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The Political Feasibility of Policy Options for the UAE's Energy Transition

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Legal Notice

Key Points

The United Arab Emirates (UAE) has said it wishes to transition toward a less carbon-intensive energy system, both as part of its Nationally Determined Contribution (NDC) within the United Nations Framework Convention on Climate Change (UNFCCC), and as one of a number of investments in 'green' research and development, technology and power generation. However, given the complexity of the UAE political system, which requires consensus among seven relatively sovereign and independent emirates, as well as commercial and financial interests, it is not immediately clear which policy instruments that might drive the UAE energy transition will prove acceptable and politically plausible. Here, we apply the KAPSARC Toolkit for Behavioral Analysis (KTAB) platform, a model of collective decision-making processes (CDMPs), to assess the political will to agree to and to implement an array of different policy alternatives within the current UAE context.

- Energy subsidy reforms in the UAE have already been undertaken, and there appears to be sufficient political will for them to continue, though extensive subsidy reforms appear politically untenable.

- Explicit carbon pricing in the UAE appears politically infeasible, as it does not appear to be able to achieve the consensus required in the face of entrenched interests that would be harmed by such an approach.

- There appears to be robust political will to effectively deliver on the UAE's renewable energy ambitions. An example includes the continuation of the utility scale solar energy tenders that have already proved successful.

- Similarly, there appears to be strong and growing support to maintain the UAE's plans to bring online 5.6GW of nuclear power in the next year, although support for nuclear beyond this level of deployment is uncertain.

- Energy efficiency standards, whether targeted toward the commercial or residential sector, appear to be a politically feasible alternative to help lower UAE energy demand. There is moderately strong political will in support of this policy approach.

- A perhaps surprising conclusion from this study is the somewhat neutral, although still positive, political will in support of natural gas, given the current dominance of natural gas in the UAE power sector.

Introduction

This paper applies a model of collective decision-making processes (CDMPs) to evaluate the political feasibility of six different policy options that could help achieve the efforts of the United Arab Emirates (UAE) to change its energy system to a less carbon-intensive one. Here, this is simply referred to as the UAE's energy transition. The opportunities, barriers and most appropriate policies for such an energy transition in the UAE and broader Gulf Cooperation Council (GCC) have been described elsewhere (Griffiths 2017a, 2017b; Sgouridis et al. 2013). However, this is the first work that makes a detailed, quantitative assessment of the viability of implementing specific policy instruments to achieve such a transition.

The strategic selection of a particular mixture of policies to achieve an energy transition is based upon both the expected impact of the policies, as well as the potential political consensus that can be achieved in order to define and implement policy. In the case that the key decision-makers and implementing authorities do not arrive at consensus about a policy instrument, we would consider that instrument to be politically infeasible. When decision-makers and implementing authorities arrive at consensus about a policy instrument, then it is likely that it will be both selected and implemented effectively.

In the following sections, the UAE's political system, energy system and efforts toward sustainability are discussed. This discussion serves as important context for the CDMP analysis that follows.

UAE political system

The UAE is a federation of seven constituent emirates: Abu Dhabi, Ajman, Dubai, Fujairah, Ras Al Khaimah, Sharjah and Umm Al Quwain. Under the UAE government system, the president of the federation is elected by a Supreme Council of Rulers (hereafter referred to as Supreme Council), which is the top policymaking body in the UAE. The UAE vice president is also elected by the Supreme Council and both the president and vice president serve renewable five-year terms. The UAE president is also commander of the UAE Armed Forces, chairman of the Supreme Council and chairman of the Supreme Petroleum Council. The Supreme Petroleum Council is the highest governing body of the UAE hydrocarbon sector and serves as the board of directors to the Abu Dhabi National Oil Company (ADNOC).

The Supreme Council has both legislative and executive powers. In addition to planning and ratifying federal laws, the Supreme Council approves the president's nominated prime minister. The prime minister, following appointment by the president, appoints a Council of Ministers, or cabinet, to oversee the development and implementation of federal policy across all portfolios of government. In addition to the Supreme Council and the Council of Ministers, a Federal National Council (FNC) exists to examine proposed new legislation and provides advice to the UAE cabinet, as required.

Sheikh Zayed bin Sultan Al Nahyan was president of the UAE from the country's founding in 1971 until his death in 2004. Following Sheikh Zayed's death, his oldest son, Khalifa bin Zayed Al Nahyan, became UAE president and continues to serve as president. Sheikh Mohammed bin Rashid Al Maktoum is currently UAE vice president and prime minister. By custom, the UAE presidency is held by the ruler of Abu Dhabi and hence the position is hereditary to the Al Nahyan clan. Likewise, the vice presidency – and de facto the prime minister role – is customarily held by the ruler of Dubai and hence hereditary to the Al Maktoum clan. Because of this political structure, the Crown Prince of Abu Dhabi is an extremely important political figure. Abu

Dhabi's current Crown Prince, Sheikh Mohamed bin Zayed Al Nahyan, is expected eventually to succeed Khalifa bin Zayed Al Nahyan as president of the UAE. While Crown Prince of Abu Dhabi, Sheikh Mohamed, also serves as Deputy Supreme Commander of the UAE Armed Forces and chairman of the Abu Dhabi Executive Council.

UAE energy system

The UAE is the world's seventh largest oil producer and fourth largest exporter (IRENA 2016). It also has substantial natural gas reserves and its power and water sector is almost entirely dependent on natural gas. Although the country has made great efforts toward economic diversification, energy intensive industries still dominate the landscape, with more than 60 percent of total final UAE energy consumption coming from the industrial sector (Sgouridis et al. 2013). Industrial energy intensity, a hot and arid climate that requires substantial energy for cooling and water desalination, together with subsidized energy prices in the power, water and transport sectors, have made the UAE one of the world's highest energy consuming countries per capita (IRENA 2016).

For energy governance, each UAE emirate constitutionally maintains considerable power over its own energy sector governance, including control over mineral rights, most notably oil, and over its power and water sector. While the UAE federal government has exclusive and executive jurisdiction over electricity services, in practice each emirate formulates and implements its own electricity policies and operates essentially independently. Although the UAE Ministry of Energy is the federal entity formally overseeing the electricity sector, there is no federal law that regulates the collective energy policies of the country. The only significant federal level authority for energy governance in the UAE is administration of transportation fuel prices.

Within the UAE power and water sector, the main entities responsible for the generation, transmission and distribution of water and electricity are:

- Abu Dhabi Water and Electricity Authority (ADWEA) – Abu Dhabi.
- Dubai Electricity and Water Authority (DEWA) – Dubai.
- Sharjah Electricity and Water Authority (SEWA) – Sharjah.
- Federal Electricity and Water Authority (FEWA) – Ajman, Fujairah, Ras Al Khaimah and Umm Al Quwain.

These state-owned utilities are the exclusive purchasers and distributors of electricity in their respective areas of operation. Although the private sector can participate in the generation of water and electricity, water and electricity transmission and distribution are exclusively carried out by the named state-owned utilities.

Energy policies are rather heterogeneous across the emirates. Abu Dhabi and Dubai have the most advanced policy and regulatory structure in their power and water sectors. Each has introduced independent regulators: the Regulatory and Supervisory Bureau, in Dubai, and the Regulation and Supervision Bureau, in Abu Dhabi. Further, Dubai has established the Dubai Supreme Council of Energy (DSCE) in an effort to centralize and formalize energy decision-making. It brings together Dubai's largest energy producers and consumers, including DEWA, to jointly set policy and investment across the emirate's energy sectors. Abu Dhabi has considered a similar model, with an Abu Dhabi Energy Authority now under development. To date, however, this has little distinct visibility. Rather, it is Abu Dhabi's Executive Council, of which the chairman of the Energy Authority is a member, which seems to have the overarching power over the emirate's power and water sector.

The Abu Dhabi Executive Affairs Authority is the body that provides strategic energy, economic, governmental and communications policy advice to the Executive Council and its chair, the Abu Dhabi Crown Prince. The chairman of the Executive Affairs Authority is also a member of the Executive Council. In addition, the current authority chairman is also the managing director and CEO of Mubadala, a state-owned holding company, and chairman of the Emirates Nuclear Energy Corporation's (ENEC) board of directors. Mubadala owns Masdar, Abu Dhabi's renewable energy and sustainable development company, plus a 51 percent stake in Dolphin Energy, the company responsible for importing natural gas from Qatar to meet approximately 23 percent of the UAE's natural gas requirements.

Abu Dhabi holds approximately 94 percent of the UAE's oil reserves and hence the hydrocarbon production sector is of great political and economic importance to the emirate. However, governance of hydrocarbon production is not directly represented on the Abu Dhabi Executive Council; it has a unified governance structure under the Supreme Petroleum Council.

Environmental stewardship in the UAE

The UAE has a long history of cautious economic development, particularly when it comes to minimizing the effect of economic activity on the environment. The UAE's first President, Sheikh Zayed Bin Sultan Al Nahyan, took a range of measures to protect the environment including, among other measures, an early decree to reduce the flaring of associated natural gas, a byproduct of oil production. In 1973, a gas liquefaction company, the Abu Dhabi Gas Liquefaction Company Limited (ADGAS), was established to collect and liquefy natural gas in the emirate for export to Japan. Additionally, all the UAE's power and water desalination plants were built using a gas feedstock supplied by ADNOC. Since then, Abu Dhabi has flared very little gas.

In 2006, in response to increasing global concerns about carbon emissions, state-owned Mubadala established a new entity to invest in clean energy. Known as the Abu Dhabi Future Energy Company, or Masdar, this initiative quickly spawned into a large-scale enterprise investing in renewable energy innovation and deployment in the UAE and abroad through a variety of subsidiaries.

Masdar completed its first solar project in the UAE in 2013 with the 100MW Shams 1 concentrated solar power plant, the world's largest at the time. Since 2013, the neighboring emirate of Dubai has moved ahead with a number of renewable energy projects. In parallel, Abu Dhabi is building the GCC's first nuclear power plant at Barakah, where ENEC is constructing up to four reactors. The first reactor, originally scheduled for completion in 2017, has been postponed until at least 2018 due to delays in issuance of generation permits.

Masdar's creation has been complemented by a number of master plans or vision statements broadly covering the UAE's sustainable economic development and climate change aspirations. Masdar takes its cue from Abu Dhabi Vision 2030, but in recent years the UAE federal government has published its UAE Vision 2021, and the emirate of Dubai has its own Plan 2021 and the Dubai Integrated Energy Strategy 2030 that map out distinct visions for a sustainable future. More recently, in 2017, the UAE Ministry of Energy announced a new UAE Energy Strategy 2050 that outlines a number of UAE energy targets for 2050 (UAE State of Energy Report 2017), including:

> Power: 44 percent of electricity from renewable energy, 38 percent from natural gas, 12 percent from clean fossil and 6 percent from nuclear energy.

> Energy Efficiency: 40 percent improvement relative to current annual growth in electricity demand of 6 percent.

> Carbon Emission Reduction: 70 percent reduction in carbon emissions from power generation.

In parallel, the UAE's federal Ministry of Foreign Affairs submitted its Intended Nationally Determined Contribution (INDC) to the United Nations Framework Convention on Climate Change (UNFCCC) in October 2015, in advance of the 21st session of the Conference of the Parties (COP21) meeting in Paris. The document was ratified in September 2016, becoming its Nationally Determined Contribution (NDC). The document sets a target of increasing clean energy contribution to the UAE's total energy mix from 0.2 percent in 2014 to 24 percent by 2021 (UNFCC 2015). As summarized below, this document additionally outlines economic diversification efforts and sustainability efforts, but falls short of committing to a specific level of carbon emissions reduction.

Sustainability actions outlined in the UAE NDC

Economic Diversification with Mitigation Co-benefits: The UAE's population has more than tripled since 1995, and will continue to grow, putting increased pressure on the supply of energy and water. The UAE has therefore made the strategic decision to diversify its energy mix, increase efficiency and continue to use world-class performance standards and the best available technologies in its energy-intensive industries and its oil and gas sectors.

Clean Energy Target: The UAE set the region's first renewable energy targets, at a time when there was widespread doubt about renewable energy's viability and value. Since then, the country's deployment of renewable energy has had a significant normalizing effect for the technology in the region. This is now supported by a compelling financial case, with recent results in the UAE recording the lowest cost for solar globally. The UAE has set a target of increasing the contribution of clean energy to the total energy mix from 0.2 percent in 2014, to 24 percent by 2021. This will be achieved through renewable and nuclear energy, and is underpinned by detailed emirate level targets and policies.

Improvements in Energy-Intensive Industries and the Oil and Gas Sector: The UAE's energy-intensive industries and oil and gas sectors will continue to use innovative technologies to improve efficiency and reduce emissions. The UAE's oil companies are among the most efficient globally. The UAE's national oil company was the first in the region to promote the reduction of gas flaring in order to reduce greenhouse gas emissions. In energy-intensive industries, overall performance indicators will be improved through carbon abatement measures and increased resource efficiency. The UAE is also developing the region's first commercial scale network for carbon capture, usage and storage. The project notably captures emissions at a steel manufacturing facility. These will be compressed and transported to oil fields, to be used to enhance oil recovery and ultimately be stored underground, providing one of the first viable mechanisms to decarbonize essential energy intensive-industries.

Energy and Water Efficiency: In addition to supply side targets, the UAE is introducing comprehensive policies to reduce energy and water demand and promote the prudent use of resources, through the following measures:

Tariff reform: The UAE recognizes the value of energy and water tariff reform in reducing inefficiencies and promoting low-carbon development, as well as addressing energy security concerns. To this end, the UAE utility authorities have introduced a number of initiatives and policies and revised the country's tariffs over the years, gradually adjusting the tariffs for commercial and industrial customers so as to reflect the cost of generation by 2021.

Building and efficiency standards: The UAE is comprehensively targeting emissions from its building sector, which account for a significant percentage of the country's electricity and water consumption, through green building regulations, efficiency standards, retrofit programs and support structures for energy service companies across the UAE.

Demand side management: The UAE has launched a number of initiatives based on consumer awareness and demand management, including new formats for water and electricity bills, which give residents detailed consumption and subsidy information.

District cooling: Air conditioning accounts for a significant share of energy consumption, given the UAE's harsh climate. Comprehensive infrastructure investments are being undertaken to move toward district cooling and improve efficiency as compared to decentralized cooling.

Appliance efficiency standards: The UAE introduced the region's first efficiency standards for air conditioning units, eliminating the lowest performing 20 percent of units on the market, and is introducing efficiency standards for refrigeration and other appliances. The UAE has also established an indoor lighting standard that introduces energy efficient lighting products and phases-out inefficient lighting products in the UAE market.

Transport and Infrastructure: Infrastructure development is critical to the UAE's plans for economic diversification. The country has made infrastructure development a key priority area and the government is investing heavily in world class traffic and transport systems. For example, the emirate of Abu Dhabi has adopted a comprehensive urban structure framework plan to optimize the city's development up to 2030. The UAE is undertaking the following investments and initiatives, which will have significant mitigation co-benefits in addressing the transport sector's greenhouse gas emissions, including:

Introduction of a new fuel pricing policy, which will bring the UAE into line with global prices. This reform aims to support the national economy, lower fuel consumption and protect the environment.

Construction of a federal freight rail network crossing the country and eventually integrated into the GCC network.

The emirate of Abu Dhabi has also set targets to shift 25 percent of government vehicle fleets to compressed natural gas.

> The emirate of Dubai has invested in a multibillion dollar light rail and metro system, which will continue to add new lines.
>
> The UAE continues to improve the emission standards for new motor vehicles, in accordance with European emission standards, as well as through the introduction of standard labels.

These initiatives target both improvements in fuel economy and reduction in local air pollution. The UAE will also introduce comprehensive regulations for electric vehicles, to facilitate their uptake domestically.

Waste Sector: The UAE will increase the amount of treated waste, and waste diverted from landfill, through a number of key initiatives, including:

> Developing a federal law to regulate and oversee waste management.
>
> Defining a federal road map for integrated waste.
>
> Developing a federal database to gather and collect information about waste.

This section is drawn from the UAE's INDC submission (UAE INDC 2015).

The UAE Energy Strategy 2050 and documents such as the UAE NDC contain general ambitions for sustainable national development and aspirational targets, but do not specify precisely how the ambitions and targets will be implemented.

One reason for this, if not the overarching one, is the UAE’s complex decision-making process, resulting from the country being a federation of seven nominally independent emirates. Power is polarized between Abu Dhabi and Dubai, which historically strictly guard their policymaking independence. The remaining smaller emirates, known collectively as the Northern Emirates, tend to follow Abu Dhabi’s policy lead.

For the purposes of this study, we have identified six policy instruments:

> Carbon pricing: Implementation of a carbon-focused tax, or related policy measures that directly impose a price on carbon.

> Renewables: Increased deployment of renewable energy sources, e.g., solar and/or wind, for electric power generation and desalination.

> Nuclear energy: Implementation of previously planned deployment of nuclear energy in electric power generation.

> Energy efficiency (EE): Increased implementation of EE standards with monitored performance and audits to achieve greater EE technology adoption and demand side management.

> Energy subsidy reform: Further reform of energy subsidies for power, water and transportation fuels.

> Natural gas: Maintaining the use of natural gas in electric power generation, perhaps taking advantage of new sources of cheap gas, e.g., liquefied natural gas, or new gas field development.

The complexities of the UAE political system add a layer of complexity to the implementation of these six policy instruments. As described elsewhere (Griffiths 2017b), the following issues must be considered:

Carbon pricing: In order to maintain a level playing field within the UAE, it would be necessary for the introduction of carbon pricing to be a federal policy, uniformly adopted by all the emirates. The UAE has no explicit commitment to a certain level of carbon emissions abatement.

Renewables: The implementation of renewable energy projects is currently the policy domain of individual emirates and their respective utility companies.

Nuclear energy: Only the emirate of Abu Dhabi has decided to develop nuclear energy, via ENEC. The company charged with building four nuclear power plants in Abu Dhabi, ENEC is fully owned by the Abu Dhabi government. However, the UAE nuclear regulator, the Federal Nuclear Energy Authority (FANR), is a federal institution, with a board made up almost exclusively of officials from Abu Dhabi.

Energy efficiency: Each UAE emirate implements its own EE regulations and standards for buildings (Friess and Rakhshan 2017), although regulation of appliance energy efficiency is at the federal level through the Emirates Authority for Standardization and Metrology (ESMA).

Energy subsidy reform: Transport fuel prices in the UAE are harmonized between all the emirates. In recent years, the federal Ministry of Energy has taken a lead in introducing variable prices for retail transportation fuels, gasoline and diesel, based on the international market price. Electricity and water prices are established by each emirate, with Dubai taking an initial lead in establishing cost reflective pricing, but with the other emirates making substantial progress in recent years.

Natural gas: The emirates of Abu Dhabi, Dubai and Sharjah all produce natural gas, either from gas fields or in the form of associated gas. However, gas production in the UAE is not enough to supply growing demand from its power sector and from industrial users. Since 2006, the UAE has imported gas from Qatar via the Dolphin pipeline (17.9bcm in 2016 (MEES 2017)) and more recently has expanded liquefied natural gas imports (3.9bcm in 2016 (MEES 2017)) through Dubai. It is introducing floating storage and regasification units (FSRU) in Abu Dhabi and Sharjah (MEES 2017). Plans for a fully-fledged gas terminal in the emirate of Fujairah appear to have stalled, given the more attractive near term economics of FSRUs. ADNOC is also putting renewed efforts into the development of non-associated sour gas fields, with new developments bringing as much as 1.8 billion cubic feet a day (bcf/d) of gas sales to the UAE within the next several years (MEES 2017). Increased use of natural gas for power and water generation is a policy choice made by individual emirates which have control over their respective electricity and industrial sectors, though the smaller Northern Emirates are dependent on Abu Dhabi for much of their power supply and thus can be clustered with it.

We model the CDMPs that surround the policy environment of each of these issues using the KAPSARC Toolkit for Behavioral Analysis (KTAB). In consultation with a group of 10 subject matter experts, we identified actors that reflect the federal makeup of the UAE, including decision-makers, government institutions, representatives of industry and business, and those that may try to influence decision-makers.

Some top actors are active at the federal level as well as in their respective emirate, while others are only relevant to their own emirate. In exclusively federal issues, such as carbon pricing and price reform, this duality has little, if any, impact. In the case of renewables, energy efficiency and natural gas policy options, most of the emirates follow a parallel track, though a KTAB study can be used to identify subtle policy differences between them. However, in the case of the nuclear energy policy option, the KTAB process reveals considerably lower levels of salience by actors outside the emirate of Abu Dhabi, though a degree of interest can be explained by concerns about the risk associated with nuclear power and the benefits to power system stability that nuclear baseload provides.

The KAPSARC Toolkit for Behavioral Analysis (KTAB)

Overview of KTAB

KTAB is a platform that enables the modeling and analysis of collective decision-making processes (CDMPs). CDMPs can be distinguished from other decision-making processes in that:

> They involve more than one actor, which can be an individual, institution, or an identifiable group or 'bloc'.

> A single decision is arrived at as a result of some form of coordinated interaction between a finite set of actors.

The form of this interaction is different in kind to large group decision-making processes such as the market-based derivation of a price, for example, which is the result of the uncoordinated actions of countless individuals.

In this paper, we will present an analysis of plausible outcomes for the collective decision-making processes that decision-makers and stakeholders in the UAE are currently engaged in regarding the policy instruments for achieving an energy transition. To do so, we used a specific instantiation of a model in KTAB, based on the Spatial Model of Politics (SMP), which is one of the most prominent models of CDMPs. It analyzes collective choice or actions of societal actors with various preferences, behavior assumptions and information under pre-defined institutional rules. The theory assumes an individual has well-defined preferences over a given set of alternatives, and will choose any alternative based on no other alternative in the set being strictly more preferred by the individual; that is, the social actor will choose a 'best' alternative. The SMP examines the possibility that individual preferences are directly aggregated into a collective preference relation, which is then maximized to yield a set of best alternatives, where 'best' is defined as being the most preferred with respect to the collective preference relation (Austen-Smith and Banks 1998). While we have chosen to use one model for our simulations, KTAB is a toolkit that enables almost limitless variant models to be implemented, based on different assumptions as to how various CDMPs work. Any and all of the assumptions in this paper can be changed, and new models built in the KTAB framework.

For this paper, we have deliberately chosen to focus on the logic of the analysis and to present a description of the results. What this paper does not contain is a detailed technical description of the underlying model and its calculations. Interested readers are pointed to two related KAPSARC papers for more detail:

> An Introduction to the KAPSARC Toolkit for Behavioral Analysis (KTAB) Using One-Dimensional Spatial Models (Wise, Lester and Efird 2015a).

> Multidimensional Bargaining using KTAB (Wise, Lester and Efird 2015b).

Both papers are available from KAPSARC's website, specifically the KTAB portal, as is the program's source code and documentation. Please visit http://ktab.kapsarc.org for all related papers, and http://kapsarc.github.io/KTAB/ for the software.

By separating the technical detail from the applied discussion, we hope to make the discussion more accessible for what is a relatively new field to most readers.

Approach and assumptions

When analyzing CDMPs, one way to show the preferences of, and differences of opinion between, the various actors is to represent them graphically using a technique referred to as spatial preferences. With this, the distances between points on a line that captures possible advocacy reflect the spatial component in this approach (Wise, Lester and Efird 2015b; Efird, Lester and Wise 2016). This approach forms the basis for a model we have implemented in KTAB, the SMP. We apply the SMP to the question of the political feasibility among policy choices for transition to a lower carbon economy in the UAE. The SMP approach exemplified in KTAB is described in detail in other work (Efird et al. 2016). The essential aspects of the SMP for the purpose of this study is that a set of actors is defined with differing positions on issues, influence that they can exert on each issue, and salience (or concern) they have for each issue, respectively. Position, influence and salience are all captured numerically on a scale of 0 to 100 during semi-structured interviews with subject matter experts. It is the combination of influence and salience that gives a particular actor his, her or their ultimate power in making the particular outcome for an issue more or less likely. Further details on the KTAB SMP are provided in Appendix 1 of this paper.

Model dynamics: turns in the KTAB SMP

KTAB's SMP provides a simulation of how actor positions change over time. Time is captured in a series of iterations or 'turns.' The exact length of time a turn takes is an abstraction: a turn should be thought of as any period of time during which all actors can exchange information and attempt to influence each other. The results of the simulation present the turn-by-turn changes to actors' positions. These shifts in position are based on several different factors in the model, all operating simultaneously. Generally speaking, the behavior of individual actors can vary quite widely, based on the configuration of numeric values in a particular dataset. There is no such thing as a 'rule of thumb' regarding how the simulation unfolds. Sometimes actors will move only incrementally as the turns progress, sometimes they may make much larger moves in the simulation. A brief, non-technical, description of the logic behind the simulation is provided in Appendix 2. In this paper we will focus on the high level outcomes calculated by the KTAB simulation, while trying to provide some explanation for the numeric calculations that result in the most interesting shifts in actor positions.

Analysis of Political Feasibility for Policy Choices in the UAE Energy Transition

Defining the question

The fundamental question addressed by this study is: What is the political feasibility in the UAE for different policy options available to decision-makers that may help drive an energy transition? We start with defining the spectrum of positions. The spectrum reflects the range of positions that actors in this simulation might take. Unlike other SMP studies, the spectrum here doesn't reflect a series of concrete alternatives that reflect an admixture of policy options, but rather the range of support for, or opposition to, one of six policies. These policy instruments were identified by the experts consulted in this study as some of the core options supporting an energy transition by the UAE. They are not mutually exclusive, nor zero sum, but there is some potential for trade-off, and not all actors view each of them, and value the policy alternatives, in the same way.

The intent at this point is not to evaluate the specifics that might be included in any one of the policy options, but to assess the political environment and actors' perceived views about whether each of them individually is a politically viable option. From this, we can draw inferences about what each policy alternative might actually look like, but we first want to assess whether each option is even politically feasible.

As shown in Figure 1, actors that take a position close to 50 are indifferent to the particular policy. Actors taking a position of 0 at the far left of the figure are extremely opposed to the policy, and actors at a position of 100 at the far right of the figure are unambiguously supportive of the policy. Positions ranging from 50 to 0 reflect increasing opposition, and positions ranging from 50-100 reflect increasing support.

As previously discussed, the six policy instruments considered in this study include:

- Implementation of carbon pricing.
- Increased deployment of renewable energy, particularly in the power sector.
- Implementation of nuclear power according to current plans.
- Increased implementation of energy efficiency technologies and demand side management.
- Further energy subsidy reform.
- Maintained role of natural gas in energy production.

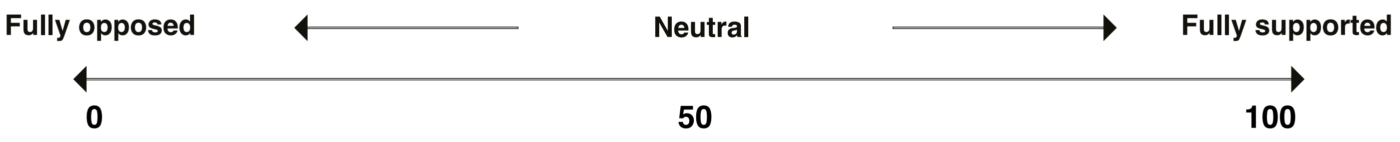

Figure 1. Spectrum of positions on policy choices for UAE energy transition – degree of support for or opposition to each policy alternative.

Source: KAPSARC and Masdar KTAB analysis.

The data sources

In order to collect data for this study, we interviewed 10 experts in Abu Dhabi who are knowledgeable about the key players that have the ability to influence the decisions regarding each of the policy alternatives discussed in the previous discussion for the UAE. The experts included a former regulator, industry figures, consultants, analysts and senior advisors – all of whom are actively involved in energy and policy reform in the UAE, and who were carefully selected because of their specific knowledge of the actors and issues. As with any KTAB study, we identified a comprehensive list of actors, including policymakers and influencers, and gathered three specific quantitative attributes for each actor. Specifically, this included each actor's:

> Position: The location of an actor on the linear spectrum. In other words, what is this actor's advocacy with respect to supporting or opposing the policy option?

> Influence: The relative degree of political power for each actor. The most powerful actor is assigned a value of 100, and others are weighted relative to the most powerful actor.

> Salience: The relative priority each actor assigns to the particular policy option as compared with other issues over which they must exert influence.

We aggregated the data collected during expert interviews into six individual data sets, which we call our baseline data set, one for each policy instrument. In this case, we started with a meeting that included all of the experts together, and followed up with individual interviews. Table 1 provides a list of those actors identified by the experts for inclusion in the study. While the majority are described in the Introduction, additional discrete actors were considered. These include TAQA, which is an international energy and water company listed in Abu Dhabi and holding a 54 percent interest in each of Abu Dhabi's eight UAE power generation and water desalination plants, the UAE Central Bank, and several ministries that have ministers who are part of the UAE cabinet. The aggregate aviation industry largely consists of Emirates Airline, the UAE national carrier based in Abu Dhabi, and Emirates Airline based in Dubai. Energy-intensive industrials are significantly represented by companies involved in aluminum, steel, cement and construction. What we have called 'civil society organizations' is a collective actor representing such organizations as the Emirates Wildlife Society.

With regard to groupings, the Regulatory and Supervisory Bureau in Dubai and the Regulation and Supervision Bureau in Abu Dhabi are collectively discussed as the Regulatory and Supervisory Bureau. Particular consideration is given to the grouping that includes both the Abu Dhabi Crown Prince and the prime minister. Both represent a UAE royal house (i.e., Al Nahyan and Al Maktoum) and hence are grouped accordingly with, in almost all cases, substantial influence given to the matters of concern to them.

Table 1. Actors and groups displayed in bar charts.

Code	Actor Description	Group
CP	Abu Dhabi Crown Prince	Royal House
PM	Prime Minister	Royal House
ADEC	Abu Dhabi Executive Council	Government
MOE	Ministry of Energy	Government
MOCCE	Ministry of Climate Change and Environment	Government
MOS	Ministry of State	Government
MOF	Ministry of Finance	Government
MOFA	Ministry of Foreign Affairs	Government
EAA	Executive Affairs Authority	Government
RSB	Regulatory and Supervisory Bureau	Government
ADWEA	Abu Dhabi Water and Electricity Authority	Government
SPC	Supreme Petroleum Council	Government
DSCE	Dubai Supreme Council of Energy	Government
DEWA	Dubai Electricity and Water Authority	Government
SEWA	Sharjah Electricity and Water Authority	Government
FEWA	Federal Electricity and Water Authority	Government
UCB	UAE Central Bank	Government
EAD	Environmental Agency - Abu Dhabi	Advisor
CSO	Civil society organizations (pro-environment)	Advisor
Mubadala	Mubadala	Energy company
ENEC	Emirates Nuclear Energy Corporation	Energy company
Masdar	Masdar	Energy company
TAQA	TAQA (Abu Dhabu National Energy Company)	Energy company
ADNOC	Abu Dhabi National Oil Company	Energy company
Dolphin	Dolphin Energy	Energy company
EII	Energy-intensive industrials	Energy-consuming company
Aviation	Aviation industry	Energy-consuming company

Source: KAPSARC and Masdar expert interviews.

As part of the group discussion among experts that began the study, the group of experts generally came to a consensus for some of the values assigned to the actors and used for the KTAB analysis. For the remaining data values, we followed up with the experts and received the remaining numeric input in individual discussion. When there are differences of opinion about the assignment of values, particularly for key stakeholders, we made a note of the differences to perform sensitivity analysis. We present our baseline data set in Table 2. This represents our best guess as to the data, using the collective knowledge of the actors from our 10 interview subjects to assign the values. The expert-based data for the policy options described above is shown in Table 2. This table presents the weighted average for each policy option, for position, influence and salience, from all experts.

Table 2. Expert-based data regarding support for or opposition to policy options for UAE energy transition.

		Carbon pricing			Renewables			Nuclear power		
Code	**Actor Description**	**Position**	**Influence**	**Salience**	**Position**	**Influence**	**Salience**	**Position**	**Influence**	**Salience**
CP	Abu Dhabi Crown Prince	50	100	10	80	100	22.5	100	100	35
PM	Prime Minister	60	85	20	90	82.5	25	67.5	52.5	20
ADEC	Abu Dhabi Executive Council	20	70	10	50	60	17.5	100	75	15
MOE	Ministry of Energy	60	30	25	70	35	37.5	70	25	27.5
MOCCE	Ministry of Climate Change and Environment	80	20	40	90	35	50	60	20	32.5
MOS	Ministry of State	0	50	15	80	55	22.5	75	40	16
MOF	Ministry of Finance	50	20	5	50	20	3.5	47.5	25	13.5
MOFA	Ministry of Foreign Affairs	75	60	5	70	35	10	60	40	12.5
EAA	Executive Affairs Authority	60	10	10	70	20	27.5	100	75	45
RSB	Regulatory and Supervisory Bureau	55	10	15	70	15	20	60	15	22.5
ADWEA	Abu Dhabi Water and Electricity Authority	60	30	15	60	25	17.5	60	25	15
SPC	Supreme Petroleum Council	20	50	5	50	60	5	50	50	7.5
DSCE	Dubai Supreme Council of Energy	65	30	15	90	40	42.5	50	20	36

DEWA	Dubai Electricity and Water Authority	65	30	30	90	40	52.5	42.5	20	35
SEWA	Sharjah Electricity and Water Authority	20	5	2	50	12.5	33.5	35	10	32.5
FEWA	Federal Electricity and Water Authority	50	2	2	60	1.5	32.5	35	6	35
UCB	UAE Central Bank	70	2	5	60	6	3	35	11	8.5
EAD	Environmental Agency – Abu Dhabi	80	20	40	100	35	45	50	20	32.5
CSO	Civil society organizations (pro-environment)	100	4	40	100	7	37.5	35	4.5	39.5
Mubadala	Mubadala	60	60	10	70	60	12.5	85	70	17.5
ENEC	Emirates Nuclear Energy Corporation	80	5	5	40	7.5	3.5	100	40	69.5
Masdar	Masdar	75	5	30	100	40	35	45	27.5	65
TAQA	TAQA (Abu Dhabu National Energy Company)	20	2	20	80	1.5	12.5	45	1.5	17.5
ADNOC	Abu Dhabi National Oil Company	0	45	20	60	37.5	7.5	50	27.5	5
Dolphin	Dolphin Energy	0	10	5	30	5.5	10	35	5.5	3.5
EII	Energy-intensive industrials	10	40	10	60	20.5	11	45	40	17.5
Aviation	Aviation industry	0	70	40	50	20	10	50	20	10

Code	Actor Description	Energy efficiency Position	Energy efficiency Influence	Energy efficiency Salience	Subsidy reform Position	Subsidy reform Influence	Subsidy reform Salience	Natural gas Position	Natural gas Influence	Natural gas Salience
CP	Abu Dhabi Crown Prince	62.5	100	12.5	75	100	35	62.5	100	10
PM	Prime Minister	72.5	87.5	13.5	80	87.5	20	72.5	85	22.5
ADEC	Abu Dhabi Executive Council	50	70	10	55	60	17.5	55	55	16.5
MOE	Ministry of Energy	75	35	20	75	32.5	20	55	52.5	27.5
MOCCE	Ministry of Climate Change and Environment	95	25	32.5	90	17.5	35	55	12.5	40
MOS	Ministry of State	65	45	17.5	85	30	12.5	57.5	35	17.5
MOF	Ministry of Finance	40	50	3.5	75	40	22.5	70	40	15
MOFA	Ministry of Foreign Affairs	47.5	45	5	60	32.5	5	60	35	5
EAA	Executive Affairs Authority	75	37.5	45	87.5	12.5	35	52.5	35	37.5
RSB	Regulatory and Supervisory Bureau	90	10	47.5	100	37.5	57.5	75	5.5	45
ADWEA	Abu Dhabi Water and Electricity Authority	80	30	40	70	50	47.5	77.5	30	52.5
SPC	Supreme Petroleum Council	65	65	5	50	65	32.5	55	70	17.5
DSCE	Dubai Supreme Council of Energy	75	30	35	90	35	35	65	35	44.5
DEWA	Dubai Electricity and Water Authority	75	45	47.5	90	37.5	45	60	45	47.5

SEWA	Sharjah Electricity and Water Authority	65	3	34.5	90	5	42.5	67.5	12.5	52.5
FEWA	Federal Electricity and Water Authority	62.5	1.5	32.5	95	1.5	45	60	1.5	52.5
UCB	UAE Central Bank	50	26	3	75	26	22.5	65	1.5	5
EAD	Environmental Agency – Abu Dhabi	90	22.5	37.5	85	15	40	35	15	40
CSO	Civil society organizations (pro-environment)	100	2.5	49.5	90	4.5	40	55	2.5	42.5
Mubadala	Mubadala	50	50	9.5	80	45	10	55	45	12.5
ENEC	Emirates Nuclear Energy Corporation	57.5	2.5	3.5	45	2.5	11	45	17.5	3
Masdar	Masdar	70	15	25	57.5	22.5	22.5	42.5	5	20
TAQA	TAQA (Abu Dhabu National Energy Company)	57.5	1.5	17.5	45	3.5	8	87.5	1.5	47.5
ADNOC	Abu Dhabi National Oil Company	50	42.5	5	55	42.5	22.5	45	57.5	32
Dolphin	Dolphin Energy	50	5.5	3	42.5	20	20.5	100	22.5	67.5
EII	Energy-intensive industrials	50	20.5	12.5	20	32.5	50	80	32.5	35
Aviation	Aviation industry	50	20	40	0	20	40	50	20	10

Source: KAPSARC and Masdar expert interviews.

With these data, we can simulate the CDMP between and among the actors in this study. That is, we can simulate how the actors interact with and influence each other over time to arrive at an 'outcome' for the issue. This reflects a model-based view of politically feasible outcomes for actors' collective support for – or opposition to – each of the identified policy alternatives.

As previously mentioned, the KTAB module used in this paper is the SMP. More information about the SMP can be found in Wise, Lester and Efird (2015a, 2015b).

Simulating policy choices for the UAE energy transition

In this study, we analyzed the six policy alternatives for the UAE energy transition described earlier in the paper using the KTAB SMP model. In this section, to be clear, we briefly refer to each of them as:

- Carbon pricing.
- Renewables.
- Nuclear energy.
- Energy efficiency.
- Energy subsidy reform.
- Natural gas.

In this section, we present the results of the simulations for each of the policy options. Once more, we use this methodology to address the question: What is the political feasibility in the UAE for different policy options available to decision-makers that may help drive an energy transition?

For each of the actors involved in this study, there are likely to be a number of different motivations for their policy choices. These differences will largely be reflected in how the actors approach each of the options identified in this study. Whereas some actors are driven more by reducing the cost of energy, others are more interested in minimizing the climate impact of energy production. More externally-focused actors might choose policies based on the notion of energy security, or take a position that is conditioned by their understanding of geopolitics and regional political interests. Other actors may have business interests in one policy instrument as compared to others, or have some personal desire and motivation that drives their advocacy on this issue.

Whatever the motivations underlying the actors' advocacy – that is to say, their position in the data we have collected – this study is based on the premise that a particular policy option is chosen and effectively implemented when the appropriate stakeholders arrive at some degree of consensus. The KTAB SMP model will simulate the interactions of actors over time, i.e, a series of turns, in the parlance of the model. Nothing about the SMP requires that actors reach some sort of consensus – they could very well not agree by the end of the simulation. However, the positions of actors at the end of the SMP simulation allows us to draw some inferences as to the political feasibility of the particular policy option. When consensus is achieved, we can say that a policy option is 'politically feasible.' When there is no consensus achieved, or when the consensus is in opposition to that particular policy option, we can say that it is 'politically infeasible.'

When consensus emerges from the simulation, the nature of that consensus sheds some light on what form of the policy is feasible. In other words, if most of the actors end the simulation clustered around a position that is near a position of 100, we can infer that there is a consensus in favor of a strong and enforceable version of the policy. If actors end the simulation clustered around a position that is closer to neutral, then we can infer that there is a consensus in favor of a weakly constructed and more symbolic version of the policy. The next sections will address each of the policy options in greater detail.

Carbon pricing – KTAB SMP simulation results

As defined earlier in the paper, carbon pricing – as considered for the KTAB SMP simulation – is treated as the general notion of applying some form of explicit price to the use of carbon for energy production or energy use in the UAE. The details are not considered here, as actors may take a different view depending on the particular implementation. Rather, the data collected consider the imposition of an explicit carbon price as a general strategy in a policy-led energy transition.

The KTAB simulation results for carbon pricing are presented in the following three figures, with two alternative visualizations of the output. Figures 2 and 3 represent the input data and final model output as bar charts which display the distribution of actors' positions over the spectrum of positions defined previously in Figure 1. These range from opposition, to neutral, to supportive of the policy, which, in this case, is carbon pricing.

As noted previously, the Turn 0 values are not generated by the KTAB model. They reflect the data collected from the group of experts before any model calculations. Each actor is represented as a segment of a bar on this figure. The location of the bars on the horizontal axis indicates the position that the actor takes. For simplicity, when actors take roughly the same position, they are stacked on top of one another and rounded to the nearest interval. The height of the bars represents exercised power. Note that exercised power is calculated by multiplying influence and salience, so that the influence applied to the actor's position is discounted by its salience. In other words, if an actor is both very influential and cares a lot about the question – i.e., has high salience – then this will be represented by a much larger bar than for an actor that has the same influence but low salience – i.e., one who cares less and applies less of its influence.

The different segments of the bars represent different actors, color coded to reflect groups of similar actors. If every actor on the figure were to be labeled, then the graph would become very difficult to read. In this case, we have color coded actors into five separate groups.

The Royal House includes the Crown Prince and the prime minister, highlighted in red. They are central actors in any policy going forward. Other government actors, colored in green, include the various UAE ministries and other authorities. Advisers, colored in blue, include entities that provide advice to the UAE leadership. Energy companies, colored in purple, include those with some capacity for energy production or development of energy technologies. Energy-consuming companies, colored in orange, represent those actors that are large commercial consumers of energy, primarily in the industrial sector. The color coding in the bar chart, according to this schema, is purely cosmetic – to assist the reader in identifying actors in the bar charts. The grouping and color coding does not have any effect on the SMP calculations.

The height of the different segments reflects the actor's exercised power, with the overall height of the bar showing the power in support of that position from the 'stack' of actors – the 'coalition' – that is advocating a particular position. Figure 2 provides the Turn 0 representation of the input data for the carbon pricing issue.

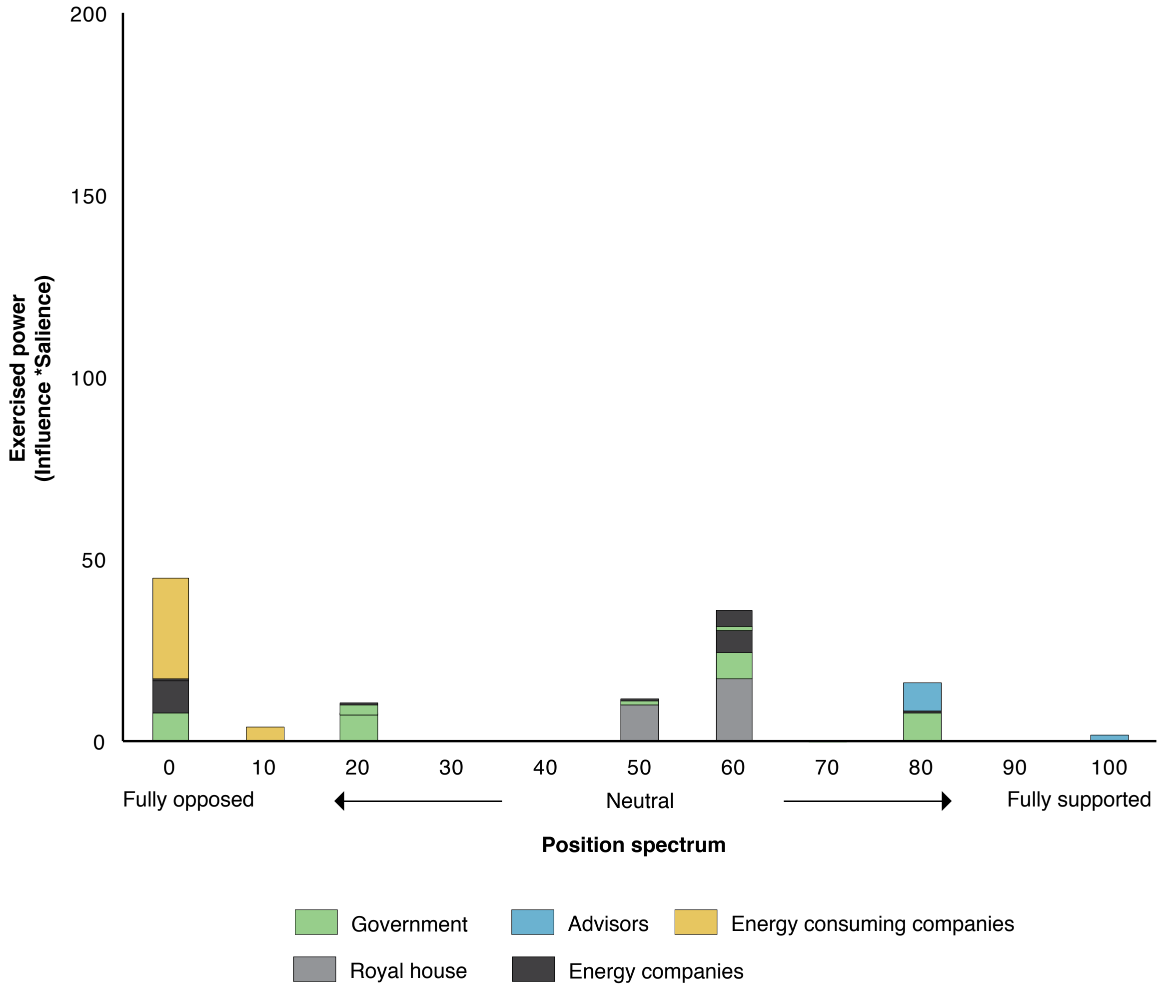

Figure 2. Turn 0 distribution of positions and exercised power: carbon pricing.

Source: KAPSARC and Masdar KTAB analysis.

As shown in the figure, there initially appears to be a broad array of views, with no consensus, regarding the application of a carbon pricing scheme in the UAE. The actor most opposed to the application of any sort of carbon pricing scheme is the aviation industry, which is the large orange bar at position 0, on the far left side of the bar chart. Given the enormous potential cost for the aviation industry's business model, this is not surprising. ADNOC and Dolphin Energy, both energy producers (also at position 0 in Figure 2, in purple), are extremely opposed to the concept of carbon pricing at the beginning of the simulation. Other actors take a range of views, with the royal house actors taking a neutral and mildly positive position, and a few advisors and government entities taking a more positive view.

By Turn 15, as shown in Figure 3, a rough consensus (ranging from position 30-50) emerges opposing the adoption of a carbon pricing platform. A KTAB simulation that lasts 15 turns represents a more protracted debate about this issue, similar to the renewable energy and energy efficiency simulations. The duration of a simulation is based on an algorithm in the KTAB model, which estimates the likelihood of significant change in positions happening in the next round.

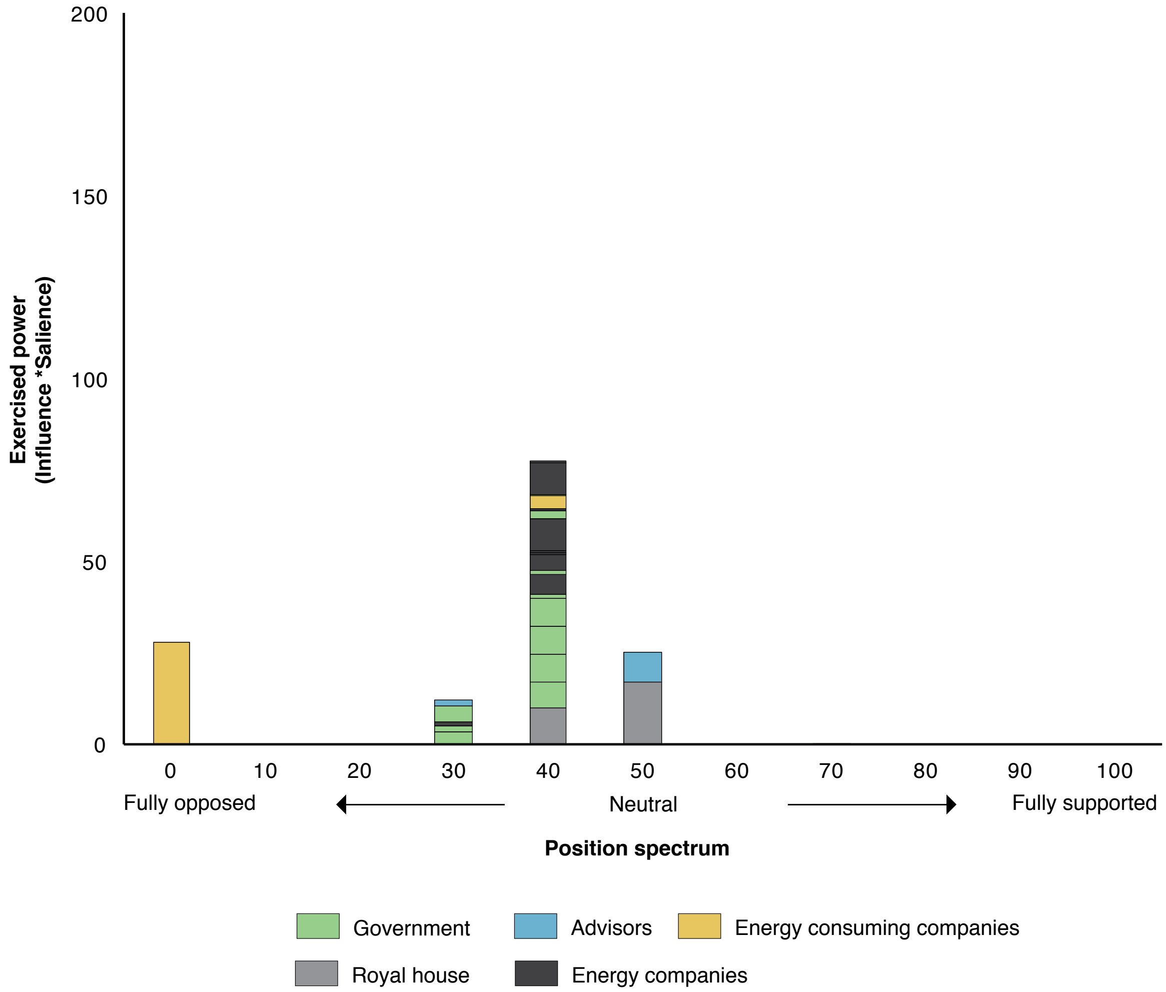

Figure 3. Turn 15 distribution of positions and exercised power: carbon pricing.
Source: KAPSARC and Masdar KTAB analysis.

When that likelihood falls below a certain threshold, the simulation terminates. A longer simulation suggests that more bargaining over the question of a carbon tax should be expected before a resolution is achieved.

As shown in Figure 3, there is generally only weak opposition to carbon pricing by the end of the simulation. No actors perceive value in positively advocating a carbon price by the end of the simulation, as none adopt a position higher than 50, which reflects a neutral view of the carbon tax. The only question remaining in this figure is how opposed a particular actor is after the CDMP.

As such, we can conclude that a carbon tax is politically infeasible in the UAE context, and all actors appear to accept this. Note that the aviation industry is the remaining exception to consensus on carbon pricing, with all other actors taking a position between 30 and 50. Aviation, the orange bar which has remained at a position of 0, very strongly and persistently opposes any form of carbon pricing throughout the simulation.

Figure 4 provides an alternative visualization made possible by the KTAB simulation output. Whereas Figures 2 and 3 display static pictures before the simulation and at the last turn of the simulation, Figure 4 presents a dynamic view on changing positions and coalitions over the course of the diagram. This diagram, known as a Sankey diagram, allows us to observe the simulation results of all actors in the data set as they shift their positions from one turn to the next. Turn 0 reflects the initial condition – data collected from experts – as described in Table 2. The remaining turns are simulated results from the KTAB SMP module. When an actor shifts a position from one turn to the next, it has been influenced by some other actor to adjust its position, i.e., through advocacy, because it sees a change in position as in its best interest. Actors are balancing their desire to achieve their preferred outcome against building consensus for an outcome – a position on the spectrum – that is close to their preferred outcome. As such, simulated changes in position capture the give-and-take that happens during a negotiation process.

The range of positions from 0 to 100 is represented on a color gradient, ranging from blue to green to yellow to red, as shown in the key on the right hand side of the figure. The vertical axis loosely corresponds to the color gradient in terms of spatial distance for positions, but the color shading is a more precise indication of the positional location of actors. This figure clusters actors that hold the same position, after rounding position to the nearest five, into a single weighted line, the thickness of which reflects the exercised power – the combination of the collective influence and salience – of actors holding that position in a particular turn or turns. Individual actors are named on the left hand side of the figure with a short descriptor consistent with Table 1.

The diagram allows the reader to track the changing levels of support for particular positions as the CDMP simulation is run for 15 turns. The color of lines shows the position being advocated while the thickness of each line denotes the collective weight of the exercised power of actors at a given position, i.e., the support for an outcome. The legend translates the color of the line into numerical and qualitative policy descriptions. Where two lines merge, one actor is now advocating the same position as another. Where lines split, a particular position is losing the support of a particular actor. The simulation leads to a narrowed range of positions. These are the plausible outcomes of the CDMP. More detail on the intuition of the progression of turns in the SMP simulation is provided in Appendix 2.

The simulation results shown in Figure 4 provide an assessment of the potential for consensus over time. We note that the Abu Dhabi Executive Council and SEWA are important actors in moderating the strongest supporters of a carbon tax, e.g., pro-environment civil society organizations.

By Turn 3, the prime minister and ADNOC align to become important opponents to carbon pricing, to build a consensus. They are joined by a weak player (TAQA). Together they find a weakly negative view on carbon pricing that is appealing to the broadest number of actors, helping to form consensus around the issue.

In Figure 4, we can see that there are a number of oscillations among actors over the course of the 15 turns in the simulation. This behavior in the simulation suggests that they are less concerned with finding support for an outcome they prefer, and more concerned with finding a consensus that everyone can agree to. The KTAB simulation has calculated that these oscillating actors are doing their best to find a position that can gain majority support. By the end of the simulation, these actors have settled on a neutral or weakly negative position.

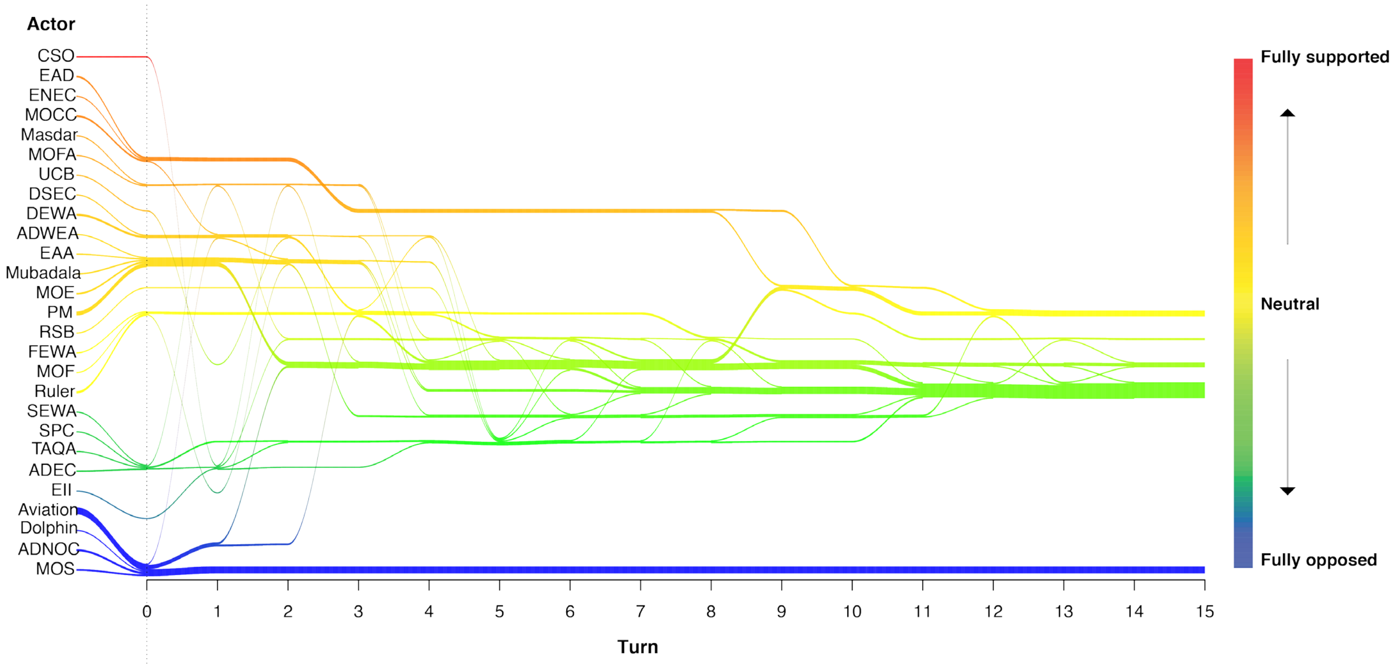

Figure 4. Sankey diagram of position and exercised power by turn: carbon pricing.

Source: KAPSARC and Masdar KTAB analysis.

There are two general exceptions to this oscillating behavior. On the one hand, the persistent opposition of the aviation industry to any form of carbon pricing is very clear in this figure. The thickness of the line also reflects the influence utilized by this actor to oppose a carbon price scheme. It is quite significant compared with other groups of actors advocating alternative positions. Not surprisingly, this actor is strongly opposed because of the threat perceived to the sector's profitability. On the other hand, two climate-oriented government entities, the Environment Agency – Abu Dhabi (EAD) and the Ministry of Climate Change, display a slow acquiescence to the infeasibility of a carbon tax policy. Over the course of the simulation, both actors come to realize that there is not support for carbon pricing, and slowly shift their position to one of neutrality, so that they are not seen to be opposing the consensus view.

Renewables – KTAB SMP simulation results

In this section we shift to the KTAB simulation for renewable energy in the UAE as an instrument supporting the energy transition. As defined earlier in the paper, this concept of a 'renewables policy' is treated as the general notion of using renewable energy as a significant means of displacing carbon-based sources of energy in the UAE, particularly in the power sector. The details are not considered here, as actors may take a different view depending on the particular implementation, e.g., solar or wind, in a variety of configurations. Rather, the data collected consider the use of renewables as a general strategy in a policy-led energy transition.

Figures 5 and 6 are constructed in the same way as Figures 2 and 3. Once again, the bars represent actors, the location on the horizontal axis indicates their position on the issue, and the height of the bars reflects the product of their influence and salience, i.e, the actors' exercised power on the policy option. Figure 5 reflects Turn 0, or the data before simulation. Figure 6 reflects Turn 10, the final turn in a 10-turn simulation.

As shown in Figure 5, there is initially a wide range of views as to the enhanced adoption of renewables for cleaner energy production and desalination in the UAE, i.e, the extended role of renewables in the UAE's energy transition. Unlike in the previous policy option, almost every actor takes a positive view of renewable energy in the UAE context.

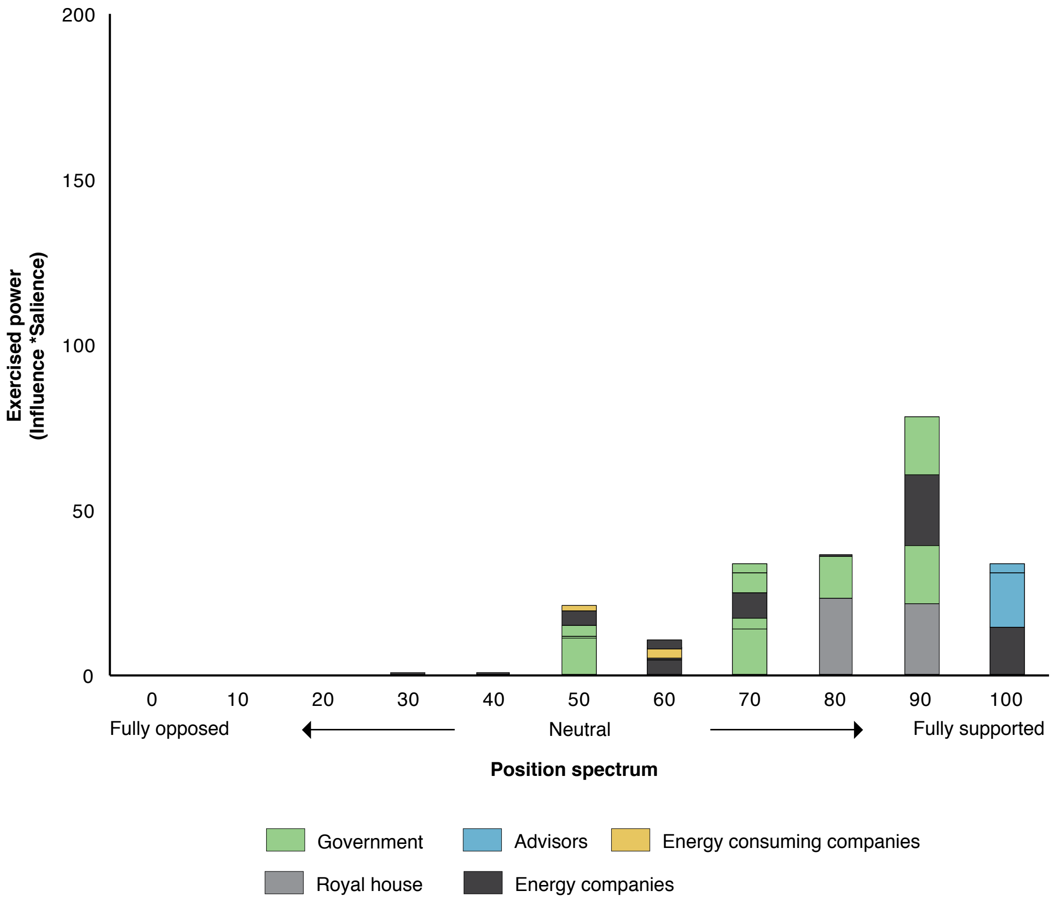

Figure 5. Turn 0 distribution of positions and exercised power: renewables.
Source: KAPSARC and Masdar KTAB analysis.

There are only two exceptions to this positive view on renewables, based on the expert data collected during the interview process: Dolphin Energy and ENEC — they can barely be seen on the graph at positions 30 and 40. Both take a marginally negative view on renewable energy, but neither is particularly motivated to advocate this position and exert influence to obtain their preferred outcome. As a gas company and nuclear company, this is not a surprising position. They would prefer to see their fuel types used without any displacement by renewable energy, but they cannot push hard against this given the preponderance of support for renewables in the UAE fuel mix.

As shown in Figure 6, by Turn 10 of the simulation there is a strong consensus among stakeholders in favor of a renewable energy strategy, ranging from positions of 80-100. The Crown Prince and prime minister (both of the red bars at position 80), in particular, strongly favor renewable energy. Other actors are at least as supportive, or even more so, with no actors remaining opposed or even neutral. Thus, we can infer from these figures that the political will to utilize renewable energy in the UAE is continuing to gain traction over time, and that it will remain quite strong.

As in Figure 4, once again the simulation results for this question are displayed in a Sankey diagram in Figure 7. This figure shows the progression of changes in actors' positions, turn-by-turn, along a color gradient that reflects the range of positions they take in each turn. The thickness of the lines indicates the sum of the exercised power in support of a particular position, again evolving over turns in the simulation.

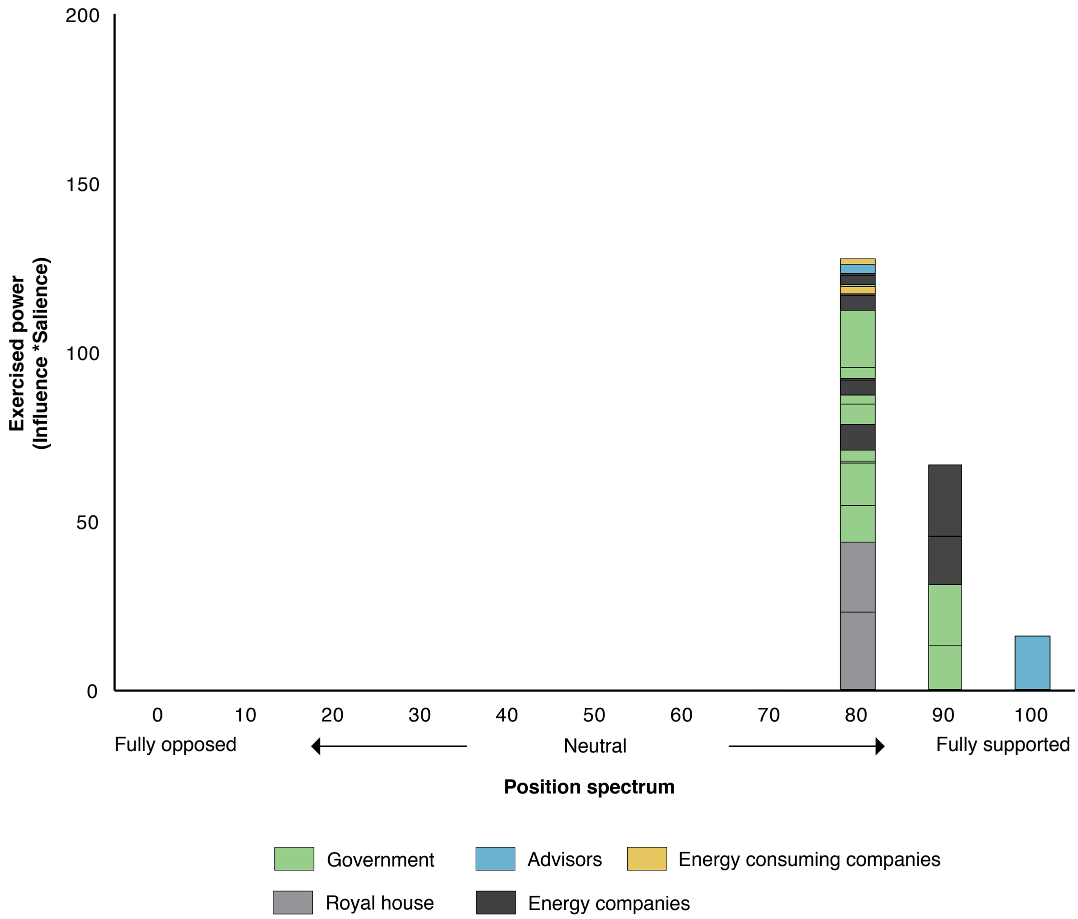

Figure 6. Turn 20 distribution of positions and exercised power: renewables.

Source: KAPSARC and Masdar KTAB analysis.

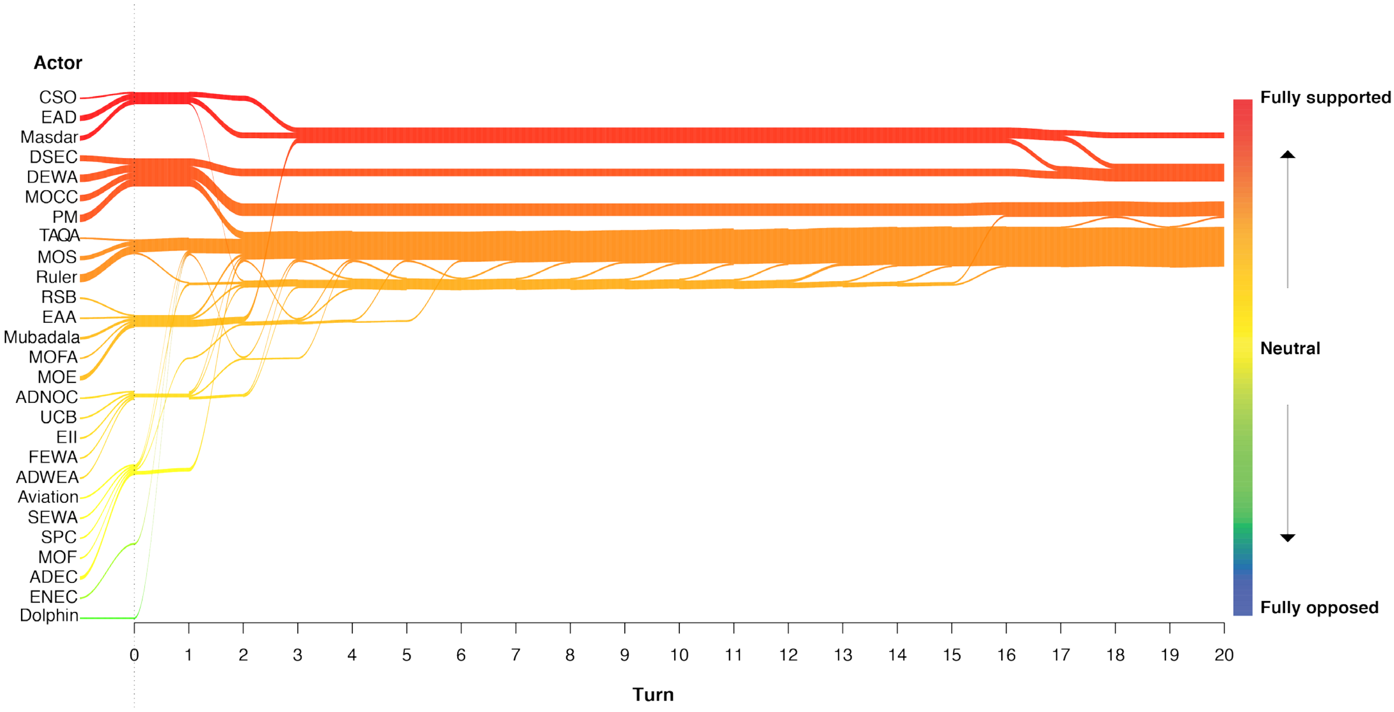

Figure 7. Sankey diagram of position and exercised power: renewables.

Source: KAPSARC and Masdar KTAB analysis.

The Crown Prince and the prime minister strongly favor a reliance on renewables, and they are two of the key drivers to building consensus around very strong support for their position. By Turn 4, the least supportive actors will see that it is in their interest to join more fully with the winning coalition over the next few turns. Note that this simulation lasts 20 turns, even more than the simulation carbon pricing. However, the extension of collection decision-making in this simulation is more a function of hammering out the details, rather than in a difference of opinion about the outcome as a whole. Figure 7 visually reaffirms the inference from the prior two figures: there is likely to be increasingly robust political will in support of renewable energy in the UAE.

Nuclear energy – KTAB SMP simulation results

In this section we focus on the KTAB simulation results for nuclear energy in the UAE as an instrument supporting the energy transition. Once more, this concept of a nuclear energy option is treated as the general notion of using nuclear power as a means to displace carbon-based sources of energy in the UAE. The details are not considered here, as actors may take a different view depending on the particular implementation – e.g., location, number of plants, scale of solution. Rather, the data collected consider the use of nuclear energy as a general strategy in a policy-led energy transition.

Figures 8 and 9 are constructed in the same way as Figures 2 and 3. Once again, the bars represent actors, the locations on the horizontal axis indicates their positions on the issue, and the height of the bars reflects the product of their influence and salience, i.e, the actors' exercised power on the policy option. Figure 8 reflects Turn 0, or the data before simulation. Figure 9 reflects Turn 11, the final turn in a 11-turn simulation.

Note in Figure 8 that most actors initially view the use of nuclear energy in the UAE energy mix in a positive light. The Crown Prince, Abu Dhabi Executive Council, the Executive Affairs Authority, and ENEC appear to be important advocates in consolidating a strong level of support for nuclear power. Non-supporters either view nuclear power as marginally negative or neutral. To the extent opponents will seek to derail the progress on nuclear power in the UAE, this would indicate a strategy of delay rather than clear arguments against nuclear energy.

Contrast this debate portrayed in the data with recent events observed regarding the nuclear power plant development in the UAE. While the construction appears to be on track for startup of the Barakh power plant, the local operating company, Nawah, has been delayed in obtaining an operating license (Chung and De Clerq 2017).

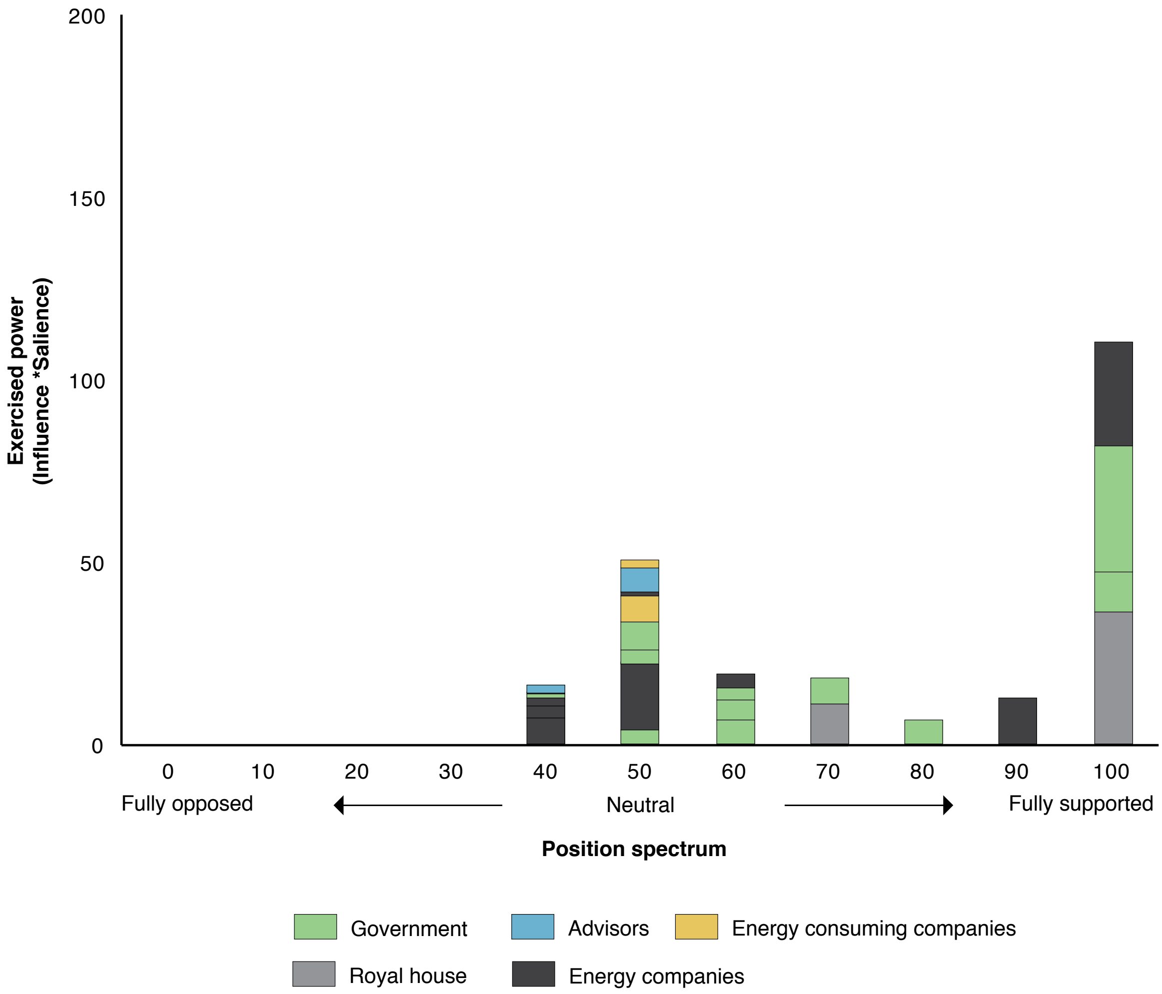

Figure 8. Turn 0 distribution of positions and exercised power: nuclear energy.
Source: KAPSARC and Masdar KTAB analysis.

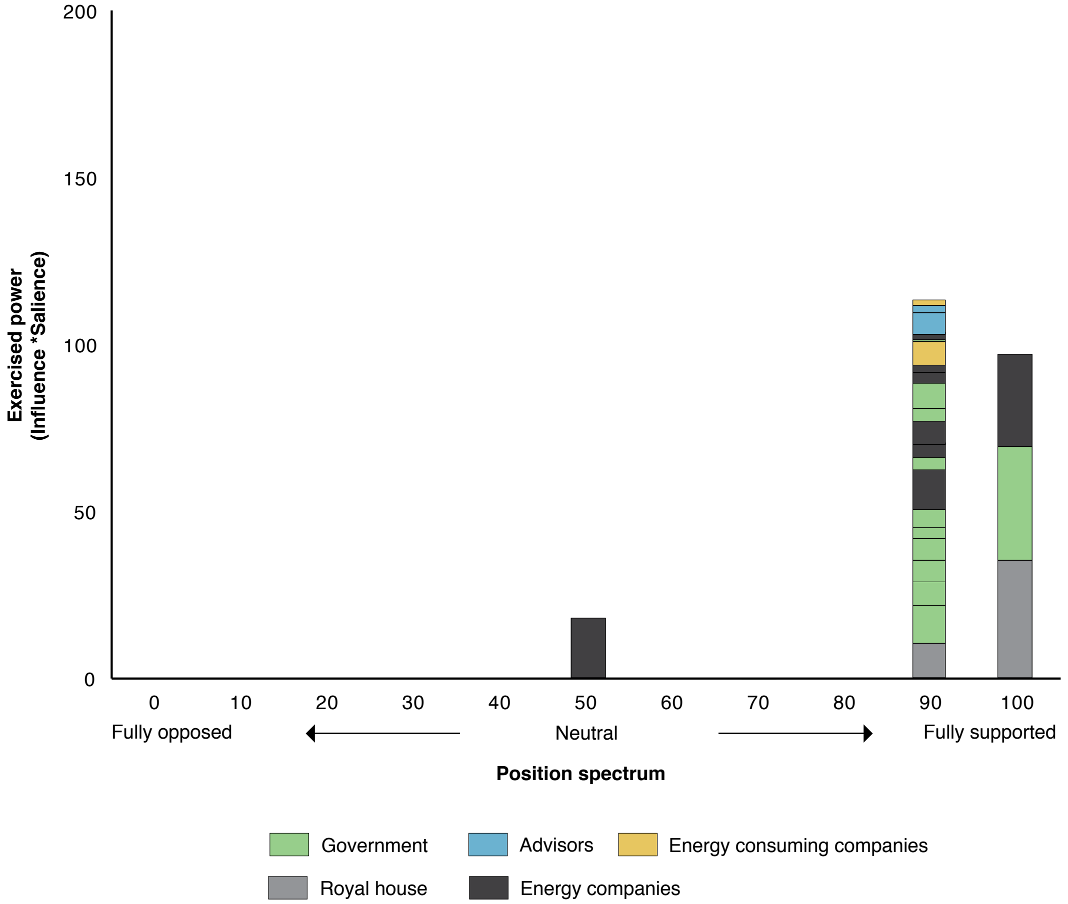

Figure 9. Turn 11 distribution of positions and exercised power: nuclear energy.
Source: KAPSARC and Masdar KTAB analysis.

By the end of the simulation, the clear majority of actors strongly support the role of nuclear energy in the UAE's current plans, ranging between positions of 90-100. Masdar remains the only actor to retain a neutral position, and not strongly supportive, of nuclear energy in the UAE. It does not shift its advocacy during the simulation. We can thus infer from Figure 9 that there is a strong trend in support of nuclear power in the UAE, and ultimately it appears that the political will to utilize nuclear power as part of the energy transition strategy is very robust.

As in Figure 4, once again the simulation results for this question are displayed in a Sankey diagram in Figure 10. This figure shows the progression of changes in actors' positions, turn-by-turn, along a color gradient that reflects the range of positions they take in each turn. The thickness of the lines indicates the sum of the exercised power in support of a particular position, again evolving over turns in the simulation.

As seen in Figure 10, the consolidation of strong support for nuclear power takes a number of turns. It is not until Turn 8 that actors are in relative agreement. In the first turns, mild opponents of nuclear power appear to accept the political inevitability of the effort. Once this support is obtained, no actors oppose nuclear power any more. By Turn 3, as actors with a similar view on nuclear power adopt a more positive position, the prime minister also becomes more aligned with Abu Dhabi's flagship nuclear project. Over subsequent turns, this consensus builds to become quite strong by Turn 10.

Thus, despite recent apparent setbacks to the launch of the Barakh power plant, the political will for nuclear power in the UAE as part of its energy transition strategy appears to remain very strong, even growing in terms of consensus.

Energy efficiency – KTAB SMP simulation results

Figures 11 and 12 are constructed in the same way as Figures 2 and 3. Once again, the bars represent actors, the location on the horizontal axis indicates their position on the issue and the height of the bars reflects the product of their influence and salience, i.e, the actors' exercised power on the policy option. Figure 11 reflects Turn 0, or the data before simulation. Figure 12 reflects Turn 10, the final turn in a 10-turn simulation.

As shown in Figure 11, most actors are initially supportive of the adoption of EE policies. However, a debate remains over the scope and strength of possible policies. Those actors not in favor of energy efficiency are either weakly opposed or neutral, suggesting they oppose the timing and scope of any changes rather than the underlying principle. Energy consuming companies – the orange bar at a position of 50 – are also neutral, implying that they will not oppose EE policies so long as the form and implementation are satisfactory. The prime minister – the red bar at a position of 70 – in particular is only a moderate advocate of energy efficiency, though his views gain resonance among almost all of the actors in the simulation.

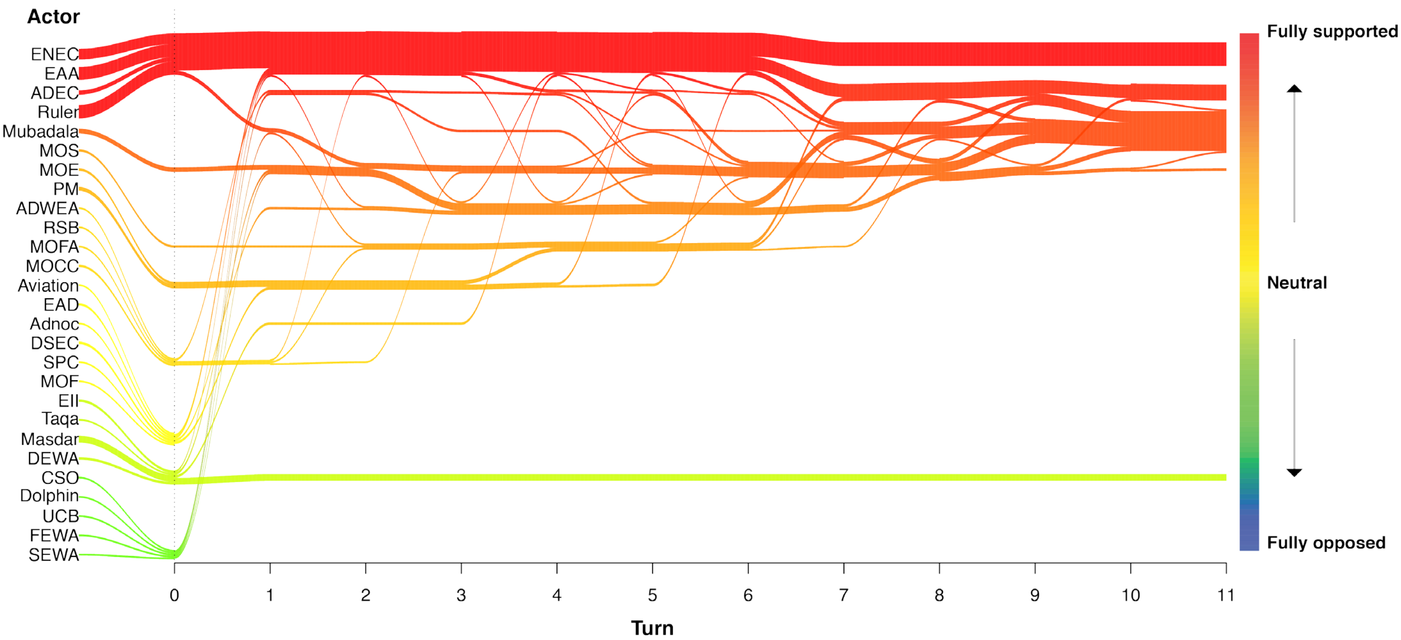

Figure 10. Sankey diagram of position and exercised power: nuclear energy.
Source: KAPSARC and Masdar KTAB analysis.

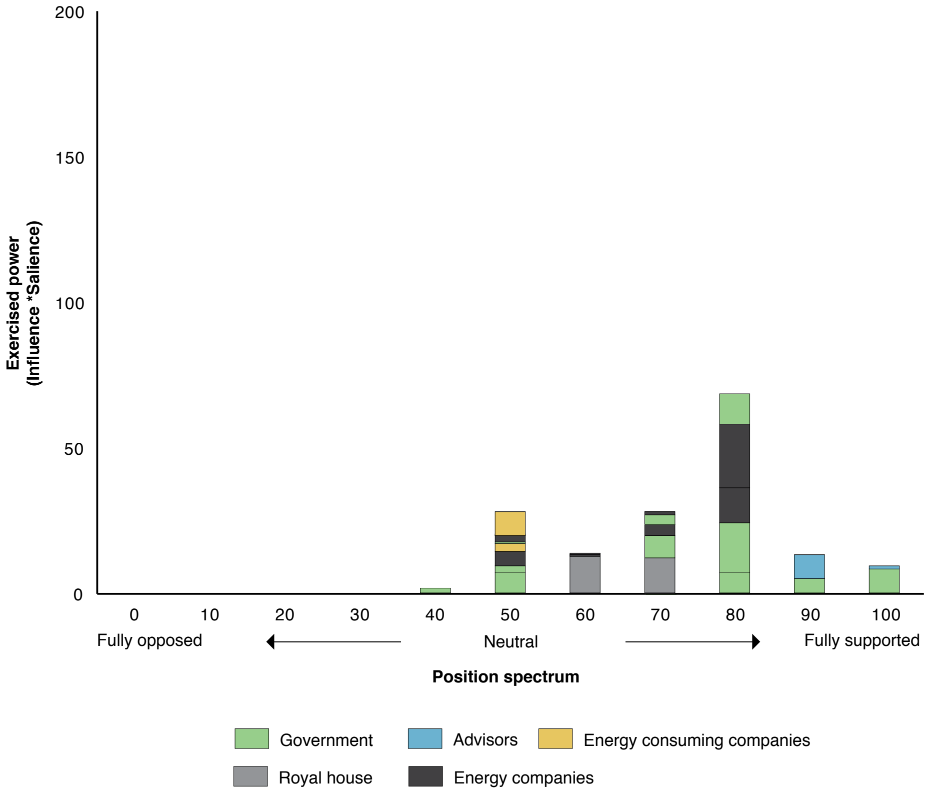

Figure 11. Turn 0 distribution of positions and exercised power: energy efficiency.
Source: KAPSARC and Masdar KTAB analysis.

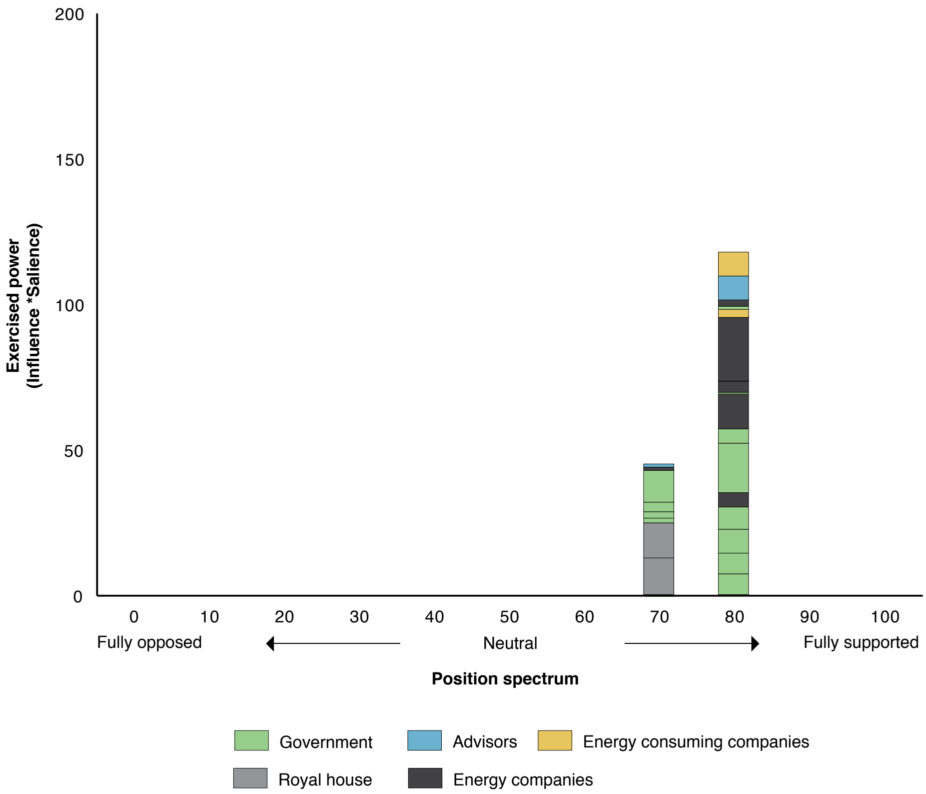

Figure 12. Turn 17 distribution of positions and exercised power: energy efficiency.
Source: KAPSARC and Masdar KTAB analysis.

As demonstrated in Figure 12, by the end of the simulation, there is consensus in favor of a moderately strong energy efficiency based approach – with actors adopting positions between 70 and 80. We can infer from these figures that the current support for EE is likely to strengthen over time. The disagreements about the scope and timing should also be minimized so that moderate progress in designing and potentially implementing policies that enjoy consensus support is possible.

As in Figure 3, once again the simulation results for this question are displayed in a Sankey diagram in Figure 13. This figure shows the progression of changes in actors' positions, turn-by-turn, along a color gradient that reflects the range of positions they take in each turn. The thickness of the lines indicates the sum of the exercised power in support of a particular position, again evolving over turns in the simulation.

As shown in Figure 13, the debate over the form and extent of EE appears to continue for around seven turns in the simulation, though consensus has been mostly achieved by Turn 5. This supports the conclusion drawn from the prior figures that there is growing consensus in favor of energy efficiency policies, and that the political will to enact EE policies that are moderate in scope appears to be in place for the UAE.

Energy subsidy reform – KTAB SMP simulation results

Figures 14 and 15 are constructed in the same way as Figures 2 and 3. Once again, the bars represent actors, the location on the horizontal axis indicates their position on the issue, and the height of the bars reflects the product of their influence and salience, i.e, the actors' exercised power on the policy option. Figure 14 reflects Turn 0, or the data before simulation. Figure 15 reflects Turn 11, the final turn in a 10-turn simulation.

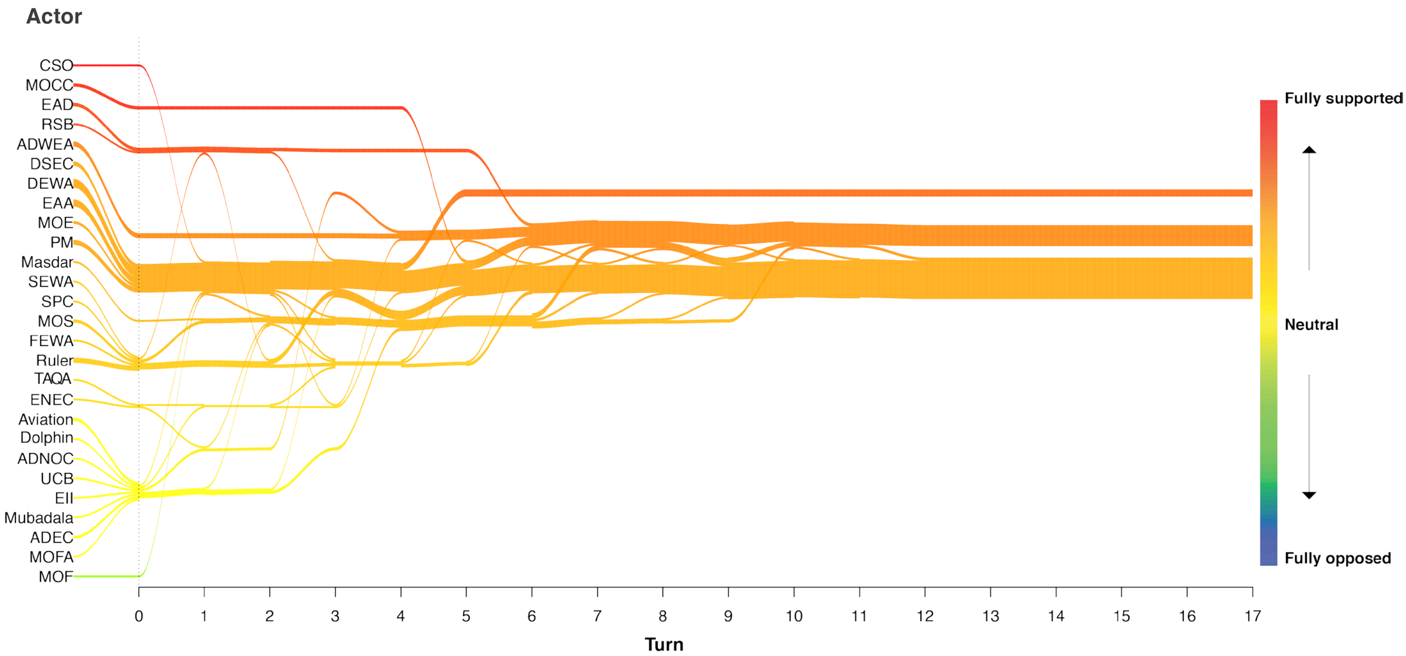

Figure 13. Sankey diagram of position and exercised power: energy efficiency.
Source: KAPSARC and Masdar KTAB analysis.

As shown in Figure 14, there is initially a broad and vigorous debate about energy subsidy reform in the UAE. Energy-consuming companies are extremely opposed to price reforms, and the aviation industry just slightly less so – both pictured in orange, at positions of 0 and 20, respectively. Critical actors, such as the Crown Prince and the prime minister –the two red bars at a position of 80 – initially adopt a strong position in favor of price reform, position 80. Despite their initially stronger advocacy, they are willing to make concessions to obtain the support of industry.

As shown in Figure 15, by the end of the simulation there is consensus in favor of applying price reforms in the UAE. However, the support consolidates around a weakly favorable position. All actors (excepting one) take a position between 60-70 by Turn 11. This implies that any price reforms adopted are likely to be much weaker than many actors currently advocate. Energy-intensive industrials moderate their position and align with the Crown Prince, finding another way to be part of the consensus, likely to help shape the form of any policies. The Regulatory and Supervisory Bureau remains an advocate for stronger price reforms at the end of the simulation, at a position of 90.

The advocacy of the Abu Dhabi Executive Council, ADNOC, the Ministry of Foreign Affairs, and Masdar – which all took a position of 60 in Turn 0 – appear to be a guide for the content of likely price reforms in the UAE. These actors are able to build consensus for a less ambitious approach to reforming energy subsidies.

As in Figure 4, once again the simulation results for this question are displayed in a Sankey diagram in Figure 16. This figure shows the progression of changes in actors' positions, turn-by-turn, along a color gradient that reflects the range of positions they take in each turn. The thickness of the lines indicates the sum of the exercised power in support of a particular position, again evolving over turns in the simulation.

As can be seen in Figure 16, the debate over subsidy reform seems to have largely settled down by Turn 6, at which point energy-intensive industrials are willing to align with the Regulatory and Supervisory Bureau, though they later moderate their position. The rationale for this in the KTAB simulation is that the industrials, once they see consensus forming at a roughly neutral position in prior turns, would rather be part of a deal that is amenable to the regulator. The dramatic shift in position reflects this calculation, and results in a moderation by the regulator to position 90. Subsequently, having achieved some regulatory moderation, the industrials support the emergent consensus.

Thus, from these figures we can infer that consensus is likely to emerge around a slightly positive view of energy subsidy reform. There appears to be the political will to undertake subsidy reform in the UAE as part of its energy transition strategy, but the scope and magnitude of potential reforms does not appear to be very significant.

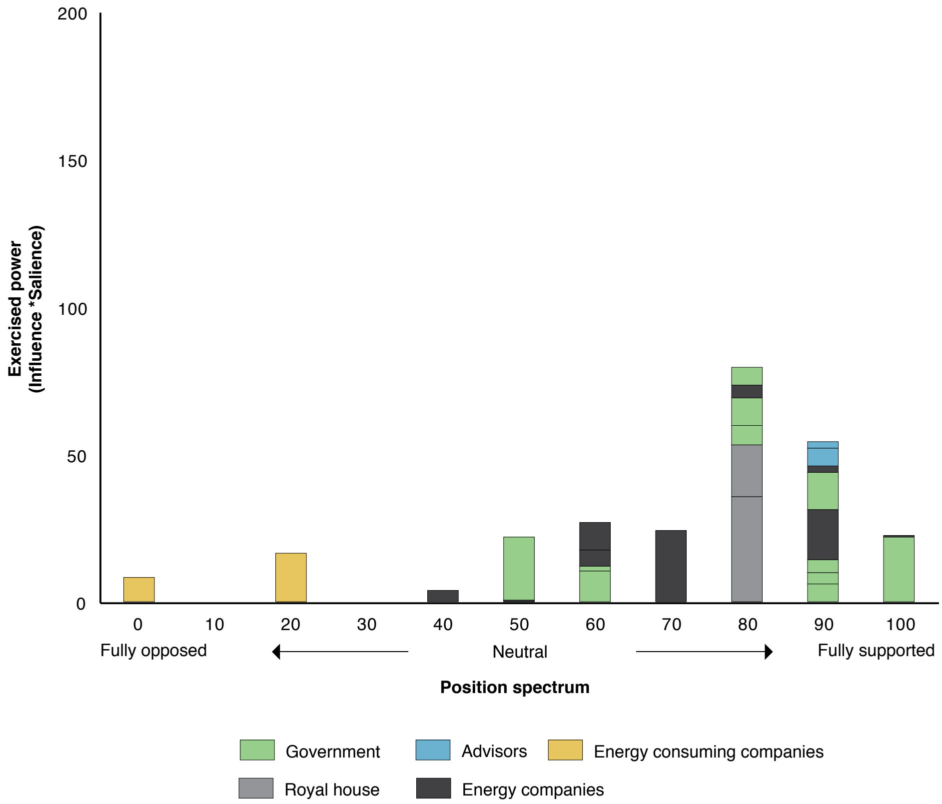

Figure 14. Turn 0 distribution of positions and exercised power: energy subsidy reform.
Source: KAPSARC and Masdar KTAB analysis.

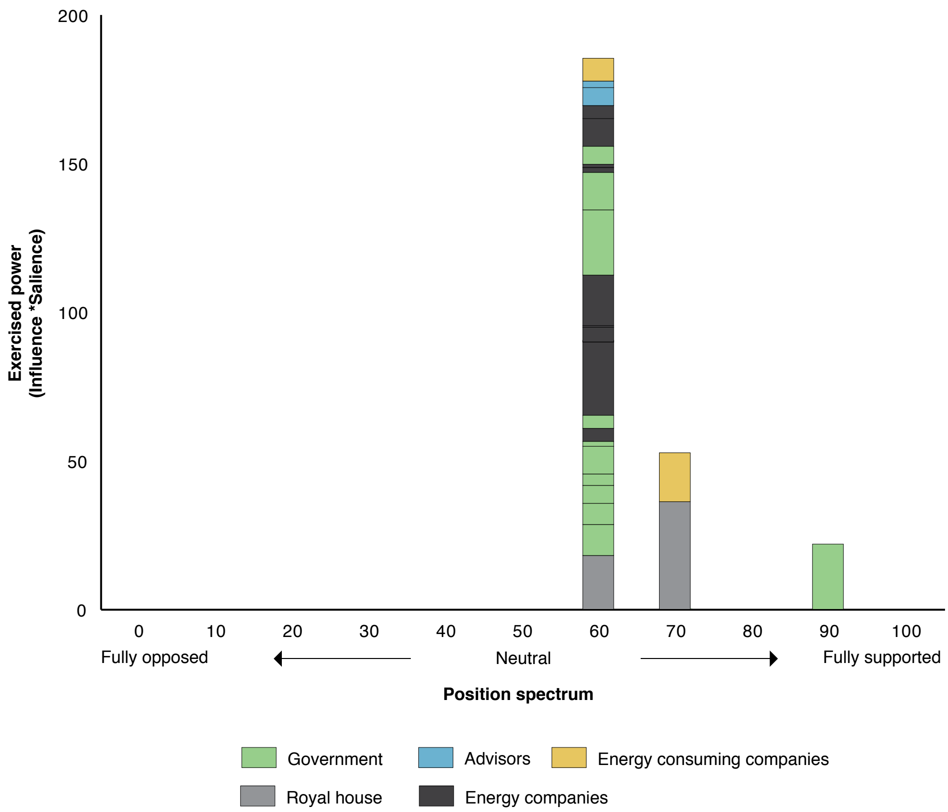

Figure 15. Turn 11 distribution of positions and exercised power: energy subsidy reform.
Source: KAPSARC and Masdar KTAB analysis.

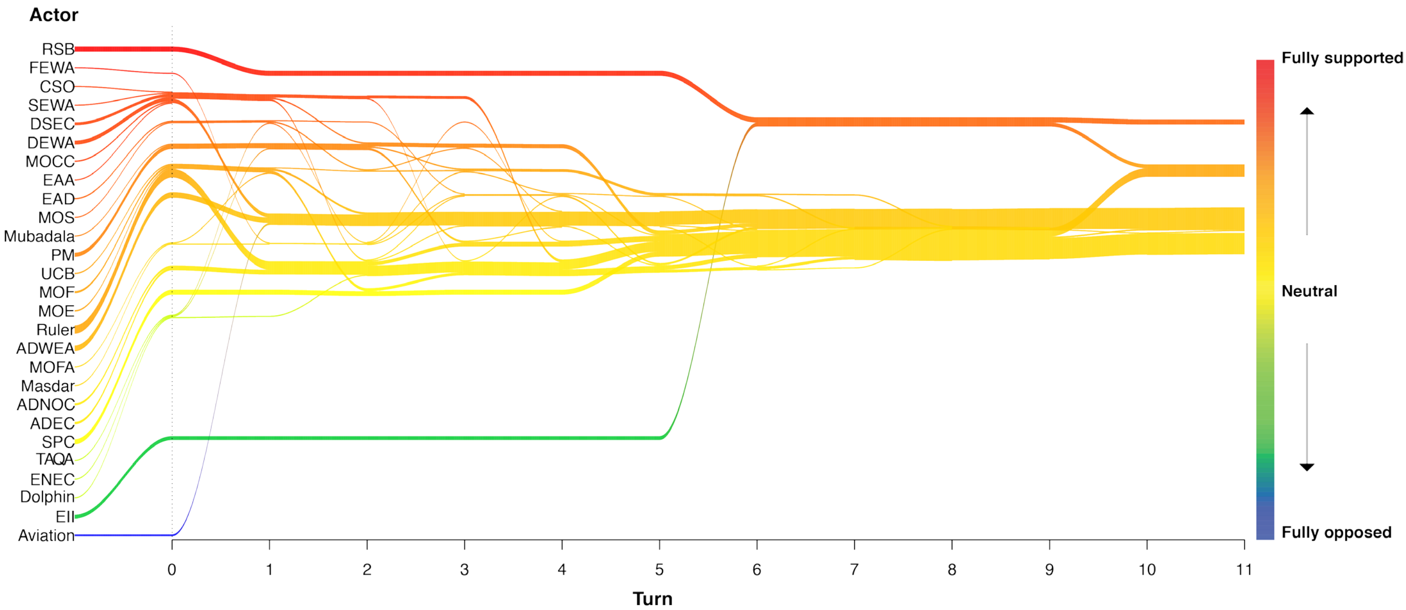

Figure 16. Sankey diagram of position and exercised power: energy subsidy reform.
Source: KAPSARC and Masdar KTAB analysis.

Natural gas – KTAB SMP simulation results

Figures 17 and 18 are constructed in the same way as Figures 2 and 3. Once again, the bars represent actors, the location on the horizontal axis indicates their position on the issue, and the height of the bars reflects the product of their influence and salience, i.e, the actors' exercised power on the policy option. Figure 17 reflects Turn 0, or the data before simulation. Figure 18 reflects Turn 15, the final turn in a 10-turn simulation.

As shown in Figure 17, there is initially a wide debate around the role of natural gas in the UAE's future electric power generation mix. However, most of the critical actors are moderately supportive of maintaining natural gas in the fuel mix. The advocacy of the Crown Prince – the red bar at a position of 60 – represents the consensus view that is formed by the end of the simulation and the final consensus identified in the simulation mirrors his current advocacy.

As shown in Figure 18, by Turn 15 a near complete consensus emerges in favor of maintaining the role of natural gas. However, because the majority of actors are at a position of 60, we can infer that they only weakly favor natural gas by the end of the simulation. Thus, while political will to keep natural gas in the fuel mix remains, it may perhaps be viewed as a less important component of the mix for the UAE strategy going forward.

Dolphin Energy, the purple bar at a position of 100, remains the strongest advocate for gas in the UAE, and its enthusiasm is not deterred by the weak support from the rest of the actors. It is worth noting that during the KTAB simulation, the model does not 'know' that Dolphin is a gas company. Rather, Dolphin, like all the other actors, is simply treated as an actor name with three numerical values capturing the characteristics of the actor.

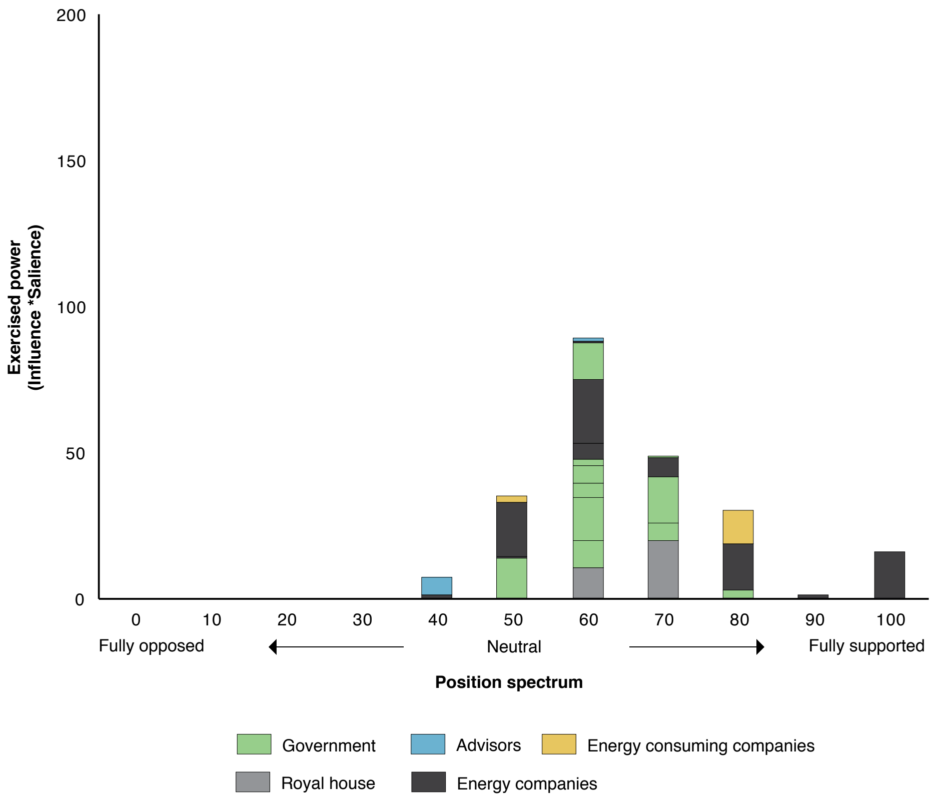

Figure 17. Turn 0 distribution of positions and exercised power: natural gas.
Source: KAPSARC and Masdar KTAB analysis.

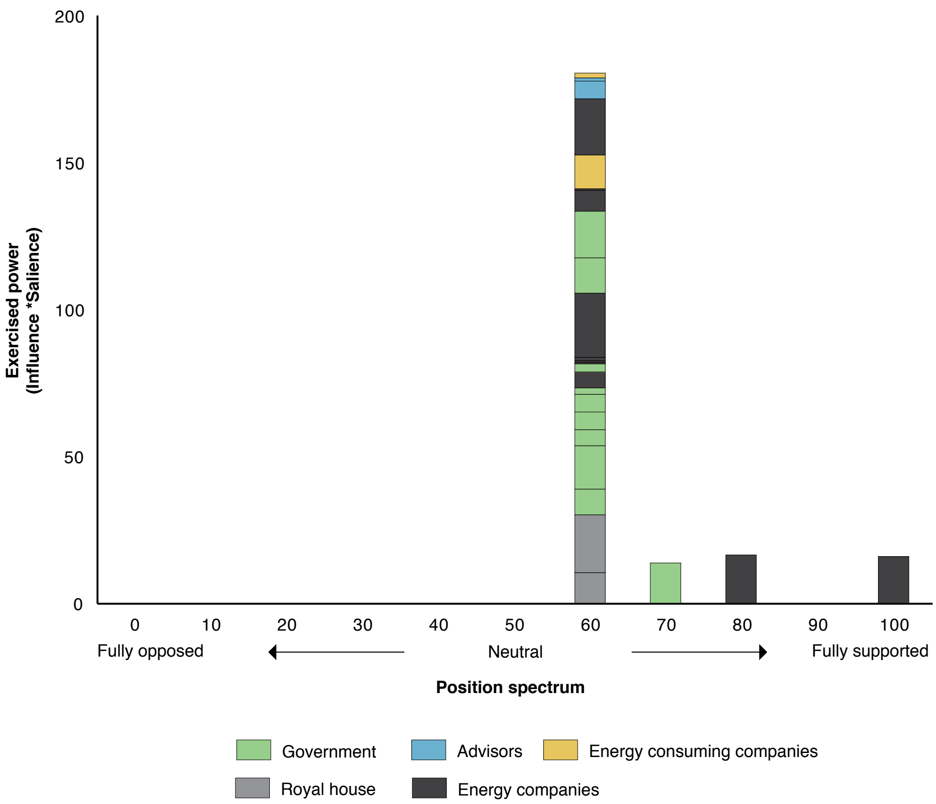

Figure 18. Turn 15 distribution of positions and exercised power: natural gas.
Source: KAPSARC and Masdar KTAB analysis.

As in Figure 4, once again the simulation results for this question are displayed in a Sankey diagram in Figure 19. This figure shows the progression of changes in actors' positions, turn-by-turn, along a color gradient that reflects the range of positions they take in each turn. The thickness of the lines indicates the sum of the exercised power in support of a particular position, again evolving over turns in the simulation.

We can clearly see the story from the prior two figures replicated in Figure 19. Dolphin Energy remains an extremely positive advocate of natural gas throughout the simulation. After some initial efforts at consensus building, by Turn 5 most of the remaining actors have achieved a rough consensus around a slightly favorable view of gas. Thus, we can infer from the simulation results that the political will for natural gas in the UAE should be weakly positive.

Summary of simulation results

In this section of the paper, we have examined the baseline results for each of six possible policy instruments considered by UAE decision-makers to effect the country's energy transition. The instruments were selected in consultation with a group of subject experts, who then provided data that formed the basis for a KTAB simulation on each, single dimension. The intent of these simulations was to analyze the political feasibility in the UAE of different policy options available to decision-makers that may help drive an energy transition.

The reasons that actors might support one or another policy option almost certainly vary by the policy instrument and the context of the debate around its utilization. In some cases, actors would like to reduce the cost of energy, while others would like to minimize climate impact. Security considerations may also play a role, either in promoting UAE energy security or in consideration of geopolitical and regional political interests. Still other actors might have business or financial interests in a particular outcome. Finally, it may be that political leaders have a personal desire or motivation for a particular policy option, based on

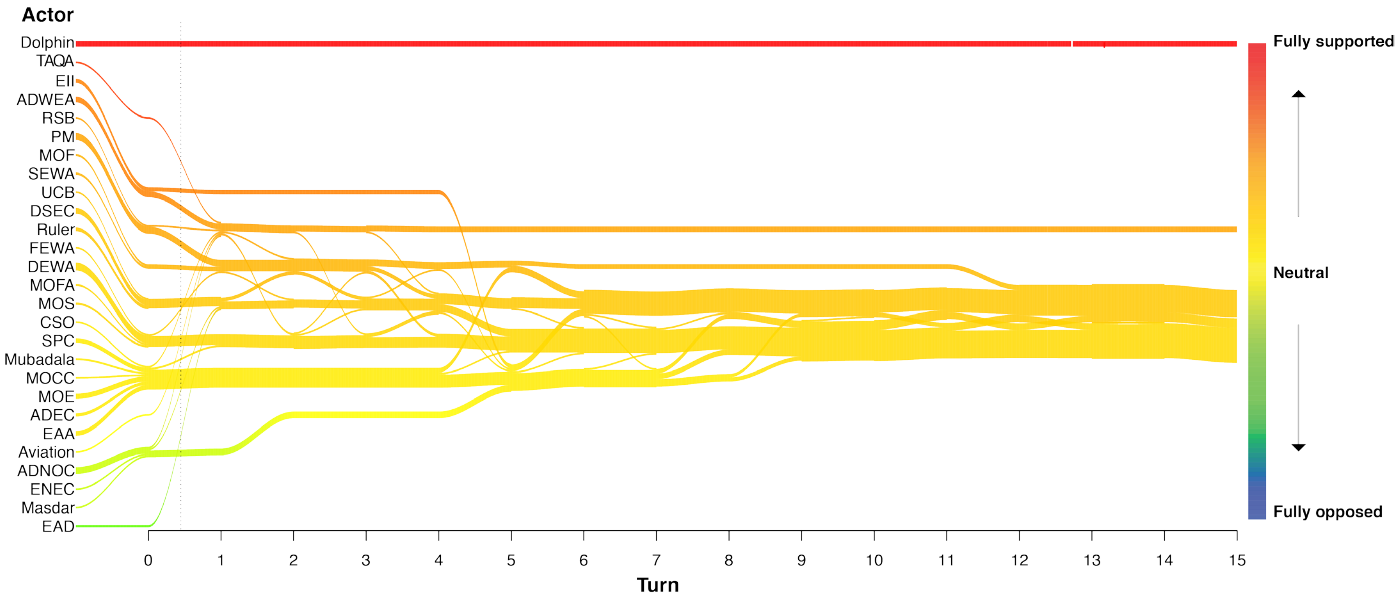

Figure 19. Sankey diagram of position and exercised power: natural gas.
Source: KAPSARC and Masdar KTAB analysis.

some unknown criteria. For the KTAB simulation, the specific motivation of each actor to support or oppose each of the policy options, and to what degree, is captured implicitly by the data used to run the simulation. During the interview process these motivations are generally discussed more explicitly, and can help us interpret the meaning behind simulation results.

This study is focused on the notion of political feasibility when, regardless of the potentially varied motivations of actors, they come to advocate for the same outcome. We assume that a particular policy option is chosen and effectively implemented when the appropriate actors arrive at some degree of consensus. Even in a system of government that runs as an absolute monarchy, such as in the UAE, if the various decision-makers and implementers of a policy do not agree with it, they can, and likely will, make it very difficult to decide on its parameters and hinder its implementation. Thus, from the KTAB simulation perspective we have been quite focused on the idea of consensus – of actors arriving at similar advocacy in support of or opposed to a particular policy option. When consensus is achieved, we can say that a policy option is ‘politically feasible.’ When consensus is not achieved, then we can that a policy option is ‘politically infeasible.’

The degree of positivity of consensus, i.e., the distance from neutral, informs the potential content of a policy which is feasible. If there is consensus around a very supportive position on the spectrum used in this study – above a position of 80 – then the implementation of that policy option, with its strong support, would more likely be concrete and more encompassing. In the case where there is consensus closer to the neutral position – in the case of consensus around positions 60-70 – we could similarly infer that the resultant policy will be a weak implementation. When no consensus emerges, or when a consensus emerges that is less than neutral, then we would expect the policy to be political infeasible, as no one will advocate for it with appropriate support.

We can summarize the current level of consensus, based on the accumulated views of subject matter experts interviewed for this study. The data used for the KTAB project provides a shared perspective on the actors’ level of support for, or opposition to, each of the various policy options considered in this study. Based on the similarity among the actors regarding their degree of support or opposition for a specific, we can make inferences about the level of consensus regarding that policy. Based on the combination of data collected from our subject matter experts, we can make an assessment of the current level of consensus for each policy alternative. Based on the KTAB simulation results, which will be described in detail in this section of the paper, we can make an assessment about the expected level of consensus for each policy alternative. These results are summarized in the following Table 3.

Based on Table 3 as well as the results of this entire section, we can see that currently there is no consensus regarding carbon pricing, a positive consensus in favor of renewables, and uncertain consensus for the remaining policy instruments. In other words, there is uncertainty and debate around each policy option considered in this study.

After simulating the CDMP among actors for each policy option, we can evaluate the political feasibility, based on the consensus projected in the simulations. Carbon pricing appears to be politically infeasible, based on a weakly negative consensus, both renewables and nuclear energy appear to be supported by a strongly positive consensus, energy efficiency less so, and energy subsidy reform and natural gas enjoy only a weakly positive consensus. In all cases except carbon pricing, some form of policy is politically feasible, but a substantive policy seems most likely only for renewables, nuclear and energy efficiency.

Table 3. Summary of consensus views on UAE energy transition policies, current and expected.

Component of Energy Transition	Current Political Will	Expected Political Will
Carbon pricing	None	Weakly negative
Renewables	Positive	Strongly positive
Nuclear energy	Mixed but positive	Strongly positive
Energy efficiency	Mixed but positive	Moderately positive
Energy subsidy reform	Mixed but positive	Weakly positive
Natural gas	Mixed but positive	Weakly positive

Source: KAPSARC and Masdar expert interviews.

Conclusions and Policy Recommendations

The UAE has committed to a target of achieving 44 percent total of renewable energy in power generation capacity by 2050, with a further commitment to achieving significant curtailment of electricity demand growth in the same time frame. This commitment to renewable energy and energy efficiency complements a commitment to nuclear energy that should ultimately result in four operational nuclear reactors in the UAE by 2021. Although the UAE has published a NDC that is supportive of mitigating greenhouse gas emissions, no definitive commitments have yet been made to a specific level of greenhouse gas emission reductions in the near or long term. The implication from the KTAB modeling, that explicit carbon pricing in the UAE is politically unlikely, reinforces the notion that the country is reluctant to address greenhouse gas emissions directly.

Regarding the sustainability commitments that the UAE has made, a key challenge to realization is that political visions are in place without detailed strategies and roadmaps to guide policy and regulatory approaches. The situation is additionally challenging given the relative sovereignty that each UAE emirate has over its energy policy. Nonetheless, the results of this work provide insights as to the policy instruments most likely be implementable based on political consensus, even without clearly defined plans – or perhaps implying which may enjoy clearer plans in the future.

From a policy perspective, it seems clear that the UAE can effectively deliver in the near term on renewable energy ambitions with continuation of the utility scale solar energy tenders that have already proven successful. Nuclear power to the level of 5.6GW is a commitment that the UAE will almost certainly deliver, although support for nuclear beyond this level of deployment is uncertain. A perhaps surprising outcome from this study is the somewhat neutral, although still positive, view on natural gas given the current dominance of natural gas in the UAE power sector. An explanation may rely on the value of natural gas in many uses for the UAE beyond power generation, most notably enhanced oil recovery and as a feedstock for petrochemicals. Even for power generation, natural gas would be expected to play a role in system balancing for intermittent renewable energy.

On the demand side, energy subsidy reforms in the UAE have already been undertaken and are expected to continue, perhaps more due to fiscal challenges from low international oil prices than direct climate concern. Policies targeting appliances and building energy efficiency as well as demand response will further support energy demand management and when targeted toward the commercial and residential buildings sector should not be politically troublesome. Although energy-intensive industrials might be expected to oppose energy efficiency and conservation in the same manner they oppose carbon pricing, this was not found to be the case in this study. Rather, energy efficiency policy appears a plausible approach to realizing sustainable energy in the UAE. This affords an opportunity, because only limited overall progress can be made toward the UAE energy transition if the industrial sector, which by far has the greatest contribution to the UAE's final energy consumption, is not in agreement with policies that are developed and implemented. Hence, energy efficiency and demand management in industry is a policy area that should be further strengthened as a complement to the current focus on renewable energy for the power sector. If the UAE is to achieve a true energy transition, the more holistic and seemingly politically acceptable approach will be necessary.

Appendix 1 – The Spatial Model of Politics

The SMP is one of the most widely applied and accepted models of CDMPs, both technically and informally (Bueno de Mesquita 1997; Abdollahian et al. 2006; Jesse 2011; Efird, Lester and Wise 2016). Even outside the field of political science, everyday language is imbued with the implicit assumptions of this model. Political parties may be described as right or left wing; less spatially explicit, we also tend to imply a linear spectrum when describing individuals – or groups, such as political parties – as conservative or liberal, aggressive or passive. Commentators and analysts will often try to uncover the positions held by politicians or other highly placed officials.

For more information on the SMP we again refer readers to the two technical papers cited above. However, a brief description of the logic follows here.

The SMP uses the following terms:

> **The Set of Actors.** This comprises all the actors, or stakeholders, that contribute to the resolution of the CDMP in some way. They can be individuals or aggregates of individuals. Aggregates can be formal, such as a corporation, or informal, such as loose affiliations based on interests, for example, young men sharing a love of fast cars. The constraint is that it must be possible to reasonably assume that each actor is a unitary entity, speaking with a single voice.

The following framework can be used to understand the range of viable outcomes rather than to narrow them down to a single 'most likely' or expected outcome.

> **A Spectrum of Positions.** This is a way of mapping out the range of responses and positions actors could give/take to a given question in the form of a linear continuum of possible positions. The extreme ends of the spectrum are associated with extreme positions. In the question of private participation, one end could be 'extremely limited private sector participation', the other 'a policy environment that is open and conducive to private participation.' These extremes are then labeled as 0 and 100, converting a qualitative spectrum into a numeric one, where each position is given its own score.

The spectrum is a scale where distance measures the change in consequences for the actors: the gap between positions corresponds to the difference in outcome. An implicit assumption is that all actors roughly agree on the order of potential costs implied by the spectrum. The potential political difficulty of moving from position 25 to position 50 would be of roughly the same magnitude as that involved in moving from 50 to 75. In other words, the spectrum requires reasonable calibration.

> **The Set of Positions.** With identified actors and a defined spectrum of positions, the position – i.e., the advocacy – of each actor can then be mapped to the spectrum with a number between 0 and 100.

> **Measures of Influence.** Not all actors are equally powerful. Influence measures how easily the actor can shape the outcome of the CDMP, if fully motivated. It does not describe how likely the actor's preferred position is to win, nor is it a measure of the actor's motivation to win. It is the actor's clout, or political power, as applied to the question, assuming that each actor will bring its full resources to winning the negotiation and taking account of all its formal and informal powers.

Influence scores are relative: an influence score of 60 means that an actor is twice as influential as one with a score of 30. Influence scores are also additive: two actors in coalition, each with influence 30, could block an actor with influence 60. The combination of relativity and additivity can make influence the most cumbersome score to collect. Each actor's score needs to be calibrated against that of all the other actors.

Again, influence is scored against a range of 0 to 100. Strictly speaking, if an actor is assigned an influence score of 0 then it would have no power and would not be counted as an actor.

Measures of Salience. Regardless of an actor’s position and level of influence, different actors will have different levels of interest in the question. Salience quantifies how much an actor cares about the issue in general. How motivated are actors to exert influence to produce their preferred outcome, if and when the issue arises? One way to answer this question is based on the observation that each actor has a portfolio of issues to which it devotes its attention. Salience identifies the importance of the specific issue in that portfolio, recognizing that people have an implicit budget constraint on exerting their influence across their whole portfolio. The salience scores are defined in Table A1 and range from 0 to 100.

The salience score is not the amount of time that an actor will devote to the negotiations but rather its willingness to use whatever influence it has to convince others of the merits of its own preferred position. The salience score does not represent an actor’s influence, merely its motivation when the issue arises.

Once again, salience scores are relative among actors. As with influence, a salience score of 0 would indicate that the actor does not care about the issue, and that it should not be counted as an actor.

The Calculation of Exercised Power. This is a derived value, calculated in the model. As we have said, influence is an indication of the actor’s political clout on the particular issue, if fully motivated, while salience indicates how much the actor actually cares about the issue. Exercised power is the product of these two values and reveals the amount of power the actor will actually bring to bear on the issue being modeled. Note that influence, salience and exercised power all map the actor’s attitudes toward each of the single policy options outlined in this paper, as opposed to some general influence in the UAE or otherwise, without the specific context of the policy option.

Table A1. Definition of salience scores.

Score	Definition
0	The stakeholder is not an actor.
5 – 10	Barely cares – the actor hardly cares and may not be aware of the issue.
10 – 20	Minor issue – the issue is minor, but the actor is aware of it.
20 – 40	One of many – the issue is one of many issues for this actor.
40	Actively monitoring – the actor pays attention actively to progress on the issue.
40 – 60	Cares but not priority – the issue is something the actor cares about but competes with many other agenda items.
60 – 70	Important but not critical – this is an important issue for the actor, but one of several important issues and not a critical issue.
70 – 90	One of top issues – the issue is the most important for this actor but there are still a limited number of other issues that need attention.
90 – 100	Top priority – the issue is that actor's absolute top priority.

Source: KAPSARC.

Appendix 2 – KTAB Model Dynamics

There are two stages within each turn of the KTAB model simulation, explained in much more detail in Wise, Lester and Efird (2015a, 2015b).

> The simulation begins at the end of Turn 0. At the end of each turn, actors generate a series of proposals and counterproposals, 'voting' – i.e., lending their influence in support of, not literally casting a vote – on each until a winning outcome is reached, where winning is a probabilistic comparative assessment of outcomes. Actors produce proposals that improve the likelihood of achieving an outcome that is closest to their preferred outcome, while also trying to appeal to others — based on their perspective — until a 'winning' position can emerge. The final outcome of the CDMP is not necessarily one with which all actors agree: weak actors might be overruled by strong ones. The probable winning position for each turn can be described through a probability curve.

> During the proposal and counterproposal process between each turn, actors can seek to persuade others to shift their position, with the inducement that this may improve the chances of achieving a generally accepted position that is closer to their preferred outcome. These shifts may change the likely outcome of the CDMP. These attempts at persuasion may or may not succeed: the weaker actors may simply concede, counter with an offer to make limited concessions, or even make their own attempt at persuasion. The changes which are calculated by the SMP to be selected by each actor create a new set of actor positions, on which the proposal process described in the first stage is restarted from this new set of positions. Note that while the initial input data define the positions in Turn 0, remaining turns are calculated strictly based on the SMP's assessment of actor interactions.

This second stage can be thought of as containing two distinct phases.

> In the first phase, each actor tries to find some other actor to be a counterparty for effective persuasion. If any attractive counterparties are identified – there may be more than one, just one or none at all, for any potential initiator – then the initiator will focus its efforts to exert influence on the target most attractive to it. Weaker actors may be targeted by multiple initiators; stronger actors may not be targeted at all. The actual shift in position made by a counterparty is determined by a calculation that considers the interactions among the entire set of actors.

> In the second phase, the assessment of how the counterparty responds may vary slightly as it is based on its perceptions and evaluation of alternative outcomes. The combination of what the initiator chooses to do, and how the counterparty will respond, results in an 'objective' calculation of the reaction. Consequently, the objective results of the second phase can differ from the subjective estimates of the first phase. These calculations can differ based on the way risk, calculated endogenously in the model, or other factors, might distort perception.

There are many calculated interactions that lead to a high degree of complexity in the set of potential results that can emerge from each turn. For example, what drives an actor to compromise is not only its view of the options available, but also its assessment of the likelihood of various options 'winning.' It is possible to imagine an actor might compromise to lend support to a position that is not its most favored outcome in order to defeat what it considers an even less desirable option. However, using this model, a detailed narrative can emerge for an individual actor's behavior in each simulation, itself a source of potential insight generated by the SMP.

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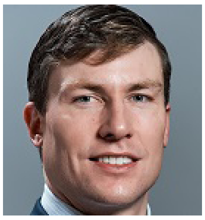

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Imtenan is a researcher in the Policy and Decision Science program at KAPSARC, focusing on energy and economic policy research with an emphasis on Saudi Arabia, GCC countries and Northeast Asia. She holds a master's degree from DePaul University, Chicago.

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I-Tsung is an assistant professor in the Department of Industrial and Systems Engineering at the Khalifa University of Science and Technology in the UAE. His current research studies the energy economics and policy of the GCC countries. He has served as an industrial policy consultant for the United Nations, the Saudi Arabia government and the Singapore government.

About the Project

This paper – prepared in collaboration with the Masdar Institute of Science and Technology, a part of Khalifa University of Science and Technology – applies a model of collective decision-making processes (CDMPs): the KAPSARC Toolkit for Behavioral Analysis (KTAB). KAPSARC has developed KTAB, an open source software platform, to support modeling and analysis of CDMPs. KTAB is intended to be the standard platform for analyzing bargaining problems, generalized voting models and policy decision-making. It is our intent to use KTAB to assemble the building blocks for a broad class of CDMPs. Typical models in KTAB will draw on the insights of subject matter experts regarding decision-makers and influencers in a methodical, consistent manner; and then assist researchers to identify feasible outcomes that are the result of CDMPs.

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