The Past and the Future:
Where CEDM has been and where its going

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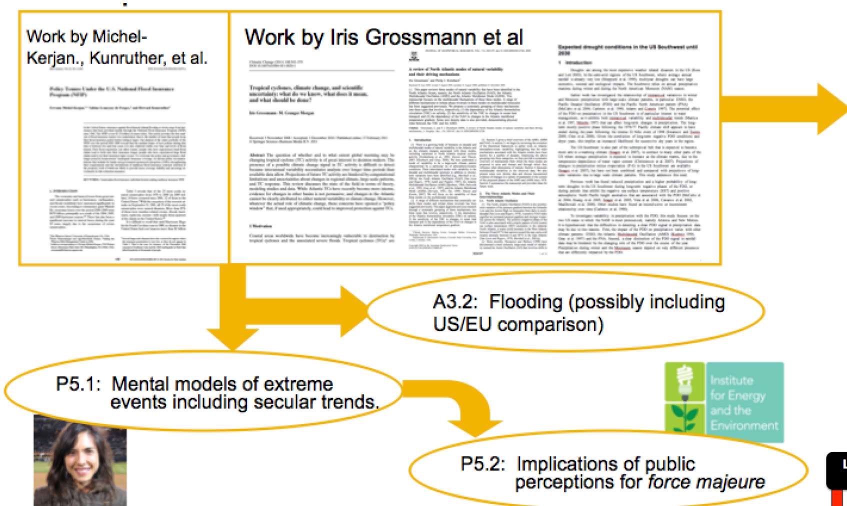
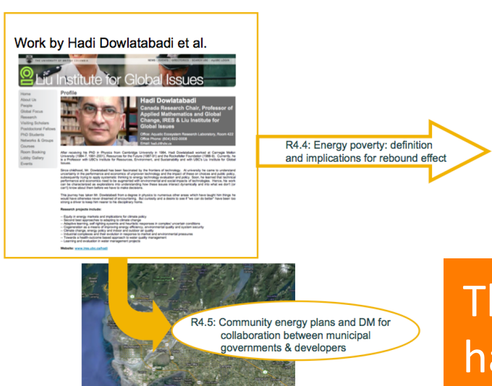
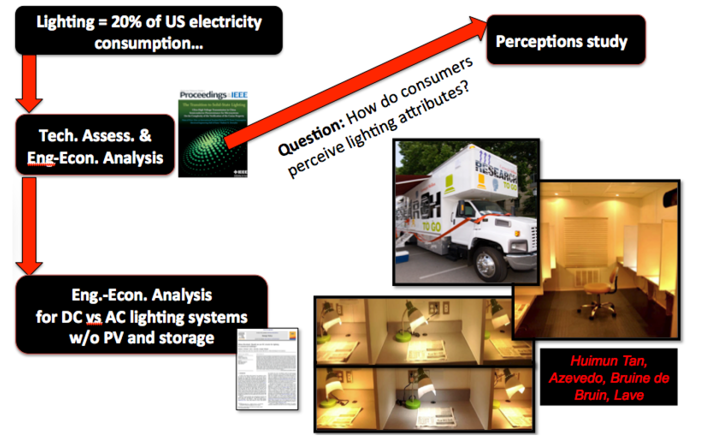
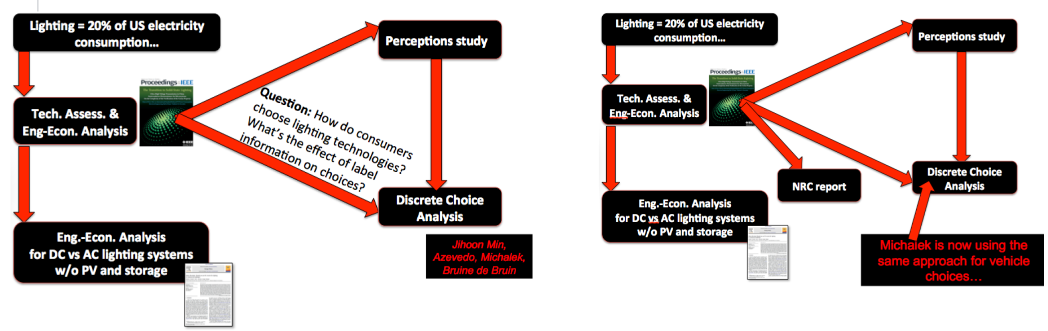
In the past at these meetings…

We've typically started with a set of "wiring diagrams" to show how the various things we have been working on fit together and build on each other.









This year I am going to do something a bit different. In the first half of my talk, I will present a few highlights from the past five years. Then I will talk about plans for the coming five years.

CEDM has been remarkably productive

Over the past five years we have:

- Graduated 38 PhDs
- Published over 200 papers
- Run 7 Theory & Methods workshops
- Held 60 invited seminars
- Developed and disseminated a variety of tools for decision support
- Provided briefings to many stakeholders, and
- Conducted numerous educational and outreach activities for policymakers, the public, and middle-school teachers and students.

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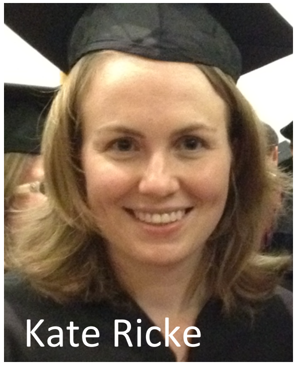
- Conducted numerous educational and outreach activities for policymakers, the public, and middle-school teachers and students.

I will say a few words about just seven.

Example 1

Policy and climate science studies of Albedo modification



FOREIGN AFFAIRS

The Geoengineering Option

A Last Resort Against Global Warming?

David G. Victor, M. Granger Morgan, Jay Apt, John Steinbruner, and Katharine Ricke

EACH YEAR, the effects of climate change are coming into sharper focus. Barely a month goes by without some fresh bad news: ice sheets and glaciers are melting faster than expected, sea levels are rising more rapidly than ever in recorded history, plants are blooming earlier in the spring, water supplies and habitats are in danger, birds are being forced to find new migratory patterns.

The odds that the global climate will reach a dangerous tipping point are increasing. Over the course of the twenty-first century, key ocean currents, such as the Gulf Stream, could shift radically, and thawing permafrost could release huge amounts of additional greenhouse gases into the atmosphere. Such scenarios, although still remote, would dramatically accelerate and compound the consequences of global warming. Scientists are taking these doomsday scenarios seriously because the steady accumulation of warming gases in the atmosphere

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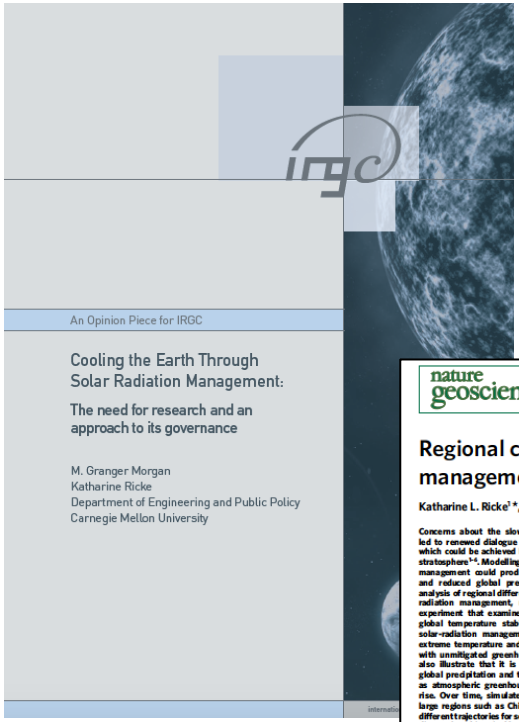
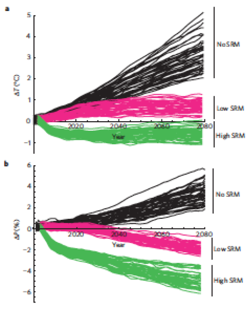


nature climate change LETTERS
PUBLISHED ONLINE: 18 DECEMBER 2011 | DOI: 10.1038/NCLIMATE1328

Effectiveness of stratospheric solar-radiation management as a function of climate sensitivity

Katharine L. Ricke[1]*†, Daniel J. Rowlands[2], William J. Ingram[2,3], David W. Keith[4†] and M. Granger Morgan[1]



nature geoscience LETTERS
PUBLISHED ONLINE: 18 JULY 2010 | DOI: 10.1038/NGEO915

Regional climate response to solar-radiation management

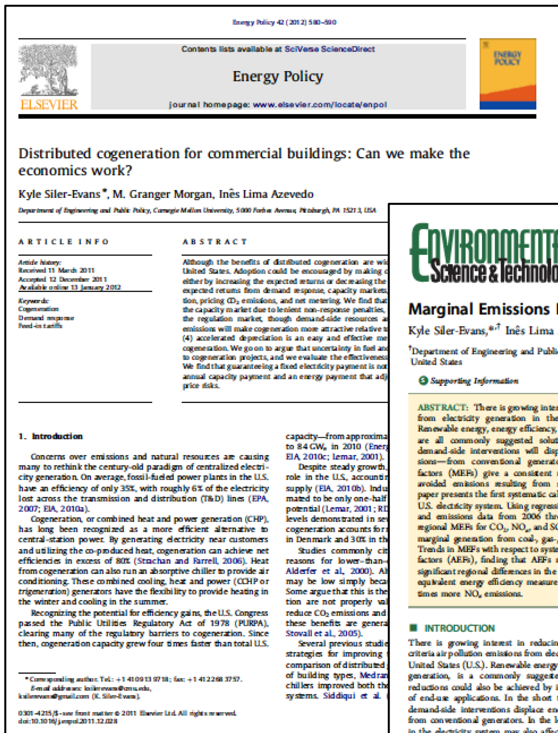
Katharine L. Ricke[1]*, M. Granger Morgan[1] and Myles R. Allen[2]

Concerns about the slow pace of climate mitigation have led to renewed dialogue about solar-radiation management, which could be achieved by adding reflecting aerosols to the stratosphere. Modelling studies suggest that solar-radiation management could produce stabilized global temperatures and reduced global precipitation. Here we present an analysis of regional differences in a climate modified by solar-radiation management, using a large-ensemble modelling experiment that examines the impacts of 54 scenarios for global temperature stabilization. Our results confirm that solar-radiation management would generally lead to less extreme temperature and precipitation anomalies, compared with unmitigated greenhouse gas emissions. However, they also illustrate that it is physically not feasible to stabilize global precipitation and temperature simultaneously as long as atmospheric greenhouse gas concentrations continue to rise. Over time, simulated temperature and precipitation in large regions such as China and India vary significantly with different trajectories for solar-radiation management, and they diverge from historical baselines in different directions. Hence, it may not be possible to stabilize the climate in all regions simultaneously using solar-radiation management. Regional diversity in the response to different levels of solar-radiation management could make consensus about the optimal level of geoengineering difficult, if not impossible, to achieve.

Example 2

Assessments of energy efficiency, renewable energy, and small-scale cogeneration

Kyle Siler-Evans addressed DG, emissions from generation and location of solar and wind.


Energy Policy 42 (2012) 580–590

Contents lists available at SciVerse ScienceDirect

Energy Policy

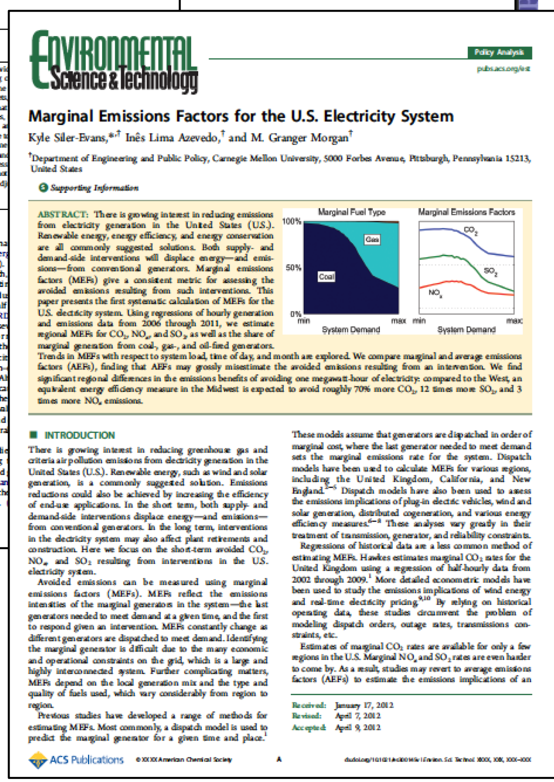
journal homepage: www.elsevier.com/locate/enpol

Distributed cogeneration for commercial buildings: Can we make the economics work?

Kyle Siler-Evans*, M. Granger Morgan, Inês Lima Azevedo


Regional variations in the health, environmental, and climate benefits of wind and solar generation

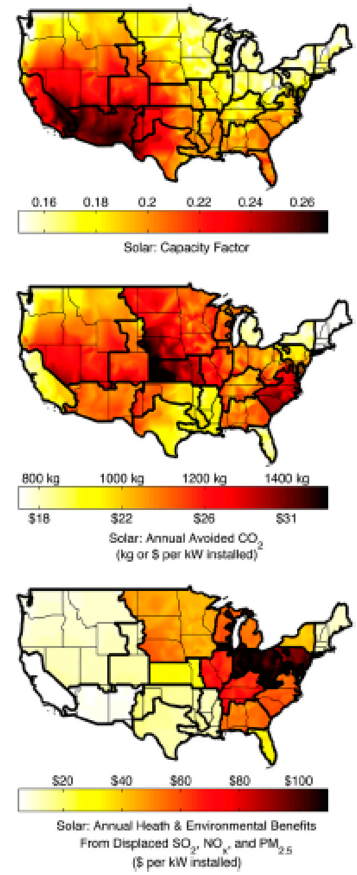
Kyle Siler-Evans, Inês Lima Azevedo, M. Granger Morgan, and Jay Apt


Environmental Science & Technology

Policy Analysis

Marginal Emissions Factors for the U.S. Electricity System

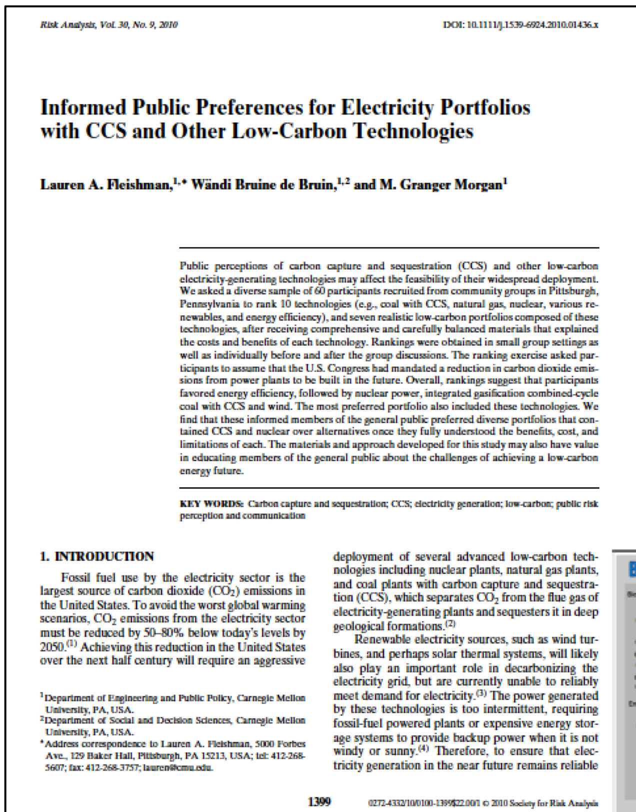
Kyle Siler-Evans, Inês Lima Azevedo, and M. Granger Morgan



Example 3

Public preferences for portfolios of low-carbon generation

Lauren Fleishman Mayer explored public preferences for portfolios of low carbon electricity generation.


Risk Analysis, Vol. 30, No. 9, 2010 DOI: 10.1111/j.1539-6924.2010.01436.x

Informed Public Preferences for Electricity Portfolios with CCS and Other Low-Carbon Technologies

Lauren A. Fleishman,[1,*] Wändi Bruine de Bruin,[1,2] and M. Granger Morgan[1]

Public perceptions of carbon capture and sequestration (CCS) and other low-carbon electricity-generating technologies may affect the feasibility of their widespread deployment. We asked a diverse sample of 60 participants recruited from community groups in Pittsburgh, Pennsylvania to rank 10 technologies (e.g., coal with CCS, natural gas, nuclear, various renewables, and energy efficiency), and seven realistic low-carbon portfolios composed of these technologies, after receiving comprehensive and carefully balanced materials that explained the costs and benefits of each technology. Rankings were obtained in small group settings as well as individually before and after the group discussions. The ranking exercise asked participants to assume that the U.S. Congress had mandated a reduction in carbon dioxide emissions from power plants to be built in the future. Overall, rankings suggest that participants favored energy efficiency, followed by nuclear power, integrated gasification combined-cycle coal with CCS and wind. The most preferred portfolio also included these technologies. We find that these informed members of the general public preferred diverse portfolios that contained CCS and nuclear over alternatives once they fully understood the benefits, cost, and limitations of each. The materials and approach developed for this study may also have value in educating members of the general public about the challenges of achieving a low-carbon energy future.

KEY WORDS: Carbon capture and sequestration; CCS; electricity generation; low-carbon; public risk perception and communication

1. INTRODUCTION

Fossil fuel use by the electricity sector is the largest source of carbon dioxide (CO_2) emissions in the United States. To avoid the worst global warming scenarios, CO_2 emissions from the electricity sector must be reduced by 50–80% below today's levels by 2050.[1] Achieving this reduction in the United States over the next half century will require an aggressive deployment of several advanced low-carbon technologies including nuclear power plants, natural gas plants, and coal plants with carbon capture and sequestration (CCS), which separates CO_2 from the flue gas of electricity-generating plants and sequesters it in deep geological formations.[2]

Renewable electricity sources, such as wind turbines, and perhaps solar thermal systems, will likely also play an important role in decarbonizing the electricity grid, but are currently unable to reliably meet demand for electricity.[3] The power generated by these technologies is too intermittent, requiring fossil-fuel powered plants or expensive energy storage systems to provide backup power when it is not windy or sunny.[4] Therefore, to ensure that electricity generation in the near future remains reliable

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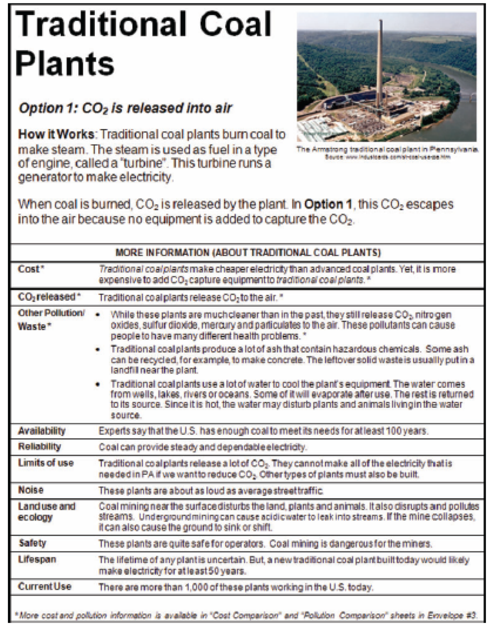


Traditional Coal Plants

Option 1: CO_2 is released into air

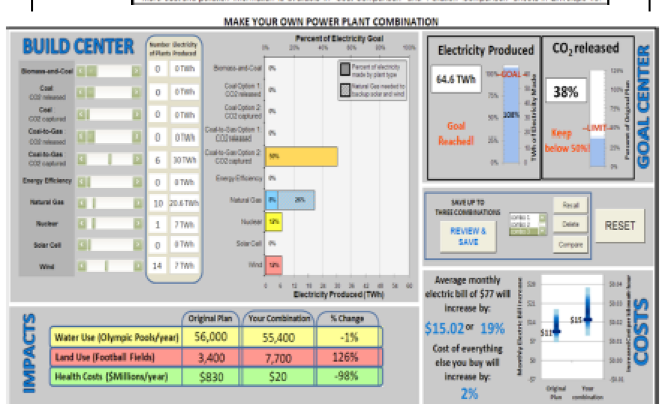
The Armstrong traditional coal plant in Pennsylvania.

How it Works: Traditional coal plants burn coal to make steam. The steam is used as fuel in a type of engine, called a "turbine". This turbine runs a generator to make electricity.

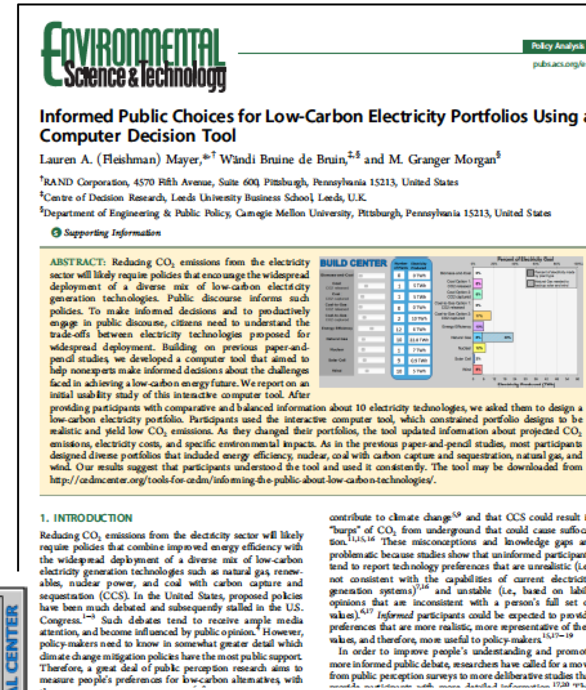
When coal is burned, CO_2 is released by the plant. In **Option 1**, this CO_2 escapes into the air because no equipment is added to capture the CO_2.

MORE INFORMATION (ABOUT TRADITIONAL COAL PLANTS)	
Cost*	*Traditional coal plants* make cheaper electricity than advanced coal plants. Yet, it is more expensive to add CO_2 capture equipment to *traditional coal plants*.*
CO_2 released*	Traditional coal plants release CO_2 to the air.*
Other Pollution/ Waste*	• While these plants are much cleaner than in the past, they still release CO_2, nitrogen oxides, sulfur dioxide, mercury and particulates to the air. These pollutants can cause people to have many different health problems.* • Traditional coal plants produce a lot of ash that contain hazardous chemicals. Some ash can be recycled, for example, to make concrete. The leftover solid waste is usually put in a landfill near the plant. • Traditional coal plants use a lot of water to cool the plant's equipment. The water comes from wells, lakes, rivers or oceans. Some of it will evaporate after use. The rest is returned to its source. Since it is hot, the water may disturb plants and animals living in the water source.
Availability	Experts say that the U.S. has enough coal to meet its needs for at least 100 years.
Reliability	Coal can provide steady and dependable electricity.
Limits of use	Traditional coal plants release a lot of CO_2. They cannot make all of the electricity that is needed in PA if we want to reduce CO_2. Other types of plants must also be built.
Noise	These plants are about as loud as average street traffic.
Land use and ecology	Coal mining near the surface disturbs the land, plants and animals. It also disrupts and pollutes streams. Underground mining can cause acidic water to leak into streams. If the mine collapses, it can also cause the ground to sink or shift.
Safety	These plants are quite safe for operators. Coal mining is dangerous for the miners.
Lifespan	The lifetime of any plant is uncertain. But, a new traditional coal plant built today would likely make electricity for at least 50 years.
Current Use	There are more than 1,000 of these plants working in the U.S. today.

*More cost and pollution information is available in "Cost Comparison" and "Pollution Comparison" sheets in Envelope #3.



	Original Plan	Your Combination	% Change
Water Use (Olympic Pools/year)	56,000	55,400	-1%
Land Use (Football Fields)	3,400	7,700	126%
Health Costs ($Millions/year)	$830	$20	-98%


Environmental Science & Technology — Policy Analysis — pubs.acs.org/est

Informed Public Choices for Low-Carbon Electricity Portfolios Using a Computer Decision Tool

Lauren A. (Fleishman) Mayer,[*,†] Wändi Bruine de Bruin,[‡,§] and M. Granger Morgan[§]
[†] RAND Corporation, 4570 Fifth Avenue, Suite 600, Pittsburgh, Pennsylvania 15213, United States
[‡] Centre of Decision Research, Leeds University Business School, Leeds, U.K.
[§] Department of Engineering & Public Policy, Carnegie Mellon University, Pittsburgh, Pennsylvania 15213, United States

Supporting Information

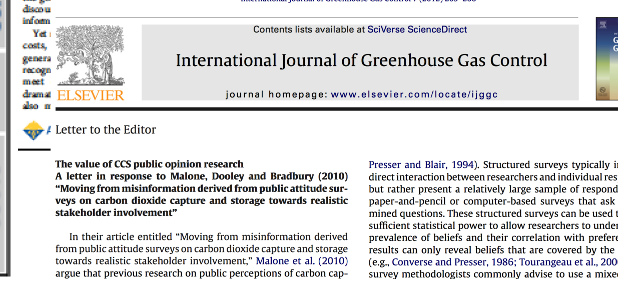
ABSTRACT: Reducing CO_2 emissions from the electricity sector will likely require policies that encourage the widespread deployment of a diverse mix of low-carbon electricity generation technologies. Public discourse informs such policies. To make informed decisions and to productively engage in public discourse, citizens need to understand the trade-offs between electricity technologies proposed for widespread deployment. Building on previous paper-and-pencil studies, we developed a computer tool that aimed to help nonexperts make informed decisions about the challenges faced in achieving a low-carbon energy future. We report on an initial usability study of this interactive computer tool. After providing participants with comparative and balanced information about 10 electricity technologies, we asked them to design a low-carbon electricity portfolio. Participants used the interactive computer tool, which constrained portfolio designs to be realistic and yield low CO_2 emissions. As they changed their portfolios, the tool updated information about projected CO_2 emissions, electricity costs, and specific environmental impacts. As in the previous paper-and-pencil studies, most participants designed diverse portfolios that included energy efficiency, nuclear, coal with carbon capture and sequestration, natural gas, and wind. Our results suggest that participants understood the tool and used it consistently. The tool may be downloaded from http://cedmcenter.org/tools-for-cedm/informing-the-public-about-low-carbon-technologies/.

1. INTRODUCTION

Reducing CO_2 emissions from the electricity sector will likely require policies that combine improved energy efficiency with the widespread deployment of a diverse mix of low-carbon electricity generation technologies such as natural gas, renewables, nuclear power, and coal with carbon capture and sequestration (CCS). In the United States, proposed policies have been much debated and subsequently stalled in the U.S. Congress. Such debates tend to receive ample media attention, and become influenced by public opinion. However, policy-makers need to know in somewhat greater detail which climate change mitigation policies have the most public support. Therefore, a great deal of public perception research aims to measure people's preferences for low-carbon alternatives, with ...

contribute to climate change and that CCS could result in "burps" of CO_2 from underground that could cause suffocation. These misconceptions and knowledge gaps are problematic because studies show that uninformed participants tend to report technology preferences that are unrealistic (i.e., not consistent with the capabilities of current electricity generation systems) and unstable (i.e., based on labile opinions that are inconsistent with a person's full set of values). *Informed* participants could be expected to provide preferences that are more realistic, more representative of their values, and therefore, more useful to policy-makers.

In order to improve people's understanding and promote more informed public debate, researchers have called for a move from public perception surveys to more deliberative studies that ...


International Journal of Greenhouse Gas Control 7 (2012) 265–266
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journal homepage: www.elsevier.com/locate/ijggc

Letter to the Editor

The value of CCS public opinion research
A letter in response to Malone, Dooley and Bradbury (2010) "Moving from misinformation derived from public attitude surveys on carbon dioxide capture and storage towards realistic stakeholder involvement"

In their article entitled "Moving from misinformation derived from public attitude surveys on carbon dioxide capture and storage towards realistic stakeholder involvement," Malone et al. (2010) argue that previous research on public perceptions of carbon cap-

Presser and Blair, 1994). Structured surveys typically i... direct interaction between researchers and individual res... but rather present a relatively large sample of respond... paper-and-pencil or computer-based surveys that ask... mined questions. These structured surveys can be used t... sufficient statistical power to allow researchers to under... prevalence of beliefs and their correlation with prefere... results can only reveal beliefs that are covered by the... (e.g., Converse and Presser, 1986; Tourangeau et al., 200... survey methodologists commonly advise to use a mixe...

Example 4

Securing electricity-dependent critical social services

Risk Analysis

DOI: 10.1111/j.1539-6924.2011.01726.x

Sustaining Critical Social Services During Extended Regional Power Blackouts

Anu Narayanan* and M. Granger Morgan

Despite continuing efforts to make the electric power system robust, some risk remains of widespread and extended power outages due to extreme weather or acts of terrorism. One way to alleviate the most serious effects of a prolonged blackout is to find local means to secure the continued provision of critical social services upon which the health and safety of society depend. This article outlines and estimates the incremental cost of a strategy that uses small distributed generation, distribution automation, and smart meters to keep a set of critical social services operational during a prolonged power outage that lasts for days or weeks and extends over hundreds of kilometers.

KEY WORDS: Critical social services; distributed generation; prolonged blackouts; smart grids

1. INTRODUCTION

Engineers have worked hard to make the electric power transmission and distribution system as reliable as possible. However, there are limits to how secure it is possible to make a system that consists of thousands of critical parts that are spread across the landscape.[1] Widespread and extended power outages can result from human error, intense geomagnetic storms,[2] extreme weather such as the 1998 ice storm in Ontario,[3] or terrorist attack.[4] The 1998 Ontario ice storm and the 2003 blackout in the Northeast left millions without power, and in the case of the former, for weeks.

Electricity supports many critical social services. When the power goes out, these services are interrupted or severely curtailed. Most of us have experience with blackouts after storms that last for just a few hours, and are relatively localized. Such blackouts are *not* the focus of this article. Here we ask

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What could be done to make critical social services
less vulnerable to low
events that cause a b
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We examine four

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2. THE MODEL SY

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0272-4332/11/0100-0

Effects of a Smart Meter Based Attack on the Stability of the Bulk Power Grid

Anu Narayanan, Eduardo Cotilla-Sanchez, Paul Hines, Granger Morgan

***Abstract*—This paper estimates the effects of a smart meter based attack on the stability of the bulk power grid using results from a PSAT simulation run on the IEEE 9 and 39 bus test networks. We address the question: What fraction of system load needs to be cycled on and off in order to notably affect system stability? We focus on a load cycling attack because the simple dropping of even entire distribution feeders (as often happens when lightning strikes) rarely causes any notable reliability problems for the bulk power grid. But a system operating at a stressed state could become unstable if a coordinated, oscillatory attack were launched on a large number of smart meters at a frequency known to be troublesome. Results indicate that it is likely infeasible for even a determined adversary to gain control of a sufficient number of meters to destabilize the bulk power grid.**

***Index Terms*—Smart grid cyber security, smart meter vulnerabilities, electric grid reliability**

that is deployed by utilities in the process of modernizing their systems [2]. Growing hand in hand with the number of deployed smart meters in the U.S. are concerns regarding the privacy and security implications of metering systems resulting from break-ins at any of the several layers of the advanced metering infrastructure[1]. Smart meter privacy concerns are not addressed in this paper. Rather, the focus here is on the security implications of smart metering systems. There have been several documented successful efforts directed at hacking smart meters and identifying the sorts of attacks that might subsequently be implemented [1]. A hacker who is relatively knowledgeable about electronics and software engineering might be able to hack into smart meters to commit energy fraud, implement a denial of service attack, or even disrupt electric service to a large number of customers by disconnecting loads via the remote disconnect switch.

Energy fraud and denial of service are likely to only cause annoyance to customers or result in financial losses for
disconnect attack, if
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l be more serious.
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ve all of the features
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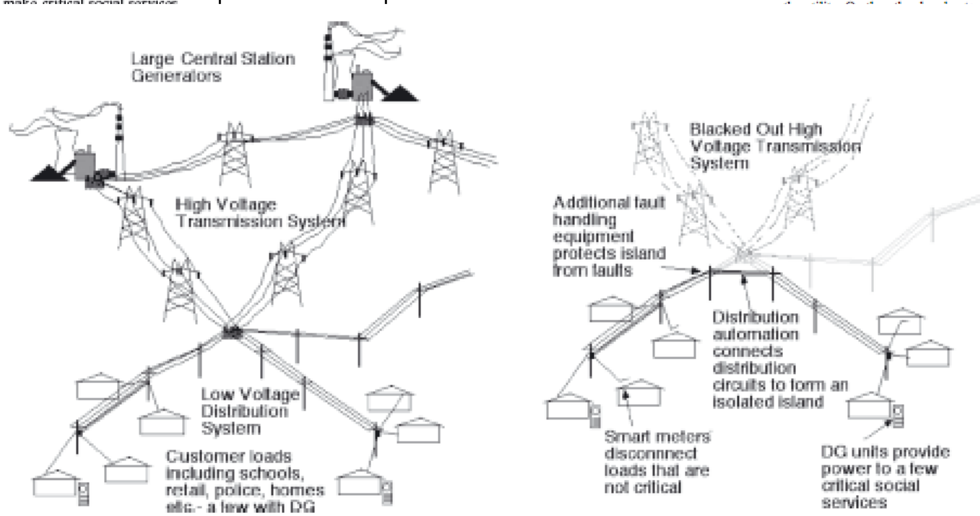
cks to detect and

or the SGIG program did
and annual reviews include

ed, it is unclear how many
PG&E has reported that as
.5 million meters have the



Example 5

CO_2 from airplanes & ocean shipping

- **Parth Vaishnav, Reducing pollution from aviation and ocean shipping, EPP PhD defended 2015 April 29.**

- Parth Vaishnav, "Greenhouse Gas Emissions from International Transport," *Issues in Science & Technology*, 2014.
- Parth Vaishnav, "Costs and Benefits of Reducing Fuel Burn and Emissions from Taxiing Aircraft," *Transportation Research Record: Journal of the Transportation Research Board* 2400, no. -1 (December 1, 2014): 65–77. doi: 10.3141/2400-08.

International Civil Aviation Organization (ICAO) straw man proposal

Images from:taxibot-international; safranmbd.com;Ground Truth Trekkin; Port of San Diego

Example 6

Choices in ligthting

Jihoon Min

Ecological Economics 97 (2014) 42–50

Contents lists available at ScienceDirect

Ecological Economics

journal homepage: www.elsevier.com/locate/ecolecon

Analysis

Labeling energy cost on light bulbs lowers implicit discount

Jihoon Min [a], Inês L. Azevedo [a,*], Jeremy Michalek [a,b], Wändi Bruine de Bruin

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[c] Leeds University Business School, The University of Leeds, Leeds, LS2 9JT, United Kingdom

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Energy efficient lighting
Implicit discount rate
Consumer preference
Choice experiment
Discrete choice analysis
Conjoint analysis

ABSTRACT

Lighting accounts for nearly 20% of overall U.S. electricity c
consumption. A transition to alternative energy-efficient te
considerably. To quantify the influence of factors that drive
choice-based conjoint field experiment with 183 participan
data, and found that politically liberal consumers have a str
technology and for low energy consumption. Greater willing
ger life was observed in conditions where estimated operatin
ed annual cost information to consumers reduced their implic
to adoption of energy efficient alternatives with higher up-fro
vided, consumers continued to use implicit discount rates of
for other energy technologies.

1. Introduction

In 2008, residential compact fluorescent lamp (CFL) socket saturation[1] was 10% nationwide (D&R International, Ltd., 2009), with the remainder being almost entirely incandescent bulbs. About half of the total lighting service (in terms of lumens) was provided by incandescent bulbs, and a little over 20% was provided by CFL bulbs (Navigant Consulting, 2010), suggesting that further adoption of CFLs – or other efficient lighting technologies, such as light emitting diodes – could achieve considerable energy savings in the residential sector. In many cases, these efficient alternatives would also save money for households. The slow transition to CFLs does not seem to be due to poor public awareness, since about 70% of Americans know about CFLs (Sylvania, 2010). These data suggest that there may be other barriers that keep consumers from adopting CFLs.

Engineering economic analyses have long suggested that there is a

1982; Brown, 2001; Golo
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access to financing optio
future price of electricity
for consumers among oth
sumers' limited cognitive
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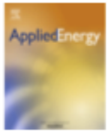
such as building energy
ciency standards could b
policy initiatives already
quadrillion BTU per year.

Researchers have take
priority consumers plac

Contents lists available at ScienceDirect

Applied Energy

journal homepage: www.elsevier.com/locate/apenergy



Assessing regional differences in lighting heat replacement effects in residential buildings across the United States

CrossMark

Jihoon Min [a], Inês Lima Azevedo [a,*], Pekka Hakkarainen [b]

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[b] Lutron Electronics Company, Inc., 7200 Suter Rd, Coopersburg, PA 18036, United States

HIGHLIGHTS

- Replacing inefficient lamps affects heating and cooling demands of a building.
- We assess regional differences of this effect at 105 cities in the U.S.
- The effect size depends on regional factors such as climate and fuel mix.
- The effect can undermine up to 40% of originally intended primary energy savings.
- The overall effect is at most 1% of total energy consumption by a house.

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Energy efficient lighting
Building energy simulation
Rebound effects

ABSTRACT

Lighting accounts for 19% of total U.S. electricity consumption and 6% of carbon dioxide equivalent (CO_2e) emissions. Existing technologies, such as compact fluorescent lamps and light emitting diodes, can substitute low-efficiency technologies such as incandescent lamps, while saving energy and reducing energy bills to consumers. For that reason, lighting efficiency goals have been emphasized in U.S. energy efficiency policies. However, incandescent bulbs release up to 95% of input energy as heat, impacting the overall building energy consumption: replacing them increases demands for heating service that needs to be provided by the heating systems and decreases demands for cooling service that needs to be provided by the cooling systems. This work investigates the net energy consumption, CO_2e emissions, and savings in energy bills for single-family detached houses across the U.S. as one adopts more efficient lighting systems. In some regions, these heating and cooling effects from more efficient lighting can undermine up to 40% of originally intended primary energy savings, erode anticipated carbon savings completely, or lead to 30% less household monetary savings than intended. The size of the effect depends on regional factors such as climate, technologies used for heating and cooling, electricity fuel mix, emissions factors, and electricity prices. However, we also find that for moderate lighting efficiency interventions, the overall effect is small in magnitude, corresponding at most to 1% of either total emissions or of energy consumption by a house.

With 2 other pieces under way using scanner data from 30K household purchases in a nationally representative sample…

Example 7

Decisions in transportation


Alan Jenn

Contents lists available at ScienceDirect

Energy Economics

journal homepage: www.elsevier.com/locate/eneco

The impact of federal incentives on the adoption of hybrid electric vehicles in the United States

Alan Jenn [a], Inês L. Azevedo [a,b,*], Pedro Ferreira [a,c]

[a] Department of Engineering and Public Policy, Carnegie Mellon University, Baker Hall 129, 5000 Forbes Avenue, Pittsburgh, PA 15213,
[b] Climate and Energy Decision Making Center, Carnegie Mellon University, Baker Hall 129, 5000 Forbes Avenue, Pittsburgh, PA 15213, U
[c] H. John Heinz III College, Carnegie Mellon University, Hamburg Hall 3042, 5000 Forbes Avenue, Pittsburgh, PA 15213, United States

A R T I C L E I N F O

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Available online xxxx

JEL classification:
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H23
L98
O31

Keywords:
Hybrid electric vehicle
Policy incentive
Technology adoption

A B S T R A C T

Starting in 2004, the federal government in the United States off
to increase the adoption of hybrid electric vehicles. This study a
of 2005 in this regard using econometric methods and data b
network externalities by using lagged sales as an independent v
nential initial growth associated with the diffusion of new tech
the policy incentives. Our results show that the Energy Policy
3% to 20% depending on the vehicle model considered. In addi
when the amount provided is sufficiently large.

Contents lists available at ScienceDirect

Transportation Research Part A

journal homepage: www.elsevier.com/locate/tra

How will we fund our roads? A case of decreasing revenue from electric vehicles

CrossMark

Alan Jenn [a], Inês Lima Azevedo [a,*], Paul Fischbeck [b]

[a] Engineering and Public Policy, Carnegie Mellon University, United States
[b] Engineering and Public Policy, Social and Decision Sciences, Carnegie Mellon University, United States

A R T I C L E I N F O

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Keywords:
Funding transportation infrastructure
Taxes and fees
Electric vehicles
Gas tax

A B S T R A C T

Annual expenditures for transportation infrastructure have recently surpassed the funding available through tax and fee collection. One large source of revenue generation for transportation infrastructure is use fees that are charged through taxes on gasoline both on a federal and state level. A massive adoption of electric vehicles (EVs) in the United States would result in significantly lower gasoline consumption and thus reduce the revenue collected to maintain the U.S. transportation infrastructure. We investigate how different vehicles will change the annual fee collected on a marginal basis. In addition, we assess the effects of adoption of alternative vehicles on revenues using several projections of alternative vehicles adoption, both on a state-by-state basis and at the national level. We find that baseline midsize and compact vehicles such as the Toyota Camry and Honda Civic generate approximately $2500–$4000 in tax revenue over their lifetime. Under the current funding structure, battery-electric vehicles (BEVs) such as the Nissan Leaf generate substantially less at $400–$1300, while plug-in hybrid electric vehicles (PHEVs) such as the Chevrolet Volt generate $1500–$2700. Even in states with high lifetime fees due to fuel taxes, such as California, revenue generation can be upwards of 50% lower than in states with high registration fees such as Colorado. Total annual revenue generation decreases by about $200 million by 2025 as a result of EV adoption in our base case, but in projections with larger adoption of alternative vehicles could lead to revenue generation reductions as large as $900 million by 2025. Potential schemes that charge user fees on alternative fuel vehicles to overcome the decrease in revenue include a flat annual registration fee at 0.6% of the vehicle's manufacturer suggested retail price (MSRP) or 22¢ per mile fee.

With 2 other pieces submitted (1 to Science, 1 to Energy Economics) and 2 other being finalized before he heads to UC Davis…

CEDM has been remarkably productive

Over the past five years we have:

- Graduated 38 PhDs
- Published over 200 papers
- Run 7 Theory & Methods workshops
- Held 60 invited seminars
- Developed and disseminated a variety of tools for decision support
- Provided briefings to many stakeholders, and
- Conducted numerous educational and outreach activities for policymakers, the public, and middle-school teachers and students.

I will say a few words about just three

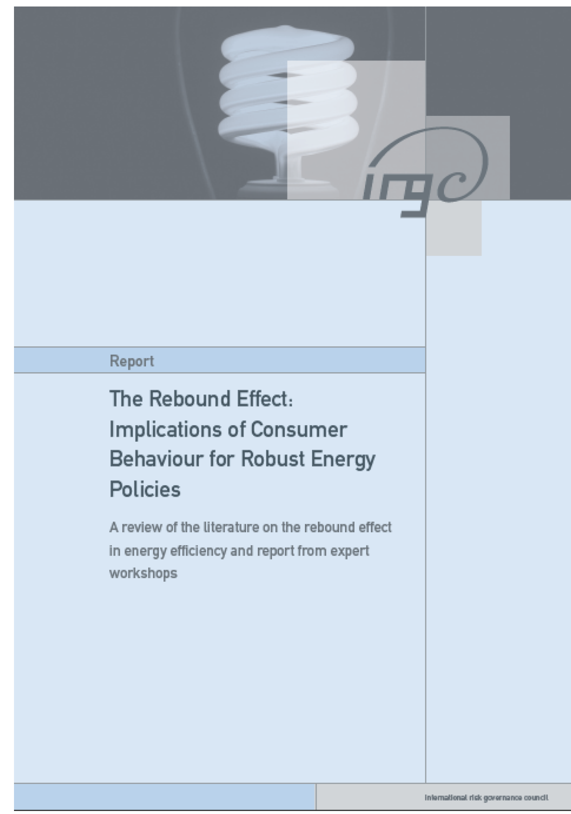
Example 1

The rebound effect

In 2011, June 27–28 we ran a T&M workshop in Washington on the rebound effect.

We reviewed the literature, participants wrote "think pieces" and we made considerable progress on issues of definition.

We then published a 35-page summary report that has been distributed internationally by IRGC.



To download this and other CEDM reports published through IRGC see: http://www.irgc.org/publications/

Rebound...(Cont.)

With Inês, CEDM PhD student Brinda Thomas went on to do new work on estimating direct and Indirect rebound that led to two papers:

And, Inês wrote an invited paper for *Annual Reviews*.

Contents lists available at SciVerse ScienceDirect
Ecological Economics
journal homepage: www.elsevier.com/locate/ecolecon

Analysis

Estimating direct and indirect rebound effects for U.S. households with input–output analysis Part 1: Theoretical framework

Brinda A. Thomas *, Inês L. Azevedo
Department of Engineering and Public Policy, Carnegie Mellon University, Pittsburgh, PA, United States

Contents lists available at SciVerse ScienceDirect
Ecological Economics
journal homepage: www.elsevier.com/locate/ecolecon

Analysis

Estimating direct and indirect rebound effects for U.S. households with input–output analysis. Part 2: Simulation

Brinda A. Thomas *, Inês L. Azevedo
Department of Engineering and Public Policy, Carnegie Mellon University, Pittsburgh, PA, United States

Ecological Economics, 188-198 and 199-210, *86*, 2013.

Consumer End-Use Energy Efficiency and Rebound Effects

Inês M.L. Azevedo
Department of Engineering and Public Policy, Carnegie Mellon University, Pittsburgh, Pennsylvania 15213; email: iazevedo@cmu.edu

Annu. Rev. Environ. Resour. 2014. 39:393–418
The *Annual Review of Environment and Resources* is online at environ.annualreviews.org
This article's doi: 10.1146/annurev-environ-021913-153558

Keywords
energy efficiency, rebound effect, consumer behavior

Abstract
Energy efficiency policies are pursued as a way to provide affordable and sustainable energy services. Efficiency measures that reduce energy service costs will free up resources that can be spent in the form of increased consumption—either of that same good or service or of other goods and services that require energy (and that have associated emissions). This is called the rebound effect. There is still significant ambiguity about how the rebound effect should be defined, how we can measure it, and how we can characterize its uncertainty. Occasionally the debate regarding its importance reemerges, in part because the existing studies are not easily comparable. The scope, region, end-uses, time period of analysis, and drivers for efficiency improvements all differ widely from study to study. As a result, listing one single number for rebound effects would be misleading. Rebound effects are likely to depend on the specific attributes of the policies that trigger the efficiency improvement, but such factors are often ignored. Implications for welfare changes resulting from rebound have also been largely ignored in the literature until recently.

393

Annu. Rev. Environ. Resour., *39*, 393–418, 2014.

CARNEGIE MELLON UNIVERSITY PITTSBURGH PENNSYLVANIA 1900

irgc international risk governance council

PAUL SCHERRER INSTITUT PSI

Example 2

Small Modular Reactors

In this case…

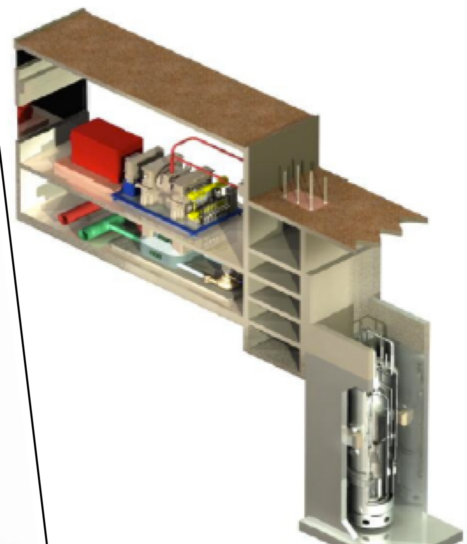
…using funds we had obtained from the MacArthur Foundation, Ahmed Abdulla had already conducted an expert elicitation on SMRs.

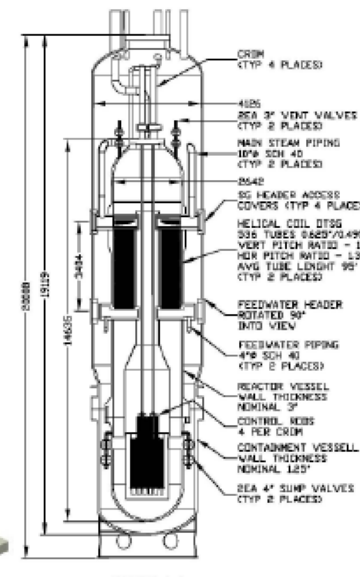

Expert assessments of the cost of light water small modular reactors

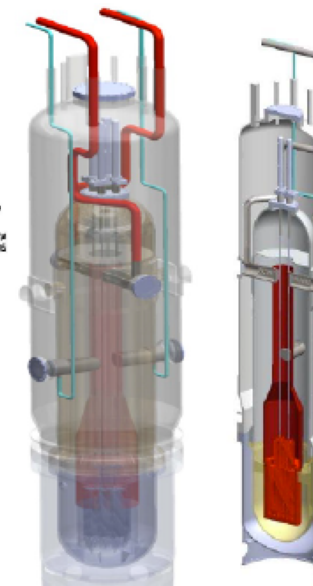
Ahmed Abdulla[1], Inês Lima Azevedo, and M. Granger Morgan

Department of Engineering and Public Policy, Carnegie Mellon University, Pittsburgh, PA 15213

Why SMRs?







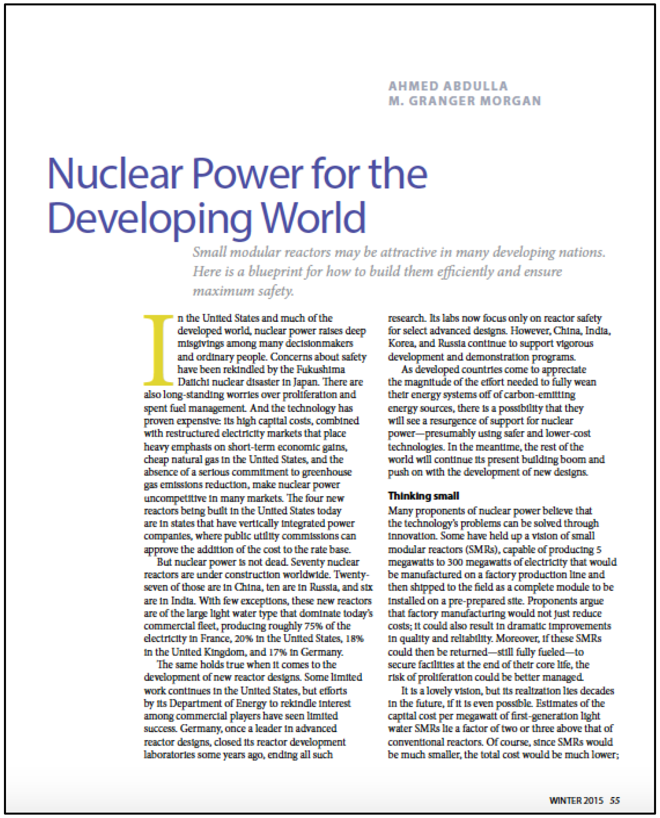
Sourse: Abdulla, Azevedo and Morgan, *PNAS*, *11*(24), 9686-9691, 2013.

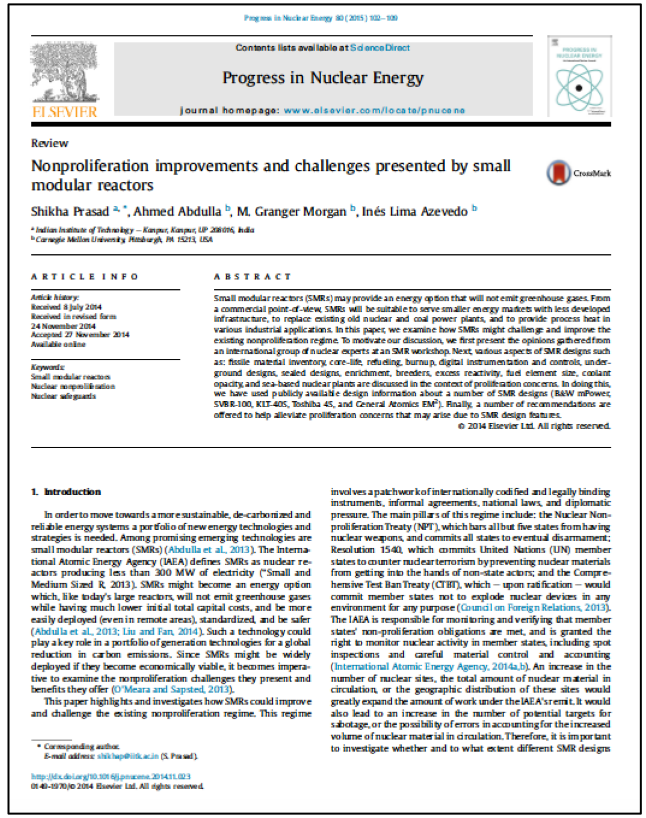
We've gone on to…

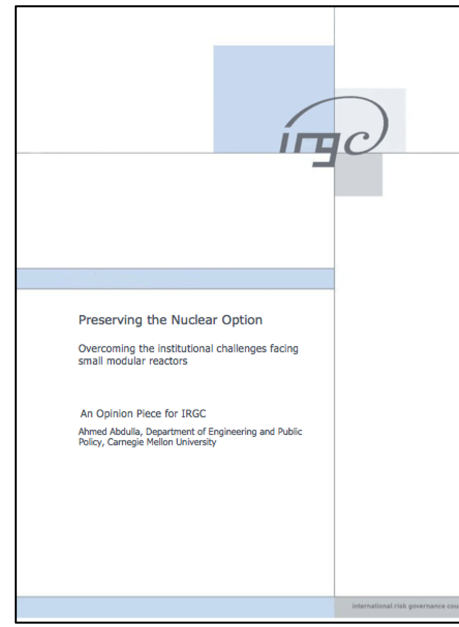
…produce a series of additional papers, present results to EPRI, AAAS and a number of others…

EPRI

AAAS







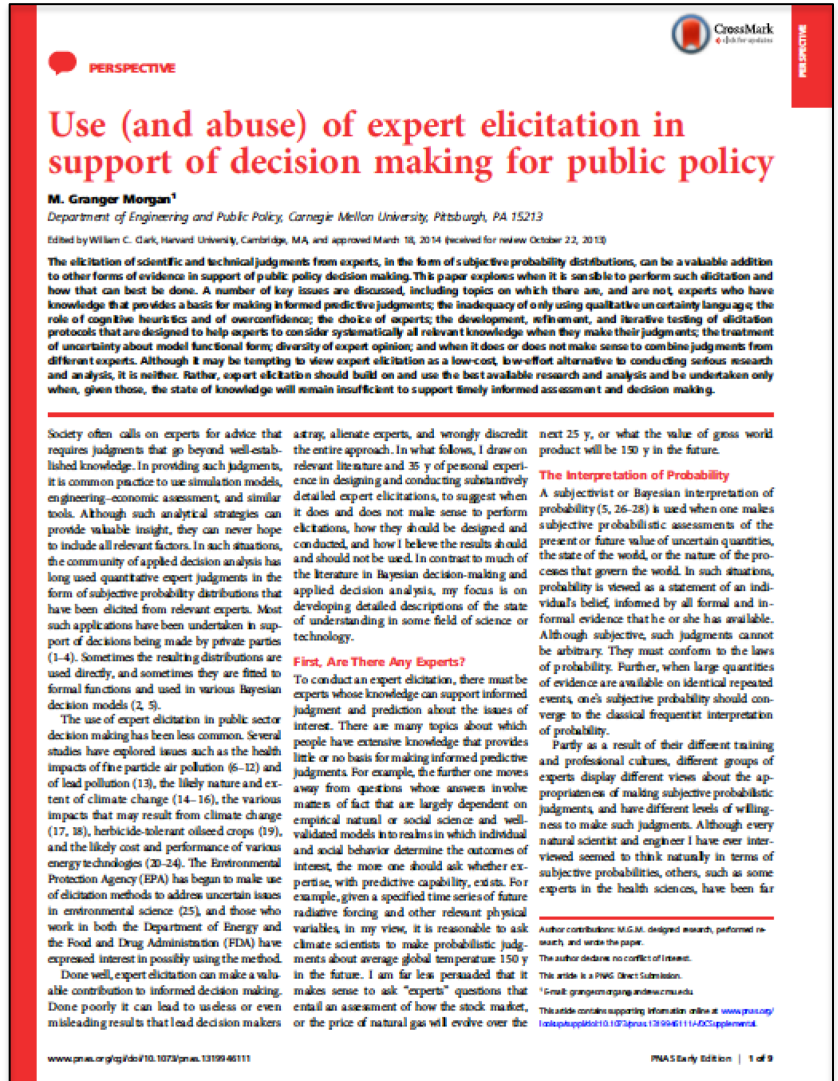
…and now PhD student Mike Ford (Capt. USN Ret) is starting work on a MacArthur-supported PhD on floating SMRs. Mike will present on his work this afternoon

One other notable consequence…

…of Ahmed's work on expert elicitation on SMRs is that the editors at *PNAS* asked me to write a nine page "perspective" piece on the use (and abuse) of expert elicitation.

This paper built on the more than 20 years of work on expert elicitation that we have conducted with NSF support in HDGC, CDMC and CEDM.

M. Granger Morgan, "The Use (and Abuse) of Expert Elicitation in support of Decision Making for Public Policy," *PNAS*, *111*(20), 7176-7184, 2014.


PERSPECTIVE

CrossMark

Use (and abuse) of expert elicitation in support of decision making for public policy

M. Granger Morgan[1]

Department of Engineering and Public Policy, Carnegie Mellon University, Pittsburgh, PA 15213

Edited by William C. Clark, Harvard University, Cambridge, MA, and approved March 18, 2014 (received for review October 22, 2013)

The elicitation of scientific and technical judgments from experts, in the form of subjective probability distributions, can be a valuable addition to other forms of evidence in support of public policy decision making. This paper explores when it is sensible to perform such elicitation and how that can best be done. A number of key issues are discussed, including topics on which there are, and are not, experts who have knowledge that provides a basis for making informed predictive judgments; the inadequacy of only using qualitative uncertainty language; the role of cognitive heuristics and of overconfidence; the choice of experts; the development, refinement, and iterative testing of elicitation protocols that are designed to help experts to consider systematically all relevant knowledge when they make their judgments; the treatment of uncertainty about model functional form; diversity of expert opinion; and when it does or does not make sense to combine judgments from different experts. Although it may be tempting to view expert elicitation as a low-cost, low-effort alternative to conducting serious research and analysis, it is neither. Rather, expert elicitation should build on and use the best available research and analysis and be undertaken only when, given those, the state of knowledge will remain insufficient to support timely informed assessment and decision making.

Society often calls on experts for advice that requires judgments that go beyond well-established knowledge. In providing such judgments, it is common practice to use simulation models, engineering–economic assessment, and similar tools. Although such analytical strategies can provide valuable insight, they can never hope to include all relevant factors. In such situations, the community of applied decision analysis has long used quantitative expert judgments in the form of subjective probability distributions that have been elicited from relevant experts. Most such applications have been undertaken in support of decisions being made by private parties (1–4). Sometimes the resulting distributions are used directly, and sometimes they are fitted to formal functions and used in various Bayesian decision models (2, 5).

The use of expert elicitation in public sector decision making has been less common. Several studies have explored issues such as the health impacts of fine particle air pollution (6–12) and of lead pollution (13), the likely nature and extent of climate change (14–16), the various impacts that may result from climate change (17, 18), herbicide-tolerant oilseed crops (19), and the likely cost and performance of various energy technologies (20–24). The Environmental Protection Agency (EPA) has begun to make use of elicitation methods to address uncertain issues in environmental science (25), and those who work in both the Department of Energy and the Food and Drug Administration (FDA) have expressed interest in possibly using the method.

Done well, expert elicitation can make a valuable contribution to informed decision making. Done poorly it can lead to useless or even misleading results that lead decision makers astray, alienate experts, and wrongly discredit the entire approach. In what follows, I draw on relevant literature and 35 y of personal experience in designing and conducting substantively detailed expert elicitations, to suggest when it does and does not make sense to perform elicitations, how they should be designed and conducted, and how I believe the results should and should not be used. In contrast to much of the literature in Bayesian decision-making and applied decision analysis, my focus is on developing detailed descriptions of the state of understanding in some field of science or technology.

First, Are There Any Experts?

To conduct an expert elicitation, there must be experts whose knowledge can support informed judgment and prediction about the issues of interest. There are many topics about which people have extensive knowledge that provides little or no basis for making informed predictive judgments. For example, the further one moves away from questions whose answers involve matters of fact that are largely dependent on empirical natural or social science and well-validated models into realms in which individual and social behavior determine the outcomes of interest, the more one should ask whether expertise, with predictive capability, exists. For example, given a specified time series of future radiative forcing and other relevant physical variables, in my view, it is reasonable to ask climate scientists to make probabilistic judgments about average global temperature 150 y in the future. I am far less persuaded that it makes sense to ask "experts" questions that entail an assessment of how the stock market, or the price of natural gas will evolve over the next 25 y, or what the value of gross world product will be 150 y in the future.

The Interpretation of Probability

A subjectivist or Bayesian interpretation of probability (5, 26–28) is used when one makes subjective probabilistic assessments of the present or future value of uncertain quantities, the state of the world, or the nature of the processes that govern the world. In such situations, probability is viewed as a statement of an individual's belief, informed by all formal and informal evidence that he or she has available. Although subjective, such judgments cannot be arbitrary. They must conform to the laws of probability. Further, when large quantities of evidence are available on identical repeated events, one's subjective probability should converge to the classical frequentist interpretation of probability.

Partly as a result of their different training and professional cultures, different groups of experts display different views about the appropriateness of making subjective probabilistic judgments, and have different levels of willingness to make such judgments. Although every natural scientist and engineer I have ever interviewed seemed to think naturally in terms of subjective probabilities, others, such as some experts in the health sciences, have been far

Author contributions: M.G.M. designed research, performed research, and wrote the paper.

The author declares no conflict of interest.

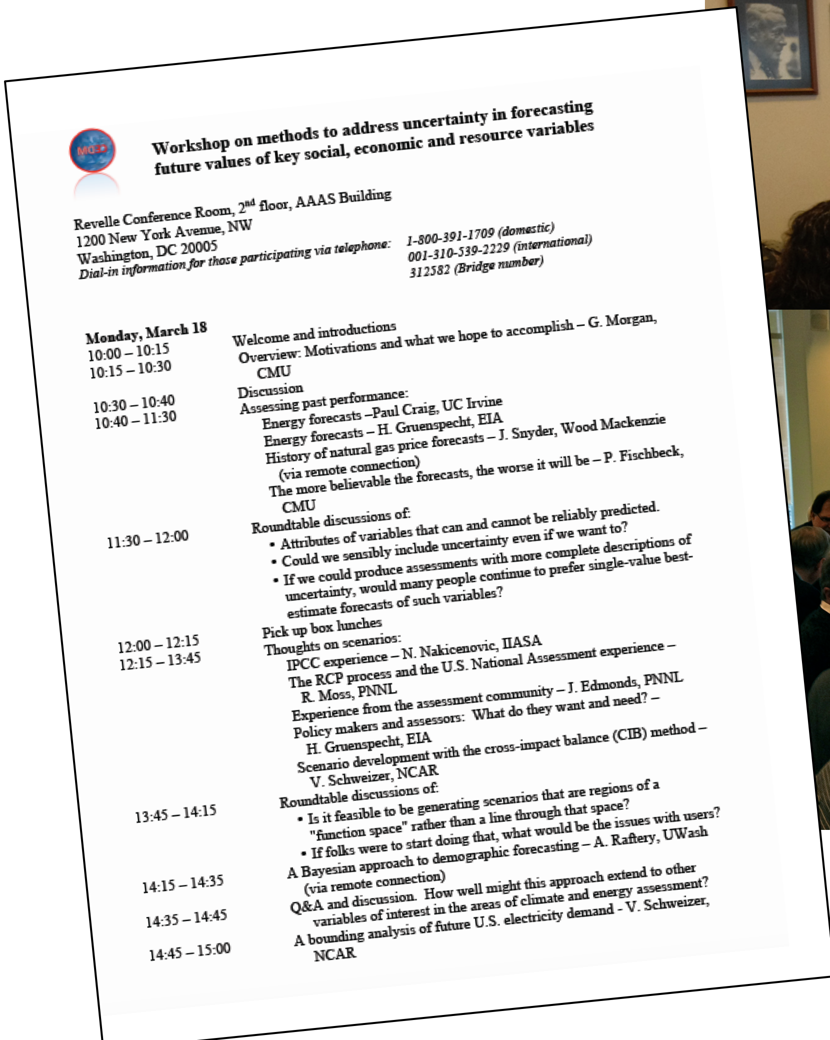
This article is a PNAS Direct Submission.

[1]E-mail: granger.morgan@andrew.cmu.edu.

This article contains supporting information online at www.pnas.org/lookup/suppl/doi:10.1073/pnas.1319946111/-/DCSupplemental.

Example 3

T&M workshop on energy forecasting



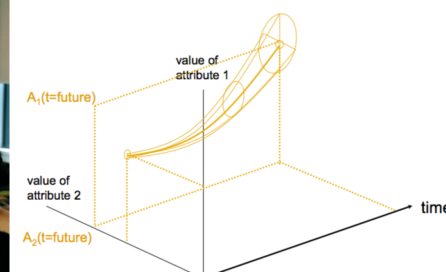
Workshop on methods to address uncertainty in forecasting future values of key social, economic and resource variables

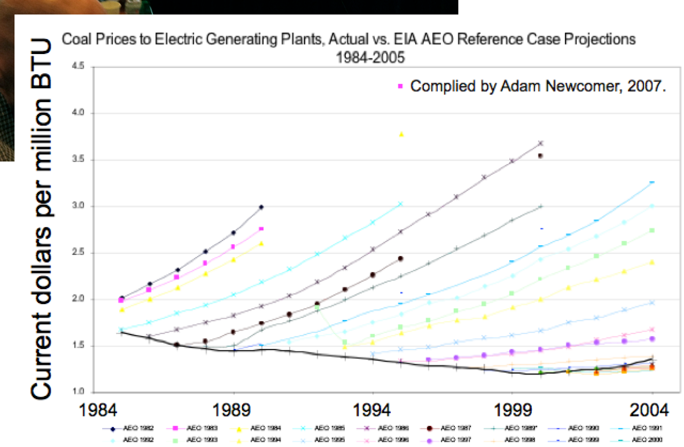
Revelle Conference Room, 2nd floor, AAAS Building
1200 New York Avenue, NW
Washington, DC 20005

Dial-in information for those participating via telephone: *1-800-391-1709 (domestic)*
001-310-539-2229 (international)
312582 (Bridge number)

Monday, March 18

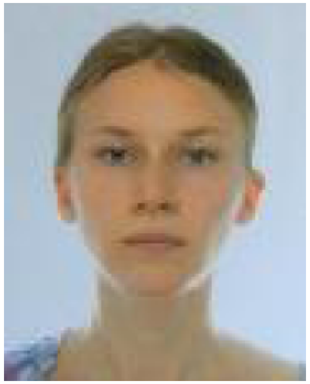
10:00 – 10:15	Welcome and introductions
10:15 – 10:30	Overview: Motivations and what we hope to accomplish – G. Morgan, CMU
	Discussion
	Assessing past performance:
10:30 – 10:40	Energy forecasts –Paul Craig, UC Irvine
10:40 – 11:30	Energy forecasts – H. Gruenspecht, EIA
	History of natural gas price forecasts – J. Snyder, Wood Mackenzie (via remote connection)
	The more believable the forecasts, the worse it will be – P. Fischbeck, CMU
11:30 – 12:00	Roundtable discussions of: • Attributes of variables that can and cannot be reliably predicted. • Could we sensibly include uncertainty even if we want to? • Could we produce assessments with more complete descriptions of uncertainty, would many people continue to prefer single-value best-estimate forecasts of such variables?
12:00 – 12:15	Pick up box lunches
12:15 – 13:45	Thoughts on scenarios:
	IPCC experience – N. Nakicenovic, IIASA
	The RCP process and the U.S. National Assessment experience – R. Moss, PNNL
	Experience from the assessment community – J. Edmonds, PNNL
	Policy makers and assessors: What do they want and need? – H. Gruenspecht, EIA
	Scenario development with the cross-impact balance (CIB) method – V. Schweizer, NCAR
13:45 – 14:15	Roundtable discussions of: • Is it feasible to be generating scenarios that are regions of a "function space" rather than a line through that space? • If folks were to start doing that, what would be the issues with users?
14:15 – 14:35	A Bayesian approach to demographic forecasting – A. Raftery, UWash (via remote connection)
14:35 – 14:45	Q&A and discussion. How well might this approach extend to other variables of interest in the areas of climate and energy assessment?
14:45 – 15:00	A bounding analysis of future U.S. electricity demand - V. Schweizer, NCAR





It took a couple of years…

…but we now have two students, Lynn Kaack and Evan Sherwin, working on PhDs that will develop and demonstrate improved methods for dealing with uncertainty in energy and other forecasts. This work is partly supported by EPRI.



Many of us will have a discussion with the two of them in a session tomorrow morning.

This summer CEDM will…

…have a full day at the annual EMF Snowmass climate meeting to summarize our accomplishments to date to folks from across the climate assessment community.

So what's next?

In April last year we got word that we were invited to submit a proposal for an additional five years

Subject: Invitation to Submit a Renewal Proposal for a DMUU Collaborative Group
Date: Friday, April 25, 2014 8:34 AM
From: Eavey, Cheryl L. <ceavey@nsf.gov>
To: Sabine Marx <sm2234@columbia.edu>, "dhk@columbia.edu" <dhk@columbia.edu>, Dave White <Dave.White@asu.edu>, Ian Foster <foster@uchicago.edu>, Granger Morgan <granger.morgan@andrew.cmu.edu>, Ines Azevedo <iazevedo@cmu.edu>
Cc: "Baerwald, Thomas J." <tbaerwal@nsf.gov>, "O'Connor, Robert E" <roconnor@nsf.gov>
Conversation: Invitation to Submit a Renewal Proposal for a DMUU Collaborative Group

Dear DMUU PIs:

In accordance with the DMUU solicitation that was the basis for your current awards (accessible at https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=503374 <https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=503374>) and the terms of your cooperative agreements, NSF invites each awardee to submit a renewal proposal to continue DMUU collaborative group activities. Our invitation to submit renewal proposals reflects both the intention of the DMUU solicitation and resulting cooperative agreements as well as the positive performances of the DMUU centers over the course of your current awards. Because of the significant demands on program budgets, however, we will not be able to provide support at the level indicated in the solicitation cited above or in the current cooperative agreements.

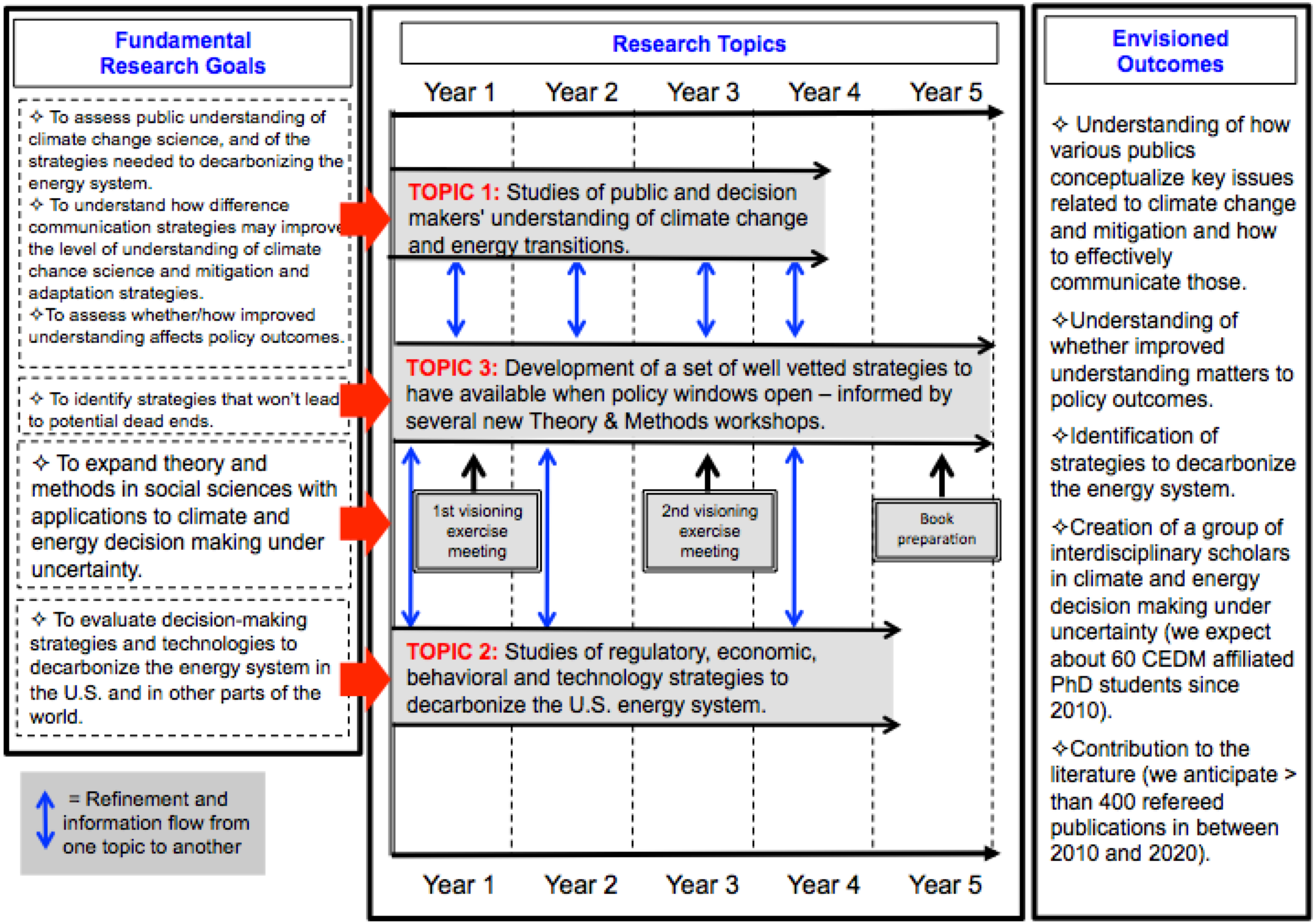
Please use the information in this email message to complement the instructions presented in the original program solicitation. In addition, please use the update information in the most recent NSF Grant Proposal Guide (GPG, accessible at h www.nsf.gov/pubs/policydocs/pappguide/nsf14001/gpg_index.jsp <http://ww pubs/policydocs/pappguide/nsf14001/gpg_index.jsp>) when you prepar proposal.

1) You may submit a renewal proposal requesting between three and five years of support. Regardless of the length of the requested support, funding (and related activities) must ramp down. No single year of funding in your renewal proposal may exceed $1,400,000 in total costs (i.e., direct plus indirect) and requested total costs over the duration of the renewal request may not exceed $4,500,000.

[for] between three and five years…No single year of funding …may exceed $1,400,000 in total costs…and…costs over the duration of the renewal request may not exceed $4,500,000.

We spent most of the spring and summer…

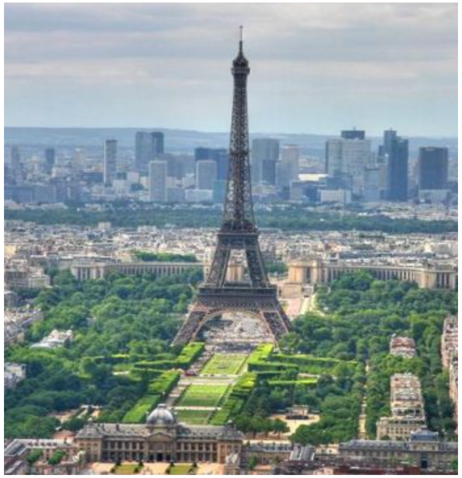
…preparing the proposal.



Task 1: Public & decision makers' understanding of climate change

For reasons I'll explain, we think many people view the problem of climate change as similar to the problem of air pollution.

If and when it gets bad enough, we'll just clean things up.



Images from: phys.org and impressivebuildings.com

Of course, the climate problem is *not* like that. We suspect that public support for consistent abatement policy requires a basic understanding that "once carbon dioxide gets into the atmosphere the stuff builds up and most of it stays there for over a century."

We also suspect…

…that too few members of the general public and indeed opinion leaders and decision makers do not realize the magnitude of the task involved in decarbonizing the energy system.

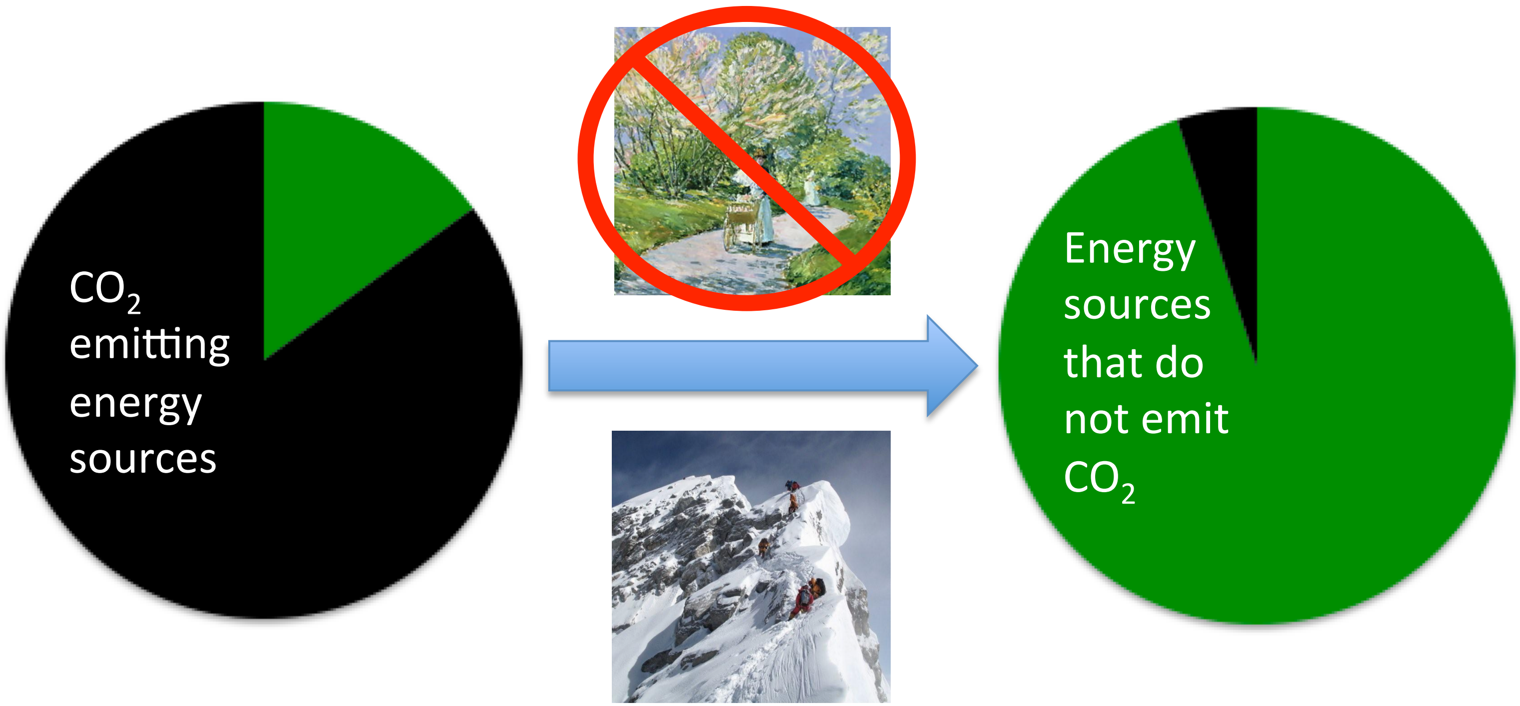


Image Sources: Artinamericamagazine.com; mountatnmadness.com

We’ve done several previous studies…

Of public understanding of climate change:

- Ann Bostrom, M. Granger Morgan, Baruch Fischhoff and Daniel Read, "What Do People Know About Global Climate Change? Part 1: Mental models," *Risk Analysis*, *14*(6), 959-970, 1994.
- Daniel Read, Ann Bostrom, M. Granger Morgan, Baruch Fischhoff and Tom Smuts, "What Do People Know About Global Climate Change? Part 2: Survey studies of educated laypeople," *Risk Analysis*, *14*(6), 971-982, 1994.
- Travis Reynolds, Ann Bostrom, Daniel Read and M. Granger Morgan, "Now What Do People Know About Climate Change?", *Risk Analysis*, *30* (10), 1520-1538, 2010.

Ann Bostrom

Wändi Bruine de Bruin

These studies and other work suggest that many view climate change as being much like air pollution.

“If it ever gets bad enough, we’ll just fix it like we did in the case of air pollution.”

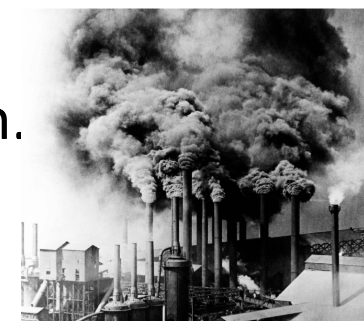


Image from explorepahistory.com

Over the next couple of years Ann, Wändi and I plan a series of studies to assess the prevalence of such a mental model, and to explore how it might best be corrected.

To be more specific:

Our objectives in Task 1 are to:

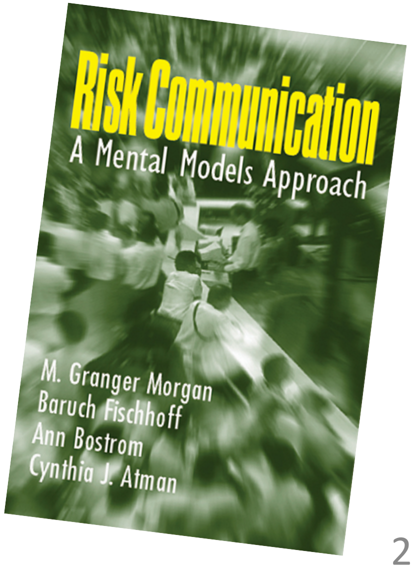
Understand how various publics think about, and how to effectively communicate:

a) the central role of CO_2 in climate change and the fundamental difference between CO_2 and conventional air pollutants;

b) the fact that transforming the energy system will require a portfolio of technologies, and the associated implications of existing long-lived energy infrastructure.

Understand whether greater public appreciation of (a) or (b) matters to policy preferences or outcomes.

We will address these issues with mental model and similar studies and with a T&M workshop on the issue "does better understanding actually matter?"

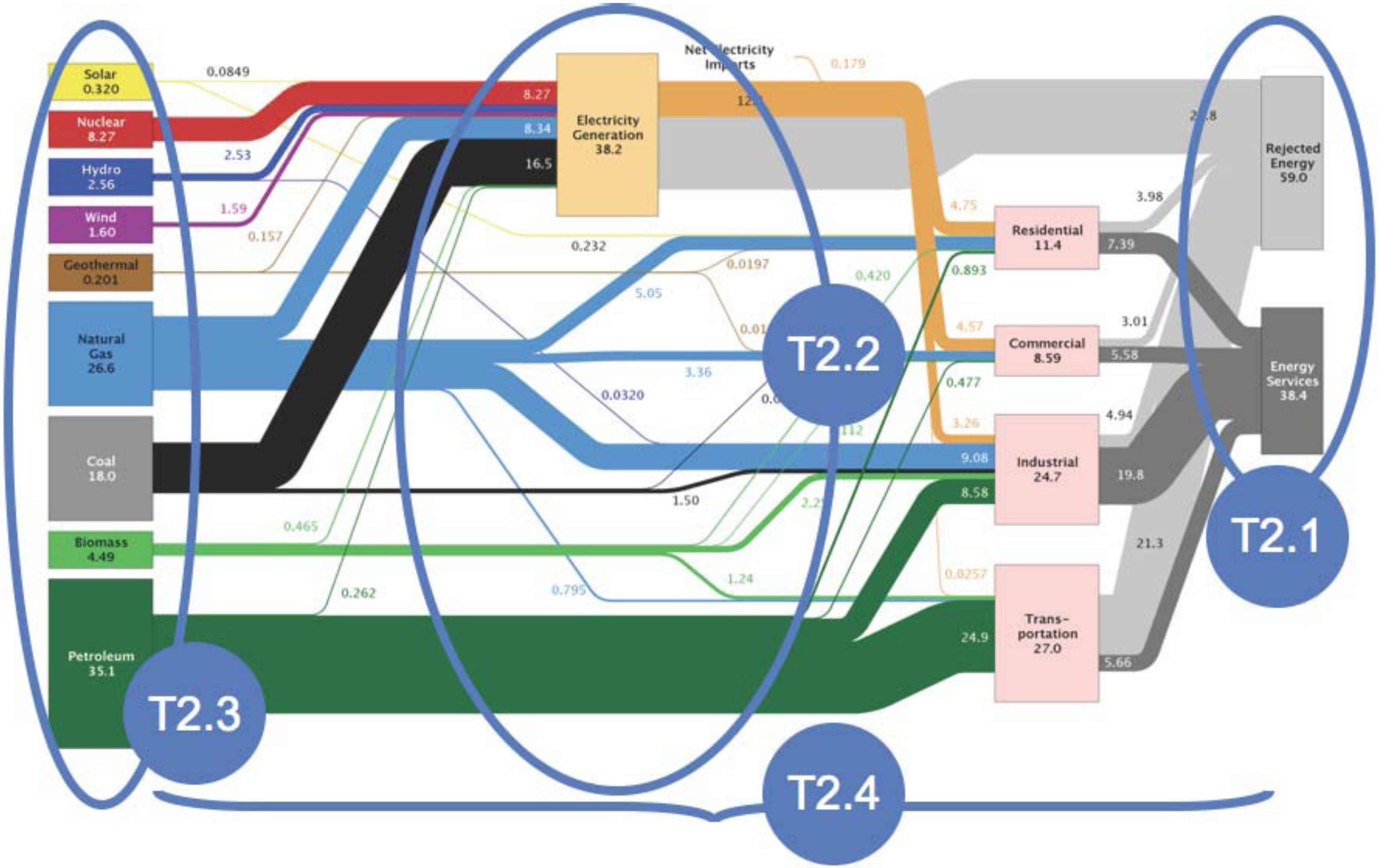


Task 2: Continue and seed research on key behavioral, economic, and technical issues, and issues in regulatory design, that lie along critical paths to decarbonizing the energy system

We will do this by focusing on a subset of important problems on which CEDM has a clear comparative advantage the team will work to:

1) find ways to use energy more efficiently;
2) develop more sources of energy that are safe, clean, affordable, secure, and sustainable;
3) deliver the energy the U.S. uses with greater security and efficiency; and
4) facilitate innovation in both technology and in organizations, regulation, and public policy.

We will address issues all across the energy system



Source: LLNL

Tasks 2.1 to 2.4

Table 1. Topics planned under Task 2. Those listed in black will be fully funded with CEDM funds.
Those in gray we will seed. While below we only describe the project we will fully support, we have prepared comparable write-ups on the projects we will seed, and can provide them on request.
Task 2.1 Find ways to use the energy we have more efficiently.
Behavioral and other barriers and market failures that impede the adoption of existing and new cost-saving energy efficiency measures, and on how these barriers may best be overcome
Further assessment of the use of direct current (DC) in buildings
Expanded use of solar water heating and ground source heat pumps
Transition to natural gas direct end-use
Task 2.2: Develop more sources of energy that are safe, clean, affordable, secure and
Strategies that private and public decision makers should be considering as they work to implement CAA 111(d)
Lessons for U.S. decision makers from a quantitative assessment of European experience
Consumer adoption and environmental assessment of electric and hybrid propulsion in transportation
Aesthetic and land-use limits to the penetration of renewables
Technical and economic analysis of hybrid fossil-fuel/renewable technologies to reduce air emissions from electricity.
Further expoloration of the possible role of small modular reactors
Task 2.3 Deliver energy services with greater security and efficiency.
Improve the resilience and adaptive capacity of energy and related infrastructure
Behaviorally realistic strategies to value complete partial electric power service disruption
The use of DG w/CHP and micro-grids toincrease energy use efficiency
Task 2.4: Innovation in technology and in organizations, regulation, public policy, economics and behaviors.
Work designed to help support and improve PUC decision making
Strategies to assist PUCs in treating CCS technology as a "prudent" investment
An evaluation of direct and indirect subsidies across the entire energy system

Task 3: Development of a set of well-vetted strategies to have available when policy windows open.

Several authors have discussed the discontinuous nature of the policy process (Downs, 1974; Kingdon, 1984; Baumgartner and Jones, 1993).

It is important to have well developed and well vetted new ideas when an opportunity arises to inject them into the policy process.

Identifying and developing such ideas will be a key objective under Task 3.

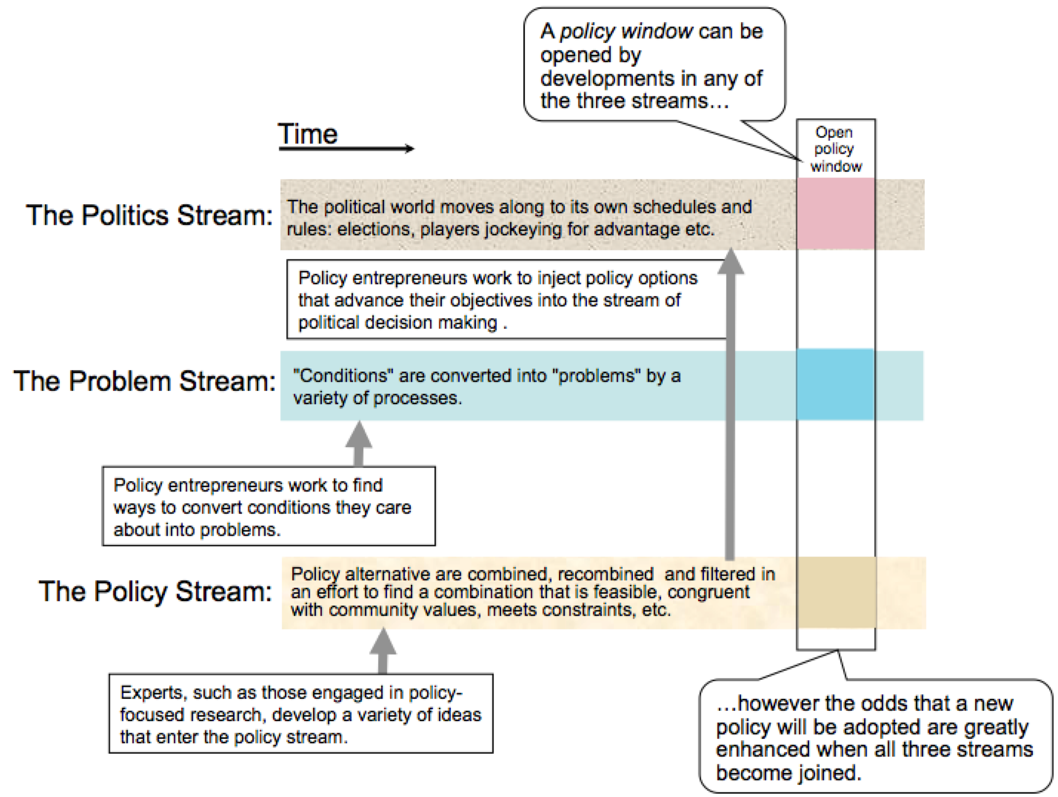


Diagram developed based on ideas articulated in J.W. Kingdon, *Agendas, Alternatives and Public Policies*, Little, Brown and Company, 240pp., 1984.

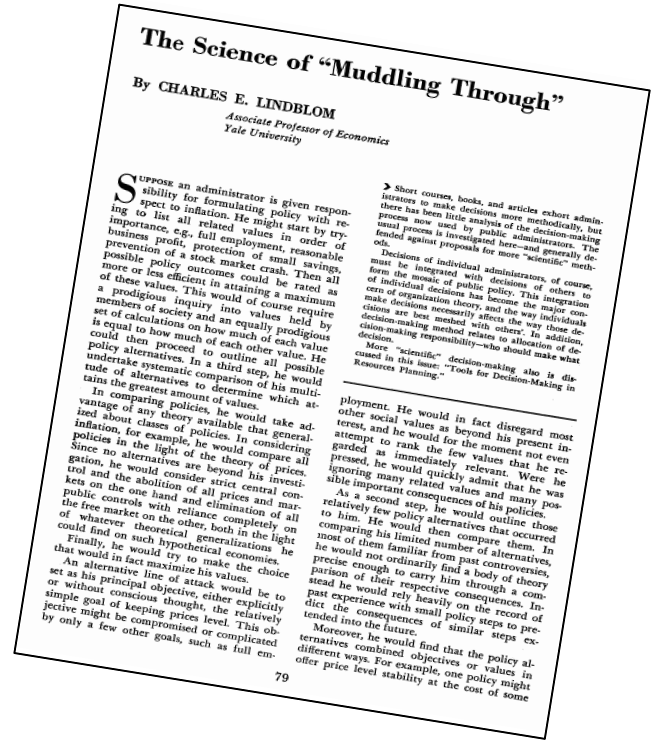
We are concerned that…

…many short-term strategies which result in some limited reduction in CO_2 emissions will not readily scale-up to larger future reductions. Hence, another objective in Task 3 is to identify and seek strategies to avoid or exit from such "dead ends."

Images from: Lymedisease.org; coolfunpics.com;clicker.com

Two weeks ago…

…I gave a talk at Rutgers titled "Muddling Through is Good Climate Policy…but Not Enough." The reference is, of course, to Lindblom.



The Science of "Muddling Through"

By CHARLES E. LINDBLOM

Associate Professor of Economics
Yale University

➤ Short courses, books, and articles exhort administrators to make decisions more methodically, but there has been little analysis of the decision-making process now used by public administrators. The usual process is investigated here—and generally defended against proposals for more "scientific" methods.

Decisions of individual administrators, of course, must be integrated with decisions of others to form the mosaic of public policy. This integration of individual decisions has become the major concern of organization theory, and the way individuals make decisions necessarily affects the way those decisions are best meshed with others'. In addition, decision-making method relates to allocation of decision-making responsibility—who should make what decision.

More "scientific" decision-making also is discussed in this issue: "Tools for Decision-Making in Resources Planning."

Suppose an administrator is given responsibility for formulating policy with respect to inflation. He might start by trying to list all related values in order of importance, e.g., full employment, reasonable business profit, protection of small savings, prevention of a stock market crash. Then all possible policy outcomes could be rated as more or less efficient in attaining a maximum of these values. This would of course require a prodigious inquiry into values held by members of society and an equally prodigious set of calculations on how much of each value is equal to how much of each other value. He could then proceed to outline all possible policy alternatives. In a third step, he would undertake systematic comparison of his multitude of alternatives to determine which attains the greatest amount of values.

In comparing policies, he would take advantage of any theory available that generalized about classes of policies. In considering inflation, for example, he would compare all policies in the light of the theory of prices. Since no alternatives are beyond his investigation, he would consider strict central control and the abolition of all prices and markets on the one hand and elimination of all public controls with reliance completely on the free market on the other, both in the light of whatever theoretical generalizations he could find on such hypothetical economies.

Finally, he would try to make the choice that would in fact maximize his values.

An alternative line of attack would be to set as his principal objective, either explicitly or without conscious thought, the relatively simple goal of keeping prices level. This objective might be compromised or complicated by only a few other goals, such as full em-

79

ployment. He would in fact disregard most other social values as beyond his present interest, and he would for the moment not even attempt to rank the few values that he regarded as immediately relevant. Were he pressed, he would quickly admit that he was ignoring many related values and many possible important consequences of his policies.

As a second step, he would outline those relatively few policy alternatives that occurred to him. He would then compare them. In comparing his limited number of alternatives, most of them familiar from past controversies, he would not ordinarily find a body of theory precise enough to carry him through a comparison of their respective consequences. Instead he would rely heavily on the record of past experience with small policy steps to predict the consequences of similar steps extended into the future.

Moreover, he would find that the policy alternatives combined objectives or values in different ways. For example, one policy might offer price level stability at the cost of some

Public Administration Review, Vol. 19, No. 2 (Spring, 1959), pp. 79-88

There is a risk that things like state-by-state programs to achieve a 30% reduction under CAA Section 111(d), or the ICAO proposal for international aircraft, may make it difficult or impossible to move on to the >90% reductions that ultimately will be needed. Through a set of "visioning exercises" and other activities we plan over the next four years, we will work to identify such possible dead ends and assess technical and regulatory strategies to avoid them.

Visioning Exercises (in the 1st and 3rd year)

These will focus on:

- A range of plausible future trajectories down that *piggy-backing* and *muddling through* could lead to dead ends, from which it would be hard, very expensive, or perhaps even impossible, for society to extract itself;
- A set of potential *path dependencies* that could influence which actions or investments get made and which get blocked;
- A set of future trajectories (informed by the work in Task 2) that could, in major ways, move society in the direction of greater resilience and a lower carbon footprint;
- Types of possible crises or other events that could open policy windows that provide an opportunity for change;
- Implications of the findings from the mental model studies planned as part of Task 1, and the associated T&M workshop, for the formulation of future abatement policy.

Theory and Methods Workshops

We will continue to run T&M workshops as we have over the course of the past five years. We will use some of them to prepare for and support the proposed Visioning Exercises while simultaneously working to expand the frontiers of social & behavioral science and decision making in energy and climate change.

Candidate topics for T&M workshops include:

- Does it make any difference if most people don't understand the climate problem?
- How can one justify investment in long-lived energy infrastructure in a short-term world
- Overcoming behavioral obstacles to the adoption of cost-effective energy efficiency
- Making energy-dependent critical social services less vulnerable to more frequent and intense extreme events



The fifth (and final year)

We proposed to spend the last year preparing a book that will summarize all the key contributions across the >20 years we have enjoyed NSF support from climate-related centers

1995-2005

2005-2010

2010-2020

One May 1st we got the following wonderful message!

Granger and Ines:

NSF has completed its review of your renewal proposal (1463492). I am happy to inform you that NSF will be able to support your project at the level requested. For your information, I have attached an advance copy of your site visit report. You will receive a link to this report and the external reviews on your proposal with the award notification.

We will be in touch soon with more information regarding the terms and conditions of your cooperative agreement and any other additional information requests. In the meantime, please prepare a draft abstract (guidelines are attached) and forward to me your IRB certification by email.

Congratulations. We are delighted to be able to support your project.

Cheryl and Tom

Cheryl L. Eavey, Program Director
Methodology, Measurement, and Statistics
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4201 Wilson Blvd., Room 995.25
Arlington, VA 22230
703.292.7269 (voice) 703.292.9068 (FAX)
ceavey@nsf.gov <mailto:ceavey@nsf.gov>

I am happy to inform you that NSF will be able to support your project *at the level requested*.

Of course...

If you are a U.S. resident, please write your U.S.

COMPETEing visions for U.S. research

A bill drafted by House Republicans matches White House spending priorities for science in some areas but diverges greatly in others.

2016 funding levels, in $ billions

	PRESIDENT'S REQUEST	COMPETES DRAFT	COMPETES COMPARED WITH REQUEST
COMPETES would boost:			
DOE fusion	0.420	0.488	16%
NSF biology	0.748	0.835	12%
NSF engineering	0.929	1.034	11%
NSF computer science	0.954	1.050	10%
NSF math/physical sciences	1.366	1.500	10%
COMPETES would reduce:			
NIST science	0.755	0.745	−1%
NSF overall	7.723	7.597	−2%
NSF education	0.962	0.866	−10%
DOE bio/environment	0.612	0.550	−10%
NSF geosciences	1.365	1.200	−12%
NIST	1.120	0.934	−17%
DOE renewables/efficiency	2.722	1.199	−56%
ARPA-E	0.325	0.140	−57%
NSF social/behavioral*	0.237	0.100	−58%
No change:			
NSF research account	6.186	6.186	0%
DOE Office of Science	5.340	5.340	0%
DOE advanced computing	0.621	0.621	0%
DOE Basic Energy Sciences	1.849	1.850	0%
DOE High Energy Physics	0.788	0.788	0%
DOE Nuclear Physics	0.625	0.625	0%

* Excludes funding for NSF's statistical agency

Science, Apr 24, 2015

I've already done that:

Carnegie Mellon University

M. Granger Morgan
Department of Engineering and Public Policy (EPP)
University and Lord Chair Professor of Engineering
Founding Head, EPP (1977-2014)

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2015 May 15

Senator Robert P. Casey, Jr.
393 Russell Senate Office Building
Washington, DC 20510

Dear Senator Casey:

The Department of Engineering and Public Policy, a department in the Engineering College at Carnegie Mellon University, is the leading department of its kind anywhere in the world. For years our department has been fortunate to receive support for research on decision-making about energy and related issues from the Directorate for the Social, Behavioral and Economic Sciences (SBES) at the National Science Foundation.

Over the period from 2010 through 2014 this NSF support through SBES has provided partial or complete funding, or other support, for the PhDs of 39 engineering students in our department. The research done by these students has addressed problems that range from the development of lower-cost, safe and reliable small modular nuclear reactors of the type that Westinghouse has worked on, demonstrated the greater benefits of locating wind and solar plants in our region rather than in the south-west, assessed strategies to make more efficient use of the energy we have, help the owners of commercial buildings find ways to reduce their energy bills, explored the use of natural gas and electricity to power vehicles, and addressed many other similar issues.

These topics may not immediately strike you as things likely to be funded by NSF's Directorate for the Social, Behavioral and Economic Sciences – but in addition to technology they all involve issues of economics, as well as human preferences and decision-making. I would be happy to provide details if that would be useful.

We have grown deeply concerned by provisions in H.R. 1806 that specifically call for a 58% reduction in the budget of the NSF's Directorate for the Social, Behavioral and Economic Sciences.

We have recently received word that NSF has approved of an additional five years of support of $4.5-million that will come to our department from SBES. Faculty in our department have at least one other large proposal now pending with that Directorate.

If language implementing a major cut to NSF-SBES makes it to the Senate, I very much hope you will do what you can to restore funding, since, if implemented, such a major cut will have a devastating impact on research and doctoral student support in our engineering department.

Thank you for your consideration. Do let me know if I or any of my colleagues can be helpful on this or related matters. A number of my colleagues and I are in Washington on a regular basis and would be happy to come and meet in person, if that would be useful.

Yours,

M. Granger Morgan

M. Granger Morgan
Department of Engineering
and Public Policy
University and Lord Chair Professor
Professor, EPP/ECE/Heinz

MGM:pjs

cc: S. Grant
D. Tekavec
T. McNulty

Carnegie Mellon University

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2015 May 15

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248 Russell Senate Office Building
Washington, DC 20510

Dear Senator Toomey:

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Yours,

M. Granger Morgan

M. Granger Morgan
Department of Engineering
and Public Policy
University and Lord Chair Professor
Professor, EPP/ECE/Heinz

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cc: S. Grant
D. Tekavec
T. McNulty

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Agenda

Marginal emissions, trade-offs, and co-benefits in climate mitigation and air quality.

10:00 – 10:10 A marginal damages framework: examples for renewables and storage – Inês Azevedo
10:10 – 10:20 Emissions and damages from personal transportation – Jeremy Michalek
10:20 – 10:30 Cost-aware load shifting for geographically distributed data centers – Nathaniel Horner
10:30 – 10:40 Results from a new air quality-damages model: EASIUR – Peter Adams
10:40 – 11:10 Panel discussion

11:10 – 11:20 *Coffee break*

Transportation Policy and Climate Change

11:20 – 11:30 How will we fund our roads? A case of decreasing revenue from electric vehicles – Alan Jenn
11:30 – 11:40 CO_2 emissions from aviation and ocean shipping – Parth Vaishnav
11:40 – 11:50 Natural gas pathways for transportation – Fan Tong
11:50 – 12:00 Social/behavioral dimensions of short-term mobility services – Hadi Dowlatabadi
12:00 – 12:30 Panel discussion

12:30 – 13:00 Lunch and informal discussions

Agenda…(Cont.)

Reducing GHG Emissions Through Low Carbon Electricity Generation

13:00 – 13:10 Meeting the objectives of EPA Section 111(d) – Paul Fischbeck

13:10 – 13:20 Alternative compliance payments for existing coal-fired power plants: the value of waiting to invest – Dalia Patiño-Echeverri

13:20 – 13:30 Floating small modular reactors – Michael Ford

13:30 – 14:00 Panel discussion

Perceptions, Attitudes, Behavior and Choices I

14:00 – 14:10 Public perceptions in the UK of weather and climate change – Wändi Bruine de Bruin

14:10 – 14:20 A strategy to improve the valuation of reliable electric power – Sunhee Baik

14:20 – 14:30 Lay judgment of visual cues of tornado risk – Barry Dewitt

14:30 – 15:00 Panel Discussion

Agenda…(Cont.)

Perceptions, Attitudes, Behavior and Choices II

15:00 – 15:10 Studies with data from smart meters and instrumented appliances – Tamar Krishnamurti

15:10 – 15:20 A behavioral decision approach to energy efficiency investments – Alex Davis

15:20 – 15:30 Views on preparing for coastal flooding risk among vulnerable communities in NJ, CT and NY – Gabrielle Wong-Parodi

15:30 – 16:00 Panel Discussion

16:00 – 16:10 Coffee break

16:10 – 16:45 Panel Discussion: future studies of public understanding of GHGs – Wändi Bruine de Bruin, Granger Morgan, Ann Bostrom, Brian Sergi

16:45 – 17:30 Poster Session, *with cheese and wine*

Adjourn and head to dinner at Café Sam's