KAPSARC
مركز الملك عبدالله للدراسات والبحوث البترولية
King Abdullah Petroleum Studies and Research Center

Workshop Policy Brief

October 2014 KS-1408-WB06A

Drawing from the best: Approaches to modeling China's energy economy

Summary

KAPSARC and the US EIA jointly convened a working group meeting on June 3, 2014 in Beijing on modeling the Chinese energy economy. This introduced the different models and methods currently being pursued by different stakeholders and so facilitate collaboration in a highly technical and demanding research space. Understanding the Chinese energy economy is of great importance to policy makers inside and outside China.

All the models presented could be used as tools for analyzing the effects of various policy options. Yet all took different approaches to look at different aspects of China's increasingly complex whole. The various experiences of the participants can help improve both the capability and accessibility of technical economic models. At the heart of the discussions was an attempt to support China's continued development and economic transition and to make the process and consequences more understandable to those outside its borders.

The following three desirable trends were identified:

- Maintaining local detail while expanding model scope;
- Integration of energy models with macroeconomic models; and
- Making policies integral to models.

Three associated challenges were also identified as requiring further work:

- Predictability and consistency of future policies;
- Data quality: availability and consistency; and
- Post-solution analysis.

This working group meeting brief elaborates on the six themes. Summaries of the contributions of the working group participants can be accessed at www.kapsarc.org.

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 joint KAPSARC-EIA June 2014 working group meeting was attended by fourteen leading Chinese energy modelers drawn from industry, the Government, and Beijing-based universities. The objective was to:

- showcase a range of activities already undertaken;
- discuss different methodological approaches; and
- facilitate discussion and collaboration opportunities among China energy modelers and subject matter experts.

KAPSARC's China Research Program is founded in the belief that a robust understanding of China's energy economy can only be gained by understanding properly both the economic fundamentals and the policy environment. KAPSARC's research activities, including developing an economic model of the Chinese energy system, target both.

Understanding the moving parts of China's energy economy has become increasingly important as China's economy has grown to overtake Germany's (in 2007), Japan's (in 2010), and is expected to overtake the USA's within the next ten years (or perhaps already has, based on measures of purchasing power parity.) As its economy has grown, so has China's energy consumption. It is now the world's largest importer of oil and consumer of energy. The diversity of its geography and its economy, combined with developmental gaps between the economic powerhouses of Beijing, Shanghai, and Shenzhen, and the country's less-developed regions, all contribute to a highly complex energy economy.

China's domestic energy consumption now has a global reach and the external consequences of Chinese internal energy policy decisions may be profound. Governments, universities, research institutions, and industry (both inside and outside China) are all interested in trying to understand the current (fast changing) energy landscape and possible consequences for the future.

It is KAPSARC's intention to help in this endeavor and to pursue modeling insights of benefit to both modelers and policy-makers relying on the model outputs.

Emerging and desirable modeling trends

As computing power and data availability have improved, so too has the scope and power of models also expanded. If, before, only simple national models could be built, now there is increasingly space for models which take account of regional and economic complexity. Energy balances need no longer be kept in isolation from the rest of the economy. The role of policies, long recognized, is also now being seen as an important component of energy models.

Maintaining local detail while expanding model scope

Given the size of China's energy sector, its regional energy supply and demand diversity, even its geographically varied pollution patterns, it is important to capture provincial (or regional) specifics and inter-provincial transfers in the process of model development. National averages cannot be properly understood without a grasp of local specifics, but local developments cannot be properly interpreted except in the light of the national picture. Together, each informs the understanding of the other. If either is lacking, interpretation becomes much harder.

Detail is an intrinsic attribute of a bottom-up model and this desirable attribute should be maintained even as the model's scope expands to incorporate the entire country. To realize their full power and potential, top-down models benefit from evolving beyond broad-brush national models to incorporate

more and more local detail. The ability of top-down approaches to model macroeconomic interactions is very useful, but without the technological, geographic and other details inherent in a bottom-up model, their use in understanding China may be limited. Adopting a hybrid approach, integrating bottom-up models in larger top-down national models, yields greater insight than either approach individually.

Integration of energy models with macroeconomic models

In a similar vein, energy is both a driver and a consequence of other economic factors. Macroeconomic issues affecting both the supply and demand of energy include income level, sectoral, provincial and national GDP, and inflation. The changing nature of China's rapid growth gives them an especial importance; for example, switching from investment to consumption driven economic growth may affect the relative increases in demand for gasoline and diesel.

Moreover, limiting the macroeconomic inputs into energy models to just the local economy may not yield the most useful results. China's deep integration into the global economy means that understanding what is happening in overseas markets can be of great importance in correctly modeling its domestic energy economy. It will no longer be viable to treat what is going on in the rest of the world as exogenous to a model of the Chinese energy economy any more than treating China as exogenous to a global energy model.

Making policies integral to models

Despite recent liberalization, China's energy sector remains heavily regulated. Government ownership and development policies mean that even where prices are market driven, the market itself is not necessarily free. Policymakers view the energy industry as a cornerstone of the country's sustained economic development and the sector's future direction is likely to be influenced by more than just energy economics. Models that reflect an understanding of China's wider energy policies (energy security, affordability and environmental protection, among the competing priorities that exercise policymakers) will more likely be truly useful.

The value of understanding the consequences of policies (and of government thinking more generally) extends beyond top-level national strategic plans all the way to locale or sector specific concerns. For example, the gas pipeline network is, at present, 70% owned by CNPC. Expanding the network will require significant capital investment but for uncertain returns. Nevertheless, the official government stance is that pipelines will be built where supply and demand suggest they are necessary, even if this would implicitly require leveraging the existing network. The reality on the ground presents a challenge in reconciling such conflicting views in a model.

Modeling challenges and avenues for further effort

Despite these advances and emerging trends in modeling efforts, challenges remain. All agree incorporating policies into energy models improves their usefulness, but their incorporation is not straightforward. Despite the growing abundance of data and the established role of official datasets within China, data quality can still be limiting. Combined, these lead to a third challenge: interpreting model outputs.

Predictability and consistency of future policies

Incorporating future policy presents a major challenge for modelers generally but the problem is particularly acute in the case of China's energy sector, both conceptually and technically. First, there is no general consensus among energy experts on the

government's current prioritization of energy policies. Second, as China's energy sector and society develop, these priorities and associated policy initiatives can change quickly. Third, not all stakeholders agree with the policies promulgated by Beijing; there can be considerable difference between national edicts and local implementation. The simplifying assumption that rules are followed and profits are maximized may not be appropriate.

How these conceptual complications are actually modeled represents a series of technical challenges. The different modeling approaches and uses to which each model is put require individually bespoke solutions. Nonetheless, within this paradigm, collaboration and frequent idea-sharing can help develop a consensus among researchers which in turn can bolster the conceptual and technical rigor.

Data quality: availability and consistency

Data limitations are a recurrent problem in China. The data required for complex and detailed models can variously be considered as state secrets, inconsistent, or just missing. Great improvements have been made in data quality over recent years, but problems remain. When starting any analysis of China, the first point of reference is obviously the official data released by such government agencies as the National Bureau of Statistics. Other state agencies, both central and provincial, along with industrial players, can also be sources of recognized and accepted data. Where such sources remain insufficient it is useful to build new datasets with very clear assumptions and rooted in official publications.

One approach is to use appropriate analogues based on a proper understanding of the economy and industry. Verified and reliable data taken from particular sectors or regions can be extrapolated to cover other sectors and regions. This approach has worked well for China's coal mining industry. With over 18,000 coal mines in China, few research endeavors have the time and resources to accurately map each one. Instead an aggregation and extrapolation method has been adopted, classifying mines by technology, coal type, and geographic location, etc.

An alternative approach is to base the model's major inputs on validated national level data and add local detail as it becomes available. Until such local detail is available, the national averages must be applied to the regions, for instance using load curves provided by the grid companies for power demand inputs. While these may initially lead to regional misrepresentations, they still allow incremental progress. Identifying the gaps between model outputs and observed reality allows one to gain an understanding of the shortfalls in both the model and the data.

Regardless of the approach taken, modelers both inside and outside China do well to consider the intended audience when moving beyond the official data sources. Assumptions and extrapolations which may be sufficient for analyses presented to private or foreign institutions may fail to pass muster with government or state organizations within China.

Post-solution analysis

Model outputs cannot be treated as forecasts without detailed interpretation. In addition to assessing whether or not the outputs are correct (in the sense of aligned with reality), modelers also need to understand why the model gives the outputs it does. Decisions made in scope and structure, as well as what data to incorporate, can lead to model artefacts.

Post-solution analysis provides insight into the system being modeled and improves the model itself. Economic rationale may not be the only or, indeed, the most important consideration for Chinese policymakers. As a simple example, power models based on costs of dispatch alone would suggest that

coal stations should be prioritized above all other fuels (as was largely the case in the decade following WTO accession). In reality, CCGT and renewables have been pursued with increasing vigor as politicians try to tackle the problems of pollution.

Way forward

Model descriptions for all the models presented during the working group can be viewed and downloaded from the KAPSARC website http://www.kapsarc.org under "Publications" Despite the different agencies involved and the different reasons for their research, there is a clear set of common goals and challenges. Through these it is possible to identify opportunities for improvements and the best scope for collaboration.

The issues presented here can be superficially viewed as both obvious and extremely difficult to put into practice. More detail is always going to be preferable to less. Energy systems will always be better understood when placed in their macroeconomic context. Models that can account for the impacts of policy are always better than those that cannot.

However, the question of how to get and incorporate the detail and how to incorporate energy, macroeconomics and policy into a single model is much less obvious. The value of collaboration lies in finding solutions to these challenges: the objective of convening the working group in the first place. In the future, KAPSARC and the EIA hope to cast more light on what works and what does not in order to advance the goal of understanding the impacts of Chinese policy on its own markets and thence, global energy markets.

About the workshop

KAPSARC and the EIA jointly convened a workshop in June 2014 with fourteen Chinese modeling experts to facilitate a dialogue on the current trends and challenges in modeling China's Energy Economy, a core part of KAPSARC's own China Research Program. The workshop was held under the Chatham House Rule or capturing the discussion under a non-attribution basis.

Participants submitted a two page template describing their own model's scope and major features. These can be viewed and downloaded from the KAPSARC website http://www.kapsarc.org under "Publications" Participants comprised:

Axel Pierru, Research Fellow, KAPSARC

Ayaka Jones, Energy Information Administration, U.S. Department of Energy

Bertrand Rioux, Senior Research Analyst, KAPSARC

Brian Efird, Research Fellow, KAPSARC

Dong Zhenyu, CNPC Economics and Technology Research Institute

Fan Ying, Institute of Policy and Management, Chinese Academy of Science

Leo Lester, Research Fellow, KAPSARC

Li Jifeng, State Information Center

Li Taoya, State Information Center

Philipp Galkin, Senior Research Associate, KAPSARC

Shan Weiguo, CNPC Economics and Technology Research Institute

Sonia Yeh, Institute of Transportation Studies, University of California, Davis

Wang Haibo, CNPC Economics and Technology Research Institute

Wang Tao, Carnegie-Tsinghua

Wang Yanjia, Tsinghua University

Yang Xiaofan, Tsinghua University

Yang Yufeng, Energy Research Institute, National Development and Reform Commission

Zhang Bo, Energy Research Institute, National Development and Reform Commission

Zhang Yaxiong, State Information Center

Zhou Xizhou, IHS

Zou Lele, CEEP Multi-Regional Energy-Environment-Economy, Institute of Policy and Management, Chinese Academy of Science

About the team

Brian Efird PhD is a Research Fellow and Program Director for Policy and Decision Sciences at KAPSARC leading teams on China, Transportation, Demography, and Bargaining Models.

Philipp Galkin is a Senior Research Associate specializing in economic and policy analysis. He holds a PhD in International Economic Relations and an MBA.

Leo Lester is a Research Fellow leading the China Research Program. Formally a macroeconomist and China specialist, he has a PhD and is a CFA and FRM.

Axel Pierru is a Research Fellow, leading KAPSARC's energy systems modeling work. He holds a PhD in economics from Pantheon-Sorbonne University

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