five new units. U.S. NRC also expects another 1,800 MW of power uprate applications in the next five years.

During the same period, the electricity industry in U.S. had been gradually deregulated, and ownership of nuclear power plants had been transferred from vertically-integrated utilities to unregulated merchant generators through company restructure, merger or transaction. So far about half of nuclear power reactors are now owned by merchant generators and are being marketed in competitive wholesale electricity markets. And the rest nuclear power reactors remain being owned by regulated investor-owned utilities and municipal or federal power agencies.

The purpose of this paper is to exam whether the merchant generators are responsive to unregulated wholesale market and investing more in new generation capacity from the empirical analysis of power uprate investments in U.S. nuclear industry. Using a panel dataset consisting of the full power uprate applications of 104 nuclear power reactors from 1991 to 2010, I find that unregulated merchant generators in general were more likely to invest in nuclear power uprate than regulated utilities. Specifically, merchant generators were investing more in "Measurement Uncertainty Recapture" and "Extended" type of power uprate, but there was no significant difference of investing in "Stretch" type of power uprate. Further cost benefit analysis is necessary to identify the difference of investment strategies between three types of nuclear power uprate.

ABSTRACT

Energy Storage for Grid Application: Informing Future Development

Eric Hittinger, Carnegie Mellon University

Energy storage technologies are not interchangeable, due to the unique set of limitations, operations, and capabilities of each technology. And while it is obvious, for example, that decreased capital cost, increased power capability, and increased efficiency would all improve the value of an energy storage technology, it is not clear which of these is most important and

what the elasticity of substitution between them might be. This study uses engineering-economic models of several energy storage technologies and examines their cost-effectiveness for different realistic applications. By performing an extended sensitivity analysis on the storage properties for each combination of application and storage type, we determine which properties are the most limiting and therefore the most valuable to improve, and calculate the elasticity of substitution between storage properties. These results can inform all entities involved in the improvement of energy storage, including manufacturers, research funding entities, and organizations that set technology targets.

ABSTRACT

Innovating for Emerging Markets—The Case of Rural Electrification

Parth Vaishnav, University of Cambridge

This research consists of a detailed survey of business models that deliver off-grid power to rural, low-income populations in developing countries.

Globally, over 1.5 billion people do not have access to electricity. It is unlikely that the electric grid will be extended to these populations in the near future. The threat of climate change makes it imperative that developing nations put in place an energy system that is greener than the one that the developed world is trying to replace.

Governments have recognized this challenge, and are also cognizant of the role of modern energy in enabling socio-economic welfare. In many cases, they have encouraged business to deploy innovative solutions to give the rural poor access to power or related services (e.g., lighting). Entrepreneurs have responded by developing innovative products and business models, based on partnerships with research institutes, government, large firms and non-government organizations.

Studying a large number of such product and business model innovations could make two contributions.

First, it could contribute to a better understanding of entrepreneurship in the developing world.

Second, the need for affordable, green, decentralized generation is not limited to the developing world. Approaches that are successful there might have wider relevance. For instance, in a recent lecture at the Royal Academy of Engineering, Steve Holliday, the CEO of Britain's transmission system operator, said that as the UK sought to decarbonize its electricity supply, the government was "looking more to communities and individuals to take power into their hands."

In summary, the research aims to generate useful insights for policymakers and businesses, as they seek to build a sustainable energy system in a resource-constrained world.

ABSTRACT***Supply Curve Estimation in Transmission-Constrained Electricity Markets*****Mostafa Sahraei-Ardakani**, Penn State University

Many important policy initiatives, such as renewable fuels mandates, would directly affect the operation of electric power networks. Evaluating such policies often requires models of how the proposed policy will impact system operations. Predictive modeling of electric transmission systems, particularly in the face of transmission constraints, is difficult unless the analyst possesses a detailed network model. Further, policy analysis must often be performed under time constraints, which may prevent the use of complex engineering models.

Our motivation in this paper is to develop a method for estimating zonal supply curves in transmission-constrained electricity markets that can be implemented quickly by policy analysts with training in statistical methods (but not necessarily engineering) and with publicly-available data. We develop a nonlinear statistical model that uses fuel prices and zonal electric loads to determine piecewise supply curves, each segment of which represents the influence of a particular fuel type on the zonal electricity price. Our problem thus requires the simultaneous estimation of the slope of each supply-curve segment, as well as the thresholds that define the endpoints of each segment.

We illustrate our methodology by estimating zonal supply curves for the seventeen utility zones in the PJM system. The estimated supply curves are robust to several different model specifications. We use then our supply curves to estimate regional impacts of Pennsylvania's legislative requirement that utilities in Pennsylvania to reduce annual and peak electric load. For most utilities in Pennsylvania, successful implementation of this requirement would reduce the influence of natural gas on electricity price formation and increase the influence of coal. We also find evidence of mixed pecuniary effects on utility zones outside of Pennsylvania; the reduction of electricity demand in Pennsylvania reduces electricity prices in most other regions, but increases prices in the Virginia and Washington, D.C. areas.

ABSTRACT***District Heating in Canada and Denmark, historical Evolution and Funding Opportunities*****Hossein Safaei Mohamadabadi**, University of Calgary

District Heating technology is more than a century old with a wide spectrum of penetration in the heating market of various countries. Currently, over 60% of the residential heated floor-area in Denmark is supplied by District Heating while this figure was 30% in late 1970s. In contrast, District Heating has seen a very slow growth in Canada and currently only provides heating to less than 2% of the total (commercial, residential, industrial, and institutional) heated floor-area. This paper focuses on the historical evolution of district heating in Denmark and Canada. Dissimilar levels of government's control over the energy market, heat and electricity generation mix, and type and availability of local energy resources are highlighted as the main drivers for such a vast different market shares of District Heating in these two countries. Finally, Canada's opportunities to effectively promote District Heating as an energy conservation and GHG reduction tool are discussed based on the successful Danish experience.

SESSION 5: Innovation and Technological Evaluation

Tuesday, June 28, 2011 – 8:30 a.m.

SESSION CHAIR: Zhen Lei, Assistant Professor of Energy and Environmental Economics

ABSTRACT

Beyond Benchmarking: The Search for Success in the Information Age

Ammar Anees Malik, George Mason University

As governments navigate the rapidly changing territory of the information age, policy makers search for signposts to guide the way to the design and implementation of “successful” information and communication technology policies. In a setting where ceaseless innovation translates into ever expanding possibilities for information and communication technologies (ICTs) and their impact on society, policymakers lack stable and objective standards by which to guide public policy, public investment and regulation. As ICTs are increasingly viewed as a key to boosting innovation and economic growth, the demands of global economic competitiveness have raised the stakes for national policymakers to get and stay ahead. In this context, international benchmarking, which has become a widely popular and influential policymaking instrument in recent years, is often seen as an attractive source of inspiration and policy learning. The underlying principle of benchmarking - performance improvement through systematic comparison against an objective target – is deemed to be a powerful technique for shaping domestic policy when historical references are thin and experimentation can seem both risky and exceedingly costly.

Yet, despite benchmarking’s ascendancy as an instrument for policymaking, its claims as a technique for policy learning and the assumptions on which these rely are surprisingly understudied. This paper critically examines the role of international benchmarking as a source of knowledge for ICT policy and leads to three key insights. First, we argue that rather than being used as a policy learning tool, international benchmarking is more often seized upon for political motives, as rankings and peer pressure prove ready levers for agenda setting. Second, in practice there is a notable resistance on the part of policymakers to adopt the “lessons” of international comparisons often claiming “exceptionalism”, viewing themselves as better teachers than students, and thus undermining the potential effectiveness of such an approach. Finally, an overemphasis on benchmarking and best practices can gloss over important contextual factors and crowd out other equally valuable streams of policy learning, such as local experimentation and learning from failure. We conclude that findings from robust international benchmarking can indeed be useful sources of inspiration for governments that can guide policy when differences in policy settings are carefully accounted for. However, benchmarks should serve as only one of many sources of policy learning. Yet, in practice the political attractiveness of benchmarking’s rankings may easily overshadow the complexity of detailed policy learning techniques.

ABSTRACT***The Geography of Biomanufacturing: Dynamics, Drivers and Implications for a Globalizing Industry*****Rachna Pande, MIT**

While the top locations in the world in terms of biomanufacturing capacity have been in the U.S. and Europe, there are changes afoot as the industry becomes more global and overcapacity leads companies to rethink their facility needs. The complexity of bioprocessing has traditionally kept it close to company R&D centers. But increased standardization, new technology and aggressive public policy are creating greater flexibility and options for companies as they decide where to manufacture their products from pilot through the commercial phase. Using quantitative data as well as qualitative inputs from the industry, this poster will examine what drives the geography of both mammalian-based and microbial biomanufacturing, how changes within and outside the industry are altering its geographic footprint, and what the implications are for the growth of the industry.

ABSTRACT***Measuring the Impacts of a Federal Workforce Development Program on Science and Technology Industries in Regions: A Quantitative Approach*****Yu Jin Jung, George Mason University**

The U.S. federal government has made a significant endeavor for job creation and workforce development in regions, assuming that creating jobs and nurturing high skilled workers is a key for regional competitiveness. Scholars and policy makers in the S&T fields as well as regional sciences become more concerned with such federal effort, as it can be an effective way to achieve regional growth and S&T personnel development concurrently. A federal program named WIRED (Workforce Innovation in Regional Economic Development) is a representative example showing the federal attempt to connect the various efforts for workforce development and economic development effectively. Despite the growing concern for the type of programs such as WIRED, less concerns are given to examining the changes and effects caused by WIRED empirically. Recognizing the importance of WIRED in the S&T policy context, this paper attempts to measure the impacts of the WIRED program on selected science and technology industries in regions from a quantitative point of view. For the purpose of the paper, literature on federal workforce development efforts and their evaluation results is reviewed while the reason these federal efforts become more importance in the S&T fields is also examined. Panel data analysis for the WIRED impact assessment is then conducted. The findings of the paper will provide a better picture on what types of impacts are caused by the WIRED program. The analysis results of the paper will also encourage scholars and policy makers in the S&T fields to explore more diverse ways for S&T labor force development as a critical asset for regions as well as for the entire country.

ABSTRACT***Analysis of System Architectures for Scientific and National Security Satellite Programs*****Matthew Daniels, Stanford University**

The role of decision theory in engineering design is increasingly seen as a means to focus on total program lifecycle value during the development of new satellite systems. This study considers the operation and management of a 'fractionated' satellite constellation, whereby spacecraft functionality is distributed across multiple wirelessly-interacting spacecraft modules operating together in orbit. A fractionated mission architecture provides potentially lower resource requirements to evolve a system in response to subsystem failure, changing user needs, or new available technologies. In theory, this design flexibility can provide additional value under certain mission regimes and stakeholder preferences. I present an overview of decision- and risk-analytic methodologies to identify system attributes associated with design flexibility, and quantify when these attributes have realizable benefits for government-operated space systems. The goal is to inform more effective systems-level risk management of national security and scientific space missions, and to inform decisions that affect R&D investment in future capabilities.

ABSTRACT***Using Prediction to Improve Patient Flow in a Health Care Delivery Chain*****Jordan Peck, MIT**

Often, in a health care delivery chain, lack of coordination has been detrimental to timely, high quality care. In 2001 the Institute of Medicine (IOM), published *Crossing the Quality Chasm*, which “formulated new rules to redesign and improve care.” One of these rules was increased anticipation of patient needs. This anticipation of needs can be used to improve coordination across a care delivery chain. However there are technical and managerial hurdles associated with making this generalized policy a reality.

This presentation focuses on two steps of the hospital health care delivery chain, an emergency department and a hospital’s inpatient units. In agreement with the IOM report, past research into this chain has suggested that early prediction of patient need for admission can be used to better align flow between the two departments. This chain and the nature of prediction in health care delivery are discussed as well as a how prediction may be useful in this context. Finally tools for making admission predictions are tested and their possible implications are explored. The results of this exploration show that both expert opinion and a Naïve Bayesian statistical approach have predictive value in this context.

SESSION 6: Energy, Environment and Decision-Making (Part 2)

Tuesday, June 28, 2011 – 10:15 a.m.

SESSION CHAIR: Seth Blumsack, Assistant Professor of Energy Policy Economics

ABSTRACT

Influences of Greenhouse Gas Emission Timing on U.S. Biofuel Development Policies

Stefan Schwietzke, Carnegie Mellon University

Land use change (LUC) induced greenhouse gas (GHG) emissions appear to be the largest single contributor to life cycle GHG emissions from some biofuels including corn ethanol. These emissions occur over a short period at the beginning of the life cycle. The atmospheric lifetime of some GHG emissions may span a century or more. Thus, the early LUC emissions may cause a greater amount of cumulative radiative forcing (CRF) over the next decades than the remaining life cycle emissions. However, traditional biofuel performance metrics used by policy makers, e.g., the GHG balance, mask the timing effect by averaging total emissions over the biofuel lifetime. Some estimate that the corn ethanol GHG balance underestimates RF impacts by 10-90% due to emissions timing, thereby whitewashing the effectiveness of biofuel development policies.

I estimate CRF from corn ethanol and gasoline based on an IPCC climate model, literature GHG inventories, and actual fuel volumes over different time frames. Impacts are simulated separately for traditional greenhouse gas accounting (GHGA), i.e., annualizing all life cycle emissions including LUC over the functional unit, and for an actual emissions time profile. An emissions timing factor (ETF), i.e., the CRF difference between both simulations, is used to quantify the masking effect of the GHG balance.

Over 100 and 50 years of impacts, the base case ETF is only 2-5% for corn ethanol, which is much lower than the earlier analyses. The LUC uncertainty itself is one to two orders of magnitude higher, which dwarfs the timing effect. From a GHGA perspective, emissions timing adds little to our understanding of the climate impacts of biofuels. However, policy makers should recognize that ETF would decrease the chance of corn ethanol meeting the 20% GHG reduction target in the Energy Independence and Security Act of 2007. While absolute RF from U.S. corn ethanol is low, adoption of full-scale emissions reductions through carbon capture and sequestration or natural gas production from shale formations may entail much more significant timing implications for climate change mitigation policy.

ABSTRACT

Effect of Outdoor Temperature, Heat Primes and Attribute Substitution of Belief Global Warming

Lisa Zaval, Columbia University

Although people are quite aware of global warming, their beliefs about it may be malleable; specifically, their beliefs may be constructed in response to questions about global warming. Beliefs may reflect irrelevant but salient information, such as the current day's temperature.

This replacement of a more complex, less easily accessed judgment with a simple, more accessible one is known as attribute substitution. In three studies, we asked residents of the United States and Australia to report their opinions about global warming and whether the temperature on the day of the study was warmer or cooler than usual. Respondents who thought that day was warmer than usual believed more in and had greater concern about global warming than did respondents who thought that day was colder than usual. They also donated more money to a global-warming charity if they thought that day seemed warmer than usual. Exploratory follow-up work, including studies of priming effects, has been conducted to examine the extent to which the results of this study are generalizable or transferable.

ABSTRACT

A Meta-Analysis of Gasoline and Diesel Powered Vehicle Emissions

Graeme Marshman, University of Calgary

Vehicular emissions, such as CO₂, are affected by numerous factors including speed, temperature (ambient and engine), fuel type, engine type, maintenance, gross vehicle weight and driving behaviour. Substantial efforts from fuel suppliers, automobile manufacturers, energy companies, government agencies, policy makers, and academia have allowed for comparative studies of environmental benefits and drawbacks of fuel types and vehicle propulsion systems. However, the results from these studies and models are often not directly comparable due to different evaluation methods and assumptions. In this meta-analysis, the factors affecting vehicular emissions are investigated for the two most common transportation fuels worldwide; gasoline and diesel. This study uses statistical methods to evaluate the contributions of each of the factors (listed above) on emissions including CO₂, CO, NO_x, SO₂ and particulate matter. The vehicular emissions (otherwise known as tank-to-wheel emissions) are then added to well-to-tank emissions results from a life cycle assessment tool developed for oil sands technology at the University of Calgary and University of Toronto. This analysis will help to inform industry and government in decision making and policy setting by providing more accurate and transparent tank-to-wheel emission estimates for use in well-to-wheel life cycle assessment models.

ABSTRACT

Techno-Economic Analysis of Lithium-Ion Batteries for Personal Vehicle Electrification

Apurba Sakti, Carnegie Mellon University

Better design and integration of lithium-ion batteries can help lower costs of plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs). The form factor of the electrode is an important design variable that directly relates to the usable power density of the cell and also affects the cost. This work examines the technical and economic effects of varying the electrode thicknesses of lithium-ion batteries for different electrified vehicles (PHEVs of varying all-electric-range and BEVs) based on their power and energy requirements. The Battery Design Studio[®] simulation package is used to model the performance and cost of a representative set of battery cells, which are then used to generate a flexible and realistic meta-model, which can then be used as a tool to inform battery/vehicle system design. The model, currently accounts only for the cell-level materials cost, and only the key battery cell parameter, electrode thickness and the length of the electrode have been varied in a controlled fashion. This work is a first step towards assessing techno-economic aspects of battery design in vehicle systems. Results are expected to help inform policy makers as they look to incentivize electrified vehicles.

ABSTRACT***Evaluating Wind Following and Ecosystem Services for Hydroelectric Dams*****Alisha Fernandez, Penn State University**

Hydropower can provide inexpensive, flexible fill-in power to compensate for intermittent renewable generation. Policies for hydropower dams maintain multiple services beyond electric generation, including environmental protection, flood control and recreation. We model the decision of a hydroelectric generator to shift some of its power production capacity away from the day-ahead energy market into a “wind-following” service that smoothes the intermittent production of wind turbines. Offering such a service imposes both private and social opportunity costs. Since fluctuations in wind energy output are not perfectly correlated with day-ahead energy prices, a wind-following service will necessarily affect generator revenues. Seasonal wind patterns produce conflicts with the goal of managing rivers for “ecosystem services” – the maintenance or enhancement of downstream ecosystems. We illustrate our decision model using the Kerr Dam in PJM’s territory in North Carolina. We simulate the operation of Kerr Dam over a three-year period that features hydrologic variability from normal water years to extreme drought conditions. We use an optimization framework to estimate reservation prices for Kerr Dam offering wind-following services in the PJM market. Wind-following may be profitable for Kerr Dam at low capacity levels during some time periods if ecosystems services are neglected and if side payments, or reserves-type payments, are provided. Wind-following with ecosystem services yields revenue losses that typically cannot be recovered with reserves market payments. Water release patterns are inconsistent with ecosystem-services goals when Kerr Dam dedicates significant capacity to wind-following, particularly in drought years.