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Decision Support for Developing Energy Strategies

Policymakers and the public need a mechanism for making a series of difficult and interrelated choices over time, and research in decision science offers a promising way forward.

The United States clearly needs a new energy strategy. In fact, many industrialized nations are in the same position. But this raises an obvious question: What is an energy strategy? In our view, it is a framework that will guide comprehensive and logical discussions about energy development and delivery. It is a deliberative process that encourages involvement from all key stakeholders and gives each of them a legitimate voice in the decisions at hand. It is a way to organize information and dialogue about energy options and their anticipated consequences. And it is a way to structure decisionmaking about energy choices in a manner that facilitates and easily incorporates learning.

What is not an energy strategy? In contrast to most efforts now under way in North America, it is not about promoting specific actions, such as drilling for oil offshore or exploiting unconventional oil and gas resources on land. It is not about advocating energy transportation options, such as oil and gas pipelines. It is not a plan to build infrastructure for renewable energy sources, such as wind or solar farms, or a rationale for providing subsidies for ethanol producers or for setting a price on carbon emissions. It is not a way to advance efficiency standards or carbon capture and storage, or an education plan aimed at demand-side management. Overall, an energy strategy is not about what can be done or (in the eyes of some observers) should be done. Instead, it is a process for organizing analyses, encouraging deliberations, and making decisions in a scientifically rigorous, transparent, and defensible manner.

A good analogy for an energy strategy is that of an individual's financial investments: Different people have different investment objectives and different tolerances for accepting risks, both of which change through time. So it makes sense that investment strategies will differ across individuals and through time. An energy strategy is also specific to the objectives of the decision participants, and a useful strategy is one that establishes a framework for helping

Yuriko Yamaguchi, *Energy*, Hand cast resin and wire, 96 x 120 x 6 inches, 2011.
Courtesy of Howard Scott Gallery, New York.

people—policymakers, scientists and innovators, and the public—to answer questions about which components of an energy system are preferred. Specifically, an energy strategy should inform choices about the desired level of investment in each element of an energy portfolio, where these investments should be made geographically, and the signals or tipping points that will trigger the reallocation of funds and attention from one resource (coal, for example) to another (say, renewables) over time. It should distinguish between sources that are ready for development and those that require additional research. Overlaid on these questions, which themselves are not easy to answer, are questions about the level of risk and uncertainty that policymakers and the public are willing to tolerate.

Barriers to good decisionmaking

Decisionmaking, although seemingly intuitive, is fraught with complexity. Staying with the example of financial planning, consider the choices that people must make about their investment portfolio. Most people have a sense of what they want to achieve with their decisions—for example, high rates of return, stability, low uncertainty, and social responsibility. People tend also to know what a subset of their options is. But despite this knowledge, the vast majority of people have made investment decisions that they have regretted. In our view, such behavior has five main causes, as demonstrated by a wealth of research:

First, people are not strict maximizers of overall utility during decisionmaking. Rather than evaluating alternatives by carefully weighing the importance of the various attributes—costs and benefits in terms of economic, environmental, health-related, and social considerations, for example—people take shortcuts. Even though these shortcuts are commonplace, many people fail to recognize their existence or the systematic biases that accompany them. It is true that these shortcuts are an essential aspect of human decisionmaking; without them, most of the decisions people face in their daily lives would be overwhelming. On the other hand, as the consequences associated with high-stakes decisions increase, as is the case in making national energy choices, so too does the level of effort and accuracy required on the part of decisionmakers.

Second, decisionmakers typically do a rather poor job of fully characterizing and appropriately bounding the decision problems (or opportunities) they are being asked to confront. In many cases, problems are cast too narrowly, such that single objectives (such as maximizing economic opportunities or minimizing carbon emissions) become the sole focus, to the detriment of other objectives that also deserve attention. In other cases, decisions are cast so broadly, with dozens of competing stakeholders and objectives, that the result is paralysis and, ultimately, inaction. And for the goals and objectives that are considered during decisionmaking, people tend not to do a terribly good job of determining accurately and precisely how to measure their performance or achievement.

Third, people tend to anchor too easily on certain alternatives and typically do not do a good job of thinking broadly and creatively about the full range options they can and should be considering. Too often, decisionmakers focus on alternatives that fit neatly with deeply held ideologies, that most easily come to mind, or that have been implemented previously. Decisionmakers also often possess a strong bias toward being unnecessarily faithful to existing investments, even when trading them in for others makes more sense in light of public, business, or national interests (decision researchers call this the sunk cost bias). Each of these tendencies is problematic for decisionmaking. Given the gravity of decisions related to energy, the alternatives under consideration must go beyond the status quo, or the obvious and familiar. They should be responsive to markedly different objectives and strategies, thereby presenting decisionmakers with real options and choices.

Fourth, when these factors—judgmental shortcuts, poorly specified problems, and insufficient creativity when thinking about alternatives—are combined, it becomes difficult, if not impossible, for decisionmakers to confront the tradeoffs that inevitably arise when choosing among options. Policymakers talk often about "win-win" alternatives and consensus. But the fact is that the design of a defensible energy strategy will always involve tradeoffs, giving up something valued in exchange for something else that is also valued, and this threatens consensus and renders win-win alternatives impossible.

Fifth, decisionmakers often fail to adequately learn from their past successes and failures or from the successes and failures of others. Rather than treating decisionmaking as a series of one-off events, there is need for a more adaptive approach designed specifically to help decisionmakers and policymakers learn about systems in which they work by carefully monitoring the outcomes of decisions through time. A good adaptive framework will also help decisionmakers draw lessons from multiple decisions across several jurisdictions as a means of identifying the next and best moves in what is viewed as a series of linked policy decisions.

Constructive in nature

These observations challenge a common assumption held by pollsters, social scientists, and policy analysts, among others, that people possess a pool of preexisting preferences that they simply uncover during the process of making judgments. It is true that in a variety of contexts, preexisting preferences can indeed be identified; people prefer red wine to white, or baseball to football. However, recent research in the decision sciences has demonstrated that there are also many situations where the preferences or preference orders needed to inform decisions are insufficient or altogether absent.

Generally, these decision contexts share one or more of three characteristics. First, the decision context may be foreign, with the implication that preexisting preferences do not exist. Second, decisionmakers may be faced with the relatively common situation in which the evaluation of competing alternatives causes two or more preexisting preferences to conflict. In other words, tradeoffs become necessary, which requires the construction of new preferences based on how decisionmakers balance or rebalance conflicting priorities. Third, decisionmakers may be required to translate qualitative expressions of preference into quantitative ones (and vice versa). Moving from the recommendation, for example, that a carbon market be created to actually setting a price on carbon requires a constructive process. Decisions about energy strategy typically include all three of these features.

Under these conditions, people are unable to evaluate decision problems and alternatives by simply drawing on preexisting and stable preferences. Instead, they must construct their preferences, and by extension, the judgments and decisions that result from them, in response to cues that are available during the decisionmaking process itself. Some of these cues will be internal, reflecting deeply held worldviews or ideologies. And some will be external, in the sense that they are associated with the information that accompanies a decision problem; for example, these cues may take the form of technical information presented by experts about problems or alternatives, or they may only become apparent in light of recent events (as the risks associated with nuclear power became much more salient after the meltdown at Japan's Fukushima Daiichi plant in 2011). From this perspective, deliberative processes convened by researchers and policymakers, be they experimental or practical, or employed by individuals or groups, have the de facto purpose of serving as engineers of judgment and decisionmaking rather than as tools for simply revealing preexisting preferences.

The implications of preference construction for decisions about an energy strategy are far-reaching. On the one hand, the constructive nature of judgments can be viewed as a "bad news" story, in that it suggests that people can be easily manipulated by interest groups or by industry. One need not look far (the protests around Canadian oil sands and the Keystone XL pipeline, for example) to see how easily and quickly public opinion and related policy preferences can be shaped by a well-organized social movement or public relations effort.

On the other hand, the constructive nature of energy strategy judgments is also very much a "good news" story. For example, the notion of constructed judgments means that decision support processes (and institutions) can be designed so that they do a better job of accounting for how information and decisionmaking strategies are used or misused during the construction of judgments. By recognizing that decisionmakers rely heavily on contextual cues that are available to them as they construct judgments, it becomes possible for analysts and facilitators to provide a defensible context or structure for decisionmaking. Indeed, it is our view that those who lead such decisionmaking processes are obligated to employ decision processes that will help people construct the highest-quality judgments possible in light of the various constraints they face, including access to high-quality information, time to think carefully and deliberate options, adequate funding, and information-processing capabilities.

Structuring decisions

If one accepts the argument that a national energy strategy is akin to a long-range investment (or in some cases, divestment) program that requires carefully constructed judgments, then a broad-based and iterative decisionmaking process will be required to engage stakeholders over an extended period.

In designing such a process, it is worth noting that many advocates of inclusivity in decisionmaking worry that too much structure will lead to biased input and will unnecessarily constrain the breadth of ideas and expertise. This is the "error of commission" argument. Although we acknowledge this concern, we argue that when incorporating stakeholder views relating to important energy choices, far more is needed than just an invitation for the interested parties to participate and share their opinions. Such an approach, typical of many public involvement processes, will have substantial shortcomings in terms of helping people to make thoughtful and defensible decisions in complex or unfamiliar contexts. This is called the "error of omission" argument. To bring this latter point to life, one need only look at the chaos and frustration accompanying the approximately 4,000 10-minute testimonies before by the Joint Review Panel that is considering (on behalf of Canada's National Energy Board) different options for transporting bitumen from the oil sands

CHARLES LEE, *Dissipative System*, Diamond ink jet print, 27 x 30 inches, 2010. Courtesy of Bios Design Collective.

in Alberta to tidewater in northwestern British Columbia (and then by ship to Asia).

Decision researchers have long demonstrated that in a variety of loosely structured situations, both individuals and groups grapple with a predictable set of difficulties when making complex decisions that are related to how information is framed and how emotions interact with, and often preempt, more in-depth analysis. One of the fundamental conclusions is that people often end up making decisions that, at best, only partially address the full range of their concerns and subsequently fail to confront required tradeoffs when evaluating competing alternatives.

These findings also suggest that along with the provision of information about the likely consequences of proposed actions, a carefully structured framework for decisionmaking is needed to help provide the necessary context needed to better understand the complex social, economic, and environmental issues that are commonplace in discussions about

energy. Such a framework is composed of six basic elements, each one supporting the others in ways that are dictated by the specific decision context. These elements serve to:

- Define clearly the decision problem that is to be the focus of analysis while taking into account the bounds and constraints under which decisions must be made.
- Identify objectives that will guide the decisionmaking process, including the performance measures that will be used to gauge success or failure in terms of meeting them.
- Create logical and creative alternatives that directly address these objectives.
- Establish the predicted consequences that are associated with alternative courses of action, including key sources of uncertainty.
- Confront inevitable tradeoffs when selecting among alternatives.
- Implement decisions, monitor outcomes (as measured by the achievement of objectives), and adapt to changing conditions.

Regional case in point

These lessons are evident in recent research in which several of us developed and tested a framework for crafting an energy strategy for Michigan State University (MSU). (For further information, see http://energytransition.msu.edu.) MSU has a cogeneration facility located on campus that converts the thermal energy from burning coal, natural gas, and biomass into electricity and steam. With a peak electrical output of 99.3 megawatts and a pressurized steam generation capacity of up to 1.3 million pounds per hour, it is the largest on-campus coal-burning power plant in the United States. The facility is the principal energy provider to the main campus and is capable of meeting approximately 97% of all electricity demand. Steam that is generated is distributed at high pressure to the campus to provide heating and cooling to a campus spread over approximately 5,000 acres.

In 2008, MSU commissioned development of a process for developing a new strategy for long-range energy generation on the campus. The goal was to transition away from a fossil fuel–based (coal and natural gas) energy strategy to one based entirely on renewables by approximately mid-century. A parallel goal was to help establish a multistakeholder decision support process that could serve as a template for similar energy strategy decisions in Michigan, elsewhere in the Unites States, and abroad.

The research team began by holding a series of meetings with university officials to define the decision problem (for example, the desire to transition from fossil fuels to renewables) and identify the boundary conditions for the decisionmaking process (for example, identifying stakeholders whose ideas would be critical to the process). We followed these meetings with several workshops and focus groups to identify the range of objectives that were important to key stakeholders on and off campus (for example, students, staff, faculty, and neighboring communities) and potential performance measures that would be useful for tracking their achievement. Through additional workshops

Opposite: Christian Kerrigan, *In the Spirit of Living*, Ink on paper, 14 x 19 inches, 2012.

and a lengthy engineering review process, we narrowed the objectives and their associated performance measures to a short list of critical considerations that would be used as part of a strategy development process cast widely across the community.

In a critical step at this stage, we created an energy system model capable of forecasting the anticipated outcomes of alternative energy strategies in terms of the key objectives and related performance measures. This model became the centerpiece of an online decision support platform that people—policymakers, experts, and the public—would use as a means of participating in the development of the energy strategy. The online platform built on recommendations from the National Research Council, issued in 2009, about how best to present information relevant to decisions about energy in a decision-focused environment. The platform was designed to engage people in the process of learning about energy systems, including their environmental, economic, and social considerations.

Beyond simply educating people, however, the decision support framework provided users with an opportunity to design their own alternative energy system. In constructing their energy system of the future, users could mix and match individual energy generation (and supporting) technologies for deployment at different times over the course of the energy strategy. The technologies for consideration included centralized power plant options (for example, coal, natural gas, biomass, or nuclear power), decentralized options (solar, natural gas, microturbines), energy from the national power grid (relying on either conventional fuels or renewables), carbon management techniques (for example, carbon capture and storage), and levels of effort expended on building efficiency. As users built their energy strategies, they were able to monitor their ability to meet future energy demand, and they could track, via the energy system model, the forecasted performance of their strategy, as measured against the agreed-on objectives and performance measures.

In addition to simply suggesting a desired energy strategy, this decision support framework also challenged users to evaluate their portfolios in comparison with a broad array of others representing markedly different priorities. In doing so, people were required to be explicit about the pros and cons of each of the energy strategy options under consideration; for example, how much additional cost were they willing to bear in exchange for reduced greenhouse gas emissions or the warm glow that comes with being at the leading edge of innovation? Conversely, to what extent were users willing to comprise on air quality or employment as a means of keeping costs near the status quo?

In order to inform these comparisons, the decision support platform included a module that helped users confront tradeoffs and make internally consistent choices (that is, choices that reflected objectives of greatest concern). We built this module, which uses tools from multicriteria decision analysis, on the notion that internally consistent choices begin by having a clear sense of how important individual objectives are to decisionmakers. With this information in hand, users could apply the energy system model and determine a rank order of energy strategy alternatives based on the degree to which each one best satisfied the most important objectives.

A scaled-down version of this decision support system is now on display at the Marian Koshland Science Museum of the National Academy of Sciences in Washington, DC. It can be used by museum visitors of all ages and all levels of education to simulate the creation of a national-level energy strategy in the United States. At the time that the MSU and Koshland frameworks were designed, they were intended for making discrete decisions required for the creation of an energy strategy. For making and revising decisions through time, users would need to revisit the decision support tool (and update the energy system model, if necessary) at various intervals during the rollout of an energy strategy. By doing so, decisionmakers could evaluate existing aspects of an energy strategy by the degree to which they still reflected the current state of the science around energy systems. And, importantly, they could evaluate an existing energy strategy by the degree to which it still reflected objectives of greatest, perhaps national, concern.

Approaching decisions about energy in this way may seem like a tall order and, worse, a recipe for making large investments (for example, in infrastructure) that cannot easily be reversed. It is true that energy strategies will require large investments of this type. But technically speaking, there are ways forward. In the case of our work with MSU, for example, energy alternatives that incorporated flexible infrastructure, such as swappable fuel power-generation units, were favored over technologies that would lock decisionmakers into a particular fuel type for decades. Practically speaking, this meant that flexibility and reversibility became high-priority objectives (trumping others related to cost, for example) in the eyes of planners and policymakers.

Another example comes from the hydroelectric utility in British Columbia, where the provincial energy strategy was designed to include regular reviews of all decisions pertaining to water releases (and, therefore, electricity generation) at hydroelectric dams. These reviews are required to ensure that energy projects remain in line with the objectives of key stakeholders and the changing state of scientific knowledge about the broader social and environmental systems in which energy infrastructure resides. In both of these cases, and in others, policymakers are also beginning to recognize that following through on sunk costs, even if devoted to projects that cannot easily be reversed or retasked, is not a sensible strategy in many energy strategy decisions, because they are irrelevant when considering the outcome that ought to matter most—namely, future benefits.

Overall, an energy strategy needs to be flexible and adaptive so that it can incorporate what is learned over time. Admittedly, however, decisionmaking over time and the adaptive demands of making a sequence of choices add additional challenges to already difficult decisions. Fortunately, the kind of decisionmaking approach we are describing provides science-based guidance, and much-needed structure, to energy strategy development that will by necessity require multiyear (or multidecade) investments.

To this end, we are currently in the process of creating an upgraded version of the MSU decision support framework for use in developing a national energy strategy in Canada. This version of the framework includes an opportunity for decisionmakers to project decisions farther into the future, taking into account the changing tenor of the energy debate in the country. Such changes may include, for example, evolving assumptions about emerging technologies and the need for infrastructure, and the national and international demand for Canadian energy resources, which may be affected by concerns about climate change, adoption of policies that put a price on carbon, or changes in policies or behavior that may affect energy recovery, processing, or use. We are also using a similar approach to lend insight to decisions about hydraulic fracturing in oil and gas development (which has cumulative effects on environmental, economic, and social systems), pipeline-permitting processes, and carbon and climate management initiatives domestically (such as carbon capture and storage or geoengineering) and in the developing world (for example, through the United Nations Collaborative Initiative on Reducing Emissions from Deforestation and Forest Degradation).

In sum, the decision support framework outlined here encapsulates the five critical decision support elements: clarifying problems, thinking clearly about objectives, designing creative alternatives, modeling consequences, and confronting tradeoffs. It works by breaking what is a very complex decision—the creation of an energy strategy—into a series of smaller, more manageable parts that are less prone to error and bias. Research conducted to evaluate this framework has shown that it leads to higher-quality decisions (measured by the degree to which users' choices are internally consistent), more-satisfied and better-educated decisionmakers, and, importantly, greater trust and transparency in the process.

The road ahead

Because of complexities associated with decisions of the type faced by policy makers and society around energy, we recommend strongly that policymakers (and researchers) turn their attention toward enhancing decision support capabilities around energy and related concerns, such as climate change. The Obama administration's creation of a climate services portal within the National Oceanic and Atmospheric Administration, as well as other independent initiatives focused on energy, are important first steps toward this goal in that they place up-to-date information about problems and opportunities in the hands of decisionmakers. However, thoughtful and defensible decisions concerning the development of energy strategies will require more than high-quality scientific information. Energy strategies, whether local, regional, or national, will also require a process for incorporating the values and risk tolerances of stakeholders and for linking values and facts as part of a series of thoughtful decisions over time and space.

In this regard, energy strategies (and the decisions that underlie them) are not vastly different from strategies that many people are familiar with and support: those relating to

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LORI NIX, *Aquarium* from *The City* series, Chromogenic archival print, 32 x 42 inches, 2007.
Courtesy of ClampArt, New York.

national defense. Strategies for national defense require investments, reinvestments, and divestments across different branches of the military. Defense strategies must also recognize the need for different investment decisions on a geographic scale, understanding that there is no one-size-fits-all approach to securing the nation. And defense strategies must be nimble in the sense that they are flexible and can shift (sometimes quickly and sometimes more slowly) in response to existing and emerging national security threats.

Likewise, the development of energy strategies will require different levels of investment in different kinds of energy-generating technologies (and perhaps in technologies for managing carbon dioxide and other greenhouse gases). In a country as large as the United States, those decisions will need to be responsive to and respectful of different needs and constraints in different geographic locations. And as boundary conditions (policies, market demands, and environmental concerns, among others) change, so too will the need for investments in different energy technologies.

Even under the best circumstances, members of the public and policymakers alike will need help in making these kinds of complex and interlocking decisions. As we have argued, decision processes are often prone to shortcuts, error, and bias. In the case of choices as important as those concerning national energy strategies, failing to address these challenges in a credible way is as irresponsible as relying on out-of-date and substandard technologies. Failing to make strides in the science and application of decision support approaches for energy development choices would be as foolish as continuing to rely on kerosene to illuminate the nation's streets and homes.

In the end, what will separate the successful actors from the unsuccessful ones in the new world energy order is the recognition that a focus on a single approach or even a bundle of approaches at a single point in time is not the answer. Moreover, successful nations will recognize that they need to go well beyond simply providing people with a menu of energy-related offerings. The real need is to provide people with a mechanism for making a series of difficult and interrelated choices among them over time. This is only way to avoid ideological stalemate. When viewed in this light, the real product of a national energy strategy is not a particular outcome. Instead, it is a sensible, credible, and defensible decisionmaking process.

Recommended reading

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