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King Abdullah Petroleum Studies and Research Center

Workshop Policy Brief

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Energy Systems Modeling Workshop

Government intervention in the micro-economy: Modeling the interventions and measuring their effects

Summary for policymakers

The challenges of energy policy are multiplying, particularly as climate change has become a feature of the discourse around the world. There is no single policy tool that addresses all elements of the energy trilemma – securing affordable, reliable, and environmentally sustainable energy. The resulting collage of often overlapping policies may yield unexpected, and potentially undesirable, results without a proper ex-ante analysis of their interactions.

Government intervention is ubiquitous in the energy landscape, including taxation, subsidization, and directly regulating market operations among others. These interventions are aimed at:

- Achieving social or political objectives, such as alleviating financial burdens on low-income households or incentivizing growth in a particular economic sector by regulating input prices.
- Mitigating the effects of externalities, such as by adopting a carbon tax or cap-and-trade system.
- Reducing the real or perceived risks of market failure.
- Controlling the presence of market power and inducing competition.

In some countries, market intervention represents the status quo leading to consideration of policies focused on transition from a centrally planned economy to more competitive markets. But such market deregulation may impact end consumers and the social compact of a nation to the point of precipitating further interventions to restore a politically acceptable balance.

Policies can achieve their intended outcomes or result in unintended consequences. For example, Independent Systems Operators in the US power market upgraded their optimization technology for clearing day-ahead electricity markets, saving millions of dollars for consumers. By contrast, US biofuel policies ran into unanticipated market conditions – declining demand for gasoline – and had to be reframed to remain viable.

The application, in a holistic, integrated framework of a range of analytical techniques may lead to better coordination among policy instruments and a better understanding of their interactions in producing policy outcomes. An example of the alternative is the uncoordinated planning and implementation of policies in the EU, which targeted a combination of carbon trading, climate, renewables and power market integration. The resulting undesirable interactions led to a rise in carbon emissions, a fall in carbon prices, which depressed "low carbon" investment, and an increase in the costs of renewable subsidies that distorted incentives to invest in capacity.

Could policy misalignments be prevented by engaging in better modeling and analysis to understand how different policies might interact? In the increasingly multidimensional policy environment, individual stakeholders that focus on only one aspect of the problem may generate misleading conclusions.

About KAPSARC

The King Abdullah Petroleum Studies and Research Center (KAPSARC) is an independent, non-profit research institution dedicated to researching energy economics, policy, technology, and the environment across all types of energy. KAPSARC's mandate is to advance the understanding of energy challenges and opportunities facing the world today and tomorrow, through unbiased, independent, and high-caliber research for the benefit of society. KAPSARC is located in Riyadh, Saudi Arabia.

Legal notice

Background to the workshop

The workshop was held in Riyadh, Saudi Arabia at the King Abdullah Petroleum Studies and Research Center (KAPSARC) on March 18 - 19, 2014. The focus was on government intervention in the micro-economy, including regulation of energy markets, sustainable technologies, case studies quantifying the impact of energy policy implementation, and climate policy.

Two key questions often raised by policymakers are:

– What are the actual impacts of policies that try to meet intended objectives?

– How can greater foresight result in policies that actually work towards achieving the intended social and economic goals?

There are a variety of analytical approaches that can be taken to address these questions including:

– Specific applications of optimization models including Linear Programming (LP), Mixed Integer Programs (MIP), and Mixed Complementary Problems (MCP);

– Systems dynamics models providing alternatives to standard optimization; and

– Econometric models for demand forecasts and assessing the role of technology learning in industrial planning.

Selection of a given methodology is based on several decision factors and desired outcomes, such as: aligning models with physical systems, reproducing market mechanisms, or incorporating stakeholder positions and their interactions within the model. Case studies of policies targeting industry, power markets, and environmental and climate change issues (including a combination of successes and unintended consequences) provide ample material to help identify key insights into what seems to have been done right and where things went wrong.

Intervention mechanisms and global experiences

The intended impact of intervention mechanisms is invariably positive but the outcomes are not. There is value in examining the lessons learned, identifying elements of success, and addressing the causes of unintended consequences. Thoughtful analysis and even models have a role in overcoming them. An example of success is the savings achieved when Independent Systems Operators in the US power market upgraded their optimization technology for clearing day-ahead electricity markets. At a more general level, government policy and planning of Chinese industries was shown to have successfully lowered energy intensity and carbon emissions (Figure 1).

In some countries market intervention represents the status quo and policies may focus on the transition from a planned economy to a more efficient competitive market. However, market deregulation can be a deeply cultural issue that directly impacts end consumers and confronts social issues within a nation. Implementing such measures so as to not degrade social welfare and prevent other rebound effects (such as public unrest) can be a key concern for policymakers. Regulations can be used to protect consumers from price fluctuations; however, these typically require a heavy regulatory and monitoring overhead.

Unintended consequences

Policy aims to achieve some desired outcome. Market experience reveals that, rather than imposing the outcome directly, market-oriented instruments can achieve outcomes indirectly. But a market may not respond to an instrument as was intended. This may result from a lack of coordinated, systems-focused planning. As a result, unintended consequences may arise and corrective actions be

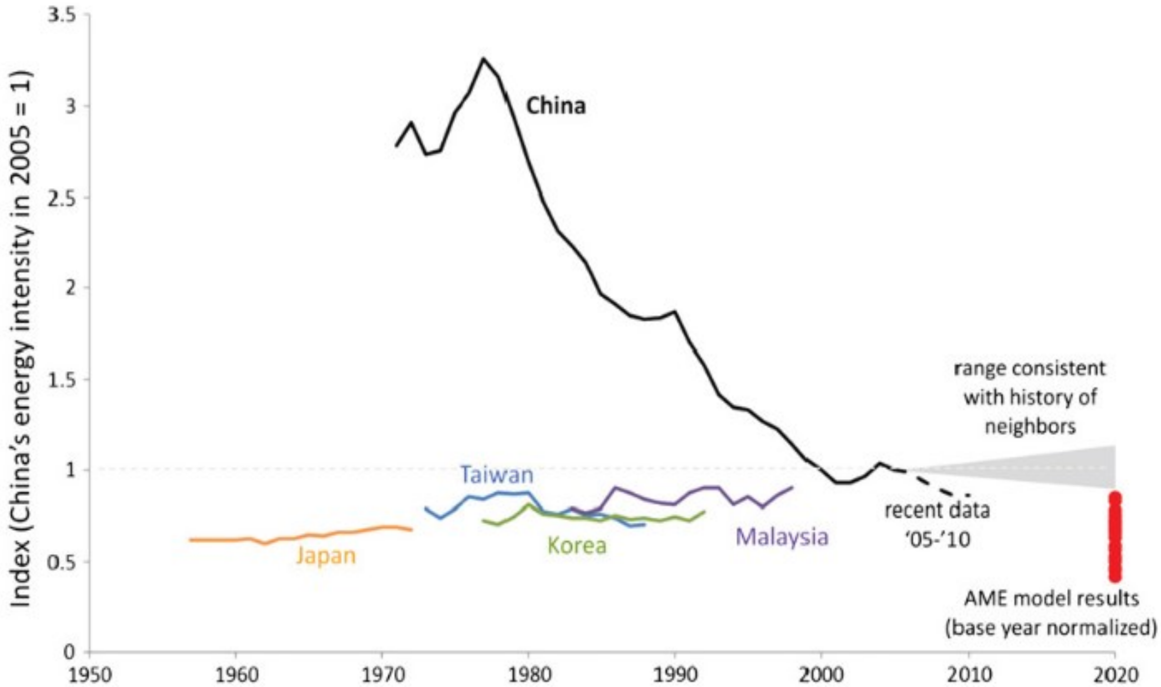

Figure 1: Energy intensity reductions driven by government policies targeting industrially planning in China. Source: Blanford, G., S. Rose and M. Tavoni 2012 "Baseline projections of energy and emissions in Asia", Energy Economics, 34-3-S284-S292

needed. The risk is that an iterative approach to policy implementation disrupts the system and may frustrate consumers and investors, potentially driving them out of the market.

One example of unintended consequences is provided by biofuel policies in the US. These do not appear to respond to market conditions. Among the policies covering this market is a requirement that the volume of biofuels to be blended with conventional fuels is mandated at an absolute level, rather than as a percentage. The policy assumed sufficiently high volumes of transportation fuel demand to blend any volume of biofuel. But there is a technical limitation on how much biofuel can be blended into a fuel without the need to modify the vehicles. In the case of gasoline, if demand decreases, this limitation (known as the blend wall, depicted in Figure 2) prevents excess ethanol production from being consumed. Unless the policy is amended, the solution lies in either increasing market demand for gasoline or making changes to existing technology (e.g., modifications to engines to accept higher percentages of ethanol). This example illustrates the danger of creating rigid policies with targets that do not respond to changing market conditions and ultimately create the need for additional intervention.

"In periods of drastic change, policy makers often dismiss model results that do not match their world view based on their past experiences"

In the EU market, unintended consequences emerging from overlapping climate and energy policies have reversed the decline in greenhouse gas emissions. Policies included:

– the European Emissions Trading Scheme (ETS);

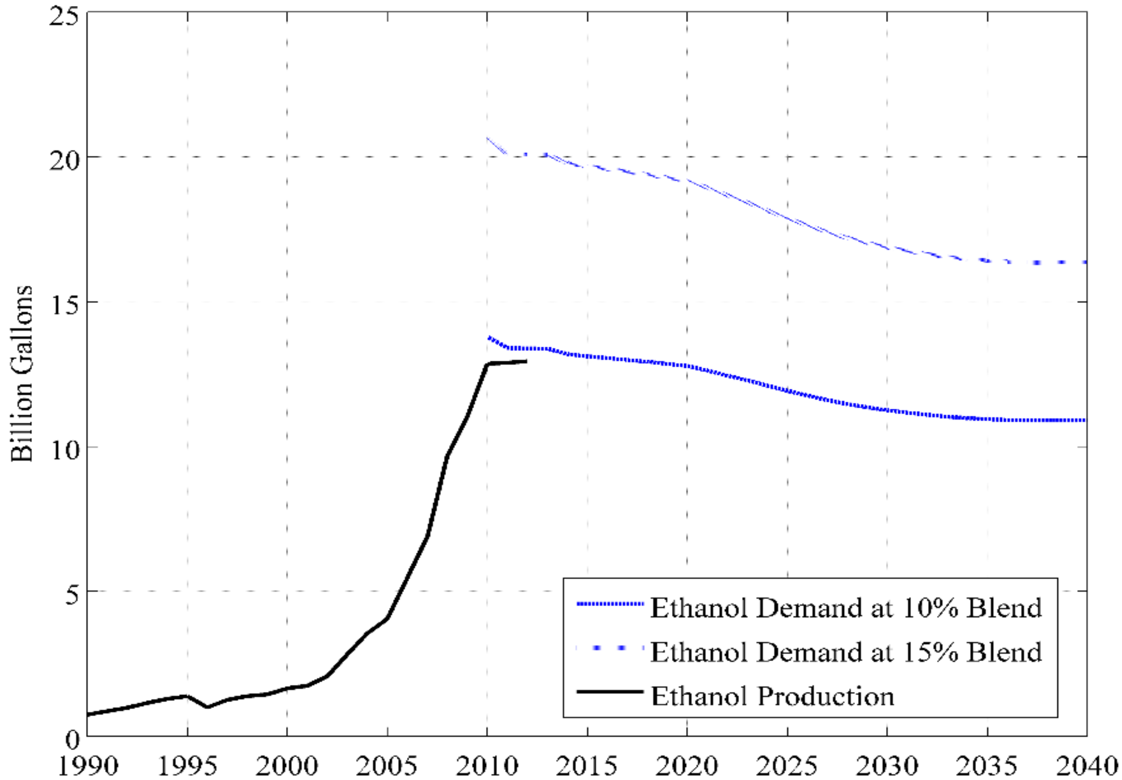

Figure 2: The blend wall impedes the production volume target set for the US biofuel market. (Courtesy Adam Christensen)

– 20/20/20 package targeting emissions, efficiency, and renewable power; and

– the 2050 de-carbonization plan.

These were implemented during the restructuring of gas and electricity through the Internal Energy Market plan. One of the greatest challenges in coordinating these objectives was the absence of a central government in the EU. Instead an approach was adopted based on a political strategy where member states had the flexibility to select and design the instruments used to achieve national targets.

These policies were designed to foster competitive generation markets and reduce carbon emissions in the EU. However, the outcomes of these policies have been large financial losses for utilities, very high electricity prices, and an increase in carbon emissions resulting from coal displacing natural gas. Another unintended consequence is that the ETS did not send a strong price signal to promote investment in low carbon technologies, since over-allocation of permits by member states, emission reductions caused by other policies, and the global recession, combined to drive down carbon prices.

In the case of renewables policies, several EU member countries pursued a subsidized “learn by building” approach to wind and solar that proved to be more costly than anticipated. The policies distorted incentives to invest in integrated electricity markets and instead resulted in a hyper-competitive internal electricity market that forced fuel-efficient conventional plants into early retirement. Two different hidden subsidies exacerbated this: priority of dispatch, which favored intermittent, non-dispatchable generators while pushing out conventional plants; and an obligation to purchase. Feed-in tariffs incentivize intermittent producers to sell power even if the price drops below zero. These producers are paid while other producers have to pay to deliver electricity. As a consequence, conventional plants pay the price for supporting renewables and some now receive subsidies to ensure they stay online to provide the needed system reliability. Another undesired effect has been a move to cheaper and more-carbon-emitting coal-fired generating plants. These unintended effects had been identified by models, but had been dismissed by policy makers because such outcomes had never happened before.

For the European Commission, planning in an uncoordinated way did not achieve the gains expected from competition, while gains from direct regulation were lost. EU policy design failures could have been revealed through better integration of modeling tools that were already in existence within the Commission. Models that take a systems view of the economy arguably provide an important analytical tool for the difficult planning of cost effective subsidies.

Transparency and independence in modeling

With the increasingly complex, interconnected policy environment, how an organization positions itself with respect to transparency and independence plays an important role when building and executing a policy model. The US Energy Information Agency (EIA) positions itself as independent (by statute), focusing on policy neutral modeling for its annual report while having the capability to do detailed policy modeling for the administration and legislature. To protect its independence, the EIA provides extensive documentation of its models and assumptions used in its reports in a transparent manner.

By contrast, there remains a lack of documentation and information on the planning models used by the EU Energy Directorate. The European Commission invests less on model documentation than the EIA, creating a more opaque view of the assumptions behind its models. Extracting a clear message from the model output, for achieving better market coordination, is correspondingly difficult.

> ***“It is incumbent on modelers to achieve transparency, and it is naïve to assume a transparent model holds less power”***

The counterpoint is that the opaqueness around the Commission’s planning models allows transmission of various politically agreeable messages to the various member states. Such an approach may obscure the consequences of a policy. Intentional ambiguity within the political environment may sometimes facilitate agreement by allowing all parties to take something positive out of the negotiation.

From the perspective of the modeler, the political process may be to blame for poor policy design rather than the model. The political environment can limit transparency, adding to the already difficult task of communicating model results and offering policy insights.

> ***“There is a thin line between being policy-neutral and policy-relevant”***

There is a tradeoff between policy staff and modelers enjoying a close relationship that enhances effectiveness and the lack of transparency that may lead to informational imbalances among those participating in the policy process. Experience shows that transparent models and clear documentation of assumptions create trust, communicate better insights, and lead to more successful policies in terms of meeting expected outcomes. This transparency leads to greater confidence among all parties involved in setting the policy agenda. It is naïve to assume that withholding information increases power for any individual constituency beyond the very short term.

Independence also takes time to establish. An organization can act independently and establish protocols to ensure independence; however, a more direct measure of independence comes from stakeholder feedback. Feedback from multiple constituents can act as a barometer of a model's independence. But an organization with too much independence runs the risk of becoming irrelevant.

For organizations with a more transparent approach to modeling, a community of modelers can help improve coordination of overlapping effort. For example, Saudi Arabia's Electricity and Cogeneration Regulatory Authority (ECRA) created a forum where knowledge is shared and disseminated on a formal basis – a multi-stakeholder study on the Saudi energy economy. Within these forums, coordination between modelers, companies, and regulators that influence the energy landscape improved the local understanding of the energy sector. The KAPSARC Energy Model (KEM) is an example of a model designed to capture the physical and market conditions specific to a country. The model was formulated as an MCP in order to represent administered prices and fuel allocations within Saudi Arabia's energy sectors. The results from KEM clarify possible policy options that would reduce growth of internal primary energy demand . It provides insights into the initial steps for reducing total energy costs in the Saudi economy, while still satisfying current social goals.

Conclusion

Focusing on the subject of market regulation, KAPSARC's workshop on energy systems modeling highlighted the tradeoffs and issues spanning regulation of energy markets, implementing sustainable technologies, and quantifying the impact of energy and climate policy implementation.

Governments often intervene to achieve social or political goals, mitigate the effects of externalities, reduce the risk of market failure, or control the presence of market power. In some countries, market intervention represents the status quo and policies may be focused on transition from a planned economy to more competitive markets. But market deregulation may impact end consumers and the social compact of a nation.

Careful implementation of policy measures is advisable to maintain social welfare and prevent unintended consequences, such as public unrest, if intervention is to provide sustainable results. This can be achieved by taking a broad view that incorporates majorly impacted sectors, improving coordination among government entities, and taking advantage of existing policy modeling tools to identify what the effects will be ex-ante rather than requiring repeated and contentious post mortems.

About the workshop

The workshop, held in March 2014 with some 40 participants to discuss energy systems modeling. Participants included:

Nourah Al-Yousef – Associate Professor, King Saud University

Mohammad Alenezi – Director, Kuwait Institute for Scientific Research (KISR)

Anas Alfaris – Assistant Professor, King Abdulaziz City for Science & Technology (KACST)

Jarullah Algahtani – Engineer, Saline Water Conversion Corporation (SWCC)

Ahmed Al-Osaimi – Director General Consulting Department, Kingdom of Saudi Arabia Supreme Economic Council

Ayed Al-Qahtani – Senior Planning/ Analyst Consultant, Saudi Aramco

Nasser Al-Qahtani – Vice Governor, Electricity & Co-generation Regulatory Authority (ECRA)

Ahmed Alzaid – Economic Specialist, Saudi Arabian Monetary Agency (SAMA)

Atul Arya – Senior Vice President, IHS

Robert Brooks – President, RBAC Inc.

Adam Christensen – NSF SEES Fellow, Johns Hopkins University

Carol Dahl – Professor, Colorado School of Mines

David Daniels – Chief Energy Modeler, Energy Information Administration (EIA)

Brian Efird – Research Fellow, KAPSARC

Andreas Ehrenmann – Chief Analyst, GDF Suez, Center of Expertise in Economic Modeling and Studies (CEEMS)

Robert Flaechsig – Economic Advisor, Private Office of HRH Price Abdulilah Bin Abdulaziz Al-Saud

Philipp Galkin – Research Associate, KAPSARC

Waleed Gowharji – Research Associate, Center for Complex Engineering Systems (CCES)

Fatemah Hasan – Princess Noura Bint Abdulrahman University (PNU)

David Hobbs – Head of Research, KAPSARC

Marcus Huebel – Director, Saudi Basic Industries Corporation (SABIC)

Fred Joutz – Senior Research Fellow, KAPSARC

Amit Kanudia – Energy Modeling Researcher and Consultant, KanORS

Walid O. Matar – Research Associate, KAPSARC

Charles Meade – Visiting Investigator, Carnegie Institution of Washington

Fred Murphy – Senior Visiting Fellow, KAPSARC (and Prof. Emeritus, Temple University)

Richard P. O'Neill – Chief Economic Advisor, Federal Energy Regulatory Commission (FERC)

Axel Pierru – Senior Research Fellow, KAPSARC

Bertrand Rioux – Research Associate, KAPSARC

Muhammad Saggaf – President, KAPSARC

Ahmed Salah – Deputy Minister for Economic Affairs, Ministry of Economy and Planning

Christopher Segar – Regional Programme Manager, International Energy Agency (IEA)

Yves Smeers – Professor, Université Catholique de Louvain (UCL)

Massimo Tavoni – Associate Professor, Fondazione Eni Enrico Mattei (FEEM)

Michael Toman – Lead Economist on Climate Change, World Bank

Sonia Yeh – Research Scientist, Institute of Transportation Studies

About the authors

Walid Matar is a Research Associate developing energy systems models. He holds a B.Sc. in Mechanical Engineering from the University of South Carolina.

Frederick Murphy is a Senior Visiting Fellow collaborating with the energy systems modeling team at KAPSARC. He has worked at the Energy Information Administration (EIA).

Axel Pierru is Program Director, Economic Modeling and Analytics and a Senior Research Fellow. Axel holds a Ph.D in Economics from Pantheon-Sorbonne University in Paris.

Bertrand Williams-Rioux is a Research Associate developing energy systems models. He completed a Master's thesis in Computational Fluid Dynamics at KAUST.

David Wogan is a Senior Research Analyst developing energy systems models. He holds Masters Degrees in Mechanical Engineering and Public Affairs from UT Austin.