took eight years to complete, totalled an estimated US$17 billion.)

Importantly, fossil fuel subsidy reform in GCC countries would also have environmental benefits. In the past, environmental considerations for subsidy reform in the GCC were often trumped by other factors. (A Chatham House report from 2011 notes that the word 'sustainability', or '*istidaama*', is a relatively recent addition to the Arabic vocabulary.) If Saudi Arabia, Kuwait, and the UAE reduced domestic oil consumption by one million barrels/day by removing fossil fuel subsidies, the corresponding reduction of carbon dioxide (CO_2) emissions could be as high as 160 million tonnes (or 15 per cent of the three countries' combined CO_2 emissions in 2014), assuming that oil use is displaced with zero-carbon fuels or completely eliminated via energy efficiency and global demand were unchanged. It would also reduce local air pollution caused by SOx and NOx.

'SUBSIDY REFORMS CAN HELP CEMENT THE POSITION OF THE LEADING GCC OIL EXPORTERS IN THEIR DRIVE FOR GLOBAL MARKET SHARE …'

As the oil market has changed in the past year, so too has the oil policy of GCC countries, especially Saudi Arabia. The result of these changes is that removal of fossil fuel subsidies is increasingly in the GCC countries' self-interest. Subsidy reforms can help cement the position of the leading GCC oil exporters in their drive for global market share, and help them boost exports or increase their spare production capacity at little cost. Subsidy reforms could financially strengthen the GCC economies in the current weak oil price environment, and make it more likely they emerge as winners when prices begin to rise again. These changes will also slow the consumption of hydrocarbons, reduce carbon emissions and local pollution, and boost energy efficiency and renewable energy. Without subsidy reforms, Saudi Arabia and the other leading oil exporters in the GCC risk losing, both in the short and the long run.

Alternative industrial fuel prices could benefit the Saudi economy

Walid Matar

Oil consumption in Saudi Arabia has grown at around 5 per cent annually since the year 2000. This growth has raised concerns over the Kingdom's ability to maintain its large export capacity in the future. Limited supply of natural gas and low energy prices have contributed to the substantial use of oil for domestic industrial production. The low administered oil and gas prices offered to industrial firms have further discouraged investment in non-hydrocarbon power generation technologies, and the production of higher value-added products. In this respect, decision-makers in the Kingdom have particularly expressed interest in displacing the use of oil in inefficient power plants by deploying other technologies. Alternative industrial fuel pricing policies can mitigate the growth in domestic oil consumption and facilitate investment in non-hydrocarbon power generation.

Employing the KAPSARC (King Abdullah Petroleum Studies and Research Center) Energy Model (KEM) for Saudi Arabia, in this article we study the impact of economic policies, such as those pertaining to industrial fuel prices and technology change. The model characterizes the operational and investment decisions of the electricity, refining, water desalination, petrochemicals, cement, and upstream industries in the Kingdom. It has been designed from the outset to represent the government-set energy prices that permeate the Saudi economy. Energy prices in Saudi Arabia are generally set by the government. Crude oil is sold to industrial firms at US$4.24/barrel, and methane and ethane are sold at US¢75/MMBtu; refined oil products are even less expensive per unit of energy content. The current mix of equipment and fuels in the industry and, in particular, in the power and water desalination sectors, reflects the low administered fuel prices.

'ELECTRICITY IN SAUDI ARABIA IS ALMOST EXCLUSIVELY GENERATED BY BURNING CRUDE OIL, REFINED OIL PRODUCTS, AND NATURAL GAS.'

Electricity in Saudi Arabia is almost exclusively generated by burning crude oil, refined oil products, and natural gas. While simple-cycle gas turbines have historically been favoured because of low fuel prices (the gas price was even lower, at US¢50/MMBtu, before 1998), their quick lead time for construction, and low investment cost, utilities are now mitigating the growing use of fossil fuels by upgrading simple-cycle gas turbines to combined-cycle plants, and installing power capacity with higher thermal efficiency.

The examined industrial fuel pricing and incentive policy scenarios

The policy options studied focus on reforming industrial fuel prices and introducing incentives that encourage investment in alternative power generation technologies. We allow capacity expansion planning to begin in 2015, and the analysis is performed up to 2032, to take into account construction lead times for all plant types and future learning effects reflected by the decreasing costs of renewable technologies. In a 'business-as-usual' case, we hold the current fuel prices offered to industrial firms constant in real terms until 2032. We also study five alternative policies as follows:

1 Industrial fuel prices are immediately deregulated, starting in 2015. The prices of crude oil and oil products sold to industry are set at projected international market values. Since natural gas is neither exported nor imported, we use its domestic market-clearing price as determined by the model.
2 Beginning in 2015, the prices of industrial fuels are gradually deregulated over an eight-year period.
3 Current quantities of fuels consumed are allocated to the sectors at the administered prices and any incremental quantities demanded are valued at deregulated prices. The quantities priced at the administered level are phased out over an eight-year period.
4 The fourth alternative scenario moderately raises fuel prices and introduces investment credits offered by the government for renewable and nuclear power technologies. The objective of this scenario is to achieve fuel-to-capital cost ratios that are similar to those facing utilities observed in a deregulated setting (and thus facing similar operational and investment decisions).
5 In lieu of investment credits, this scenario introduces feed-in tariffs that would produce the same investment decisions observed when only investment credits are applied. The purpose of this scenario is to calculate the value of technology-specific tariffs needed to replicate the effect of investment credits. These incentive mechanisms have practical differences. Investment credits are a one-time payment at the time of construction, whereas feed-in tariffs are paid over the operating life of the plants.

The alternative policies show the optimal allocations of natural gas in the Kingdom's production sectors; those scenarios allow available gas to flow to where it adds the greatest value based on the domestic market-clearing price determined by the model. In all scenarios, the Kingdom honours the contractual agreements between the upstream and petrochemicals firms that set long-term methane and ethane prices at the current administered price. Additionally, electricity and transportation fuel prices are unchanged to households and other end-users.

All alternative scenarios yield large reductions in the use of fossil fuels in the analysis horizon. By keeping current policies, oil and gas consumption approaches 8 million barrels of oil equivalent (boe) per day in 2032. Our analysis suggests up to 2 million boe per day would be saved by applying the alternative policies. According to the Electricity & Co-generation Regulatory Authority, crude oil and refined products constituted more than half of the fuels used for domestic electricity generation in 2013. Utilities would continue to burn substantial quantities of oil if current fuel prices were maintained in real terms. When prices are deregulated and decisions are made based on the actual economic value of the fuels, oil is quickly displaced by other fuels and technologies. Available natural gas is used in efficient combined-cycle plants.

In short, future growth in domestic oil and gas consumption is mitigated by improving efficiency in the energy system over time. Of course, the lower dependence on oil for domestic industrial operation in the alternative scenarios allows the Kingdom to raise its crude oil export capacity.

Current price policies will dis-incentivize new technologies

Inefficient simple-cycle gas turbines and steam turbine plants dominate the current electricity generation mix. When present fuel prices are kept intact, the power sector gradually invests in upgrading existing gas turbines to combined-cycle plants. In this case, our analysis shows that in 2032 most of the electricity is produced by combined-cycle plants. The average efficiency of the electricity generated by power plants at that time would consequently increase, approaching 48 per cent.

'THE LEVEL OF RENEWABLE AND NUCLEAR CAPACITY DEPLOYED WILL BE SENSITIVE TO FUTURE NATURAL GAS AVAILABILITY …'

Despite improved generation efficiency, the continuation of current policies would prevent the price-induced investment in renewable and nuclear power technologies. The higher fuel prices and/or incentives in the alternative policy scenarios provide the proper fuel-to-capital cost ratios that lead to the emergence of renewables and nuclear. Investment in photovoltaic capacity is made despite the additional system costs of maintaining spinning reserves that mitigate the effects of intermittency. The level of renewable and nuclear capacity deployed will be sensitive to future natural gas

availability, as high gas supply will mean more gas-fired capacity.

The solution may lie in a gradual approach

We use the overall economic gain to gauge the efficacy of the alternative policy scenarios. This measure is defined as the discounted sum of the annual differences between aggregate revenue and social cost relative to a policy where current industrial fuel prices are unchanged. Immediate deregulation of prices generates the largest economic gain for the Kingdom and serves as a benchmark against which other policy options are assessed. When decisions are made based on deregulated prices, the higher economic value of oil leads the sectors to forgo its use, resulting in economic gains from its potential export.

Our results suggest that a more gradual transition, such as that in the second and third alternative policies, can achieve the vast majority of the benchmark economic benefits, without the shock of immediate deregulation. Furthermore, we find that most of the gains of immediate deregulation can be attained by raising fuel prices slightly (to well below their deregulated values) and offering financial support to the utilities for constructing renewable and nuclear capacity. The introduction of investment credits reduces the cash outflows that would be incurred by the utilities in a deregulated setting.

The observed overall economic gain does not necessarily mean that no additional costs are sustained if the analysed policies are implemented. But the incremental revenue of the aggregate system, which is mainly driven by the value of the oil saved, is higher in magnitude in all alternative scenarios than the corresponding additional costs. While the energy system as whole enjoys a substantial economic gain, the power and water utilities will experience higher costs by increasing fuel prices, since the prices of their products are unchanged. Manufacturing sectors that can export are able to alter the mix of exported products to gain increased revenue. The additional costs experienced by the petrochemicals sector are, however, alleviated by honouring existing long-term contracts that keep feedstock prices at the current values. The utilities' costs are mitigated in an investment credit policy in which the government bears a proportion of new capacity cost. The resulting lower net revenues in the alternative policy scenarios may either be absorbed by the sectors themselves or covered by financial transfers from the government.

Transitioning into a more efficient Saudi energy economy

Policies targeting industrial sectors such as petrochemicals, cement, and the power sector may be viewed as a first step in achieving a more efficient Saudi energy system. We show that large reductions in domestic fossil fuel use can be realized by the alternative industrial fuel pricing policies. The higher prices and/or financial incentives induce investment in more efficient industrial production technologies. While efficiency improvements are made over time under a business-as-usual scenario, the current prices would not encourage investment in renewable and nuclear power generation; also, crude oil would still be burned in large quantities to satisfy electricity demand. Although deregulated fuel prices induce the deployment of renewables and nuclear and achieve the highest economic benefits, the drastic increase in prices may not be politically tenable. Instead, our analysis shows that a large part of these economic benefits can be attained without a drastic surge in prices. Therefore, policies comprising a moderate increase in fuel prices, coupled with investment credits for non-hydrocarbon technologies, would facilitate the construction of renewable and nuclear plants in the Saudi power system, and attain most of the benefits of deregulation. Investment credits also alleviate the power sector's expenditure requirements.

'… LARGE REDUCTIONS IN DOMESTIC FOSSIL FUEL USE CAN BE REALIZED BY THE ALTERNATIVE INDUSTRIAL FUEL PRICING POLICIES.'

Reforming end-user energy prices could rationalize GCC energy demand

Jim Krane

The six GCC economies – Saudi Arabia, the UAE, Oman, Kuwait, Qatar, and Bahrain – are some of the world's most profligate consumers of energy and emitters of greenhouse gases, relative to their size. Other hydrocarbon exporters in the region, notably Iran and Algeria, are beset by similar circumstances. Observers have attributed this state of affairs to the very low prices at which energy is sold in these countries. However, there have been few attempts to quantify the effects of subsidies on domestic consumption.