KAPSARC Energy Workshop Series

Models for the economies and energy systems of GCC countries: Current development and a path forward

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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

Summary for policymakers

Members of the Gulf Cooperation Council (GCC) play a key role in the global energy system. Collectively, in 2014 the six countries supplied the global market with over 28 million barrels of oil equivalent per day of oil and natural gas. They also hold approximately 30% of global proven oil reserves, according to the 2014 BP Statistical Review. The oil and natural gas sector dominates local economic activity, constituting 44% of the region's gross domestic product and 82% of government revenues in 2013. Beyond the upstream sector, a substantial share of the non-oil exports are still derived from crude oil and natural gas; the region is a large exporter of refined products and petrochemicals. Additionally, public government expenditure has been the main driver of infrastructure and services development in recent years. Thus, the activity of oil and gas production permeates almost the entire economy. The high dependence on hydrocarbon export revenues has placed economic diversification among the key issues for local policymakers.

Also, the region has experienced significant economic growth throughout most of the last decade, driven by the rise in oil prices. High oil revenues have allowed for an increase in public investment, and for local governments to bear the costs of providing inexpensive fuel and electricity to consumers. For the most part, households and local industries enjoy a set of administered energy prices that are well below global market values. These prices, which are intended to catalyze industrialization and achieve social objectives, have economy-wide ramifications. Economic growth and low energy prices have contributed to a rapid increase in domestic energy use. Some of the solutions proposed by policymakers to curb regional oil and gas consumption have included the adoption of alternative power generation technologies and enforcing higher efficiency standards.

In recent years, models have been built for individual countries within the GCC to assess how sectors in an economy interact by characterizing the operational and investment decisions in the energy system. These models are diverse in methodology and the resolution at which the economy is represented; some take a partial view of the economy while others find an economy-wide general equilibrium.

Although the members of the GCC share the challenges and opportunities of hydrocarbon-driven economies and face similar development issues, no model has been built for the aggregate GCC energy economy. Initiatives that propose a shared energy infrastructure (regional gas and electricity grids) may not have been able to assess the costs and benefits at the level of the aggregate economy of the region. However integrated, shared infrastructure requires at least three layers of foundation to succeed:

- Common definitions and transparent sharing of data
- Consistent and, ideally, integrated models of the member country energy economies
- Consistent and harmonized regulatory regimes that do not create exploitable arbitrages

KAPSARC's research is seeking to drive the first pre-requisite by building models of the energy economies of the GCC members in partnership with local think tanks and research institutions. Calibration of these models will expose differences in data definitions and availability that can be harmonized before proposing policies that optimize the benefits of shared infrastructure.

Background to the workshop

Models are designed to measure the implications of policies and help inform decision makers. As part of the KAPSARC Energy Workshop Series on energy modeling, KAPSARC hosted a workshop in March 2015 to discuss existing models and initiatives for the GCC countries. The event brought together modelers, economists, and users of models to encourage further discussion and cooperation among local institutions. Participants discussed the ways current models are used and how they aim to characterize the particular economic features of the region.

The objectives of the workshop were to discuss:

- the unique features of domestic energy markets in the GCC region and how they are – or may be – incorporated into current models
- the potential value of establishing an integrated model for the Gulf countries and forming a regional network of modelers and economists
- the steps that could be taken in the region to develop modeling capacity that is relevant for informing domestic policies

Addressing the unique features of the GCC economies in models

GCC countries exhibit unique socio-economic attributes that should be considered in any regional modeling effort. One such attribute is the demographic structure. Around half of the region's population is composed of expatriates, whose migration is correlated with economic activity; Figure 1 illustrates this relationship for Kuwait. By making a distinction between national citizens and expatriates in the workforce and in the make-up of households, a model would consider aspects such as the evolution of the population as a result of economic activity. Energy models typically treat population growth projections that factor in these migration dynamics as an exogenous input.

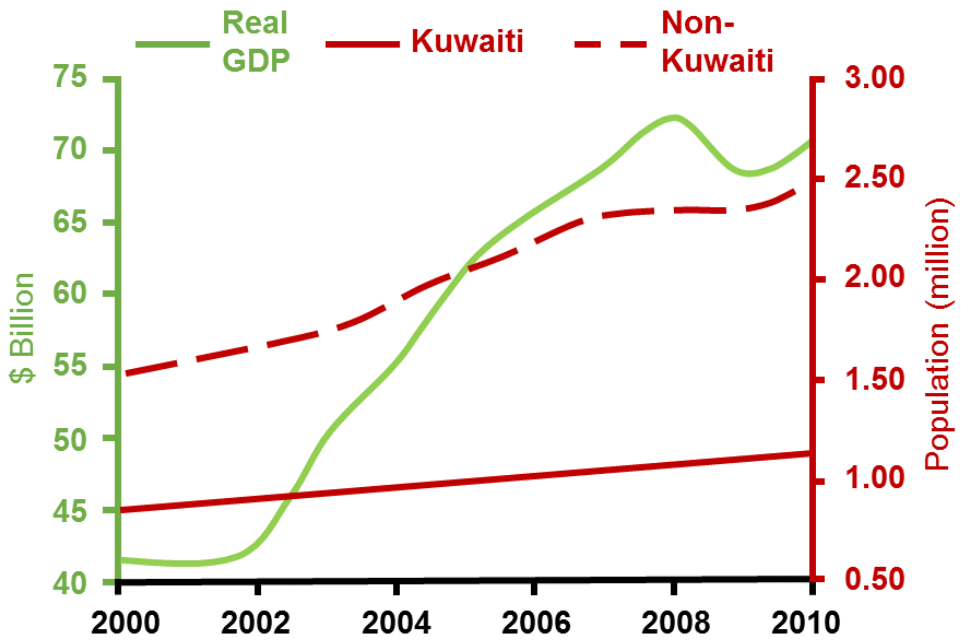

Figure 1: The expatriate population and real GDP in Kuwait
Sources: Kuwait Institute for Scientific Research

General equilibrium models represent a region's entire economy. When designing such a platform for the GCC, it is important to distinguish not only between the skill levels of employees in the labor market, but also to make the distinction between domestic and expatriate households. According to Naufal and Genc (2014), the outflow of remittances from the GCC region reached 75 billion USD in 2012. Jointly, the region surpasses the United States as the leader in this metric, notwithstanding that the population of the US is more than six times greater than that of the GCC countries. Figures published by SAMA (2014) show that remittances from Saudi Arabia alone totaled more than 34 billion USD in 2013; this was around 4.5% of the GDP for that year. In this respect, if the level of household income varies as a result of a policy change, the behavioral response of both types of households would likely be different.

We need to be careful about applying CGE models developed for other regions that may not incorporate different distortions in the labor and capital markets.

Administered electricity prices in the region have often been below the cost of generation and distribution. Historically, these prices have been low and experienced only minor fluctuations. This means there is little empirical evidence from which to assess how households might react to significant price changes. Even if time series data were available to produce some estimates of demand price elasticities around the historical levels, the figures would likely not be useful to predict the consumers' response at a significantly higher level of prices. Care is needed in parameterizing regional models with these elasticities, and sensitivity analyses are required so as to avoid risking policies that dramatically misestimate demand responsiveness to price change.

The distinction of household types is additionally required when representing end-use energy prices. In the UAE and Qatar, electricity tariffs are lower for citizens, who constitute a minority share of the countries' total populations. A deregulation of electricity prices in some member countries may not drastically raise the overall average tariff paid for electricity.

It is dangerous to assume that the price elasticity of energy demand in the region is low.

By contrast, the prices paid for liquid fuels are essentially the same for the entire population of individual countries, but due to lack of coordination among the countries, unintended consequences of pricing policies may be distorting the energy consumption picture. Figure 2 shows the current end-use gasoline and diesel prices in the region. Alyousef and Stevens (2011) have reported that due to these price discrepancies, as much as 10% of the domestic fuel consumption attributed to Saudi Arabia comes in the form of illegal smuggling across its borders.

Models characterizing the GCC energy system

Models are typically customized to provide insight on a specific issue, so it is natural that existing platforms are diverse in methodology and function. The use of models that reflect different levels of geographical resolution, and scope of the sectors covered, has prevented the integration of an internally consistent set of models of the entire GCC. Some existing models are designed to study policies within a partial view of the economy, while others have adopted general equilibrium frameworks.

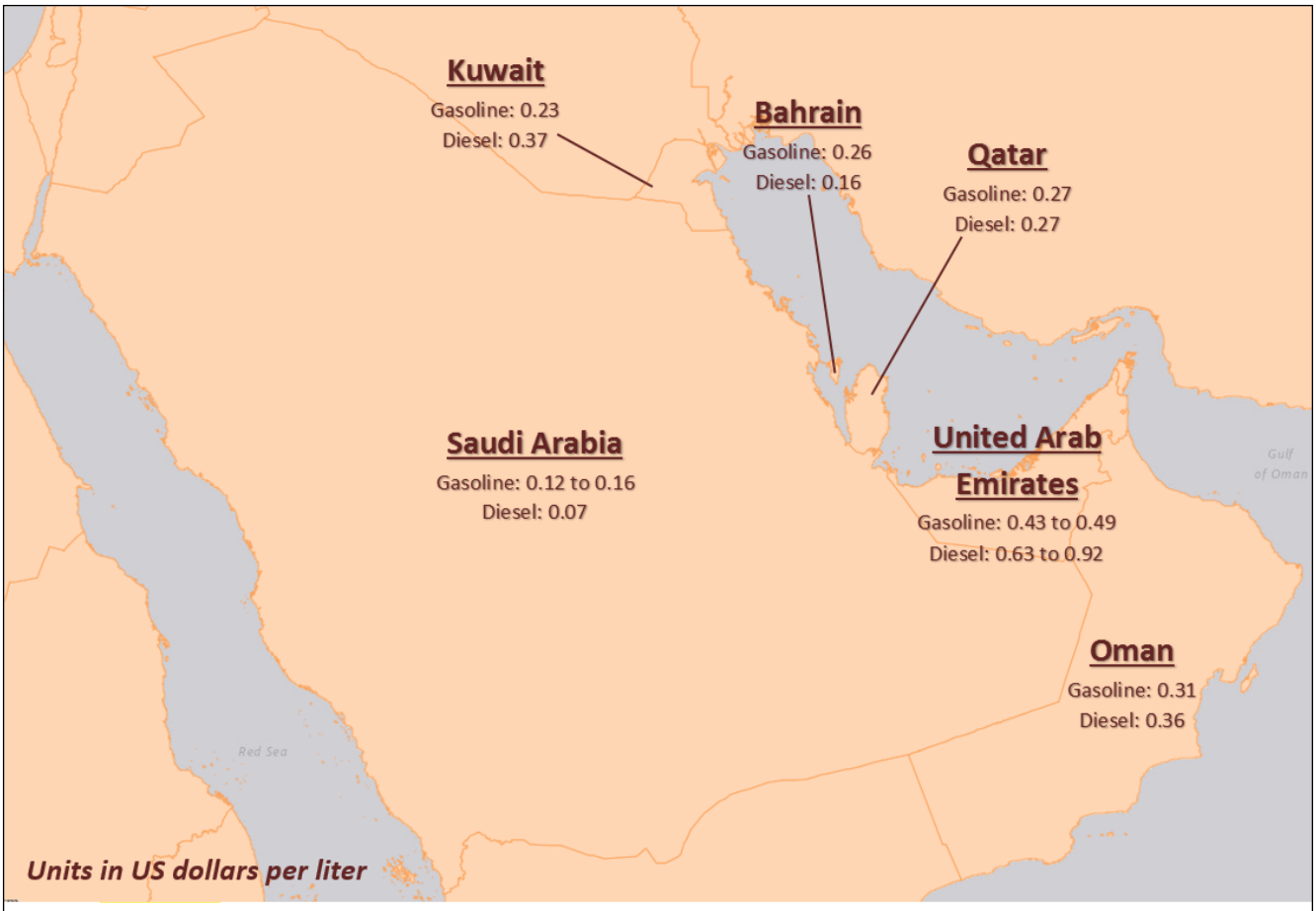

Figure 2: Transportation fuel prices in GCC countries (Image adapted from ArcGIS)
Source: UAE Ministry of Energy, KAPSARC analysis, Global Petrol Prices database

Macroeconometric methods are used within the region to inform fiscal policy. Such approaches are well-suited for providing short-term forecasts of economic activity. Purely econometric models are, by their nature, estimated using historical information. They also do not possess a fine representation of technology in industrial production. For these reasons, they are not typically used to examine the impact of policies that may alter the economic structure.

Optimization techniques model the decisions made by economic actors in response to a policy change or economic circumstances. Using these techniques would also be consistent with how industrial firms make planning decisions. Thus, optimization is the methodology of choice for most models addressing policy change. Optimization models have been built for the different countries of the GCC. An example of one such platform has been developed by the Kuwait Institute for Scientific Research and builds on TIMES/MARKAL to make energy consumption and emissions projections for Kuwait.

The Kuwait Energy System Model deploys a bottom-up approach to represent energy supply and conversion sectors. It takes a holistic view of the domestic energy system, from the production and import of hydrocarbons to end-use demands by households, industry, and commercial buildings. The model has been used as a planning tool for power generation capacity expansion and projecting fuel consumption in Kuwait.

More recently built models have also been designed to examine regional administered prices. While these pricing schemes are present at all consumption levels, pricing reform has typically not been contemplated at the residential consumer level but is considered tenable in the industrial sectors. Analyses suggest that industry can significantly reduce its energy consumption without significantly harming its competitiveness. This may also be viewed as a first step of creating a more efficient energy economy. In Saudi Arabia, for example, the administered prices for industrial consumers are aimed to encourage economic diversification. These prices, however, have generated inefficiencies in the domestic energy system. With the aim of exploring policies that simultaneously maintain social objectives and increase efficiency, policy assessments are being conducted using the KAPSARC Energy Model (KEM) for Saudi Arabia.

In the same vein, the integration of renewable and nuclear technologies into the local power generation mix has garnered significant interest. Fuel prices at their current levels make price-induced investment in these technologies infeasible. KEM has been applied to help formulate pricing and investment policies that facilitate the transition into alternative technologies in Saudi Arabia.

For Abu Dhabi, where citizens pay a lower electricity tariff than expatriate households, a general equilibrium model has been developed to include six labor types, three types of households, and a more explicit representation of energy commodities. The household types consist of nationals, expatriates who live in single-family residences, and expatriates living in collective housing units. The labor classification consists of three skill levels for nationals and expatriates. It has been used by the Abu Dhabi Council for Economic Development to study the effects of gradually deregulating end-use prices, introducing nuclear power generation, and adopting higher energy efficiency.

Potential for collaboration and advancing the current state of regional models

While models have been developed for individual countries and sub-regions within the GCC, there has yet to be success at integrating all six member countries. Such an effort would help design energy policies that improve coordination among the countries and their industrial sectors. A concrete example of such potential coordination deals with the integration of the GCC power transmission system. There are several layers of foundational collaboration required before there is a likelihood of shared infrastructure in the GCC proving successful. These include common definitions and transparent sharing of data, consistent and, ideally, integrated models of the member country energy economies, and better harmonized regulatory regimes that do not create exploitable arbitrages.

KAPSARC proposes establishing a forum for modelers and economists in the region. An example paradigm is that of the Energy Modeling Forum (established by Stanford University), which serves as a platform that brings together experts to study specific policies and share model-based insights. If the models arrive at different conclusions, the dialogue allows the community to better understand the structural or input reasons for the discrepancy. This exchange of ideas and experiences also facilitates modeling advancements as the participants learn from one another.

To this end, and based on the already established structure of KEM, KAPSARC is preparing to expand the modeling framework to be used for other GCC countries.

Data collection and surveys have improved in recent years, but more work is required to develop the data needed to populate the energy systems models. This

is especially true when it comes to end-use surveys. For the most part, the GCC countries do not have detailed information on how and when households use their lighting or appliances over time. However this is beginning to change. For example, in Saudi Arabia, the Electricity & Co-generation Regulatory Authority and the Saudi Electricity Company have an ongoing survey effort to collect household time-use data.

A reliable understanding of the region's energy sector, without the underpinning of good quality data, is simply not available.

GCC-STAT has been formed recently by the GCC to consolidate data on key economic indicators published by the countries' statistical agencies. There is, however, no centralized organization responsible for the collection and maintenance of energy-related data in the region, or even within the member countries. The majority of information has either to be sourced from international agencies or gathered sporadically from the relevant local institutions. In doing so, modelers may face situations where data on the same subject varies substantially among sources, often because international agencies use inconsistent definitions for energy metrics.

Conclusions and future research efforts

With a focus on GCC energy economies, KAPSARC's workshop reviewed the current state of individual country models and explored the steps needed to make progress towards greater consistency and integration of both models and infrastructure. Creating a forum to convene experts and decision makers in the region would advance the current state of energy modeling in the GCC countries. The resulting exchange of knowledge and ideas would benefit all stakeholders. Such a platform could involve encouraging the joint study of regional energy issues and improving coordination among the relevant local institutions.

Several models have emerged in recent years to study the GCC economies. They deploy a range of techniques with the purpose of examining the impact of policy, economic, and technological changes, and inform market observers of trends in their domestic energy markets. There is a large potential gain in understanding the dynamics of the aggregate energy system in a model that integrates all member countries. KAPSARC will undertake an effort to make the framework used for KEM available throughout the region.

The work on KEM has so far been focused on the supply-side of the energy system. However, our future research will also expand the representation of the demand-side issues. The scope of KEM will be broadened to include end-use energy demands, including those for residential and transportation uses.

About the workshop

The workshop was hosted by KAPSARC in March 2015. It was conducted under the rule of capturing the discussion on a non-attribution basis. Thirty international and local experts participated, as follows:

Mohammed Akmal – Corporate Planning, Saudi Aramco

Saad Al-Jandal – Kuwait Institute for Scientific Research

Samer AlAshgar – President, KAPSARC

Abdullah AlAwad – Research Specialist, Center for Complex Engineering Systems

Abdullah AlHassan – International Monetary Fund

Khalid AlKhathlan – Assistant Professor, King Saud University

Ayman AlOdaily – Electricity and Co-generation Regulatory Authority

Goblan AlQahtani – Economic Specialist, Saudi Arabian Monetary Agency

Ahmed AlSayari – Economic Specialist, Saudi Arabian Monetary Agency

Osamah AlSayegh – Director of Science & Technology, Kuwait Institute for Scientific Research

Nourah AlYousef – Associate Professor, King Saud University

Mustafa Babiker – Corporate Planning, Saudi Aramco

Ali Bayar –President, EcoMod

Mohamed Hedi Bchir – Chief of Modeling and Forecasting Section, UNESCWA

Leila Benali – Corporate Planning, Saudi Aramco

Frederic Gonand –Associate Professor, Université Paris Dauphine

Tim Gould – Senior Energy Analyst, International Energy Agency

David Hobbs – Head of Research, KAPSARC

Ali Jamhour – Economic Specialist, Saudi Arabian Monetary Agency

Fred Joutz – Senior Research Fellow, KAPSARC

Abdulaziz Khiyami – Research Associate, Center for Complex Engineering Systems

Glada Lahn – Senior Research Fellow, Chatham House

Walid Matar – Research Associate, KAPSARC

Frederic Murphy – KAPSARC Visiting Fellow, Temple University

Øystein Noreng – Professor Emeritus, BI Norwegian Business School

Axel Pierru – Program Director, KAPSARC

Bertrand Rioux – Research Associate, KAPSARC

Christof van Agt – Senior Energy Analyst, Saudi Arabian Monetary Agency

David Wogan – Senior Research Analyst, KAPSARC

Michael Wood – Consultant, Kuwaiti Ministry of Electricity & Water

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Notes

About the team

Walid Matar is a Research Associate developing energy systems models. He holds a Master's degree in mechanical engineering from North Carolina State University.

Axel Pierru is a Program Director leading KAPSARC's Energy Systems Modeling work. Axel holds a PhD in Economics from Pantheon-Sorbonne University in Paris.

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).

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

Nayef Al-Musehel is a senior research associate developing energy systems models. He holds a PhD in Economics from American University Washington, D.C.

David Wogan is a Senior Research Analyst developing energy systems models. He holds Master's degrees in Mechanical Engineering and Public Affairs from UT Austin.

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