Energy Open Data, Energy Policy Scenario Models and Tools

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About KAPSARC

The King Abdullah Petroleum Studies and Research Center (KAPSARC) is a non-profit global institution dedicated to independent research into 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.

This publication is also available in Arabic.

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APSARC hosted a workshop on October 9, 2019, to explore tools, modeling, and best practices for energy policy analysis. It yielded the following insights and recommendations for policymakers:

### Energy data tools

- Energy economics and climate models require machine-readable data to produce useful policy insights, but high quality data sources are difficult to find. KAPSARC has developed tools to address this challenge.
  - The KAPSARC Data Portal freely provides the public with around 1,300 machine-readable application programming interface (API) datasets. It focuses on energy supply and use, and various demographic and environmental categories relevant to energy policy.
  - The KAPSARC Energy Modelers Datahub is an open platform for energy data for models, with API support. It features visualization tools and data versioning, and can integrate modeling ecosystems such as the General Algebraic Modeling System (GAMS).
- Open-source data for the Middle East has become more widely available but data granularity and resolution remain relatively poor. To improve this, further collaborative work with data publishers will be necessary.
- Data wrangling tools are evolving but require further development. These involve storing and sharing data recipes that capture the rules to transform raw data to model-ready inputs.

### Energy models

- KAPSARC, in collaboration with Energy Innovation, a policy research organization focused on energy policy pathways, has launched the Saudi Arabia Energy Policy Simulator, which models the effects of over 50 policy variables. The simulator illustrates the interactions and cumulative effects of measures to help lower emissions and improve energy efficiency.
- The Open Source Energy Modelling System (OSeMOSYS) facilitates long-run integrated assessment and energy planning. KAPSARC is adapting this modeling system for a customized analysis of Saudi Arabia to support and advance policy research.
- The China 2050 Demand Resources Energy Analysis Model (DREAM), developed by the Lawrence Berkeley National Laboratory, models past and future Chinese energy consumption, including the impact of specific policies on energy and emissions.
- The World Resources Institute estimates China’s non-greenhouse gas emissions. Three scenario analyses are focused on policies, trends and mitigation opportunities and recommendations.
Key Points

Data management best practices

- Reviews of open energy data management systems across five organizations — OPEC, BP, Spain’s Corporación de Reservas Estratégicas de Productos Petrolíferos (CORES), the National Institution for Transforming India (NITI Aayog), and KAPSARC — reveal best practices including:

  ° Metadata: Publish metadata standards, data assumptions, terminology glossaries, data availability, and change alerts.

  ° Engage: Periodically train data publishers on downstream data use cases, and improve trust by allowing platform/portal users to comment on dataset quality.

  ° Terms of use: Whenever possible, use industry standard data licenses, such as those from opendatacommon.org and creativecommons.org, rather than custom licenses.

  ° Quality: Preserve the most granular level of data and enable modelers to change aggregation levels, compare, calibrate, and crosswalk between datasets. Report data quality in terms of the ‘four C’s’: currency (age since publication), completeness (breadth, temporality and granularity), consistency (standards such as ISO country codes) and correctness (reference to source data).
Summary

The workshop brought together over 40 experts from research, academia, government and industry to exchange ideas and experiences around the theme of open data for the energy sector. Participants discussed obstacles for Saudi Arabia, including the limited availability of open-source data and the lack of cutting-edge tools and modeling systems, and how these challenges can be addressed to improve energy sector analysis and policy design. The event also focused on the KAPSARC Data Portal (KDP), which aggregates around 1,300 relevant datasets from 80 publishers, and how energy modelers can use it to advance their research.

Representatives of eight government agencies and international organizations attended the workshop: Saudi Arabia’s General Authority of Statistics (GaStat), the Saudi Basic Industries Corporation (SABIC), the Clean Development Mechanism Designated National Authority (CDMDNA), the International Energy Forum (IEF), Saudi Arabia’s Ministry of Energy, Gulf Intelligence, the United Nations Economic Commission for Western Asia, and Effat University. Eight global institutes also joined to share their best practices: CORES Spain, the Lawrence Berkeley National Laboratory, the World Resources Institute, OPEC, the National Institution for Transforming India (NITI Ayog), the Argonne National Lab, IHS Markit, and The Energy and Resources Institute.

The event comprised roundtable discussions around the following four themes:

- Saudi Arabia’s energy policy simulator and approaches to managing carbon.
- Low carbon pathways for the Kingdom, China and India.
- Energy modelers’ data, tools and best practices.
- A walk through of energy economic modelers’ data flows and challenges.

KAPSARC relies heavily on regional data publishers for data to aggregate, cleanse and host in a machine-readable format on its data portal. Participants discussed best practices for data supply chains and tools management aimed at increasing the pace of research. The KAPSARC Energy Modelers Datahub (Datahub) platform helps to delineate raw data from sources and model code. The Datahub is an open-source portal that allows users to manage model data and call on data when needed using an application programming interface. Features include onboarding data using the interface, a data editor in a grid, track versions of data, the ability to copy data from any point in time, manage model templates, fine grained permissions, visualize data through charts and business intelligence software. Upcoming features include data recipes and the ability to add custom code transforming data to fit a model. Data recipes can be in programming languages such as Python and R.

Approaches to using three energy and carbon management models, EPS (Saudi Arabia), DREAM (China), and KOSMOSYS (Saudi Arabia) were showcased. Workshop members noted that these tools help to plan for carbon management pathways in easy-to-use simulation tools.

The Saudi Arabia Energy Policy Simulator (ESP), available in English and Arabic, was launched to design effective policy packages aligned to carbon management. This energy policy simulator needed Saudi Arabia-specific open data for over 150 variables. Some of them are very simple yet not readily available from public sources, such as the number of vehicles by category in the Kingdom. Saudi Arabia-specific features include desalination electricity co-generation, fuel price deregulation, Ministry of Energy renewable targets, water
withdrawal, fuel oil use, power sector dispatch with primal fuel constraint and an Arabic user interface. The energy policy simulator was launched to help policy analysts and stakeholders understand the challenges and opportunities ahead for Saudi Arabia. This simulation tool has already served seven countries — India, China, the United States (U.S.), Canada, Poland, Mexico, and Indonesia. Saudi Arabia leveraged the experience and best practices learned here to build the eps.kapsarc.org tool.

There is a huge potential for residential energy efficiency retrofits in the Kingdom: 50% of the country’s total electricity consumption comes from the residential sector and 65% of this figure is from cooling. Saudi Arabia will invest in the best combination of efficiency retrofits. Using the United States Department of Energy’s building energy eQuest model, KAPSARC used publicly available data to characterize 54 prototype buildings that represent the residential housing stock in six climate zones in four electricity regions in the Kingdom. It is estimated that R8 insulation or upgrading to moderate efficient air conditioners (AC-EER-12) reduces energy consumption by almost 20%-30%. The Open Source Energy Model is used for long-run integrated assessment and energy planning. KAPSARC is developing this model further to fit the context of Saudi Arabia and advise stakeholders on policy pathways.

Contrasting the approach taken by Saudi Arabia’s EPS, eQuest and KOSEMOSYS with models for China, we reviewed the China 2050 DREAM model developed by the Lawrence Berkeley National Laboratory, which incorporates cross-sector linkages such as land, buildings and materials. This model produces full reports for a time horizon of 2050, such as the peak and plateau in China’s energy and carbon dioxide (CO2) emissions. The model is used for specific policy assessments, such as evaluating sectoral policies in buildings, appliances, transport and the power sector. It also evaluates alternative energy sources, maximum demand-side renewable demand, demand for the energy-water nexus, and non-CO2 greenhouse gas emissions. The model provides policy pathways through the 2050 Reinventing Fire Scenario, which shows demand shifts in end-use sectors. KAPSARC will start work on a China energy data catalog using calibrated and open-source time series data.

The workshop discussed the availability of Saudi Arabia’s Clean Development Mechanism Designated Authority’s (CDMDNA’s) data via their reports and projects. KAPSARC collaborated with the CDMDNA to better understand their reports on Saudi Arabia. There is a strong desire across government and industry to move toward low-carbon green pathways. SABIC presented their approach in implementing carbon capture, utilization and storage (CCUS). Utilization involves recycling carbon byproducts into useful chemicals, while ‘storage’ refers to trapping carbon in geological formations.
KAPSARC has prioritized data as a key strategic asset for further development. Under its open data policy, KAPSARC shares data, models and tools to support advanced, reproducible research. This includes the KAPSARC Data Portal (KDP), which serves some 4,000 searches, 40 downloads, and hundreds of users from over 40 countries daily, in addition to 14 energy policy tools, which can also be found on KAPSARC’s website.

These efforts to provide open-source energy data and tools for its analysis also help support Saudi Vision 2030, the government of Saudi Arabia’s blueprint for social and economic development. The initiative is ushering in a major transformation toward a green economy through policies that prioritize energy diversification, energy efficiency, domestic energy price reform, and a less carbon-intensive fuel mix.

The open energy data workshop anchored “Carbon Management Tools” as a topic of discussion. The KDP has about 1,300 public datasets with 80 million records of open energy data covering the Gulf Cooperation Council (GCC) countries, India and China. KAPSARC publishes regular data insights that advance the understanding of energy trends.

New: The Saudi Arabia Energy Policy Simulator (EPS), launched concurrently with this workshop, is an easy to use web simulator which allows users to select over 50 policy levers and simulate the impact of carbon emissions. The simulator covers fuels and electricity supply to industry, buildings, and transportation. The model considers research and development progress, carbon capture and storage, land use to calculate pollutants and cash flows. It generates over 200 output charts and enables an understanding of the impact of energy policy packages and carbon management. KAPSARC soft-launched the EPS in the World Energy Congress, where it received positive feedback on its alignment with clean energy policy tools.

Upcoming: The KAPSARC Energy Modelers Datahub (Datahub) is a new data platform built exclusively for energy modelers to collaborate on base open data. Modelers can fork into base data and create their own versions of the data to run scenarios and compare the results. Modelers can compare input data versions as well as model results. This platform includes raw data storage, data wrangling recipes, and models to facilitate research and collaboration.

KAPSARC convened this workshop to gather experts from within the Kingdom and abroad to discuss best practices for open-source data, models and tools for energy and carbon management scenario analysis.
Simulation Tools for Energy and CO2 Emission Policy Scenarios

1. Energy Policy Simulator

The Energy Policy Simulator (EPS), developed by KAPSARC and Energy Innovation, a policy research organization focused on clean energy, can help policymakers achieve climate, financial and other goals. It has been extensively reviewed and improved through collaborations with researchers at national laboratories, universities and research institutes. The EPS has been utilized to analyze eight regions of the world that collectively account for more than half of global emissions.

The EPS can simultaneously model and compare the impacts and cost-effectiveness of multiple energy and environmental policies, making it more effective than classical optimization-driven computable general equilibrium models. However, it should be viewed as a screening tool and used alongside other models for maximum effectiveness. Rather than pinpointing the single best policy for a given scenario, it helps policymakers sort through many possible options and develop policy packages that can meet their goals.

The simulator incorporates system dynamic models, including for emissions and cash flows, to predict the combined effects of packages of policies on multiple outputs. The EPS includes thousands of different variables spanning the electricity sector, transportation, industrial energy consumption, and many other areas.

The EPS first creates a reference case based on estimates from existing regional models. It then tests how this base case changes as additional policies are layered on, drawing insights from both top-down and bottom-up model results. For example, inputs from top-down models use elasticities of items such as fuel prices, imports and exports and reference case a projection from bottom-up models on elements such as final energy demand, technology costs, and efficiencies of different technologies. The EPS then allows layering additional policies on the previous outputs and reference scenarios to continue to explore how emissions and other results will change. Figure 1 offers a stylized example of how the EPS functions for the transportation sector.

For example, the EPS takes annual demand for travel in passenger-kilometers, and freight transportation in tonne-kilometers, to forecast overall vehicle demand. The average rate of vehicle retirement and the average vehicle lifespan can then help determine how many new vehicles are likely to be purchased. With these data points, as well as vehicle prices and operating costs for different models, the EPS can calculate the numbers and models of vehicles that should be purchased. This is done through optimization, which takes into account operating costs and vehicle prices to minimize overall purchase and operating costs.

The EPS also includes endogenous learning for newer technologies such as solar power and battery-powered electric cars. The deployment of new technologies drives down the future prices of all vehicles, and the model’s projections will impact sales growth. Based on how many of each vehicle type and model are purchased, and the respective fuel efficiency and emissions profiles, the EPS can then calculate the fleet-level fuel efficiency, emissions and operating costs. It can also add policies such as electric vehicle (EV) subsidies to test how they affect purchasing decisions and the resulting changes to fleet composition, which would feed back into future vehicle prices through endogenous learning.
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Fuel efficiency standards can also be added for new vehicles, lowering average fuel consumption, emissions and operating costs but increasing initial purchase prices due to more expensive production costs to achieve lower emissions. This would then feed back into the annual vehicle distance traveled, as people tend to drive more when fuel and operating expenses are lower, and in turn the EPS would find a different optimal new vehicle purchase mix. Transportation demand management policies could also be added, causing people to shift from private cars to public transportation, reducing emissions and passenger-kilometers, and causing the EPS to find a different optimization. Figure 2 illustrates another example of EPS interactions, this time for the power sector.

**Figure 1.** Transport module flow in the Energy Policy Simulator.

The reference model starts with the existing set of power plants. Building and dispatching power plants in the future is based on electricity demand. The model includes three primary electricity demand sectors: transportation, buildings and industry.

The EPS can add various modules to the reference model for more sophisticated policy analysis. A carbon capture and sequestration module allows for capturing carbon dioxide (CO2), which reduces emissions from fossil fuel-based power generation but increases costs. A fuels module controls the prices and emissions intensity of each fuel type. Research and development policy levers can drive cost reductions and greater efficiency, feeding back to the future deployment of more advanced technologies, which endogenous learning further accelerates. The number and type of new power plants also impacts emissions related to land use and forestry. Based on all these variables, and others, the EPS optimizes the number and types of new power plants, determining emissions output, cash flow and other critical outcomes.
The EPS tracks twelve different pollutants: four types each of greenhouse gases, particulates and gas aerosols. First order cash flows show who pays more or less in response to policy changes and focuses on capital equipment operating expenditures including fuel, maintenance and labor. However, note that the EPS is not a macroeconomic model and does not factor in changes to gross domestic product (GDP) or labor.

The model incorporates the sectors that drive most energy demand. For the buildings sector, the EPS tracks six categories of end uses for electricity (heating, cooling, ventilation, lighting, appliances and other), divides buildings into urban residential buildings and commercial buildings and subtypes of each, and records fuel types consumed. It also includes industries that are heavily impacted by energy and climate policies, such as cement, petroleum, natural gas, iron and steel, chemicals, water and waste, desalination, and agriculture, among others.

The EPS model for Saudi Arabia offers a customized module for the electricity sector that reflects the unique fuel supply profile of the country. It differentiates between power plants fueled by crude oil, diesel, heavy residual fuel oil, and two types of natural gas, and accounts for power produced by desalination plants. It also tracks water withdrawals and consumption for all power plant types to modify power sector dispatch to reflect primary fuel supply constraints (for example, limited natural gas availability in different parts of the country).

The transportation module tracks both passenger and freight vehicles. For passenger vehicles, this includes automobiles (for personal use and public transportation), motorcycles, trains and aircraft. For freight, it includes light, medium and heavy trucks,
trains, ships and vehicle technologies for all the different modes.

The EPS has broad economic and technical coverage and can adapt to country specifics, such as new fuel types, given the important role of crude oil and petroleum products in Saudi Arabia. It tracks fuels and fuel-consuming technologies including crude oil, fuel oil, liquified petroleum gas (LPG), propane, butane, municipal solid waste and hydrogen.

Therefore, the EPS is a robust tool that can be used to model the impact of a wide range of policy scenarios. For example, it can estimate the effects on emissions and electricity use from deploying EV charging infrastructure, improving the longevity of industrial machinery, or changing manufacturing policy incentives. It can forecast the rise in Saudi Arabia’s energy exports caused by a policy that reduces domestic crude oil demand, the accompanying increase in state revenue and the impact it would have on oil prices. Using additional scripts that come with the model, the EPS can also model the effect of cap and trade policies on emission levels. Custom policies were input into the model to represent the Kingdom, such as fuel price deregulation and the country’s renewables target.

The EPS outputs 150 graphs to illustrate the impacts of policy settings, permitting informative visual comparisons of different interactions. For example, changes in fuel prices are reflected not only by short-term and long-term fuel price elasticities but also by shifts in vehicle preference. It is important to note that the EPS uses point estimates, and not time series, for elasticities. Therefore, a worthwhile area for future research would be to combine the EPS with a macroeconomic model.

During the development of the EPS, KAPSARC collaborated with the Clean Development Mechanism Designated National Authority (CDMDNA) to better understand the energy data available for Saudi Arabia. The CDMDNA is a government agency mandated with supporting international efforts to reduce greenhouse gas emissions. It is responsible for:

- Designing measurement, verification and reporting systems.
- Developing the Intended Nationally Determined Contributions (INDC) as a requirement of the Paris Agreement.
- Coordinating and promoting carbon management.
- Ensuring international cooperation.

The CDMDNA is also charged with submitting Saudi Arabia’s updates to the United Nations Framework Convention on Climate Change (UNFCCC). These include topics such as INDC actions on climate change, greenhouse gas inventories, national circumstances and climate change scenarios. The CDMDNA publishes the Biennial Transparency and National Inventory report.

Saudi Arabia’s INDC plans include the following:

- Economic diversification with mitigation co-benefits that focus on energy efficiency, renewable energy, carbon capture and utilization/storage, and advancements in natural gas extraction to maximize gas and methane recovery and minimize flaring.
- Adaptation with mitigation co-benefits that focus on urban planning, water and wastewater management, marine protection and reduced diversification.
Adaptation initiatives, including an early warning system, integrated water management planning and integrated coastal zone management.

The Kingdom’s INDC scenarios assume that Saudi Arabia diversifies its economy by reducing its dependence on oil revenues while utilizing its domestic oil supply to accelerate industrialization.

2. Residential energy efficiency and the KAPSARC Open Source Energy Modelling System (KOSeMOSYS)

Consumers in Saudi Arabia have long enjoyed extremely low energy prices and had little reason to invest in residential energy efficiency. As a result, over 70% of buildings in the Kingdom have no insulation and 90% of its air conditioners have very low energy efficiency ratios (EER) of 7.5 or below.

To improve the energy efficiency of residential cooling, policymakers must determine the most effective combination of policies and where to focus investments, based on the Kingdom’s existing housing stock configuration and climate. Using the U.S. Department of Energy’s eQuest building energy model, KAPSARC has identified three main characteristics of residential housing stock in Saudi Arabia that result in 54 possible prototypes: three core dwelling types (traditional house, villa, and apartment building), three vintages (old, recent, and new), and six climate zones, which will later be mapped to four electricity regions. KAPSARC will calibrate these prototypes to match aggregate residential electricity consumption.

Basic insulation and air-conditioner upgrades can greatly increase energy efficiency. Adding R-8 grade insulation reduces energy used for cooling by almost 20% compared with no insulation, and upgrading to a moderately efficient EER-12 air conditioner cuts electricity consumption by 30%. In tandem, these measures bring more significant gains and cost savings because insulation allows a smaller air conditioner to achieve the desired level of cooling for a given space. The Saudi Energy Efficiency Center (SEEC) has defined building codes and efficiency standards for air conditioners since 2011. It offers a 600 SAR subsidy for units with a minimum EER of 13.8.

The non-linear relationship between energy efficiency, insulation and air-conditioners makes building energy models important tools for identifying the most efficient and cost-effective combinations. The KAPSARC Building Energy Efficiency Assessment Tool helps to analyze the energy efficiency of residential buildings. KAPSARC is also developing a custom algorithm that can determine the optimal mix of energy efficiency upgrades. In the aggregate, each unit reduction in national energy consumption is equivalent to an additional unit generated, and energy efficiency can be modeled as demand-side ‘generating units.’ Importantly, energy efficiency follows load much more closely than solar photovoltaic generation does, and its cost in terms of upfront investment is comparable — thus, energy efficiency offers a greater return.

The Open Source Energy Modelling System (OSeMOSYS) is an open-source, deterministic, linear optimization model for long-run integrated assessment and energy planning. It can be applied to energy systems of any scale from villages to entire continents. OSeMOSYS provides foresight and a paradigm comparable to the Model for Energy Supply Strategy Alternatives and its General Environmental Impact (MESSAGE), or the Integrated MARKAL-EFOM1 System (TIMES). OSeMOSYS determines the energy system configuration with the minimum total discounted cost over decades,
constrained by energy demand. The model features technologies and their techno-economic characteristics (capital cost, efficiency, lifetime, among others), emissions taxation, generation targets (e.g., renewable goals) and other constraints, such as the availability of resources.

KAPSARC is developing KOSeMOSYS, a version of OSeMOSYS specifically modified for its application to Saudi Arabia. It includes a reference energy system defined for the Kingdom’s electricity sector. KOSeMOSYS can model energy efficiency ‘generating units’ and costs to find the optimal level of investment in energy efficiency upgrades by region, dwelling type and vintage, to the year 2030. It incorporates three core dwelling types, three vintages and four regions, resulting in 36 categories of dwellings. Because KOSeMOSYS simultaneously optimizes investments in supply and energy efficiency, it can inform energy policymakers about cost-effective investment opportunities on the demand side. An important advantage of KOSeMOSYS is its fast run time: less than 10 minutes for runs with 16 energy efficiency retrofit choices.

KOSeMOSYS includes the following data inputs:

- Renewable capacity targets.
- Investment constraints.
- Transmission connections between regions.
- Residential and other demand by region, with demand growth out to 2030.
- Energy efficiency load profiles and costs.

3. Climate change impact and industry response, SABIC case study

The Saudi Basic Industries Corporation (SABIC) operates one of the world’s largest carbon capture and purification plants, located in the industrial city of Jubail. It converts up to 500,000 tonnes of CO2 per year for use in fertilizers, carbonated drinks and methanol. The petrochemicals industry could increase its use of renewable energy and improve its efficiency, allowing the Kingdom to position itself as a supplier of low-carbon basic petrochemicals as well as higher-value specialty chemicals and materials.

Global chemical companies are assessing climate change risks and the magnitude of their impact. Key risks identified include:

- Failure to comply with carbon regulations (especially in Chinese, European, or U.S. markets), incurring fines and/or reputational damage.
- Changes in customer preferences that hurt sales.
- Physical damage to assets caused by climate change.
Simulation Tools for Energy and CO2 Emission Policy Scenarios

- Increased costs from compulsory low-carbon and other climate change requirements.
- Reputational damage from lack of carbon management or sustainability reporting.
- Inability to adequately raise capital.

By 2025, SABIC targets a 25% reduction in its greenhouse gas (GHG) emissions, water use, and energy intensity, and a 50% decline in material loss intensity from 2010 base levels. The world’s largest CO2 plant, located in Japan, has a capacity of 500,000 megatonnes per year and converts CO2 into urea and methanol. SABIC has initiated other clean development mechanism projects that will reduce CO2 emissions by 660,000 tonnes over their lifetime. The company is also investing in cleaner liquified natural gas (LNG) carriers that eliminate sulfur dioxide emissions and reduce CO2 and nitrogen dioxide (NO2) emissions by 20% and 85%, respectively.

4. China energy and emissions modeling

The China 2050 Demand Resource Energy Analysis Model (DREAM), developed by the Lawrence Berkeley National Laboratory (LBNL), is a dynamically updated tool that incorporates Chinese statistics. It is capable of analyzing China’s past and future energy consumption and generation. The model has provided the basis for China’s 2050 economic reports, which include a 2010-2011 study showing a peak and plateau in China’s energy and CO2 emissions. The reports have informed China’s 13th Five Year Plan, its INDCs, and U.S.-China negotiations leading up to the U.S.-China Joint Announcement on Climate Change and the Paris Agreement.

China 2050 DREAM can inform policy assessments in areas such as:

- Energy policies for the buildings, appliances, transport and power sectors.
- Alternative energy sources and maximum renewable energy demand.
- The impact of the energy sector on water supply and on non-CO2 GHG emissions.

The LBNL has worked with China’s Energy Research Institute (ERI) to produce a China Energy Outlook for 2020, 2025 and 2030. The model employed in this analysis incorporates the LBNL China Energy Databook, which has data from 1949 onward and is freely available. Model inputs include macroeconomic data, demand drivers, technologies and scenarios. Its outputs include primary and final energy consumption, emissions, and savings potential. The model comprises buildings, industry and transport to assess the country’s energy intensity and fuel mix, and incorporates granular data such as building codes, appliance ownership, floor areas, vehicle ownership, and industrial output.

The China 2050 DREAM model allows users to analyze policy scenarios through 2050. It can project primary energy use savings through factors such as demand reduction, energy efficiency, decarbonization, smart grids and systems, clean energy tech, activity reduction, and fuel switching. The Reinventing Fire Scenario shows notable shifts in end-use sectors such as industry, buildings, transportation and transformation. Under this scenario, China can reduce its emissions at a profit: an upfront cost of 46 trillion Chinese yuan (CNY) secures 68 trillion CNY in savings, with 22 trillion CNY of net present value. The buildings sector technology roadmaps reduce CO2 emissions by 74%.
CO2 could peak as early as 2025 under alternative reduction strategies that center around accelerating electrification, efficiency programs, and renewable energy. Reducing energy demand growth through efficiency will be key, with refrigeration and air conditioners alone accounting for one-third of potential energy efficiency savings. The transportation sector has the greatest potential for energy demand reduction through stricter fuel economy requirements, shifts to electric and hybrid vehicles, and broader changes in transportation-related behavior and modes. Within the industrial sector, energy efficiency initiatives, especially in the metals and cement industries, can have substantial impacts but are not as policy-specific. More stringent ‘green’ building codes and standards can also bring substantial energy savings.

The model predicts that China’s shift to EVs will reduce its CO2 emissions by 100 million tonnes and significantly impact the country’s trade balance for oil products. Annual imports of hydrocarbon products could also be reduced by 175 million tonnes of oil equivalent by 2050. However, China’s demand for natural gas imports could increase fivefold by 2030, reaching 250-280 billion cubic meters per year in 2030. In this scenario, the non-CO2 share of total GHGs increases from 17% to 20% in 2050, with methane and NO2 the most used gases.

5. China’s non-CO2 GHG emissions projection

China has significant opportunities to reduce its non-CO2 GHG emissions, which come primarily from methane, nitrous oxide, and fluorinated-gases (F-gases). The latter include perfluorinated compounds (PFCs), sulfur hexafluoride (SF6), hydrofluorocarbons (HFCs), and nitrogen trifluoride (NF3). Methane is the leading precursor to background tropospheric ozone, and is linked to 79-121 million tonnes of crop production loss, and around 1 million premature deaths per year globally. Nitrous oxide destroys the stratospheric ozone layer, which protects the Earth from ultraviolet radiation.

China’s NDC gives no topline targets for non-CO2 GHG reduction. Instead, it provides three scenarios: the Reference Scenario (RS), based on policies and trends as of 2015 (including the implication of the NDC); the Current Policies Scenario (CPS), based on policies and trends as of 2018 (including the Kigali Amendment, targets in the first Biennial Update Report, and the 13th Five Year Plan sectoral targets); and the Strengthened Policies Scenario (SPS), which expands the CPS to decrease non-CO2 GHG emissions.
1. CORES oil and gas information system best practices

The government of Spain established CORES, a non-profit oil stockholding agency, in 1995 as part of wider efforts to liberalize the country’s oil sector. The firm plays a critical role in safeguarding national energy security by maintaining strategic oil stocks in conjunction with the oil and gas industry. In addition, the agency serves as Spain’s authority for oil and gas information. It collects mandatory monthly data submissions from industry players on consumption, imports, exports, production balance, stocks, and domestic production, which it disseminates to the public. It also publishes other information and reports and offers consultancy services.

CORES developed an econometric model to forecast the demand of oil and gas products to adjust reserves, anticipate short- and medium-term storage needs, and provide other market analysis. The model takes monthly consumption data as its input into a temporary series model and outputs a twelve-month outlook for petroleum products and natural gas.

CORES developed a short- and mid-term energy model that incorporates macroeconomic, demographic, and operational variables and historical monthly consumption data. It covers sectors including transportation, residential buildings, electricity and other industries. The model can output five-year annual forecasts for petroleum and natural gas, alongside other projections.

The CORES transport model provides further analysis of the transportation sector. It covers seven modes (individual, light commercial, road passenger, road freight, aviation, maritime and rail) and six categories of fuel (LPG, gasoline, diesel, kerosene, fuel oil and natural gas). The model’s three stage process includes structural consumption analysis, the correlation of explanatory variables, and consumption forecasts by fuel type per segment.

The methodology for CORES’ annual oil sector data combines model-based estimates with questionnaires of industry players to produce final petroleum product consumption data. Its quantitative analysis employs 150 specific models for each sector/product, while the surveys target 14 key agents with customized questionnaires.

2. India’s evolving energy data availability

The management of India’s energy sector is fragmented and decentralized across numerous federal and state authorities. Central government organizations that publish energy data include the National Institution for Transforming India (NITI Ayog), the Ministry of Power, the Coal Controller’s Organization, the Petroleum and Natural Gas Regulatory Board, the Ministry of New and Renewable Energy, and the Department of Atomic Energy. State governments meanwhile have their own agencies for energy, power utilities, transportation, and other areas, which release various energy-related data.

Demand-side data comes from the Census Survey, the Central Electricity Authority, the Bureau of Energy Efficiency, the National Sample Survey Office and the Ministry of Statistics. Supply-side data comes from the Coal Controller Organization, the Central Electricity Authority, the Ministry of Power, the Ministry of New and Renewable Energy, the National Institute of Wind Energy, the National Institute of Solar Energy and the National Institute of Bio-Energy.
India’s key data agencies include the Coal Controller of India, the Directorate General of Hydrocarbons, the Ministry of Petroleum and Natural Gas, the Central Electricity Authority, the Central Statistical Office, and the National Sample Survey Office.

Federal and state authorities in India gather energy data mainly to publish as statistics and for administrative purposes, and their data and methods have significant shortcomings. Most importantly, the many agencies mentioned above lack a common data format and collection methodology. Data on demand and consumption, especially for areas such as biomass and micro-grids, are lacking. While supply-side data is better, the authorities can still improve their reporting frequency and data accessibility.

Nevertheless, the availability of energy data for India is improving. NITI Aayog has released a prototype version of its India Energy Dashboards, an energy data portal that allows users to easily download data and create visualizations. The agency also offers the India Energy Security Scenarios tool, which the authorities used to set NDC targets and track progress toward meeting them. Built with support from the World Bank, the model can project India’s future energy supply and demand, and includes variables such as water use, liquified natural gas supply, and electric vehicle penetration. The India Energy Model was developed by the International Institute for Applied Systems Analysis and NITI Aayog. A new decision support model is being developed. “The GeoSpatial Energy Map of India” is a map of India’s energy assets. The Indian Energy Modelling Forum sets priorities for research topics, including air quality, energy-water-land nexus issues, renewable energy deployment, and long-term strategies for energy management.

3. Energy open data best practices

BP Statistical Review of World Energy:
International energy firm BP and the Centre for Energy Economics Research and Policy (CEERP), a collaboration between Heriot-Watt University and BP, have produced this annual statistical energy review of world energy since 2007. The research team compiles publicly available data, which it standardizes to common units, and has designed a hierarchy of data sources in order of importance and strict data governance. Sources include the World Bank, Eurostat, the U.S. Energy Information Administration (EIA) and OPEC, among others.

JODI: The International Energy Forum (IEF) Joint Organisations Data Initiative (JODI) serves as a critical source of information on the global energy sector. JODI publishes two key databases of statistics collected from energy companies and national administrators through seven partners — OPEC, the Asia-Pacific Economic Cooperation (APEC), Eurostat, the Gas Exporting Countries Forum (GECF), the International Energy Agency (IEA), the Latin America Energy Organization (OLADE), and the United Nations Statistics Division (UNSD). The JODI-Oil World Database covers over 100 countries that account for 98% of global oil supply and 88% of consumption, and the JODI-Gas World Database includes over 90 countries representing 90% of total gas supply and 93% of consumption. The metadata adheres to International Recommendations for Energy Statistics (IRES) guidelines, which provide a comprehensive methodological framework for the collection, compilation and dissemination of energy statistics.
JODI offers several recommendations for KAPSARC. First, KAPSARC should consider developing an energy balance table for Saudi Arabia that includes non-oil fuels, especially natural gas. Second, KAPSARC could enhance its Data Portal by improving data compilation and user feedback mechanisms. In addition, KAPSARC could further research and provide data on seasonal energy patterns, including those related to important annual events such as Ramadan and Hajj, to advance the understanding of energy demand and modeling precision.

**Saudi Arabia Energy Policy and Strategic Planning Department:** In 2019, the Kingdom issued a Royal Decree to establish a deputyship for energy policy and strategic planning under the energy ministry, a function previously served by Saudi Aramco and the Electricity and Co-Generation Regulatory Authority (ECRA). The main responsibilities of this new department include economic analysis, data integration and analytics, strategic decision support and establishing the Oil and Gas Information Center, which will publish official energy statistics and operate a data hub for government use.

**OPEC:** The organization began data collection in the 1960s and has built comprehensive energy data systems to produce short- and long-term outlook models and facilitate planning. OPEC’s database incorporates a wide range of energy, macroeconomic, and other datasets, facilitating complex energy sector modeling. OPEC employs standardized data methodologies and validation processes utilizing statistical tools, and data estimation and consolidation processes to fill gaps and harmonize data.

The OPEC World Energy Model (OWEM) is an integrated world energy planning system that can produce a range of long-term energy forecasts. OPEC publishes numerous statistics and reports, including its flagship World Oil Outlook, which includes an interactive online database.

OPEC data sources include direct communication with the OPEC secretariat, official sources, JODI and other initiatives. Reports include daily data in relation to crude and product prices, monthly information on fundamental oil and gas flows, quarterly oil-related information, annual oil, gas and energy balances, ministries and governmental pages, fundamental oil and gas flows, official monthly oil and gas balances. The OPEC Annual Survey includes oil balances covering primary/secondary oil flows and oil trade; oil infrastructure, including refinery capacity and operations, upstream activity and projects, and refinery and petrochemical expansions; natural gas: balances and trade and upstream activity; conversion factors, energy balances and macroeconomics. OPEC uses secondary sources such as international organizations, private entities and specialized publications.

OPEC provides the following best practice recommendations:

1. Processes for data collection, consolidation, and estimation should be well-defined and standardized, with reporting lags minimized. They select adequate variables from official and, if necessary, third parties.

2. Data processing validation and analysis requires continuous interaction between data providers, database operators, and end users. It is critical to conduct periodic meetings, training workshops, and reviews of methodology and implementation.
3. Data should be screened using statistical analysis to identify errors, significant trends and patterns.

4. Data should be disseminated and shared online for easy access, and disaggregation options should be provided and be simple to use.

4. From the perspective of energy statisticians

Energy models are broadly classified into technology-rich least-cost models (e.g., MESSAGE, MARKAL), computational general equilibrium models (e.g., the KAPSAR Energy Model, the General Equilibrium Model for Economy, Energy and Environment), econometric models (e.g., E4MG, INFORGE), technology-rich simulation models or accounting frameworks (e.g., EPS, WEM).

Energy modeling data requirements include:

- Supply data by type and source, capacity and electricity generation data by source, planned capacity expansions and retirements.

- Demand data by end use (e.g., cooling, heating) by industry and sector (e.g., household, commercial, transport) for each energy source; industry-level data and public and private transport data.

- Population, number of households, average household size, commercial floor area, value added and employment by industry and sector.

Energy balances allow modelers to:

- Evaluate the energy mix, supply and demand balance, energy system efficiency, and transformation (e.g., the shift from carbon-based to renewable energy generation by geography (e.g., global, national, local), sector, and industry.

- Estimate indicators such as country-level energy self-sufficiency, emissions intensity, CO2 emissions from fuel combustion.

- Assess the quality of energy commodity balance data and provide data for modeling and other analysis.

Total primary energy supply available for use is calculated by summing up supply sources. Total final consumption is energy available for final use in the domestic market. Supply, transformation and final consumption allow for an assessment of energy intensity, self-sufficiency, the efficiency of the electricity sector, and the respective shares of energy consumption sectors. The benefits of energy balances include enhanced supply chain knowledge, leading to better planning and decisions and improving market stability.

Policymakers increasingly seek detailed data on energy end use, which allows them to better understand consumption patterns and design effective policies. The G20 Energy End-Use Data and Energy Efficiency Metrics initiative, co-led by France and the IEA, aims to improve the quality and availability of energy data through transparency and digitalization. It recommends the following best practice guidelines:

Transparency

- Transparency of data builds confidence, increases engagement and informs debate.
Better data improves market efficiency, while data vacuums cause uncertainty and volatility.

Open data fosters innovation and supports academic work.

Digitalization

The wide use of geographic information systems (GIS) helps increase the availability of granular locational data.

Real-time data via digital twins (copies) of power stations and the direct monitoring of networks.

Now is the time to plan for automatic data flows from digital systems in homes and businesses.

Advancing the quality and availability of energy models for Saudi Arabia and the wider Middle East will provide a great benefit, given the region’s primacy in energy exports.

5. From the perspective of energy modelers

Energy datasets and models should be maintained and periodically reviewed for potential improvement. All updates and changes should be documented following best practices for version controlling and annotations.

The KAPSARC Energy Model (KEM) is a general framework for studying pricing policies in an economy. It is a partial equilibrium model covering high energy-intensive sectors.

Figure 3. KAPSARC Energy Model for long-term planning and policy analysis.

Source: KAPSARC.
KEM provides insights on energy investments (e.g., fossil fuel plants and renewables), fuel mix and consumption, climate change and environmental impacts, and the effects of pricing policies. Modified versions of KEM exist for Saudi Arabia, the Gulf Cooperation Council (GCC) countries and China. KEM for the Kingdom is a bottom-up model and the computable general equilibrium model is a top-down hard link model.

Modelers who use KEM have encountered various data-related challenges. These include a rigid data structure and data embedded in the model’s code. The latter causes numerous problems, requiring significant alteration and debugging of the code to adjust the model for new studies. This also makes ‘forking’ the code, or the independent development of multiple projects using the same initial code, cumbersome.

Energy modeling best practices suggest a number of ways to address these challenges. Most importantly, extracting the model’s data into a structured database and creating a core model that follows the latest development paradigm independently of the data will mitigate the embedded code issue. This allows different projects to utilize the identical base code with different calibrations (currently available for Saudi Arabia, the GCC countries, and China) with a hard link to a general equilibrium model.

Other recommended improvements include a transparent system for data version management, processes to preserve the integrity and utility of models and data, and options to disaggregate data to the most granular level available.

The KAPSARC Energy Modelers Datahub (Datahub) is an open-source collaboration platform that hosts a repository for model datasets and helps modelers manage data. Currently the platform supports five energy models: KEM, EPS, international transport energy models, the Maritime Energy Model, and TIMES MARKAL. As shown in Figure 4, the Datahub can delineate data from model code using application programming interfaces (APIs), easing data version management.

Datahub’s core features include a user interface for onboarding data, a spreadsheet-style data editor, and visualization tools. The platform also offers data version tracking, which allows users to retrieve data from any prior point since the relevant dataset was brought onto the platform, and it can manage data and models with fine grained permissions. Additional features will be added in the future, such as the incorporation of data recipes and the ability to add custom code/data transforming script to fit data into a model. Data recipes can be programmed in languages such as Python and R.

The KAPSARC Data Portal (KDP) facilitates energy research with clean and machine-readable, model-ready data. The advancement of ‘big data’ and associated analytical tools means that the demand for API-ready data will rise significantly. As a result, KAPSARC developed, and continues to improve, the KDP to serve the needs of energy researchers worldwide. The portal enables researchers to better understand the dynamics of the energy supply chain, including energy capacity, production, consumption, productivity, and other relevant economic data.

The KDP aims to remove three barriers to the advancement of research: highly time-consuming data preparation, hundreds of disparate data sources, and the lack (or unavailability) of critical energy-relevant data. The portal includes web applications and analytical tools that enable easy search, analysis, geo-map lookup, charting and the ability to share data views with just a few clicks. It also provides metadata for every dataset.
Energy Data Management Best Practices

Figure 4. Illustration of how Datahub delineates data from models.

Source: KAPSARC.

Figure 5. Datahub is a repository of models and datasets.

Source: KAPSARC.
A primary goal of the KDP initiative is to expand the understanding of energy demand in fast-growing developing countries. It initially focuses on key energy producers (the Kingdom and other GCC countries) and consumers (India and China), with datasets tailored to these countries. The KDP team draws lessons from established best practices to provide data that can help shape the Kingdom’s energy policies.
Figure 7. KAPSARC Data Portal home page.

The KDP hosts about 1,300 energy, economics and climate-related datasets with over 80 million datapoints from over 200 energy data publishers (80 for Saudi Arabia alone). These datasets are primarily for Saudi Arabia and the GCC, India and China. The datasets are broadly classified into energy, economy, and climate, and further categorized into 16 themes: crude oil and refined products, natural gas, coal, renewable and alternative fuels, nuclear, electricity, water, transportation, industry, residential, agriculture, environment, economy, demography, trade, and policies.

Each dataset has an information tab that links to the data use terms, shows the data source, and provides a timestamp of its last update. The KDP team regularly adds new datasets and checks the validity of each updated dataset at least once every 45 days. Regular communication and collaboration with data publishers, modelers and energy policy stakeholders will be key to improving KDP further.

KAPSARC has published 12 web policy simulator tools that can provide energy policy insights (Figure 9).
Figure 8. Example of KAPSARC Data Portal ‘Analyze’ visualization view.

Source: datasource.kapsarc.org.

Figure 9. KAPSARC web policy simulator tools.

Source: KAPSARC.
Energy Data Management Best Practices

Collaboration platform case study: Ejaad is a platform that facilitates interactions among academics, policymakers and businesses involved in research related to the energy sector.

Ejaad’s objectives are:

- **Connect**: Link academic research to industry needs.
- **Promote**: Uphold industry-industry, academia-academia and industry-academia collaborations.
- **Exploit**: Maximize value by routing business research and development (R&D) requests to local academic institutions.
- **Add value**: Deploy, commercialize and facilitate the technology transfer of research outcomes.

Ejaad serves as a venue for networking, international collaboration, career development events (such as workshops), job opportunities, and sharing research ideas. It also includes a database of all equipment available across industry and academia in a given market.

Another example of a collaboration platform is the S&P Global Platts blockchain distributed ledger system. It is a secure blockchain network built to allow market participants, terminal operators to submit weekly inventory oil storage data to the Fujairah Oil Industry Zone (FOIZ) and the regulator FEDCom. This offers the regulator and its port operators security, ease of use, and an audit trail to collate weekly inventory oil products storage data.

The benefits of Ejaad include reducing the burden of manual data management, the dynamic display of reported numbers at an aggregated or individual operator level, improved reporting quality by automatically validating numbers with predefined criteria, aggregating numbers, avoiding human errors, the simplified certification of asset ownership with improved security when sharing data and storage through smart contracts.
Conclusion

KAPSARC Data Portal and Energy Modelers Datahub

The workshop revealed several key priorities to further enhance KAPSARC’s energy tools:

1. Develop dashboards with options for subscriber alerts to be issued upon defined changes in key energy indicators.

2. Add analytics features to the Energy Modelers Datahub that make it easy for users to visualize model inputs and outputs. Extend integration to other modeling tools, such as eViews.

3. Increase data coverage for the wider Middle East, with more granular, high-frequency monthly open-source energy data, as is currently available for the GCC, India and China.

4. Adopt IRES energy data standards that provide a comprehensive methodological framework for the collection, compilation and dissemination of energy statistics.

5. Develop the energy balance table for Saudi Arabia, specifically focusing on fuels other than crude oil, such as natural gas.

6. Enhancing the data portal platform to improve its data compilation and user feedback mechanism.

Energy Models

The Saudi Arabia Energy Policy Simulator (EPS) is a useful tool for quickly examining the effects of over 50 policy variables. The interactions and cumulative effects of the most common measures are aligned with lowering emissions and improving energy efficiency. The model could be improved by adding fuel shifting for power plants, based on the price difference between fuels and a specified elasticity; this can represent fuel switching between heavy fuel oil and natural gas in dual-fuel units. Pairing the EPS with a macroeconomic model is a potential area for further research.

OSeMOSYS offers users insights for long-run integrated assessment and energy planning. KAPSARC’s modified KOSeMOSYS model fits Saudi Arabia’s context and can help determine the most effective policy approaches for increasing residential energy efficiency. The developers will extend the online version of this model for global access.

Data Management Best Practices

Based on discussions at the workshop, the best practices for energy data management include:

- **Metadata**: Publish metadata standards, data assumptions, a terminology glossary, data availability and alerts of data changes for data consumers.

- **Engage**: Train data publishers periodically on downstream data use cases, improve trust by allowing data users to comment on the dataset quality of the data portal.

- **Use terms**: Use industry standard data licenses such as opendatacommons.org and creativecommons.org where possible, rather than custom licenses.
Conclusion

Quality: Host data with granular and aggregate levels and enable modelers to compare, calibrate, and crosswalk between datasets. Report data quality in terms of the ‘four C’s’: currency (time from published date to database), completeness (breadth, temporality and granularity), consistency (standards such as ISO country codes) and correctness (reference to source data).

Delineate the data from models, improving the ease of maintaining models and data.

Trust among data consumers improves when data:
- Is current and granular.
- Includes traceable sources.
- Can be reviewed, commented on, and critiqued.
- Is relevant to researchers.
- Includes data-transforming recipe scripts.
- Provides accessibility across systems (e.g., using APIs).
- Offers standard data definitions with metadata.
- Is transparent regarding security and privacy (e.g., whether data is public, restricted, or confidential).

An annual workshop to revisit this topic would serve as a valuable forum for experts from academia, industry and government to discuss the opportunities and challenges surrounding open-source energy data, models and tools. Active collaboration with data publishers and data consumers will further advance efforts to improve the availability and quality of data. Finally, providing open data portals and tools to the public will increase the transparency of energy sector research and benefit policymakers and researchers around the world.
About the Workshop

KAPSARC convened the workshop Energy Open Data, Policy Scenario Models and Tools in Riyadh, Saudi Arabia, on October 9, 2019. It brought together over 40 experts from 18 organizations, spanning government, academia, non-profit organizations, and businesses, to discuss best practices for open data and modeling for energy policy analysis.

List of participants

Fahad Alturki – VP, Head of Research, KAPSARC

Amar Amarnath – Energy Information Management Director, KAPSARC

Abeer Alghamdi – Information management lead, KAPSARC

Sadeem Alhosain – Information Management Lead, KAPSARC

Pavithra Shetty – Lead Web Developer, KAPSARC

Linah Alhamdan – Senior Analyst, KAPSARC

Saleh Alansari – Senior Engineer, SABIC

Saeed Alasmari – General Authority for Statistics

Sarah Albassam – EIM Intern, KAPSARC

Sara Alfayez – Analyst, SABIC

Ali Alhamdi – Manager, General Authority for Statistics

Hassan Alharbi – Engineer, Designated National Authority Clean Development Mechanism

Shahad Alhowaish – General Authority for Statistics

Abdullah Aljarboua – Research Associate, KAPSARC

Ali Alqahtani – Director, Ministry of Energy

Abdulaziz Alsalim – Director, Ministry of Energy

Reem Alshahrani – General Authority for Statistics

Ahmed Altuwayjiri – Director, National Digital Transformation Unit

Faris Alwohaibi – Specialist, Ministry of Energy

Osama Alyafi – Energy Economist, Designated National Authority Clean Development Mechanism

Bansidhar Bandi – Energy Analyst, National Institute for Transforming India Aayog

Lujaen Basri – Director, Ministry of Energy

Yagyavalk Bhatt – Research Associate, KAPSARC

Dongmei Chen – Research Fellow, KAPSARC

Pantelis Christodoulides – Senior Statistical Research Analyst, The Organization of the Petroleum Exporting Countries

Imran Chughtai – Manager, KAPSARC

Sean Evers – Managing Partner, Gulf Intelligence

Mark Finley – Visiting Researcher, KAPSARC

Tana Garcia Lastra – Director, Cores, Spanish Oil Strategic Stockholding Agency

George Giannakidis – Head, IEA ETSAP

Fakhri Hasanov – Research Fellow, KAPSARC
About the Workshop

Fouad Hejazi – Senior Engineer, Designated National Authority Clean Development Mechanism

Scott Hutchins – Energy Attaché, U.S. Department of Energy

Anup Kumar – Data Developer, KAPSARC

Abdullah Maghrabi – Engineer, SABIC

Duncan Millard – Independent Advisor, International Energy Agency

Prasanna Mulki – Associate Director, IHSMarkit

Robbie Orvis – Director, Energy Innovation

Aymeric Rousseau – Manager, Argonne National Laboratory

Niranjan Sarangi – First Economic Affairs Officer, UN Economic and Social Commission for Western Asia

Rozina Shaheen – Professor, Effat University

Adam Sieminski – President, KAPSARC

Ranping Song – Manager, WRI

Yuichiro Toirkata – Data Analyst, International Energy Forum (IEF)

Kamna Waghray Mahendra – Research Associate, The Energy and Resources Institute

Eric Williams – Program Director, KAPSARC

Nan Zhou – Scientist, Lawrence Berkeley National Laboratory
About the team

Dr. Fahad Alturki

Dr. Fahad Alturki is Vice President of Research at the King Abdullah Petroleum Studies and Research Center (KAPSARC). In this role, he oversees KAPSARC's research programs and priorities, ensuring that these are strategically focused on impacts within the Kingdom of Saudi Arabia. Dr. Fahad interacts with key stakeholder groups within the Kingdom and internationally in the private, academic, and governmental sectors. Moreover, he is responsible for setting the overall direction and parameters for collaboration with KAPSARC's partners and affiliates. Prior to joining KAPSARC, Dr. Fahad was the Chief Economist and Head of Research at Jadwa Investment Company in Riyadh, where he managed the economic research department and published regular reports on issues related to the Saudi and global economies and the world oil market. He was also the Chairperson of the Public Funds Board, a board member of the Jadwa REIT Al Haramain Fund and Jadwa REIT Saudi Fund, and a member of Jadwa's executive management committee. Dr. Fahad has a proven track record in economics, with over 20 years of experience in the field. Before joining Jadwa, Dr. Fahad was the Chief Economist at Barclays, Saudi Arabia. Prior to his time at Barclays, Dr. Fahad was an economic specialist at the Saudi Arabian Monetary Authority, where he worked for 11 years in the Economic Research and Statistics Department. Dr. Fahad has also worked as an economist at the Middle East and Central Asia Department of the International Monetary Fund. Dr. Fahad holds a B.A. in Business Administration from King Saud University, Saudi Arabia, and master's and Ph.D. degrees in economics from the University of Oregon (Eugene, United States).

Amar Amarnath

As head of the Energy Information Management program at KAPSARC, Amar is responsible for running all facets of the Energy Data Portal design, and the development and energy policy scenario tools. He has over 20 years of experience building data management platforms for the research and technology industries. Prior to joining KAPSARC, Amar was the Chief Information Officer of Swiftpage. At Swiftpage he led the company’s technology transformation to enterprise-ready platforms. Before that, he was Information Technology Vice President at IHS, where he led the design and implementation of global data operations, technology platforms and strategies. He also served as senior director of i2 Technologies’ data consulting services division for a decade, holding several international positions. Amar holds a master's in business administration from Madras University and a bachelor's degree in engineering from Bangalore University.

Abeer AlGhamdi

Abeer AlGhamdi is an information management lead with expertise in energy data management and energy research applications. She has focused on data analysis for research, analyzing Saudi and GCC energy data in various energy fields. She has led related energy data projects, such as the Saudi Arabia energy balance and energy database. She has worked on building and developing the KAPSARC Data Portal and research applications for energy and transportation.
Sadeem Alhosain

Sadeem Alhosain is an information management lead in the Energy and Macroeconomics team, focused on data, model and tool-related projects, and the development of KAPSARC’s Data Portal. She is an economic data specialist on Saudi Arabia, other GCC countries, India and China. Sadeem is an expert in data quality, availability, data sources, and data transformation. She is building the KAPSARC energy Data Portal and developing data insight applications.

Pavithrakumar Shetty

Pavithrakumar Shetty is a senior web developer in the Energy Information Management team. He is responsible for developing and designing web applications for policy scenario tools. He led the web-based energy efficiency Java server. He has over 14 years of development experience in all areas of web software development, including user interfaces, middleware and cloud infrastructure. He has mastered full stack development using Java, MongDB, ExpressJS, AngularJS, and NodeJS. Pavithrakumar was the principal architect at Grabhouse, a technology-driven real estate startup in India. He was responsible for building a scalable web portal with no downtime and backend processes. Prior to that, he worked as a principal software engineer at IHS and played a key role in building the web product suite for their electronics database.

Linah AlHamdan

Linah AlHamdan is an information management specialist in the Energy Information Management team focused on building energy insight web applications and the KAPSARC Data Portal. She specializes in energy datasets sourced from Saudi Arabia, other GCC countries, India and China. She has worked extensively on developing research insight applications such as the KAPSARC Energy Policy Database, the KAPSARC Global Energy Macroeconomic Model, the KAPSARC Building Energy Efficiency, the KAPSARC Vehicle Fleet Model and the KAPSARC Solar Photovoltaic Toolkit.

Abdullah AlJarboua

Abdullah was a senior research analyst in the Energy and Macroeconomics program with interest in developing energy systems and energy-economic models. He holds a master's degree in Computer Science from King Abdullah University of Science and Technology and a B.S. degree in Computer Engineering from Tennessee Technological University.
Fakhri Hasanov

Fakhri Hasanov is a research fellow at KAPSARC and leads the KAPSARC Global Energy Macroeconometric Model (KGEMM) project. Previously, he was an associate professor and director of the Center for Socio-Economic Research at Qafqaz University, Azerbaijan. He has served as a deputy director of the Research Institute at the Azerbaijan Ministry of Economic Development, and as a senior economist at the Research Department of the Central Bank of Azerbaijan Republic. He received a Fulbright Post-Doctoral Scholarship from the George Washington University, where he conducted research on building and applying a macroeconometric model for policy analysis. Fakhri is a member of the research program on forecasting at the George Washington University and a member of the editorial board of the Asian Journal of Business and Management Sciences. His research interests and experience span econometric modeling and forecasting, building and applying macroeconometric models for policy purposes, and energy economics, with a particular focus on natural resource-rich countries.

Eric Williams

Eric Williams has over 20 years of experience as an energy and environmental economist focusing on energy and climate change policy, energy systems analysis, and climate change mitigation and adaptation options. Eric managed the writing and publication of a series of reports on the concept of Circular Carbon Economy, delivered to the G20 in 2020. The reports were written by international organizations, including the International Energy Agency (IEA), the OECD, the International Renewable Energy Agency (IRENA), the Nuclear Energy Agency (NEA), and the Global CCS Institute (GCCSI). Eric was previously the acting program director of KAPSARC’s Climate Change and Environment program. Before joining KAPSARC, Eric worked as an economist for the North Carolina Utilities Commission and was a consultant at the OECD. He has also worked for the United Nations, academic research institutes, think tanks, and government.

Anup Kumar

Anup is responsible for designing and implementing data platforms that automate data sourcing, transformation, and publishing needed for research at KAPSARC. He led the development of insight web applications such as the KAPSARC Energy Model – Saudi Arabia, KAPSARC Energy Policy Database, KAPSARC Global Energy Macroeconomic Model and KAPSARC Building Energy Efficiency. Anup brings eight years of database management in enterprise data warehouse, process automation, data analysis, and web development expertise. Prior to KAPSARC, he worked for several large data publishers and startups with massive energy data portals. He has also developed several data transformation tools using new age platforms such as elastic search, JavaScript and Mongo database. Anup specializes in the extract-transform-load process and has automated hundreds of manual processes significantly improving speed and efficiency.
About the Project

The Energy Information Management (EIM) project team works to improve the understanding of energy economics through open data, policy scenarios and energy policy scenario tools. It develops visualization tools and dashboards that provide web-based applications for researchers and policy stakeholders. Thus far this project has published over 1,300 open energy-, economic- and climate-related datasets on the KAPSARC Data Portal and 14 energy model tools.