KAPSARC

مركز الملك عبدالله للدراسات والبحوث البترولية

King Abdullah Petroleum Studies and Research Center

ENERGY RESEARCH INSTITUTE

Toward Economic Prosperity Through Industrial Energy Productivity Improvement

A Saudi Arabia-China joint report

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About the Project

King Abdullah Petroleum Studies and Research Center (KAPSARC) and the Energy Research Institute (ERI) have worked together on a review of industrial energy productivity and associated policies in Saudi Arabia and China. This work builds on generous inputs from participants in a workshop conducted in March 2017 in Riyadh, as well as a follow-up workshop held in December 2017 in Beijing, and reviews the current status and future plans of industrial development, restructuring and modernization, energy efficiency and industrial energy pricing. This project aims to help increase transparency and mutual understanding of the policy practices that might be relevant and valuable to support both countries' further sustainable development. It also aims to inform activities and deeper collaboration under China's Belt and Road Initiative, which is supported by the Kingdom and aligns with investment priorities under Saudi Arabia's Vision 2030.

About KAPSARC

The King Abdullah Petroleum Studies and Research Center (KAPSARC) is a non-profit global institution dedicated to independent research into energy economics, policy, technology and the environment, across all types of energy. KAPSARC's mandate is to advance the understanding of energy challenges and opportunities facing the world today and tomorrow, through unbiased, independent, and high-caliber research for the benefit of society. KAPSARC is located in Riyadh, Saudi Arabia.

Legal Notice

Key Points

In this report, we explore the main trends and policies that relate to industrial energy productivity in China and Saudi Arabia, focusing on energy efficiency, structural economic reform, industrial upgrading and energy pricing. Our objective is to increase shared understanding on these issues as both countries deepen their engagement as part of China's Belt and Road Initiative and Saudi Arabia's Vision 2030.

China has implemented a system of energy intensity targets, energy efficiency benchmarking, structural reform for industry and energy price reform that have helped it achieve one of the highest rates of energy intensity reduction in the world at around 5 percent per year. Energy intensity in Saudi Arabia may have peaked in 2010 at just above the G20 average, and has declined since then around 1 percent per year.

We estimate that in 2016 around $5 trillion more, or about 23 percent, was added to China's gross domestic product (GDP) than if its economy had still functioned at its 2010 energy intensity. A similar analysis conducted for Saudi Arabia suggests that in 2016 around $140 billion, or about 8 percent, was added to its GDP.

While it still takes less energy to produce the same amount of industrial value added in Saudi Arabia than in China, China has been reducing its energy intensity at a much faster rate. In 2016, it took around 26 percent less energy to produce the same amount of industrial value added in China than it did in 2010, while in Saudi Arabia it took around 8 percent less energy.

Greater efforts to share international experiences on industrial energy productivity can help achieve greater prosperity and sustainable development goals. Areas for the exchange of knowledge and experience could potentially include: how differential industrial energy pricing can support energy efficiency, benchmarking, and establishing a market for industrial energy efficiency service companies (ESCOs), as well as how to build competitive high-value industrial ecosystems.

Summary for Policymakers

While the energy economies of China and Saudi Arabia differ in many respects, they are similar in that both countries have rapidly growing economies that are in transition. In both countries, the industrial sector accounted for the majority of energy demand at around 58 percent and 55 percent in 2016, respectively. The question of how industrial energy productivity supports economic growth is thus of particular importance for sustainable development in both countries. The insights from this report are organized around six main themes.

What is the added value of focusing on energy productivity?

Researchers often emphasize labor and capital when considering which factors of production drive economic growth, while simply incorporating energy into 'other resources' or 'materials' of production. However, given the critical importance of energy and the dramatic shifts underway in how we secure, price and use it, there is a strong case for improving our understanding of how energy, in conjunction with other inputs, supports economic growth. Moving toward a standard language, along with using technical indicators and implementing targets to manage energy in industry, would help to facilitate this improvement.

Energy productivity is an emerging policy agenda focusing on how energy can best be used to create value in the economy. It also incorporates some specific indicators that integrate economic performance and energy consumption. At the macroeconomic level, energy productivity is equivalent to its mathematical inverse of energy intensity – or how much energy it takes to produce a unit of gross domestic product (GDP). At the microeconomic level, energy productivity focuses on the revenue produced per unit of energy consumed by a company or sector. Energy efficiency, on the other hand, is generally focused on the energy consumed per unit of output (e.g., gigajoule (GJ)/ tonne of cement). As a result of this difference, energy productivity may provide a better foundation for industrial policy. Energy productivity more strongly incorporates industrial upgrading and structural reform. However, energy efficiency is still a core element of energy productivity.

What are the key energy productivity trends in China and Saudi Arabia? How do they compare globally?

The industrial sector is the prime driver of energy consumption in both Saudi Arabia and China. In China, industrial energy consumption has recently begun to decline, even though industrial value added continues to rise strongly. This shift is the major driver behind China's overall rate of decline in energy intensity of about 5 percent per annum in recent years. This rate of decline is among the fastest in the world and is globally significant. We estimate that in 2016 around $5 trillion more was added to China's GDP than if its economy still functioned with the energy intensity it had in 2010.

In contrast, after potentially peaking in 2010, Saudi Arabia's energy intensity has only recently been declining, with an overall decline of 8 percent. However, it is still much higher than in 2000. In some years Saudi Arabia's energy intensity has declined, in others it has increased. This compares with relatively consistent average annual declines in energy intensity across the G20 of about 2.5 percent per year over the period 2011-2016.

What are the key economic and energy objectives in both China and Saudi Arabia, and how does industrial energy productivity support these plans?

In response to rapidly rising energy consumption, China first imposed mandatory energy intensity targets in its 11th Five Year Plan (FYP) (2006-2010). These energy intensity targets were expanded and refined in China's 12th (2011-2015) FYP and continued in its 13th FYP (2016-2020), which set a reduction target of 15 percent relative to 2015 levels. As part of its 13th FYP, China also plans to boost the share of non-fossil fuels in the primary energy mix to 15 percent, reduce the share of coal from 64 percent to below 58 percent and increase the share of natural gas in the energy mix from 5.9 percent to 10 percent. China also plans to increase the share of the service sectors in the economy from 50 percent to 56 percent.

With the introduction of Saudi Arabia's Vision 2030, the Kingdom plans on moving toward a new era of non-oil growth, transparency and privatization. A key target is to improve the Kingdom's position in the global ranking of leading economies, from 19th place to within the top 15 by 2030. Saudi Arabia also aims to expand the share of private sector non-oil GDP from around 40 percent in 2015 to 65 percent by 2030. The Kingdom has plans to increase the share of gas, nuclear and renewable energy in the fuel mix, including a 9.5 gigawatt (GW) renewable energy target by 2023. While the Kingdom has a target to increase the energy efficiency of power generation from 33 percent to 40 percent by 2020, the energy implications of Vision 2030 have not been clearly established. As the China example shows, setting national energy productivity or intensity targets and using them to inform policy could help the Kingdom achieve its industrial diversification and energy efficiency goals.

How far can energy efficiency in energy-intensive industries move the needle?

Both Saudi Arabia and China have implemented energy intensity targets and programs to improve energy efficiency in their biggest energy consuming companies. China's approach to improving industrial energy efficiency is threefold: phasing out outdated inefficient capacity, mandatory improvement targets for existing plants and strict market entrance requirements for new plants. Energy Research International (ERI) estimates that the implementation of energy efficiency measures, especially the Top 10,000 Enterprises Program, resulted in energy intensity improvements of between 5-20 percent across the industrial sector for the period 2010-2014 and energy savings of 309 million tonnes of coal equivalent (TCE). The energy service company (ESCO) industry grew at a rapid rate between 2003 and 2016, generating more than 652,000 jobs in over 5,800 businesses. The gross output value from the ESCO sector increased from around renminbi (RMB) 1.7 billion in 2003 to over RMB 356 billion in 2016, creating the world's largest ESCO market.

In Saudi Arabia, the Saudi Energy Efficiency Center (SEEC) established baselines and benchmarking frameworks for over 180 industrial plants covering 59 different production processes. SEEC agreed on aspirational energy intensity targets for 2019 and reviewed energy efficiency improvement plans for 42 companies. SEEC's scheme for industry separates existing plants from new plants. Companies must submit energy efficiency improvement plans for their existing plants that identify the energy savings potential. New plants must target the average energy efficiency in the first quartile of the relevant

global benchmark for their sector. SEEC reports that from 2011 to 2015 energy intensity improved in the petrochemical sector by around 2 percent, and by about 3 percent for cement. Overall, these initiatives are expected to save around 9 percent of total industrial energy consumption by 2019 compared with a 2011 baseline.

What is the importance of industrial strategy for managing structural economic change?

It is not preordained that economies will naturally move up the value chain from simply exporting mineral resources and basic commodities to adopting high-value growth models of advanced manufacturing and services. In China, industrial transformation dominates economic policymaking, shaping everything from the government's efforts to reduce excess industrial capacity and increase energy efficiency, to programs designed to reign in excessive debt and lower corporate costs. Transformation to higher value production will depend on developing a professional skill base, research and development, and higher incomes to support domestic demand. In Saudi Arabia, energy-intensive industry still dominates the industrial landscape. Plans to grow new economic sectors through the National Industrial Strategy, building on the Kingdom's competitive advantage in energy-intensive industry, is an area of ongoing development.

How does energy price reform support industrial transformation goals?

Society tends to value higher priced goods more and put them to their highest value use. This is the key idea behind energy pricing for greater energy productivity in industry. Using energy productivity as a framework for energy price reform suggests that higher energy prices should aim to preserve the competitive edge of energy-intensive industries, but still be high enough to make enhancing energy efficiency a priority for business leadership and to encourage a more efficient allocation of resources.

Energy prices in China, and more recently Saudi Arabia, have been or are in the process of being deregulated in the transition to more market-oriented systems. In China, energy prices have transitioned from being 'government-set' to 'government-guided,' with coal, oil and gas prices moving with the market within certain acceptable bounds. Electricity prices have increased less than the underlying fuel inputs. China also operates differential electricity pricing for energy-intensive industry by charging higher prices for companies with lower energy efficiency performance. These are the kind of incentives that could also work in Saudi Arabia.

Saudi Arabia's Fiscal Balance Program incorporates plans to increase domestic energy prices to levels more reflective of international benchmarks. The opportunity cost of providing energy at the cost of supply rather than based on international benchmarks was estimated at around Saudi Arabian Riyal (SAR) 300 billion in 2015. The first phase of energy and water price reform was implemented in 2016, raising electricity prices for industry from 0.14 SAR/kWh to 0.18 SAR/kWh. The reported impacts of the energy price reforms already implemented include increased revenue from fuel sales of SAR 27-29 billion in 2016, and a reduction in the annualized rate of growth of energy consumption from 3.5 percent in the first half of 2015 to 1.7 percent in the first half of 2016. These reforms are being phased in gradually and are expected to realign economic incentives toward enhanced energy efficiency and higher value-added manufacturing.

What is the Added Value of Focusing on Energy Productivity?

Energy productivity is an emerging policy agenda focusing on how energy can best be used to create value in the economy. It incorporates specific indicators that integrate economic performance and energy consumption.

At the macroeconomic level, energy productivity describes how much GDP can be produced using a specified amount of energy. Energy productivity is also the mathematical inverse of energy intensity (energy consumed per unit of GDP). It is thus both a reflection of an economy's energy-intensive and non-energy intensive activities, as well as of how efficiently the sectors use energy in those activities (Figure 1).

Achieving greater energy productivity is the result of using technologies that increase the size of the economy or improve business profitability, and those that reduce energy consumption through energy efficiency and diversification strategies. It is important to note that both these actions – promoting growth or revenue on the one hand and reducing energy consumption on the other – are key elements of an energy productivity agenda (Figure 2). Importantly, they are not mutually exclusive; it should be possible to grow industry and achieve more prudent energy consumption simultaneously.

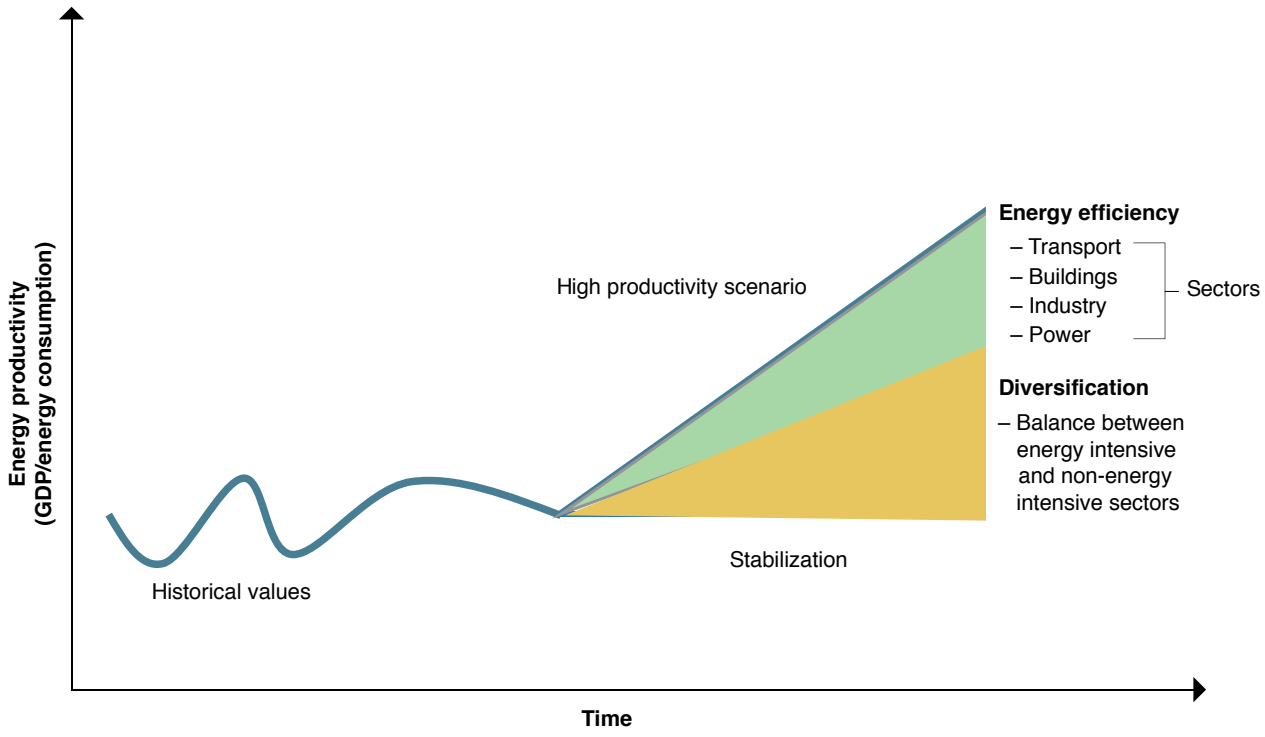

Figure 1. The key drivers of energy productivity.

Source: KAPSARC.

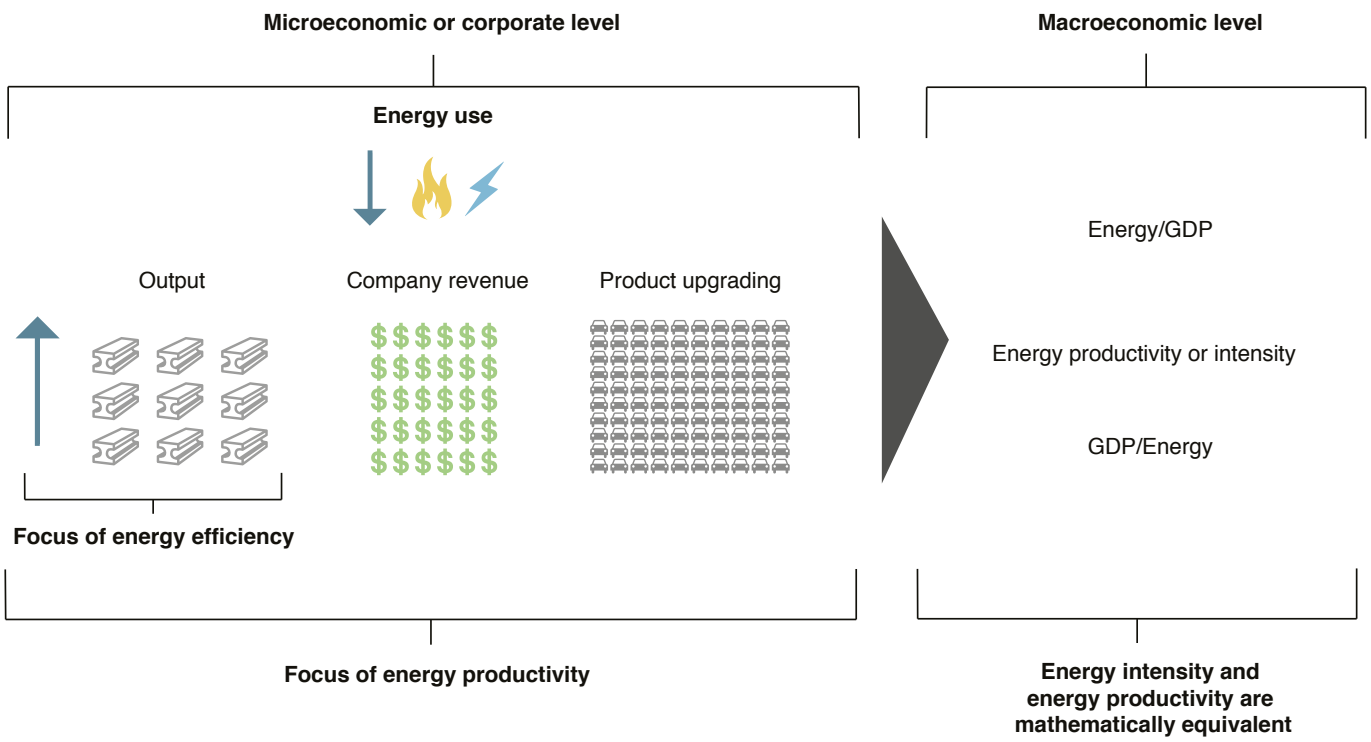

Figure 2. Areas of overlap and difference between energy productivity and efficiency agendas.

Source: KAPSARC based on Climate Works Australia (2015).

At the microeconomic level, energy productivity focuses on how much revenue economic activities produce per unit of energy consumption. It is related to but distinct from energy efficiency, which generally focuses on how much energy is consumed to produce a unit of physical output. For example, measures of energy efficiency in the industrial sector focus on total energy use per unit of output, such as GJ/tonne of steel. In contrast, measures of energy productivity focus on company revenue against total energy use. Energy-intensive industries, such as petrochemicals and cement, tend to have much lower energy productivity than sectors such as aerospace, health care or automotive manufacturing, irrespective of how energy efficient they are within their sub-sector. Therefore, an expansion of energy-intensive industry will put downward pressure on energy productivity, or upward pressure on energy intensity.

Energy productivity highlights two key matters for company executives. First is the need to account for energy separately in corporate reporting; and second is to assess its use in terms of the value it creates, rather than simply focus on the physical outputs created.

A broader view of energy productivity, 'integrated energy productivity,' was proposed by the Climate Policy Initiative in conjunction with the South Pole Group and other stakeholders (see Figure 3). This proposal incorporates the environmental and social benefits attached to energy use in addition to the economic or 'traditional' components. By including these 'additional' elements, the concept of integrated energy productivity more explicitly brings into focus sources of economic value such as health benefits from pollution reduction, positive employment effects from higher value industry development, avoided greenhouse gas emissions and energy efficiency's multiple benefits.

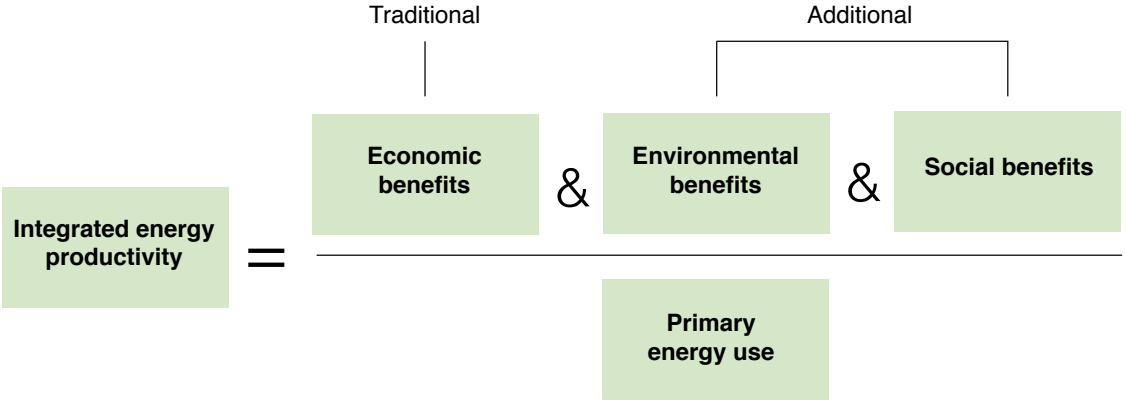

Figure 3. Integrated energy productivity.

Source: Energy Foundation (2017).

Energy intensity versus energy productivity

People have debated whether the difference between energy intensity and energy productivity is purely theoretical. If one views energy productivity as the inverse of energy intensity, there is a case to suggest that there is little difference between the two. Some people, notably policymakers in Australia and the United States, have argued that energy productivity has a more positive connotation since it focuses on valuing the additional economic output, rather than on shrinking energy demand.

Others argue that people are used to using the term 'energy intensity' and that this is reason enough to maintain attention on it. China, for example, has a long history of using energy intensity targets. However, because energy productivity and energy intensity can be used to focus on different objectives – increasing growth on the one hand and reducing energy consumption on the other – what might seem to be a simple technical distinction can attract a significant amount of debate. This debate stems from deeply held convictions around what is most important for public policy.

> **"Ultimately what may be most important in the energy productivity-intensity discussion is not the choice of metric, but whether the target is ambitious but realistic and is backed up by strong energy efficiency and modernization policies which promote socially desirable investment and change."**
>
> Source: Quote from KAPSARC-ERI March 2017 Workshop.

Energy Productivity Trends and Key Indicators

While the energy economies of China and Saudi Arabia differ regarding the scale and diversity of their energy mixes, they are both similar in that industry is the main driver of overall energy consumption. Both are in the top quartile of countries with economic structures geared toward energy intensive sectors, with industry in China accounting for 58 percent of energy consumption and at around 55 percent in Saudi Arabia (Figure 4). Included in this is non-energy use, mainly the energy used as feedstock in petrochemicals and fertilizers, which accounts for 14 percent of total industrial energy consumption in China and 35 percent in Saudi Arabia.

Since 2000, energy consumption has risen strongly in both countries, led by the industrial sector. In China, industry's share of total final energy consumption peaked around 2012 at 65 percent and has recently declined to 58 percent (Figure 5). In Saudi Arabia, industrial energy consumption as a share of total energy consumption has stayed constant at around 55 percent since 2000. These figures position both countries in the top quartile of energy-intensive countries in the world (Figure 6).

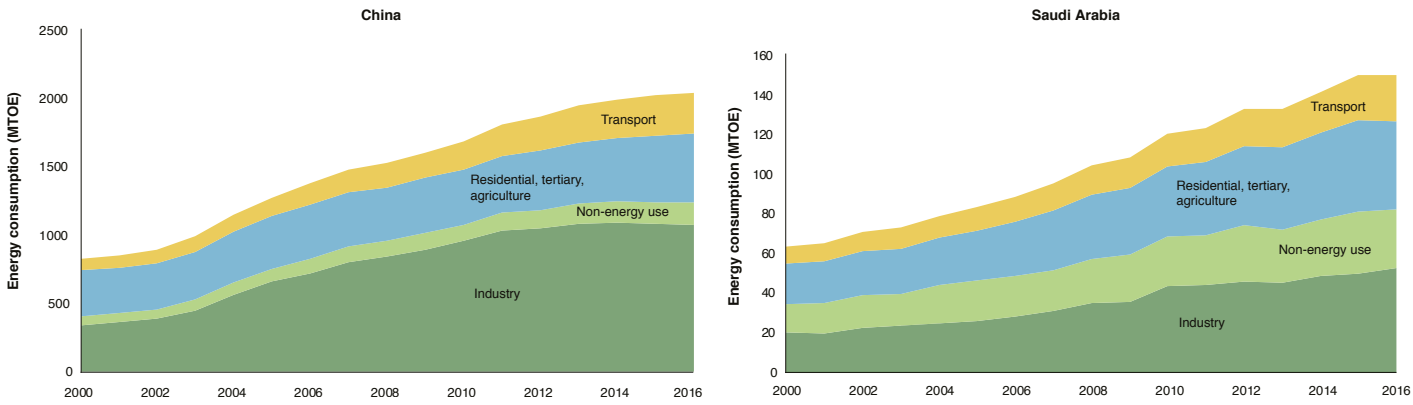

Figure 4. Energy consumption profiles of China and Saudi Arabia.

Source: KAPSARC based on Enerdata.

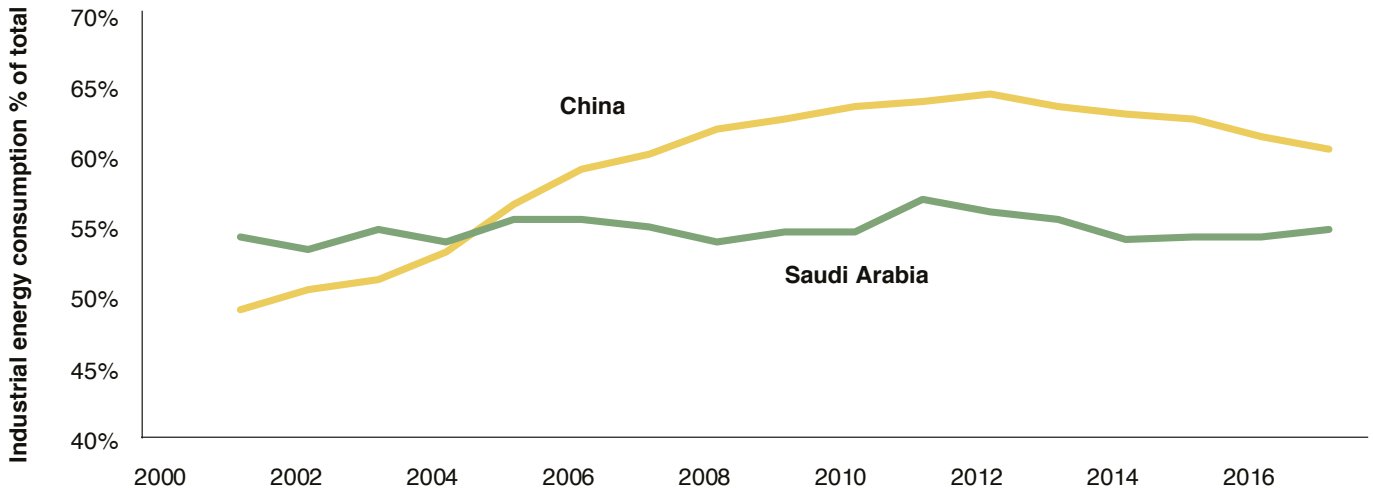

Figure 5. Share of industry (incl. non-energy) in total final energy consumption.

Source: KAPSARC based on Enerdata.

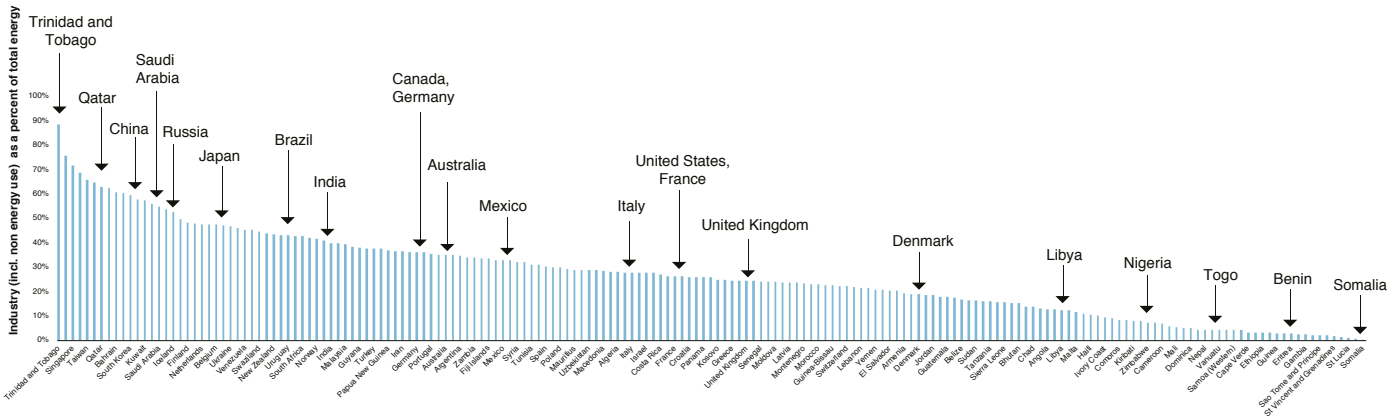

Figure 6. 2016 Industrial energy consumption (% of total final energy consumption).

Source: KAPSARC based on Enerdata (2015 data used where 2016 not available).

To understand how the industrial sector contributes to energy productivity in the economy, it is useful to see how it fits within overall energy intensity trends. Figures 7-9 show the year-on-year growth rates for total primary energy consumption, GDP and overall energy intensity for Saudi Arabia, China and the G20 group of countries.

After a period of rising energy intensity associated with the boom in industrial output following its admission to the World Trade Organization in 2001, China now exhibits a strong trend of improving energy intensity. Growth rates for total primary energy consumption have transitioned from a period with well over 5 percent (2002-2011) to under 5 percent, where it has recently stabilized. While GDP growth has also moderated in these two periods, it is still more than 5 percent year-on-year. This means overall energy intensity is falling by about 5 percent each year, one of the highest rates of improvement in the world.

In contrast to China, Saudi Arabia exhibits no strong energy intensity trend, with energy consumption growth far exceeding GDP growth in some years and vice versa. Part of this variation reflects the volatility in GDP as a result of swings in international energy prices, with oil-based GDP accounting for around 42 percent of GDP. Growth in energy consumption is also quite variable, reflecting a combination of drivers including population growth, shifts in income, changes in industrial output and improving energy efficiency.

We can compare these trends in China and Saudi Arabia to those observed in the G20 group of major economies. Both countries are quite exceptional in that China's annual rate of improvement in its energy intensity is around double that of the rest of the G20. China thus raises the G20 average significantly.

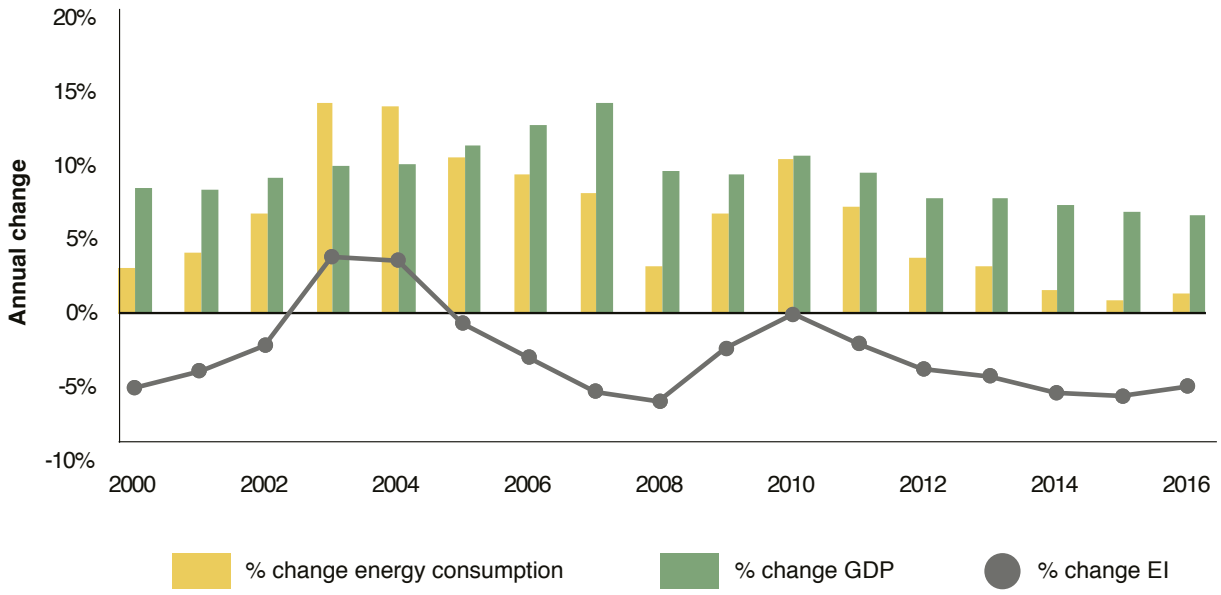

Figure 7. Energy consumption, GDP and energy intensity in China.

Source: KAPSARC based on Enerdata (based on total primary energy consumption and GDP purchasing power parity (PPP) 2015).

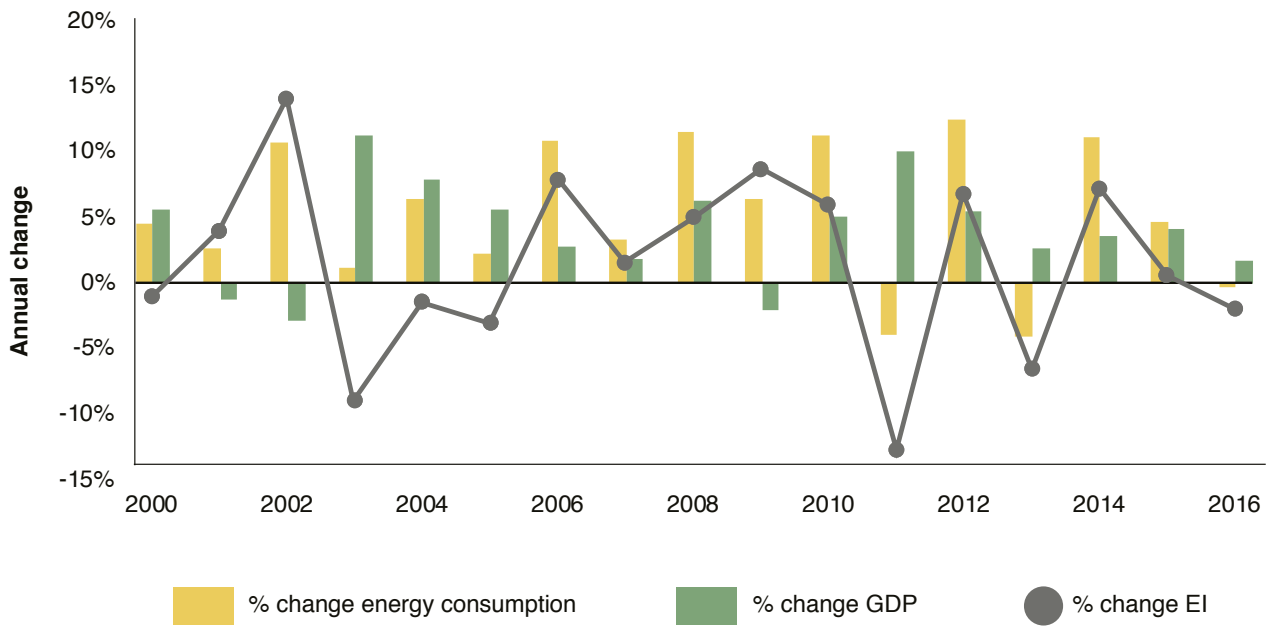

Figure 8. Energy consumption, GDP and energy intensity in Saudi Arabia.

Source: KAPSARC based on Enerdata (based on total primary energy consumption and GDP PPP 2015).

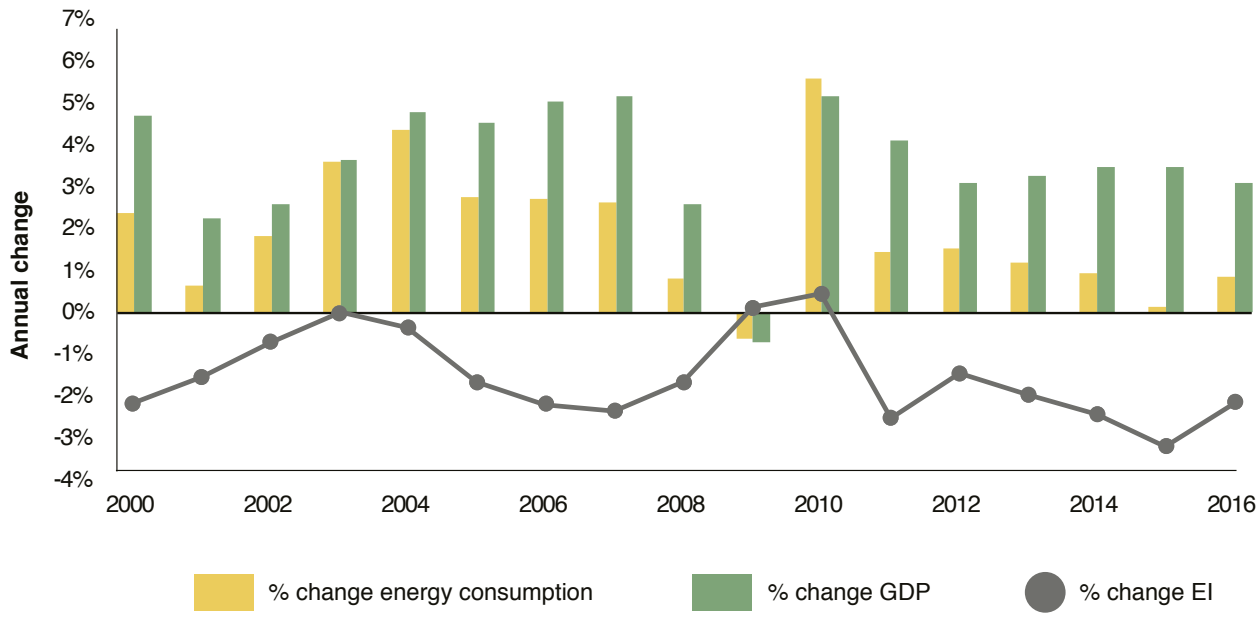

Figure 9. Energy consumption, GDP and energy intensity in the G20.

Source: KAPSARC based on Enerdata (based on total primary energy consumption and GDP PPP 2015).

The effects of the global financial crisis of 2008 are also much more visible at the G20 level, with GDP growth and energy consumption declining in 2009 as a result of economic recession in many countries. Since the financial crisis GDP and energy consumption growth have averaged about 1 and 3 percent respectively, whereas before the crisis they averaged around 3 and 4 percent.

These trends suggest a broader shift in what was once a very predictable relationship between rising economic activity and growth in energy demand. Among OECD countries that are part of the G20, energy demand has peaked and is now mostly on a declining trend. Industrializing and developing countries are now at the center of energy demand growth. According to the IEA's World Energy Outlook (2016a), declining energy intensity, especially in China, has been a major driver of slower growth in global energy demand and the stalling of energy-related CO_2 emissions.

Figure 10 shows energy intensity trends for China, Saudi Arabia and the G20 from 2000 to 2016. Viewing energy intensity in absolute terms rather than growth rates reveals that one of the reasons for China's high rates of improvement in energy intensity over this period is its high initial quantity. In 2000 China required around 0.22 tons of oil equivalent (TOE) to generate $1,000 of GDP, almost double that of the G20 average. By 2016 this had dropped to 0.15 TOE/$1,000.

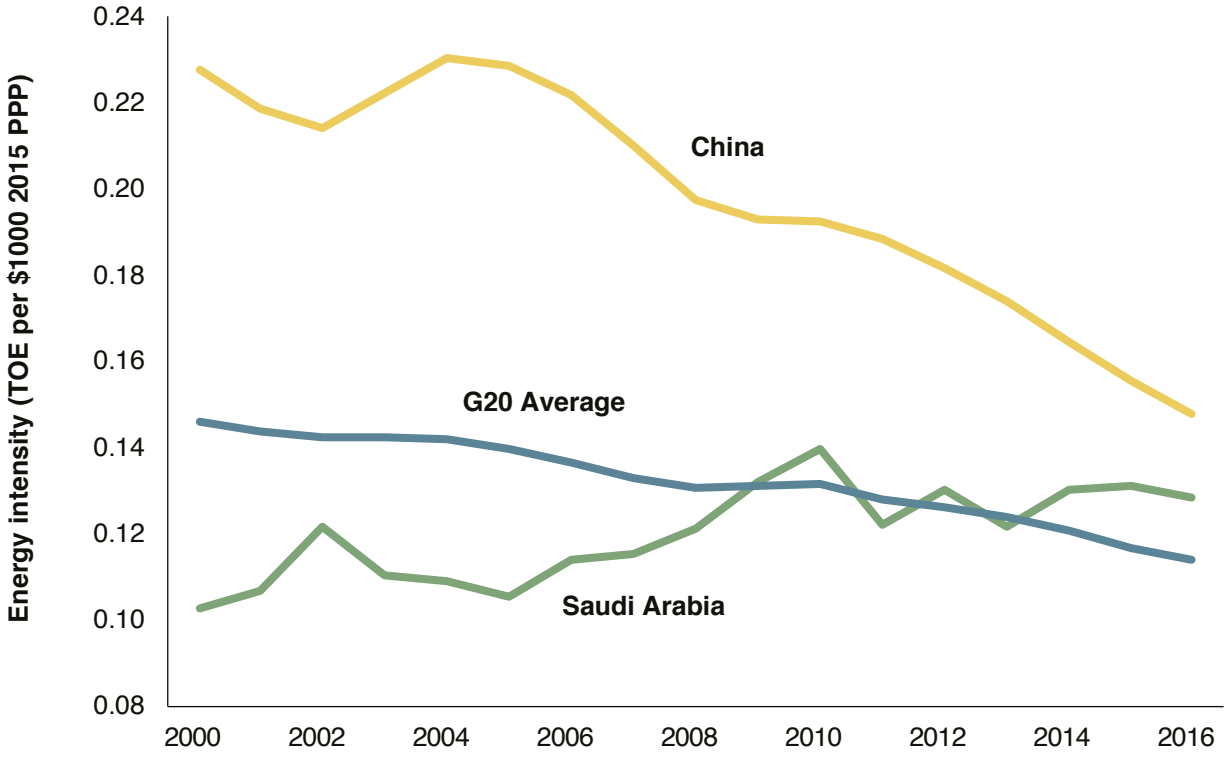

Figure 10. Saudi Arabia, China and G20 primary energy intensity trends.

Source: KAPSARC based on Enerdata.

While energy intensity has been improving over this period for China and the broader G20, in Saudi Arabia the amount of energy required to produce $1,000 of GDP has risen from around 0.10 TOE to 0.13 TOE. This rise is in part due to the increase in the amount of energy-intensive non-oil GDP, such as petrochemical manufacture, in Saudi Arabia's economic structure (KAPSARC-UNESCWA 2017). Since oil extraction results in relatively high amounts of GDP for the amount of energy used in its production, this may explain the initial very low levels of energy intensity in the Kingdom and the rise in energy intensity as the share of non-oil GDP grows. Taking a more recent base year, the Kingdom's energy intensity has in fact improved from a potential peak at 0.1399 in 2010 to 0.1285 TOE/$1,000 in 2016.

Figure 11 translates these trends in energy intensity into their equivalent values for energy productivity. Here we make the point that energy intensity and energy productivity have a direct mathematical relationship at the macroeconomic level and can be used for the same purpose in national target setting.

Here we calculate an energy productivity dividend as the difference between the actual 2016 GDP and the GDP that would have been generated using the same energy intensity as in 2010. This calculation follows an approach set out by the IEA in their 2017 Energy Efficiency Market Report.

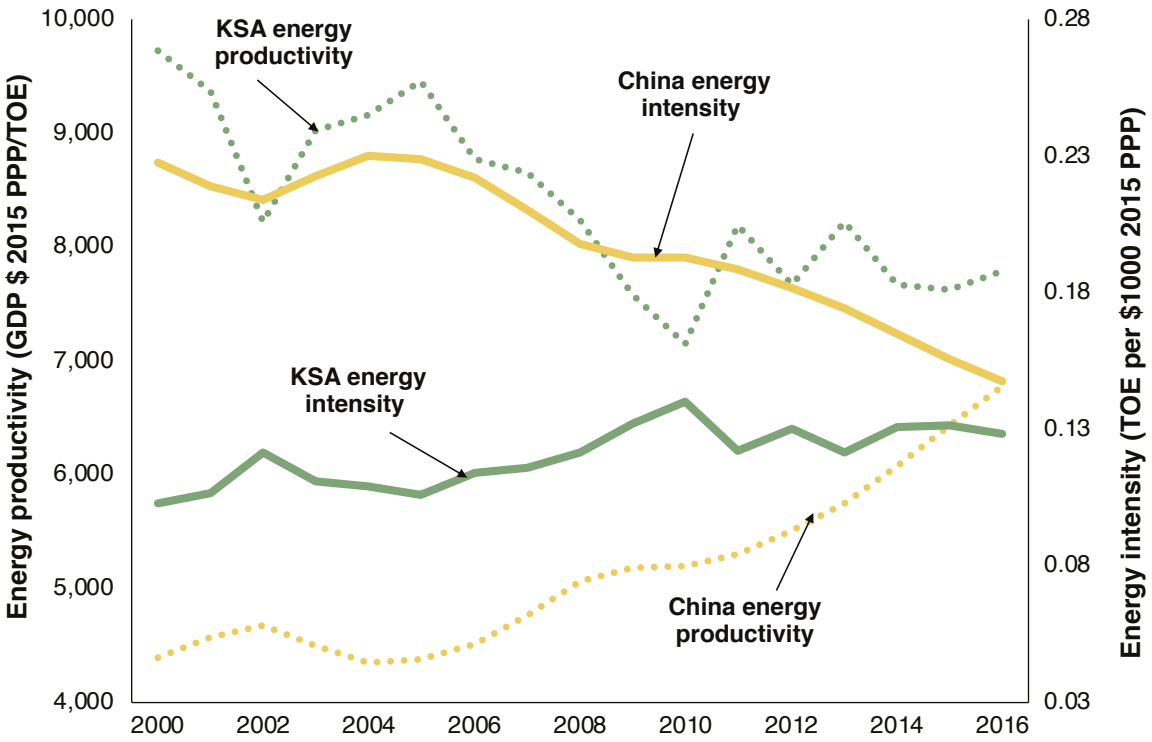

Figure 11. National energy productivity and intensity trends in Saudi Arabia and China.

Source: KAPSARC based on Enerdata.

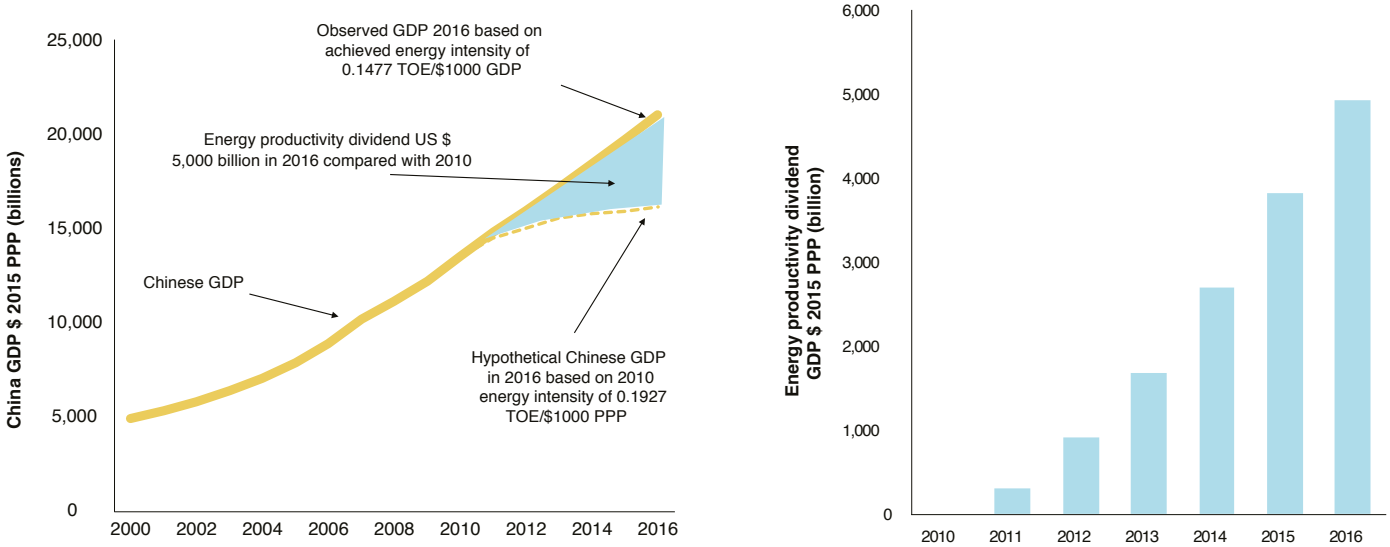

Figure 12. Energy productivity dividend from energy intensity improvements in China (2010-2016).

Source: KAPSARC based on Enerdata.

Using 2010 as a base year, we calculate how much extra GDP could be achieved through the observed improvement in energy intensity each year. From this, we show that if the Chinese economy were still operating with the same economic structure and energy efficiency that it had in 2010, it would be generating $5,000 billion less GDP in 2016.

A similar analysis conducted for Saudi Arabia (Figure 13) reveals that between 2010 and 2016 the Kingdom's energy intensity improved from 0.1399 to 0.1285 TOE/$1,000 purchasing power parity (PPP). This improvement delivered an energy productivity dividend of around $140 billion in 2016, compared to the GDP that the economy functioning at its 2010 level of energy intensity would have produced.

A closer look at energy intensity trends within the industrial sector, as illustrated in Figure 14, shows growth in industrial value added relative to growth in industrial energy consumption for Saudi Arabia and China between 2000 and 2016.

Industrial energy consumption and output have grown strongly in both countries. Chinese industrial energy consumption has risen from an index level of 100 in 2000 to stabilize at just under 300 by 2016, while industrial value added rose from the same base to around 400 and continues to grow strongly.

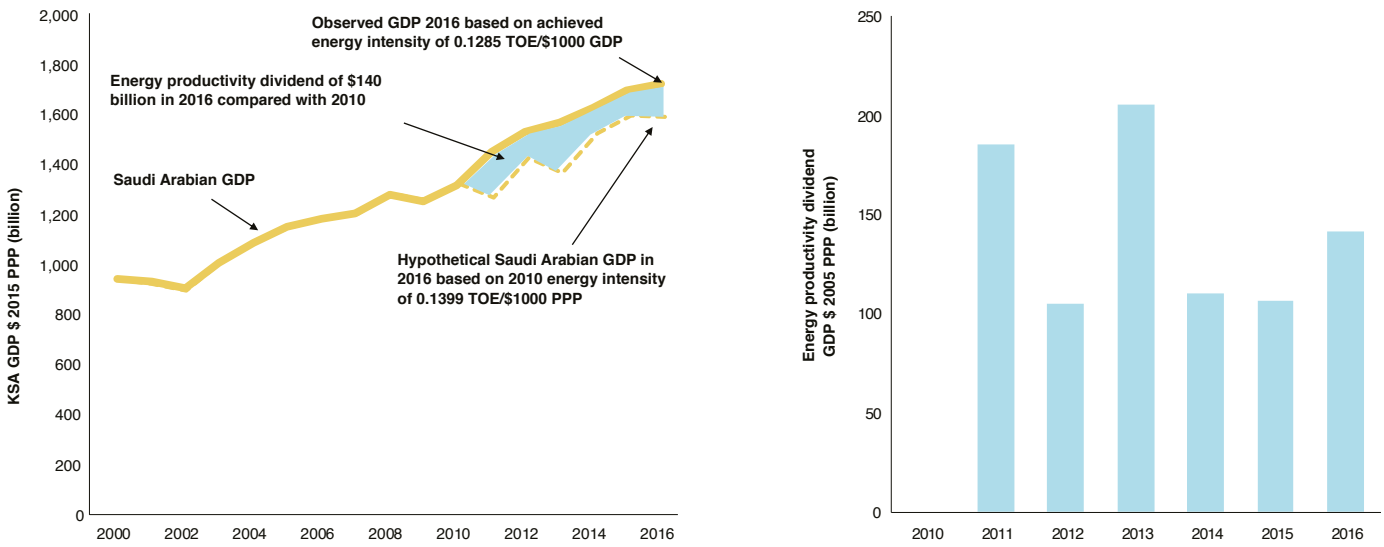

Figure 13. Energy productivity dividend from energy intensity improvements in Saudi Arabia (2010-2016).

Source: KAPSARC based on Enerdata.

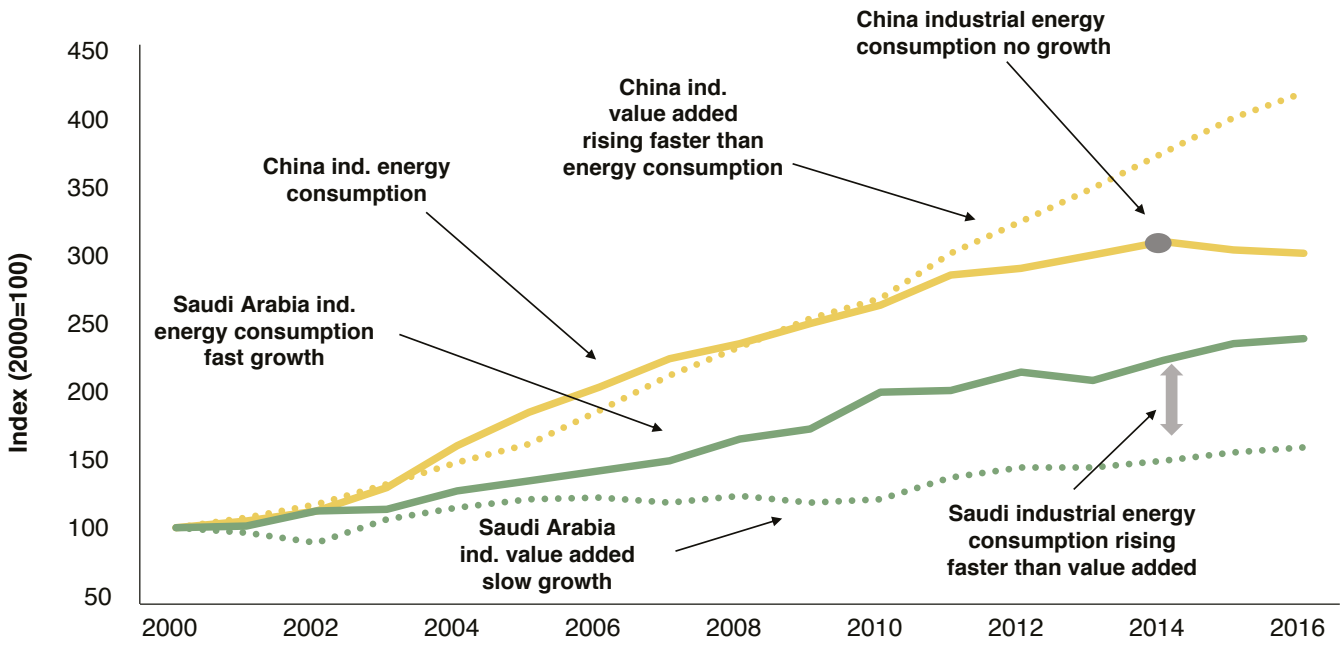

Figure 14. Growth in industrial energy consumption versus industrial value added.

Source: KAPSARC based on Enerdata.

This rise suggests that Chinese plans to develop higher value-added manufacturing are having a significant impact. More value added is being created per unit of energy consumed, increasing the energy productivity of industry.

In Saudi Arabia, energy consumption has risen in index terms from a base of 100 in 2000 to almost 250 by 2016. Industrial value added has risen at a slower pace, increasing from 100 in 2000 to around 150 in 2016, implying declining industrial energy productivity or rising energy intensity in the industrial sector over this period. This suggests that the Kingdom has experienced either a pivot into more energy-intensive activities over this time, a lower energy efficiency of industrial production, or both.

Using a Fisher decomposition technique, Figure 15 shows that the main drivers of Saudi Arabia's strong growth in energy consumption from value added activities (i.e., nonresidential energy consumption) have been a pivot toward energy-intensive industry (the structure effect), accompanied by a strong expansion of overall economic activity (activity effect). The efficiency effect shows improvements in the underlying energy intensity of the economy. This improvement suggests increasing energy efficiency achieved significant downward pressure on the strong growth in energy consumption in value-added sectors.

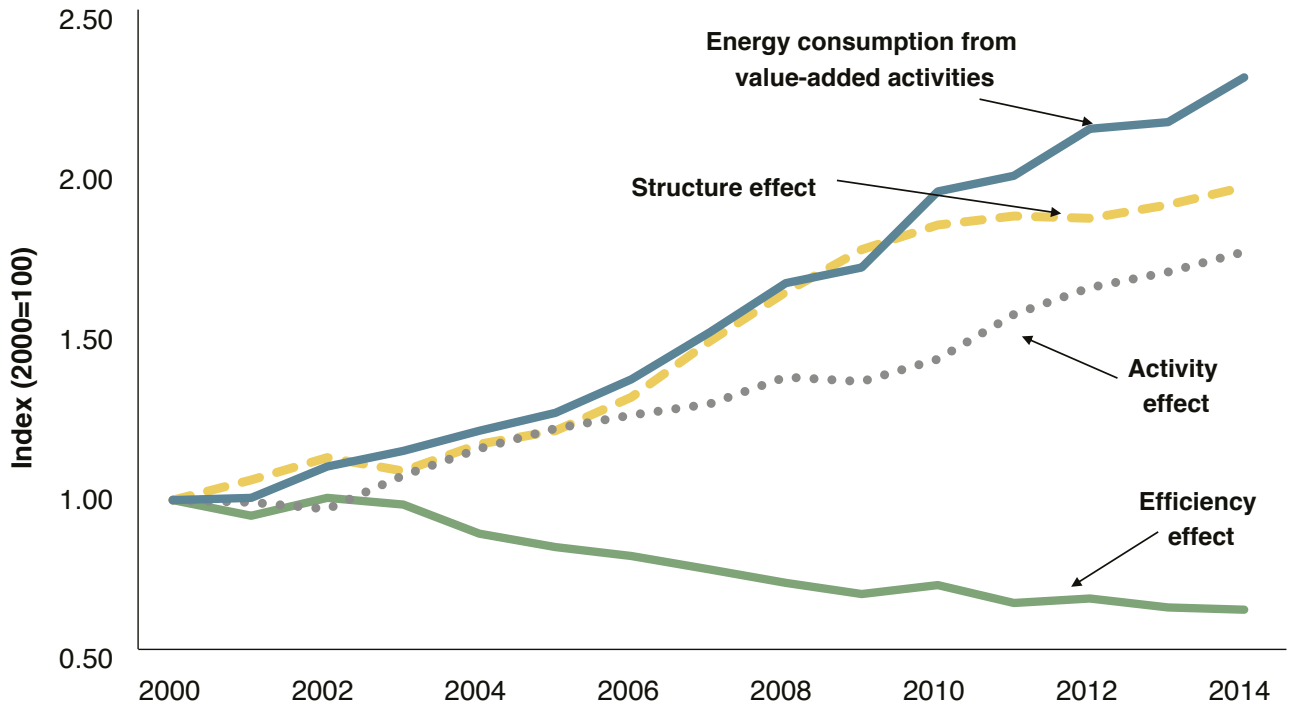

Figure 15. Decomposition of energy demand from value-added activities in Saudi Arabia.

Source: KAPSARC analysis based on UNSTAT value-added data and IEA energy balances.

Figure 16 illustrates that energy consumption from value-added activities in China was mainly driven by an expansion in the size of the economy (activity effect). In contrast to Saudi Arabia, the proportion of the economy devoted to energy-intensive industry stayed roughly constant between 2000 and 2014. After a period of deterioration between 2003 and 2005, the energy efficiency effect suggests significant improvement in energy efficiency.

The energy efficiency effect for Saudi Arabia was very large, even relative to China, suggesting that the increase in overall energy intensity was primarily due to changes in the structural makeup of the economy, rather than worsening energy efficiency in the economy. The strong growth of energy-intensive industry in the Kingdom, in particular petrochemicals, supports this suggestion.

If we focus on industrial energy consumption per unit of industrial value added, we see a similar pattern to overall energy intensity. Figure 17 shows that the energy intensity of Saudi Arabia's industrial sector rose from around 0.08 TOE per $1,000 of industrial output in 2000 to about 0.12 TOE in 2016. This suggests it took around 50 percent more energy to produce the same quantity of industrial value added in Saudi Arabia in 2016 than it did in 2000. In China industrial energy intensity fell from around 0.18 TOE per $1,000 in 2000 to around 0.13 TOE in 2016, suggesting it took around 28 percent less energy to produce the same amount of GDP. However, it is important to note it still took less energy in 2016 to produce the same amount of GDP in Saudi Arabia than in China.

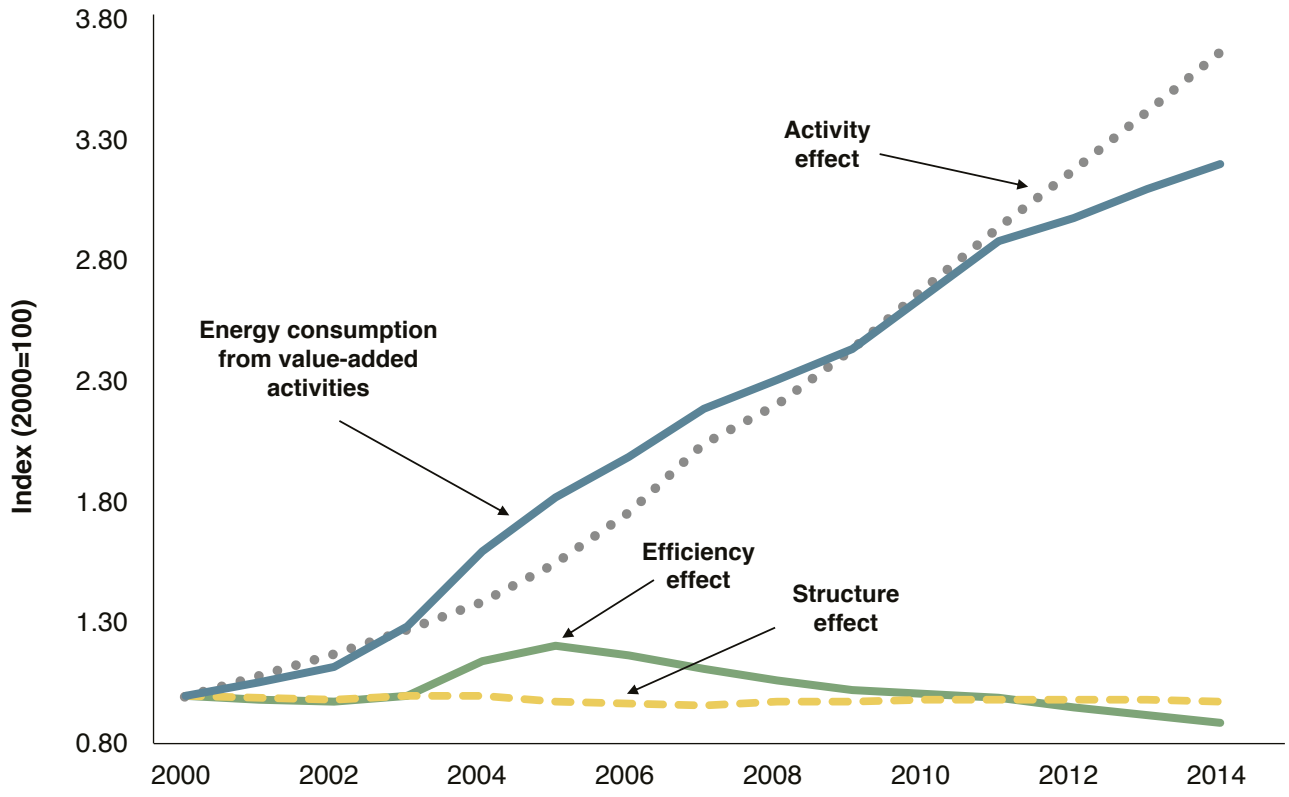

Figure 16. Decomposition of energy demand from value-added activities in China.

Source: KAPSARC analysis based on UNSTAT value-added data and IEA energy balances.

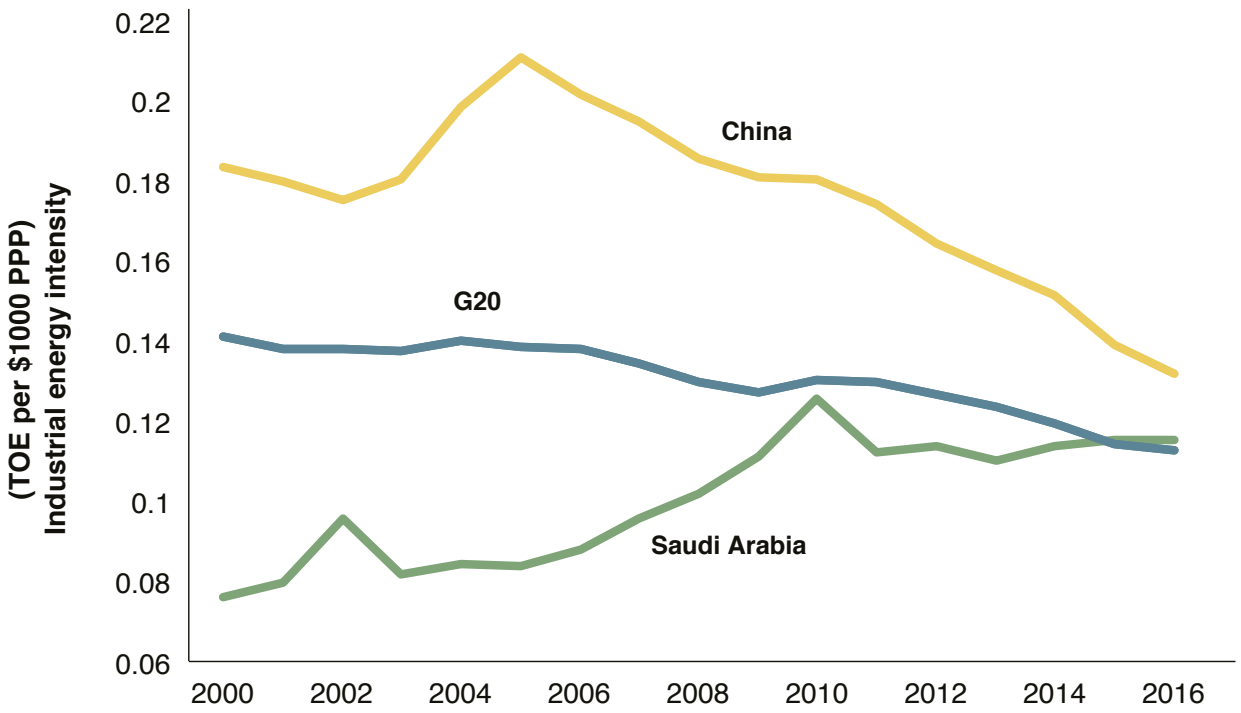

Figure 17. Industrial energy intensity in China, Saudi Arabia and the G20.

Source: KAPSARC based on Enerdata.

Note: Industrial energy consumption includes direct and non-energy industrial use, value added from industry (excluding the service sector).

To the extent that Saudi Arabia has a competitive advantage in the production of energy-intensive industrial products, such as petrochemicals, this is likely to reflect an underlying efficient allocation of resources in the global economy. However, access to energy resources at very low domestic energy prices has resulted in the expansion of energy-intensive industry. This competitive landscape may change with the implementation of the Kingdom's announced energy price reforms.

Key Targets of Economic and Energy Plans in Saudi Arabia and China

Saudi Arabia – Vision 2030 Economic Plans

Building on the country's competitive advantages, Saudi Arabia's Vision 2030 sets out a new economic plan for the Kingdom. The plan articulates key targets across social, economic and government domains, aimed at stimulating private sector investment and creating a more sustainable, diverse, economy. From an economic perspective, key objectives of the plan involve reducing reliance on oil and generating employment opportunities for an ambitious and young population.

The central element of the economic plan in Saudi Vision 2030 is to improve the Kingdom's position in the global ranking of leading economies, from 19th place to within the top 15 by 2030. To achieve this the Kingdom plans to grow the economy, increase jobs and expand the share of private sector non-oil GDP from around 40 percent in 2015 to 65 percent by 2030. Figure 18 shows the economic landscape of the Kingdom in 2016 and the challenge to grow the non-oil sectors, which account for about 64 percent of total value added. The largest non-oil sector is energy-intensive industry, dominated by the petrochemical and refining sectors. Non-energy-intensive industry accounts for only 4 percent of total operating surplus in the Kingdom.

Vision 2030 and its associated National Transformation Program have a series of 2020 targets. These include increasing non-oil mining from around SAR 64 billion to SAR 97 billion; increasing the information technology sector from 1.2 percent of non-oil GDP to 2.24 percent; increasing the media sector from SAR 5.2 billion to SAR 6.5 billion; lifting tourism from 2.9 percent to 3.1 percent of GDP and raising the share of real estate from 5 percent to 10 percent of GDP. The latter will be achieved by almost doubling annual growth in this sector from 4 percent to 7 percent.

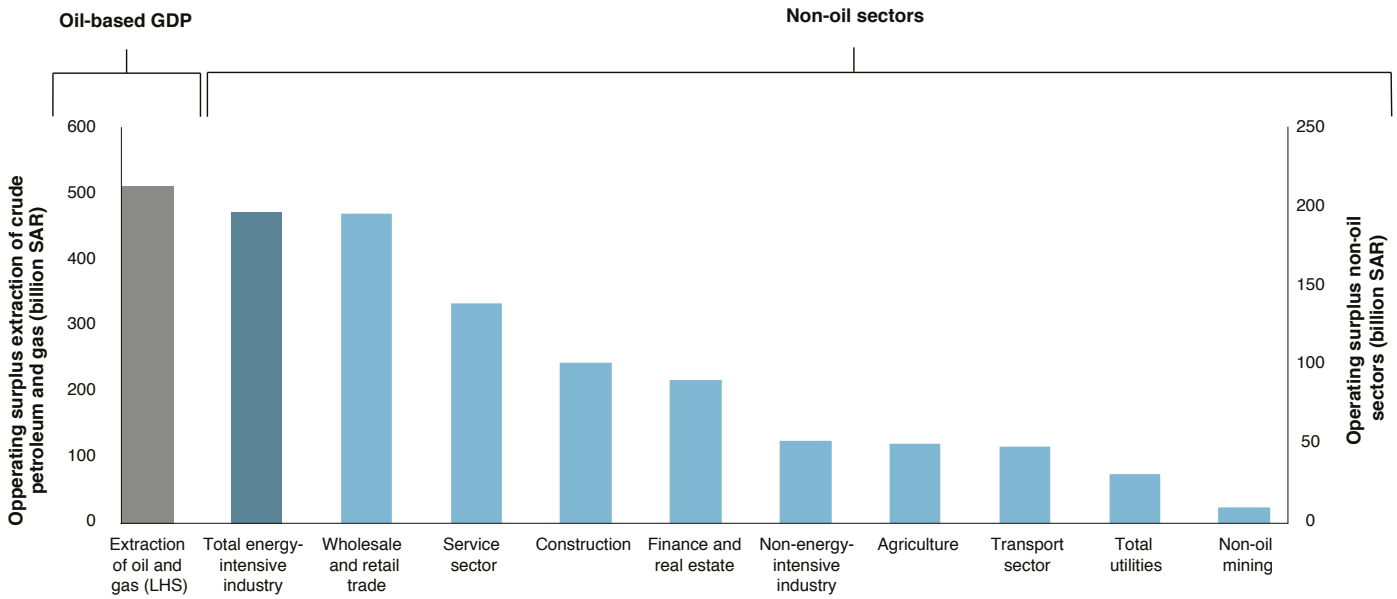

Figure 18. Saudi Arabia's economic landscape sectoral value-added* contributions (2016).

Source: Saudi Arabia's General Authority of Statistics, Annual Economic Survey.

Note: Net operating surplus: operating revenues less operating expenses and compensation.

The government plans to focus public sector activity on policy setting, defense, internal security, foreign affairs, basic education and selective infrastructure development, leaving other activities to the private sector.

As part of these reforms, the government intends to privatize many state-owned companies in sectors such as electricity generation, water desalination, airports, seaports, the postal service, health care and airlines. Large subsidies will be phased out to provide market-based incentives more aligned with international norms and to allow a market rate of return for investors. Vision 2030 contains significant investment opportunities ranging from the traditional oil, gas, chemicals and mining sectors to railways, services and the move to high-end technologies such as information and communications technologies (ICT), biotechnologies, renewables, nanotechnologies, entrepreneurial initiatives and entertainment.

Key strategic elements of Vision 2030 involve:

- Securing a sustainable, competitive advantage that allows the Kingdom to compete at a global level while offering full, high-quality employment to its people through greater local content.
- Recognizing the Kingdom's central position at the heart of the Arab and Islamic worlds.
- Enhancing capacity for both inward and outbound investment.
- Taking advantage of its location at the crossroads of Asia, Europe and Africa.

The Public Investment Fund will play a major role in the implementation of Vision 2030, with its capabilities enlarged to manage a broader portfolio of assets. These assets are targeted to increase from around SAR 600 billion to more than SAR 7 trillion, utilizing resources from the privatization program, including the public offering of Saudi Arabian Oil Company.

Privatization of the Kingdom's 75 GW of power generation capacity will play a key role in diversifying the primary energy mix away from oil toward gas and nuclear power. It will also help to achieve its 9.5 GW 2023 renewable energy target which is expected to deliver around 10 percent of the Kingdom's electricity mix. Transmission and distribution is another strategic area. The Kingdom plans to develop regional electricity grids that will allow it to become a major exporter of electricity across the Gulf Cooperation Council (GCC) into Egypt and Africa, as well as Turkey and eventually Europe.

China's Five Year Planning Cycle

When China experienced rapid economic growth in the early 2000s, the expansion of energy consumption at a rate faster than GDP growth prompted policymakers to bring in a system of mandatory energy intensity targets in its 11th Five Year Plan (FYP) (2006-2010). These were intended to encourage more moderate growth in energy consumption, enhance energy efficiency, control air pollution and carbon emissions. These targets were expanded and refined in the 12th (2011-2015) and 13th (2016-2020) FYPs, and are widely recognized as having played a major role in managing China's overall sustainable economic development. Table 1 summarizes key targets of the Chinese economic planning system which intersect with the energy system. Ton of coal equivalent (TCE) is used in the Chinese context.

President Xi Jing Ping's Belt and Road Initiative followed by visits to China from Crown Prince

Mohammed bin Salman and King Salman in 2017 have opened up a new era of deeper bilateral relations between the two countries. As part of these efforts, the two countries signed 14 collaboration agreements covering economic development and trade, energy, industrial production, culture and education and science and technology exchanges, with a total value of $65 billion. These initiatives provide substantial scope for mutual benefits between the two countries, and create opportunities in the areas of energy efficiency and structural reform toward higher-value economic activities.

Table 1. China's Strategic Economic and Energy Targets in 13th FYP Period (2016-2020).

2020 Targets	13th FYP for National Economic and Social Development	13th FYP for Energy Development	Energy Conservation and Carbon Reduction Comprehensive Work Plan	Level of 2015
Cap of total energy consumption	5 GTCE	5 GTCE	5 GTCE	4.3 GTCE
Energy consumption per GDP unit	-15% (from 2015 level)			0.71 TCE/RMB 10,000 (constant price in 2010)
Energy consumption per industrial value added			-18% (from 2015 level)	1.16 TCE/RMB 10,000 (constant price in 2010)
CO_2 emission per GDP unit	-18% (from 2015 level)			NA
Share of non-fossil fuel in primary energy consumption	15%	Above 15%		12%
Share of coal in primary energy consumption		Below 58%		64%
Share of natural gas in primary energy consumption		10%		5.9%
Added value of strategic and emerging industry in total GDP			15%	8%
Added value of service industry in total GDP			56%	50.2%
Installed capacity of wind		Above 210 GW		129 GW
Installed capacity of solar		Above 110 GW		43 GW
Installed capacity of hydropower		380 GW		320 GW

Source: National Development & Reform Commission (NDRC) planning documents.

How Far Can Energy Efficiency in Energy-Intensive Industries Move the Needle?

China's industrial energy efficiency strategy

The top six industrial sectors, including iron and steel, non-ferrous metals, building materials, petrochemicals and chemicals and power, constitute 70 percent of the total industrial energy consumption in China. To improve the energy productivity of energy-intensive industry, China has adopted a differentiated strategy for three types of industrial enterprises:

> Existing industrial enterprises are required to achieve a mandatory target set by the government by establishing energy management systems, energy efficiency benchmarking, energy auditing and investment in energy efficiency measures.

> Outdated production capacity is scheduled to be shut down according to the standards and legislation on energy, environment, quality, safety and technology, with iron and steel, coal, cement and glass sub-sectors as a special focus.

> New production capacity is required to meet the market entrance requirements for each industrial sector and can only be built after obtaining approval through an energy conservation assessment for fixed-asset investment.

Energy efficiency benchmark standards have been developed systematically and rapidly in China to support the implementation of the above mentioned industrial strategies. As of today, China has issued 105 national energy efficiency benchmark standards, covering products and processes in iron and steel, non-ferrous metals, building materials, petrochemicals, chemicals and power sectors. Each of these standards defines three levels of energy intensity value: limit, access and advanced, in accordance with industrial management strategies. The limit value is set to manage the existing industrial enterprises and phase out outdated capacity; the access value sets a higher bar for new investment and expansion projects, and the advanced value provides direction for performance improvement and industrial upgrading. The energy-intensity (efficiency) values for key industry sub-sectors is shown in Table 2.

Table 2. Selected energy efficiency benchmark standards for industry in China.

	Limit Value		Access Value		Advanced Value		Actual 2012 Avg.	
Steel	**kgce/t**	**GJ/t**	**kgce/t**	**GJ/t**	**kgce/t**	**GJ/t**	**kgce/t**	**GJ/t**
Sintering	55	1.61	50	1.47	45	1.32	50.6	1.48
Pelletizing	36	1.06	24	0.70	15	0.44	29	0.85
Blast furnace	435	12.75	370	10.84	361	10.58	402	11.78
Basic oxygen furnace	-10	-0.29	-25	-0.73	-30	-0.88	-8.58	-0.25
Cement								
Clinker	120	3.52	115	3.37	110	3.22		
Cement	98	2.87	93	2.73	88	2.58		

	Limit Value	Access Value	Advanced Value	Actual 2012 Avg.
Aluminum	**kWh/t**	**kWh/t**	**kWh/t**	**kWh/t**
Liquid product	14050	13150	13050	13596
Ethylene	**kgoe/t**	**kgoe/t**	**kgoe/t**	**kgoe/t**
< 300K tons	830	640	610	860
> 300K tons	720			
Coal-fired power plant	**gce/kWh**	**gce/kWh**	**gce/kWh**	**gce/kWh**
USC (1,000 MW)	288	298	284	319
USC (600 MW)	297		292	
Super critical (600 MW)	306		302	
Super critical (300 MW)	319		312	
Subcritical (600 MW)	320		313	
Subcritical (300 MW)	331		323	
Super high pressure	360		355	

Source: ERI.

The development, promotion and deployment of energy efficiency technologies in the industrial sector has generated significant savings during the program's early stages. A review report estimated that energy-efficient technology retrofits in the 11th FYP period (2006-2010) accounted for energy savings of around 200 million TCE (CECEP 2014). We attribute this saving to:

- The selection and promotion of energy efficiency technologies through a bottom-up approach.
- The provision of financial incentives and policy directives through a top-down approach.

The technologies identified by the Chinese government's Top Ten Energy Efficiency Program and listed in the National Key Energy Technology Catalog was a key reference tool for industrial planning (see Appendix 1). China's success in combining energy-efficient technology promotion with the budgetary allocation of funds as well as monitoring results and rewarding performance by government and enterprise officials has valuable lessons for countries such as Saudi Arabia. Key features of the program are:

- In consultation with local governments and industrial associations, the NDRC organizes the national level assessment, screening and selection of technologies. The catalog provides the list of technologies and salient information relating to application, investment, potential energy saving and carbon reduction. The document includes illustrative case examples where the technologies have been deployed, tested and validated.
- The National Key Energy Efficiency Technology Catalog was initially released in 2008 by the NDRC and updated every year. The latest catalog (ninth volume) lists 296 key energy efficiency technologies across 13 industrial sub-sectors (NDRC 2016).

In coordination with seven other government ministries, the NDRC developed the implementation plan for the Top Ten Energy Efficiency Program in 2006. It covered retrofits of coal-fired industrial boilers (furnaces), combined heat and power generation, waste heat and waste pressure recovery and motor system energy-efficiency improvement (Appendix 1). Projects whose scope and objectives aligned with the program were eligible for both central government and local government rewards. For example, the government allocated a rate of RMB 200 for every TCE saved annually for enterprises in East China and RMB 250 for every TCE saved annually for enterprises in Central or Western China. This annual incentive is provided by the central government and around RMB 60 per TCE is provided by local governments. By the end of the 11th FYP (2010), the central government in China had allocated RMB 8.1 billion for more than 5,100 projects implemented under the Top Ten Energy Efficiency Program.

China's energy efficiency program has been an evolution of measures, consistent with its institutional capacity to implement and manage the reform process (Figure 19). In the early stages, the focus was on setting initial national targets and promoting energy-efficient technologies for the top 1,000 energy-consuming companies. In the 12th FYP, the focus of the policies and initiatives shifted toward systematizing energy management systems for the top 10,000 enterprises. Then in the 13th FYP, the strategy is to create a business and market-oriented ecosystem for delivery of energy efficiency services. Energy efficiency technologies still play an important role, but the focus of reform is on the introduction of market instruments such as carbon emissions trading and energy price reforms. Importantly, the 13th FYP places greater emphasis on the creation of incentives within enterprises to save energy to maintain competitiveness in the long run, instead of short-term responses to the government's financial incentives.

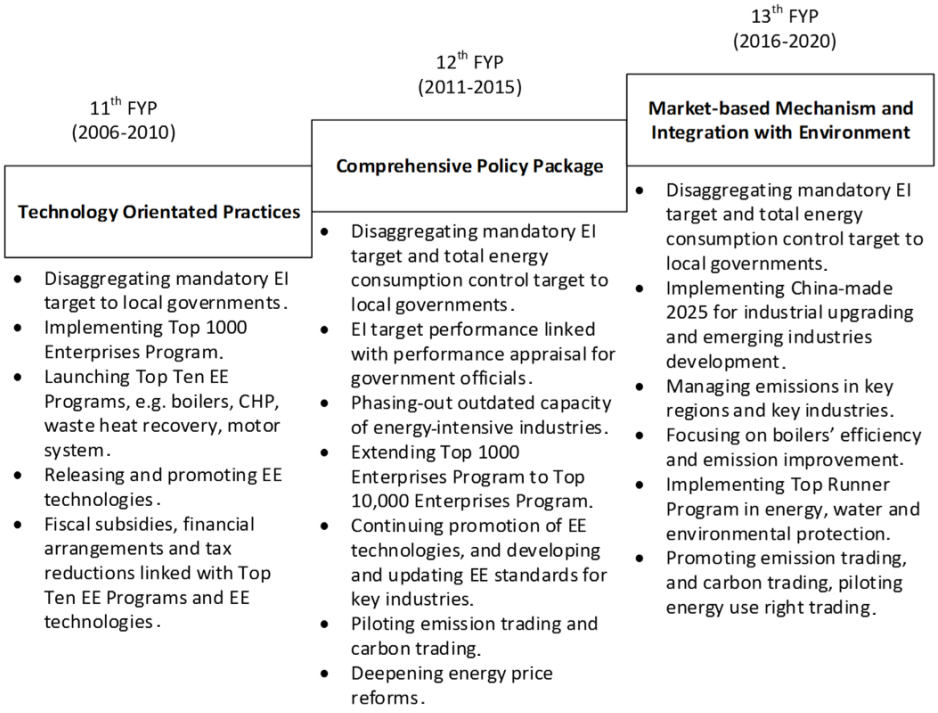

Figure 19. Evolution of Energy Efficiency Measures in China.

Source: KAPSARC based on Chinese government policy papers.

The combination of enterprise-driven energy efficiency actions together with government initiated programs has resulted in a comprehensive, integrated policy framework (Figure 20). Some of the key features of the framework are:

- Absolute energy intensity reduction targets for industrial subsectors.
- Development of an enterprise level energy management function with assigned personnel.
- Mandatory reporting of energy consumption data and energy audits.
- Differentiated electricity pricing policy, with higher prices for companies with higher electricity intensity.
- Availability of financial incentives for energy-efficient retrofits and qualifying ESCOs and utility-driven demand-side management programs, including new financing mechanisms and lending instruments offered by banks.
- Capacity building programs to develop skilled workforces in industry and local government.

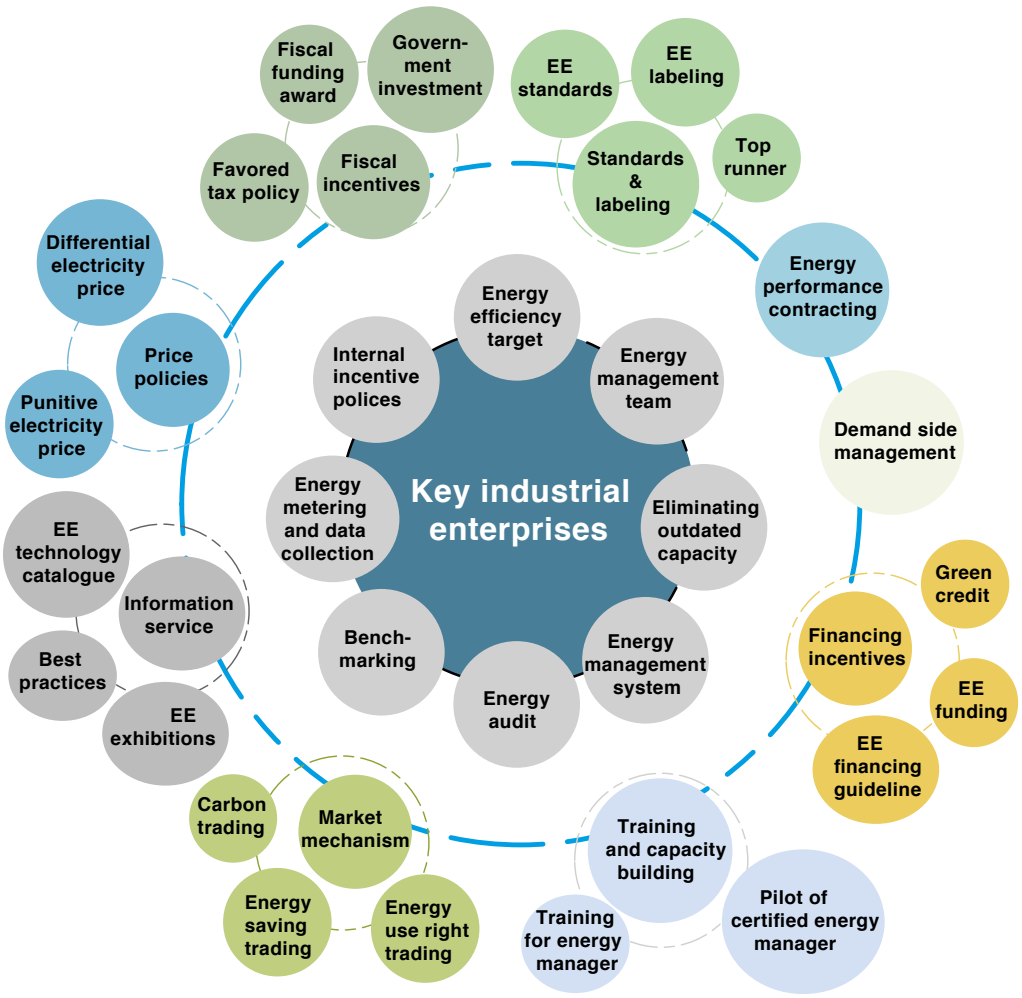

Figure 20. Chinese Policy Framework for Industrial Enterprises and Energy Efficiency.

Source: Energy Research Institute.

Implementation of the key-industry-enterprises-orientated policy package, especially the Top 10,000 Program has resulted in an energy saving of 309 million TCE during 2011-2014; 21 percent more than the target set at the beginning of the 12th FYP (NDRC 2015). ERI estimates energy efficiency improvements of between 5-20 percent across the industrial sector for the period 2010-2014 (see Table 3). The data show wide variations in energy intensity improvements across the industry sub-sectors. While plate glass achieved improvements in excess of 20 percent, aluminum oxide, ethylene, cement and oil refineries achieved 7-11 percent and the remainder achieved less than 5 percent.

Saudi Arabia's industrial energy efficiency strategy

In Saudi Arabia, the industrial sector represents the area with the greatest potential impact for managing domestic energy consumption. Leading this effort is the Saudi Energy Efficiency Center (SEEC), established by the Council of Ministers to coordinate a multi-agency, national program to rationalize energy consumption and enhance energy efficiency. In consultation with key stakeholders, SEEC has developed policies, regulations and rules to support the implementation and participation in pioneering energy efficiency projects.

With three of the most important industrial sectors, petrochemicals, cement and steel, SEEC started the process of establishing baselines and benchmarking frameworks for over 180 industrial plants from 59 different production processes (see Figure 21).

SEEC has agreed on aspirational energy intensity targets for 2019 and has reviewed energy efficiency improvement plans for 42 companies. Eleven government entities have signed joint agreements to help plants achieve their goals. Overall, these initiatives are expected to save around 9 percent of total industrial energy consumption by 2019, compared to a 2011 baseline, or an annual rate of improvement of about 1 percent a year. From 2011 to 2015, SEEC reports that energy intensity has improved in the petrochemical sector by around 2 percent, and by about 3 percent for cement.

Table 3. Outcomes of energy efficiency Improvements in China.

	Energy efficiency improvement 2010-2014	Avoided energy consumption MTOE 2010-2014	Reduction in energy costs ($ millions) 2010-2014
Cement	7.5%	48.6	7,547
Raw steel	3.4%	11.7	1,815
Aluminium oxide	11%	2.3	358
Crude oil refining	11%	1.7	265
Ethylene	9%	1.0	150
Ammonia	1.7%	0.9	143
Plate glass	21%	2.1	322

Source: ERI analysis and State Statistical Yearbook, 2015 quoted in IEA (2016b).

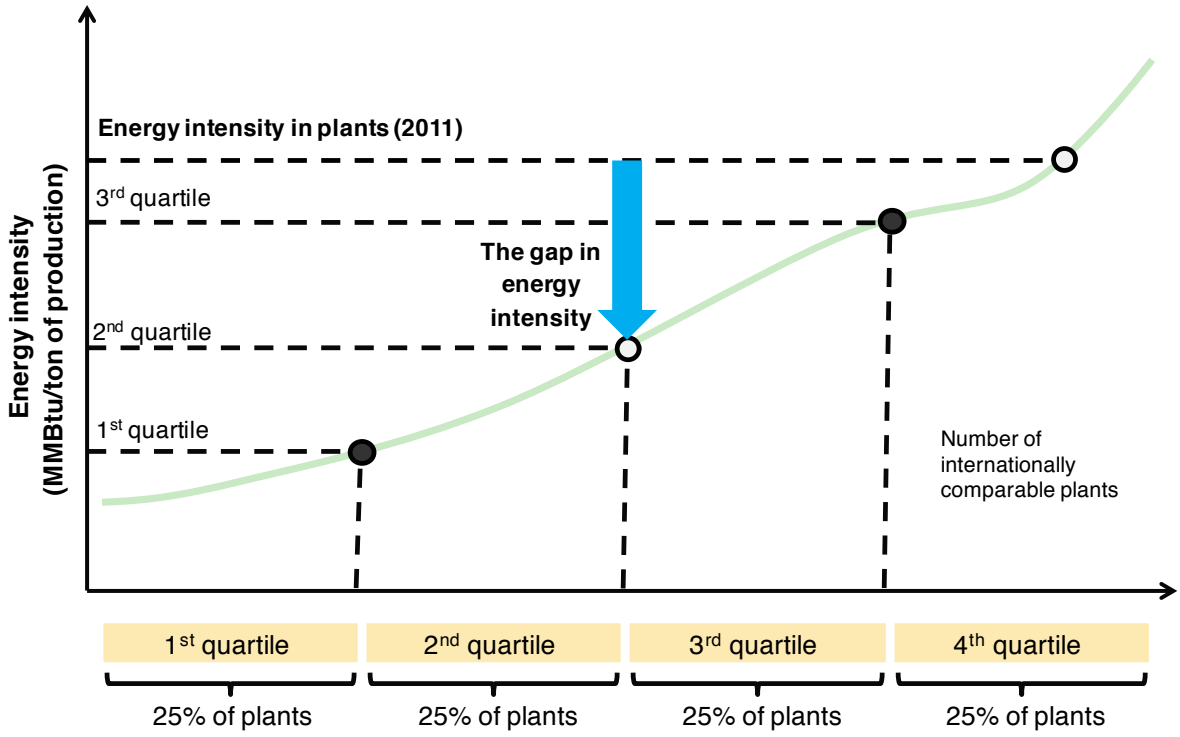

Figure 21. General approach for benchmarking energy efficiency in Saudi Arabia.

Source: Saudi Energy Efficiency Center.

Saudi Arabia's scheme for industry separates existing plants from new ones. Companies must submit energy efficiency improvement plans for their existing plants, identifying the energy savings potential. Twenty companies, representing over 150 plants, have submitted such plans. New plants must target the average energy efficiency in the first quartile of the relevant global benchmark for their sector.

Vision 2030 also highlighted reform in energy efficiency within the power generation sector, with a target to increase fuel utilization efficiency in the electricity sector from a baseline of 33 percent to 40 percent by 2020, compared with a global benchmark efficiency of 44 percent. Finding a way to desalinate water with less energy is of special priority for Saudi Arabia, the world's largest producer of desalinated water. Desalination powered by renewable energy offers tremendous potential. In times of excess electricity capacity, such as during the winter months, the production of water is one way to store energy or optimize reserve capacity.

For this report to obtain benchmarks, we have drawn on a sample of firms from across the GCC region drawing on industry plant-level data obtained from the IHS midstream database and other publically available company data. Global statistics on specific energy consumption for the industry sub-sectors was obtained from the IEA World Energy Statistics, 2014.

Using this admittedly limited data from a variety of sources, dry process cement production across the GCC has higher specific energy consumption than the global average and has significant scope to adopt the best available technology. While in

terms of indicative efficiency, fertilizer production compares favorably to global benchmarks. Steel also offers an area for improving energy efficiency, with specific energy consumption above the global average (Figure 22).

The petrochemical sector is the largest energy-consuming industrial subsector. GCC countries are a hub for the refining, chemicals and petrochemical industries, with their abundance of oil and gas. It is not possible to derive a meaningful single specific energy consumption value for the refinery sector due to the numerous processes that take place, each with their own best process technology values. To deal with this, energy efficiency benchmarking requires refining to be typically classified into 13 main processes: atmospheric distillation, vacuum distillation, coking, thermal operations, catalytic cracking, catalytic reforming, catalytic hydrocracking, catalytic hydrotreating, alkylation, aromatics, lubricants and the production of hydrogen and sulphur (see Solomon Associates as reported in (Matthes et al. 2008).

The chemicals and petrochemicals industry is highly diverse and complex, making energy efficiency benchmarking less straightforward than other industrial sectors. In addition, feedstock (non-energy consumption) accounts for more than half of the total fuel inputs to this sub-sector. Steam cracking is by far the largest energy user in the sector, accounting for more than one-third of the sector's final energy use including feedstock. UNIDO (2010) reports benchmark information for steam cracking for the production of ethylene and other high-value chemicals (propylene, butadiene, benzene and hydrogen) and ammonia production for 2005 in Figure 23 and Figure 24. Updating this information is an important focus area for future work for the Kingdom.

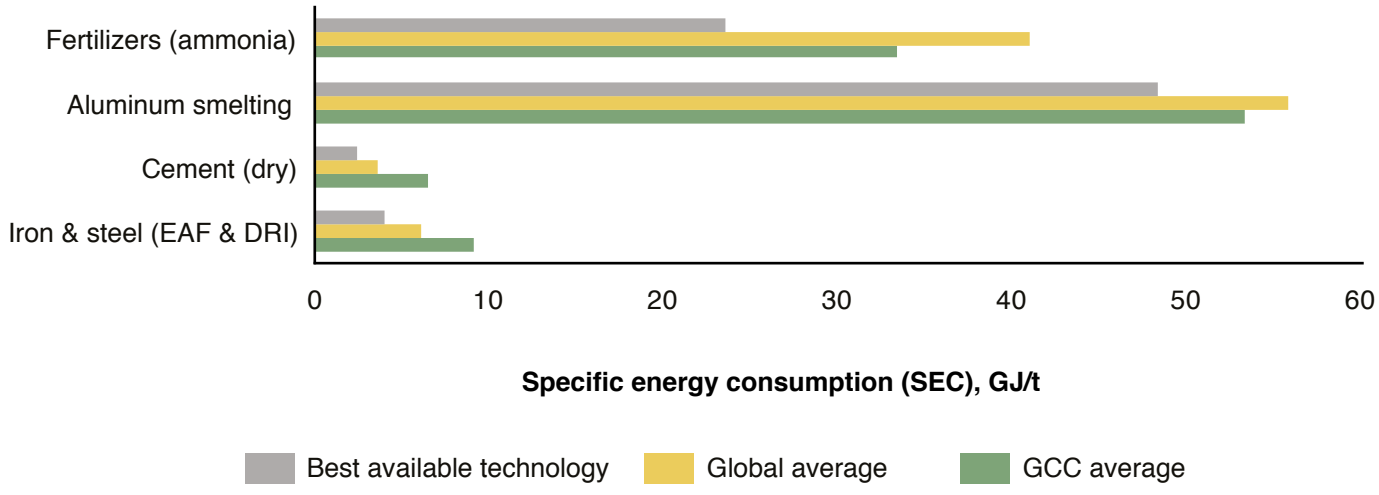

Figure 22. Specific energy consumption for key industrial sectors in the GCC.

Source: KAPSARC, IEA, IHS.

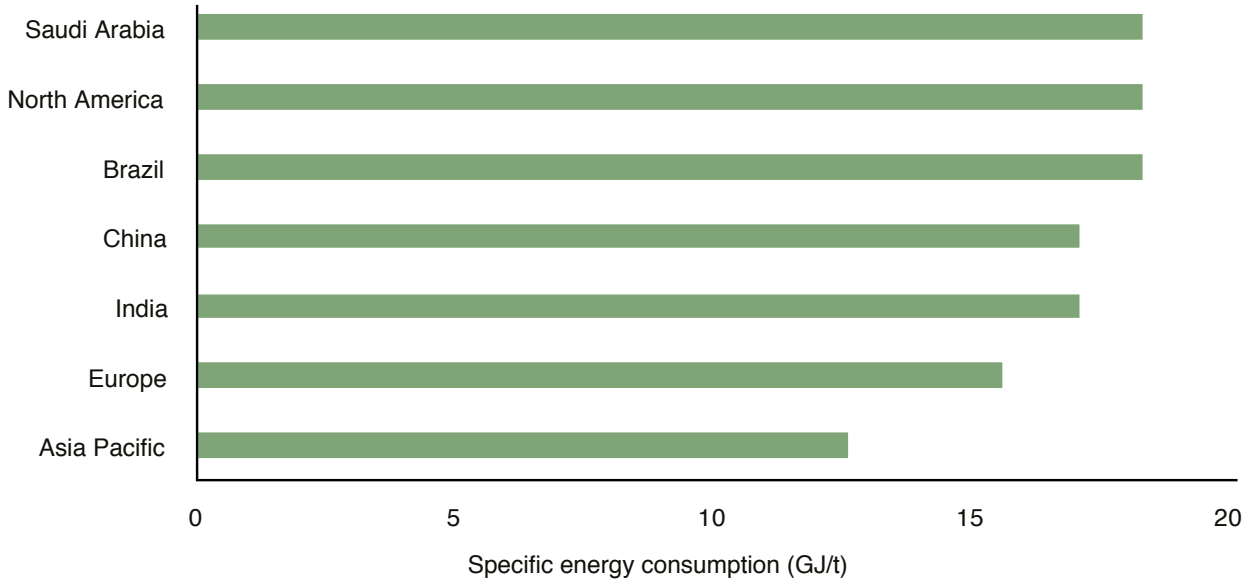

Figure 23. Estimated specific energy consumption for steam cracking high-value chemicals (2005).

Source: UNIDO 2010.

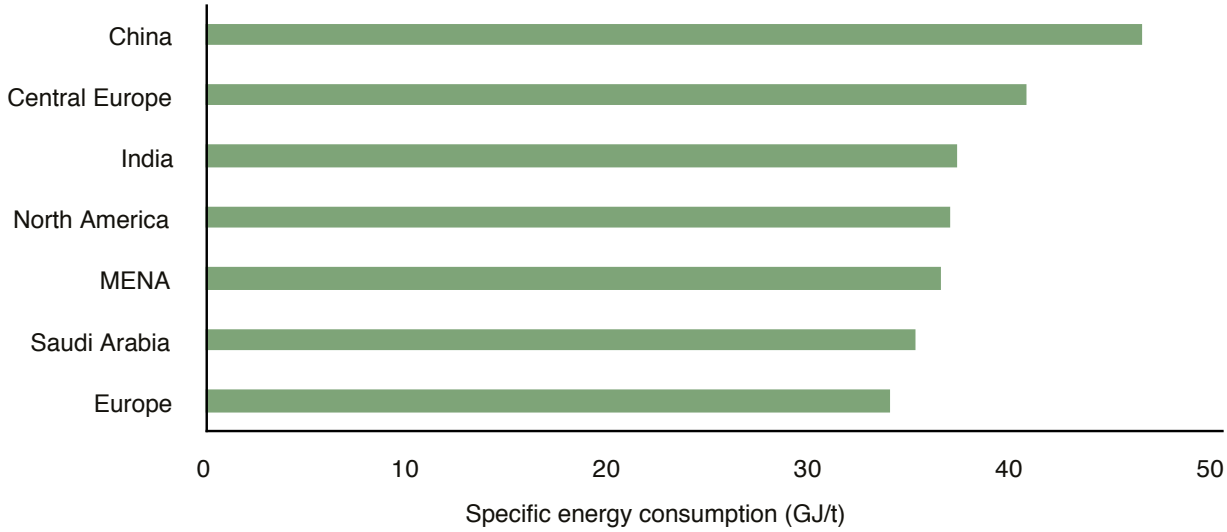

Figure 24. Estimated specific energy consumption for ammonia industry (2007).

Source: UNIDO 2010.

Industrial Strategy and Structural Change

The role of industrial policy in shaping and driving economic growth has a long and much debated history. Some have argued that it is fruitless for governments to 'pick winners' and that a more appropriate policy is to 'get the prices right' and 'let the market decide' which industries and businesses succeed or fail. Others have argued that this is a simplistic view that ignores the important role of history in shaping a country's industrial landscape. They contend that this view also ignores the necessity of taking into account the years, sometimes generations, involved in building a modern capital stock, institutional laws and norms of behavior, as well as securing access to technology and labor force capabilities, which shape competitive advantage.

While it is not our intention here to delve too deeply into theoretical debates, we do however observe that government policy works across a spectrum of both market-based and more interventionist approaches. We also observe that it can have a profound effect on creating the enabling environment needed for industrial development and transition to greater economic complexity and higher-value growth.

Recent advances in economics suggest viewing industry as a complex evolutionary ecosystem can usefully reframe the debate between those who favor strong interventionist action over more market-based approaches (Hausmann et al. 2014). This view suggests socio-technological structures often crystalize around small events and existing capabilities, especially productive knowledge. The idea of lock-in around industrial development pathways also suggests that governments should seek to 'nudge' the system toward desired socio-economic outcomes that grow and emerge naturally, or that government needs to provide "not a heavy hand, not an invisible hand, but a guiding hand" (Arthur 1999).

When one considers energy productivity as a framework for industrial strategy, three broad elements emerge. First, establishing an energy-efficient and internationally competitive foundation of energy-intensive industries. Second, establishing the local labor force and supply chain linkages to use these basic commodities. Third, supporting the development of higher value-added manufacturing and services (Figure 25).

Moving up the production value chain, from simply exporting mineral resources and basic commodities to more advanced manufacturing and services, is an industrial transformation process that some countries seem to manage more successfully than others.

Transition from basic manufacture to higher value products: The Saudi experience

Energy-intensive sectors, particularly petrochemicals and refining, which are the two largest sources of operating surplus in the economy, followed by the manufacture of food products, building materials and metals, currently dominate industry in the Kingdom (Figure 26).

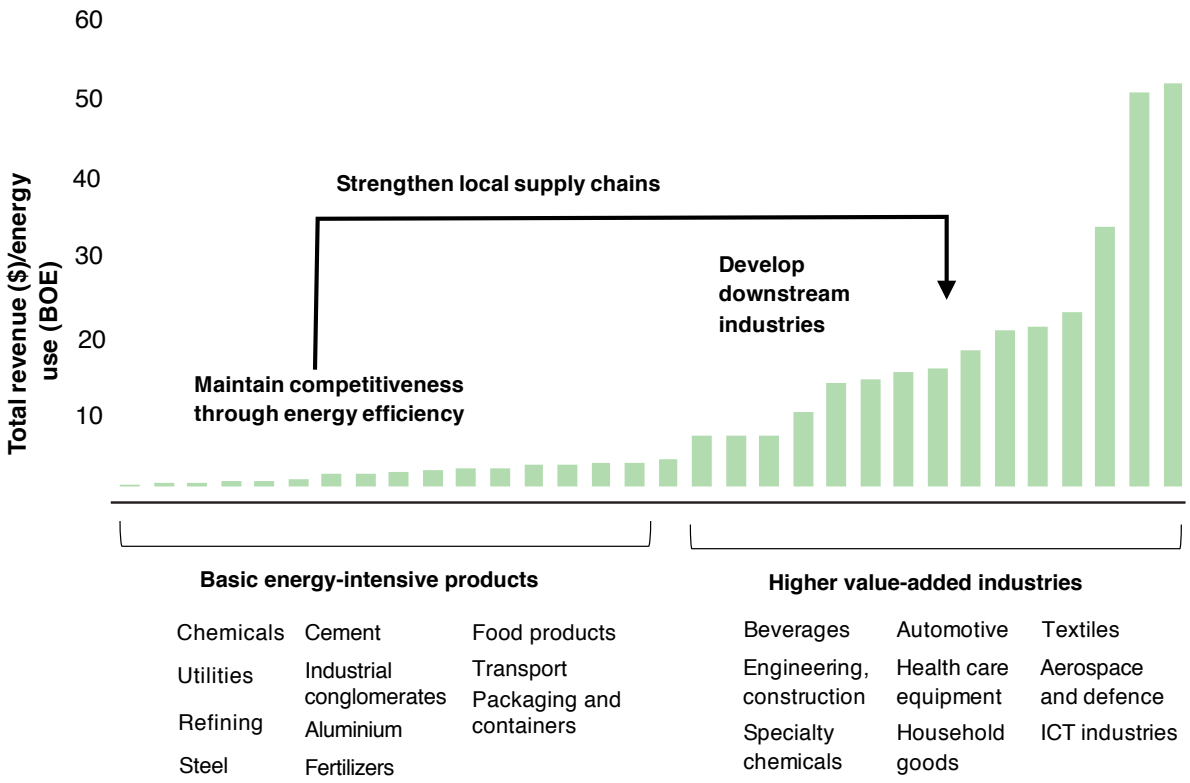

Figure 25. Energy productivity as a framework for industrial strategy.

Source: KAPSARC based on ClimateWorks Australia (2016).

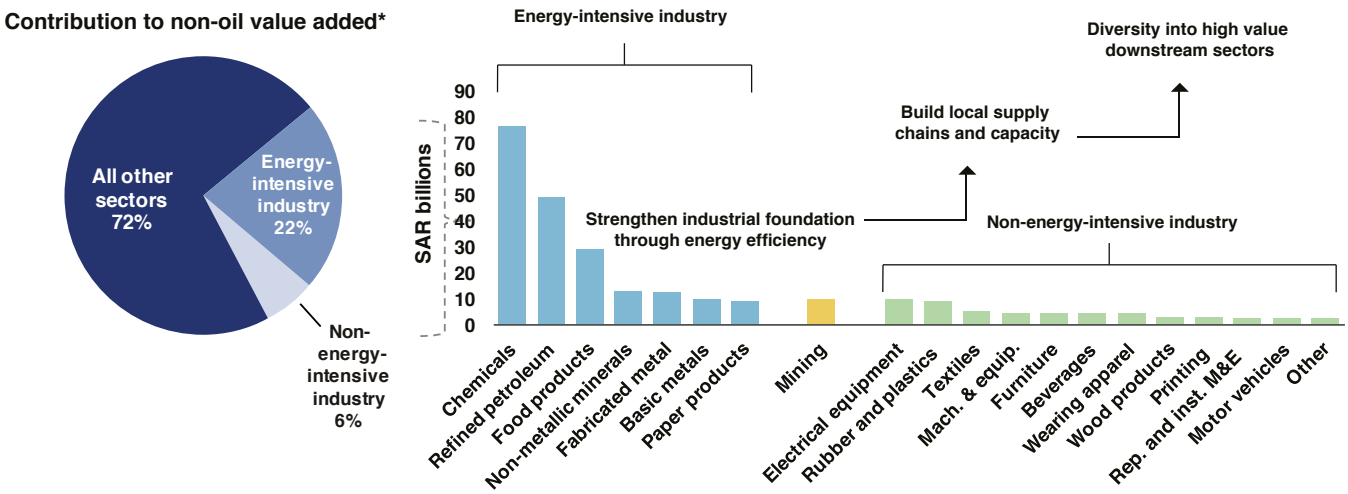

Figure 26. Industrial strategy and shifting the industrial landscape in Saudi Arabia.

Source: KAPSARC based on Saudi Arabia's Annual Economic Survey, General Bureau of Statistics.
Note: *Net operating surplus: operating revenues less operating expenses and compensation.

The National Industrial Clusters Program is one of the schemes underpinning the Kingdom's industrial strategy. Among its stated aims are:

- Diversifying the Kingdom's income sources.
- Developing knowledge-based industries.
- Creating qualified job opportunities.
- Providing value-added products to compete globally.

It has identified five industrial clusters, focusing on solar, pharma and biotech, automotive, minerals and metal, and plastic and packaging. The program has so far contributed to 48 industrial projects with an investment value of SAR 76 billion, creating 36,000 direct jobs. Two further potential clusters, in the energy and desalination sectors, are being considered (Saudi National Industrial Clusters Program 2016).

The Advanced Fiber Industries Project (Figure 27) is one example of how the Kingdom is building on its competitive advantage in basic commodities production to support downstream higher value-added growth opportunities.

Transition from basic manufacture to higher value products: The China experience

In China, the manufacturing industry is the major engine of economic growth. It helped China become a world leader in terms of manufacturing value added and the largest producer of goods for about 210 products. However, a heavy reliance on energy- and resource-intensive investment, especially in basic commodities such as steel, has put pressure on the economic and environmental sustainability of China's growth model.

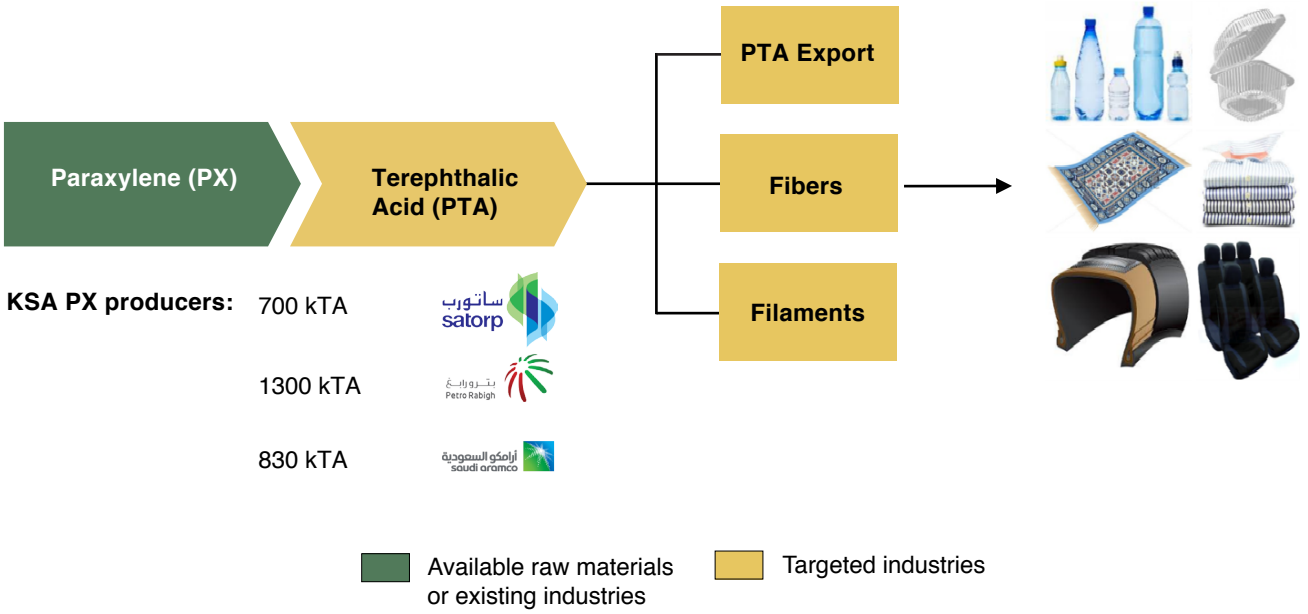

Figure 27. The advanced fiber industries project at Jazan Economic City.

Source: National Industrial Clusters Program (2017).

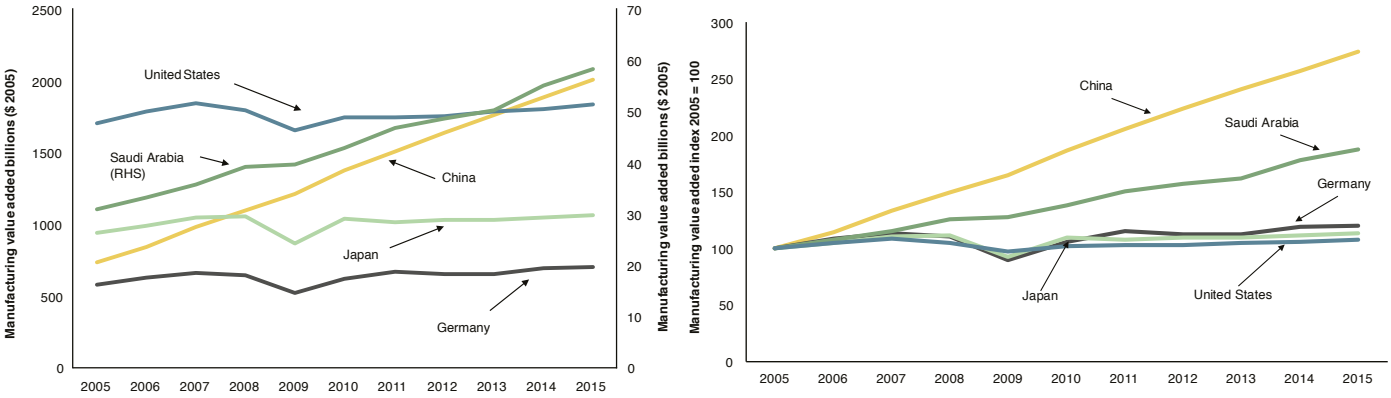

Figure 28. Manufacturing value added in selected economies.

Source: KAPSARC based on UNSTAT; Saudi Arabia, right hand axis (RHS).

As shown in Figure 28, between 2005 and 2015 the value added of manufacturing industries in China grew from around $700 billion to more than $2 trillion (in constant 2005 prices). Manufacturing value added also grew strongly in Saudi Arabia, doubling from around $30 billion to $60 billion over the same period (shown on the right-hand axis).

Focusing now on the value added of high-tech manufacturing, we can observe that in the past 15 years the value added of high-tech manufacturing industries in China grew a stunning 10 times from $50 billion in 2000 to $500 billion (in current dollars). In 2000, the value-added output of high-tech industries in China was only about one-seventh of that in the U.S. In 2014 it was very close to parity (Figure 29). Value added from high-tech industry also grew strongly in Saudi Arabia, increasing four times from an index level of 100 in 2000 to over 400 in 2014. While growing strongly, in absolute terms the contribution of high-tech industry to value added is still relatively small compared with other countries, shown on the right-hand axis of Figure 29.

Among the five high-tech manufacturing industries the leading sub-sector in China is ICT, which has a global share of 39 percent of value-added output. China has built adequate infrastructure and world scale of manufacturing plants for most ICT products. China also became the world's largest producer of pharmaceuticals with a 28 percent share of the global market, also with rapid growth in related testing, measuring and control instruments sub-sectors.

Figure 30 shows the sectoral breakdown for value added drawn from the UNSTAT, database. Here we see that both China and Saudi Arabia are experiencing a structural shift from primary industry to secondary manufacturing sectors. Primary industry is still a major component of economic activity in the Kingdom, due to the important role oil and gas extraction plays in its economic landscape. While the service sectors have grown significantly in absolute terms in both countries, according to UNSTAT, services comprise about the same share of total value added in both countries at just over 30 percent of total economic activity.

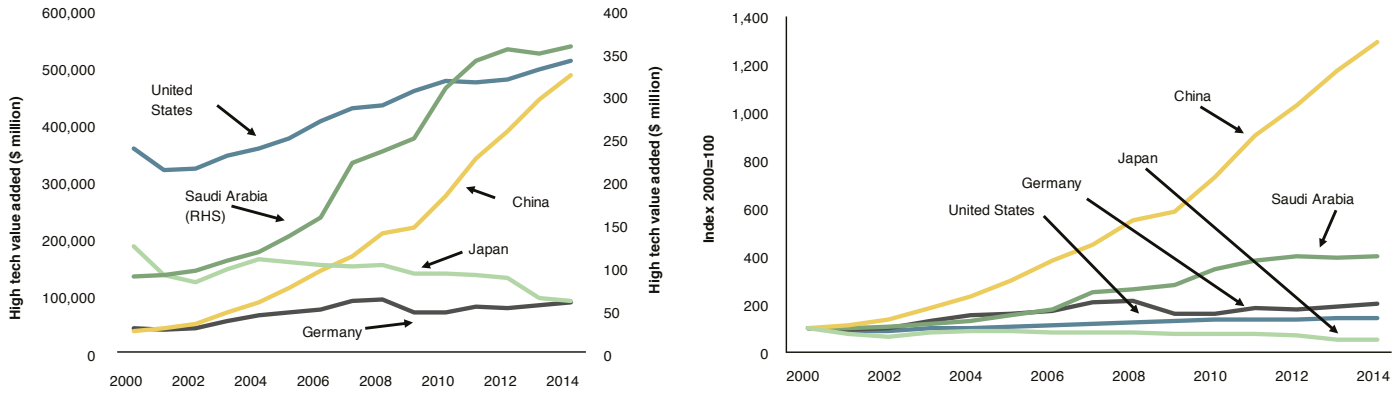

Figure 30. Value added of high-tech industry in selected economies.

Source: SEI 2016 based on IHS Global Insight, special tabulations (2015) of the world industry.

Note: Saudi Arabia, right-hand axis (RHS).

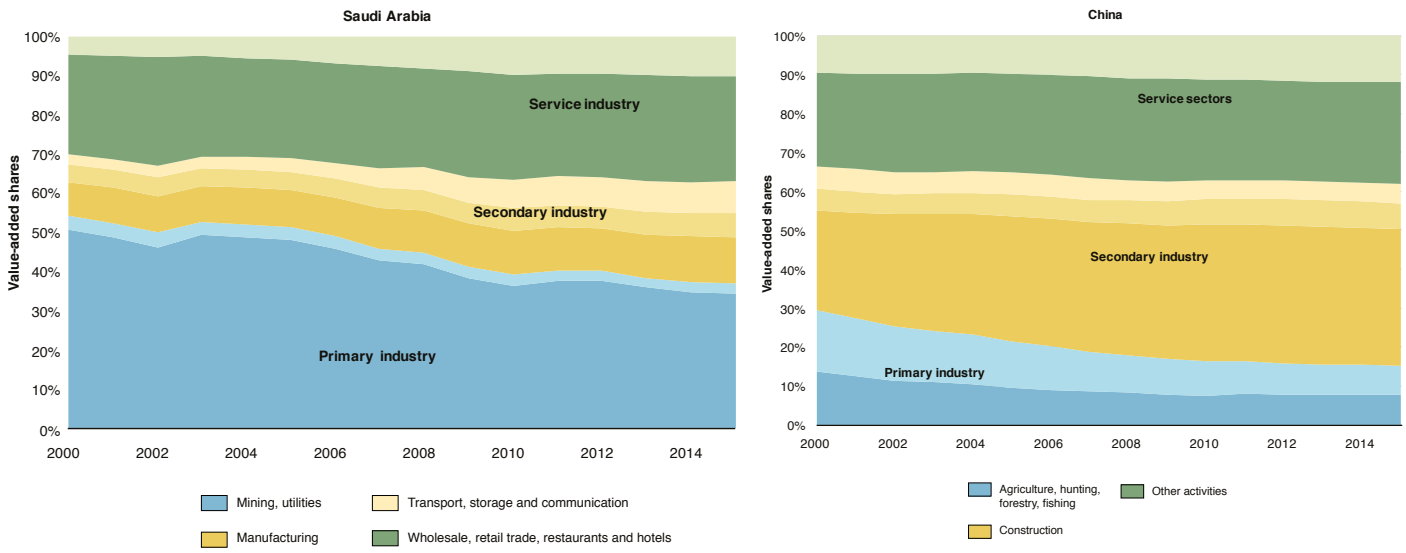

Figure 30. Structural change in major sectors of the economy in China and Saudi Arabia (2000-2015).

Source: UNSTAT.

To strengthen the development of the service industry, China extended the coverage of service categories and redesignated tertiary industry as service industry in its national statistical system in 2013. This redesignation incorporates manufacturing services into service industry, which may explain the difference with the UNSTAT figures. According to this designation, in 2012 China's service sectors overtook secondary industry as the largest source of value added (Figure 31).

For example, the output value of the internet grew to $94 billion in 2014, with an average annual growth of 30 percent since 2011. Another noteworthy sector is the rapid development of the energy service or ESCO industry. Driven by China's energy efficiency market, perhaps the world's largest, its gross output value increased from RMB 1.7 billion in 2003 to RMB 357 billion in 2016. During this period ESCOs are estimated to have increased jobs from less than 10,000 to 652,000, with the number of businesses engaged also increasing from less than 100 to 5,816 (Dai et al. 2017).

China's progress to more advanced stages of industrialization has relied on two important conditions:

- A foundation of skills, research and development aligned with new higher-value activities.
- Rising per capita incomes and urbanization to support domestic consumer demand for new higher-value goods and services, as well as education, culture, health and other public services.

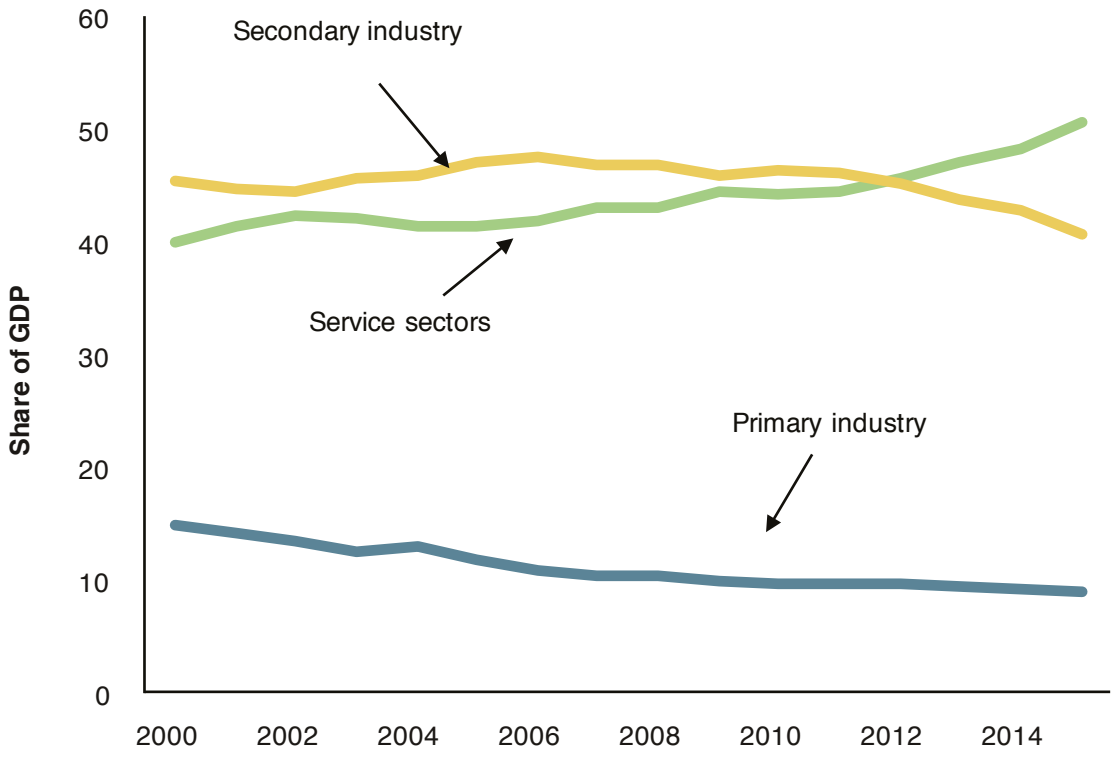

Figure 31. Sectoral share of value added in China.

Source: National Bureau of Statistics, China.

Government programs have played an important role in industrial restructuring, transformation and upgrading in China. For example, the first Industrial Transformation and Upgrading Plan (2011-2015) was released in 2012 and emphasized improving technological innovation in the environmental protection industry and smart manufacturing. The "Made in China 2025" Plan, released on May 19, 2015, laid out a 10-year blueprint for shifting China's manufacturing competitiveness from mid and low-end products to higher-end sectors.

The supply-side structural reform process initiated in 2015 currently dominates the economic policymaking landscape. It shapes everything from the government's efforts to reduce excess industrial capacity to initiatives designed to reduce property inventory, curb high levels of corporate debt and lower corporate costs.

In conclusion, using energy productivity as a guiding principle for managing structural economic change in both China and Saudi Arabia can add value by providing a focus on the following key themes:

Ensuring that basic energy-intensive products are produced in the most energy-efficient way to support competitiveness, in order to increase profitability and grow market share. Pursuing a comprehensive program to bring companies up to, or beyond, industry energy efficiency benchmarks. Companies that fail to comply can face a combination of financial penalties, a reduction in their allocation of energy or, in extreme cases, mandated plant closures.

Building on a strong and efficient industrial base of basic industries to develop domestic and international supply chains, and build downstream higher value-added manufacturing and service sectors.

Strengthening advanced higher value-added industries through local capacity building, technology transfer, international investment and education and training.

How Does Energy Price Reform Support Industrial Transformation Goals?

Society tends to value higher priced energy resources more and put them to higher value use. Along with the need to raise fiscal revenues and create an environment supportive of private sector investment, this desire to improve allocative efficiency is a key reason why governments choose to implement more market-oriented reforms. However, at the same time, if energy prices rise too far then energy-intensive industry will simply relocate to other countries. Consequently, energy prices need to be high enough to warrant senior management attention, but not so high as to make industry uncompetitive.

Figure 32 provides a snapshot of industrial electricity and gas prices in 2016. While these are aggregate averages, this data suggests that industrial energy tariffs in Saudi Arabia are among the lowest in the world. Electricity tariffs in Chinese industry are also low in comparison to other countries largely because of relatively inexpensive coal-fired power.

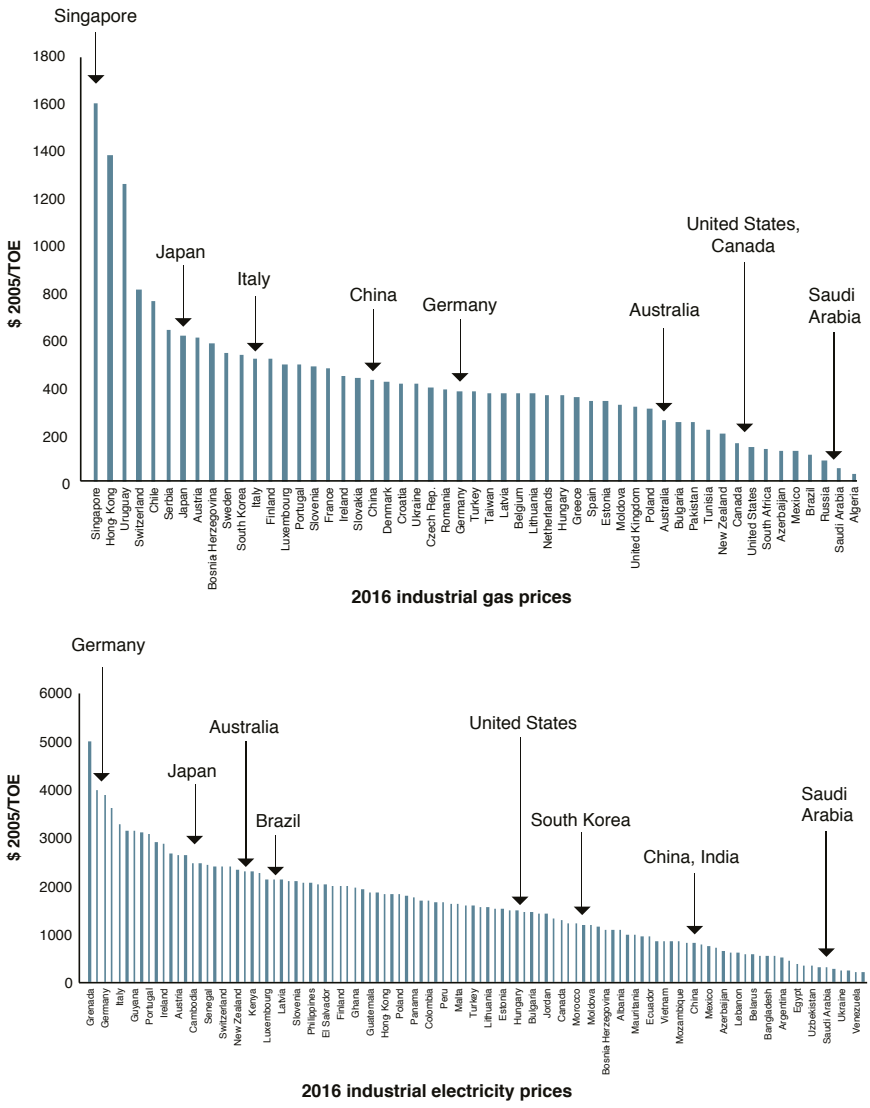

Figure 32. 2016 industrial electricity and gas prices.

Source: KAPSARC based on Enerdata (2015 data used where 2016 not available).

Energy pricing reforms in China

Over the last 20 years, as part of reforms to transition to a more market-oriented economy, China has designed and implemented energy price reforms for various energy commodities and end users. Experience in China can provide a valuable reference for other countries looking to implement similar reforms in an administered price environment.

It is worth noting two important approaches to setting prices when we discuss energy price reforms in China. Government-set price is a fixed price set by the pricing authority, and government-guided price is the benchmark price set by the pricing authority but open to negotiation by producers and wholesalers.

Previously, under the era of centralized economic planning in China, oil prices were uniformly set by the government until the introduction in 1981 of a hybrid-pricing system as part of China's transition from a planned to a market economy. Since then market-based pricing reform has been continuously refined with improved mechanisms and methodologies for price adjustment to reflect changes in the economy and international markets.

Under the Crude Oil and Refined Oil Price Reform Scheme launched in 1998 two state-owned petrochemical companies, Sinopec and the China National Petroleum Corporation (CNPC), were allowed to set pump prices of refined oil products based on a government-released price reference that was linked with benchmark refined oil prices in Singapore (Figure 33). In 2001, the government added two other markets, Rotterdam and New York, to the price reference package. To contain the adverse impact of price increases to industry, heavy oil used in the fertilizer industry and jet fuel was administered by the government.

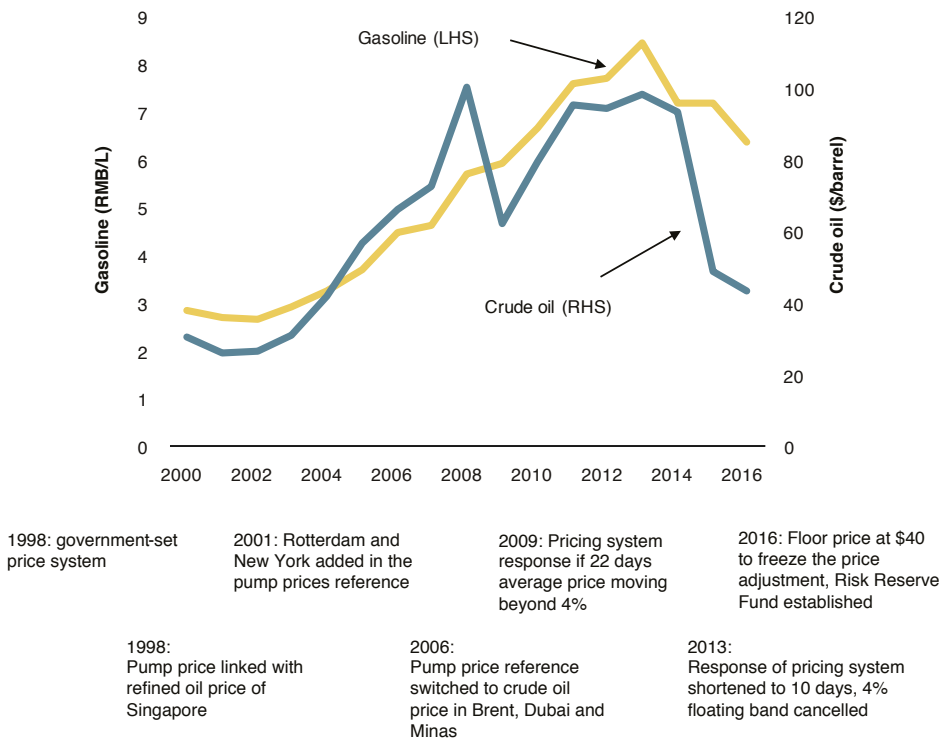

Figure 33. Chinese gasoline prices and international oil prices and market reforms.

Source: KAPSARC based on ENERDATA, BP Statistical Review of World Energy and Chinese government policy papers.

Note: Gasoline, left-hand axis (LHS); crude oil, right-hand axis (RHS).

In the second phase of its price reform, the international oil market experienced significant price rises from 2003 to 2008 and significant drops in 2009 and 2014. Price reforms in China mostly focused on sharpening the price reference system and building buffer zones to minimize the shock of these impacts to consumers, including the petrochemical industry. The price reference system, plus a certain range of fluctuation, remained as the basic model for refined oil product pricing, but the following mechanisms improved the response mechanism:

- In 2006, the direct linkage with international refined oil prices in Singapore, Rotterdam and New York switched to indirect linkage with international crude oil prices of Brent, Dubai and Minas.
- In 2009, the government modified the pricing system to respond when international crude oil price averages moved beyond 4 percent of the established price over 22 consecutive working days.
- China followed a different price adjustment strategy when crude oil prices went below $80/bbl, between $80-130/bbl and higher than $130/bbl.
- In 2013, the price adjustment period was shortened to 10 working days, and the 4 percent floating band was canceled.
- In 2016, the government introduced a floor price ($40) for crude oil to freeze the price adjustment for refined oil products, and a special risk reserve fund was established to increase investment in energy conservation and emission reductions.

Over the last 18 years, market price reforms for oil products have developed into a mature pricing system linked with changes in the international market. However, the government still decides when and how much to adjust the price. In the short term, this has curtailed the adverse impact of rising prices on industrial development, but in the long run it could hinder production upgrades, modernization and competitiveness if the government does not deliver the market signal promptly.

Industry support in oil price regulation

In 2005 and 2007, as international crude oil prices rose and the retail price of refined oil was maintained at a lower level by the government, refiners suffered financial losses. This prompted the refining industry to curtail production capacity, eventually leading to oil product shortage in several Chinese provinces and cities, which had negative social impacts (China.com.cn 2007).

The government provided direct and indirect subsidies to the refining industry to make up for the losses incurred. For example, CNPC received a direct subsidy of RMB 6.1 billion and RMB 1.11 billion in 2006 and 2007, respectively (CNPC 2007). Sinopec received a direct subsidy of RMB 5.1 billion and RMB 4.8 billion in 2006 and 2007, respectively (Sinopec 2007).

In addition, Sinopec and CNPC also enjoyed VAT exemption for crude oil and oil import. Qian et al. (2009) calculated that Sinopec received RMB 52.7 billion in VAT exemption for crude oil and oil product import in 2007 as indirect subsidy. Sinopec still claimed a 50 percent profit reduction in its financial report for the 1st quarter of 2008.

Domestic gas prices, which usually cover wellhead prices, processing fees, and transmission and distribution tariffs, were traditionally regulated by the government along the value chain. The degree of regulation varied according to the source of the gas, the means and routes of transportation and the type of end user (Figure 34).

After more than 10 years of price reforms, there has been a significant change in onshore gas pricing from the cost-plus and wellhead controlled gas pricing regime to a net-back pricing regime that is indexed to alternative fuels.

The prices for offshore gas and unconventional gas, for example coal-bed methane, coal-to-gas, liquefied natural gas (LNG) and shale gas, are usually subject to negotiations between the seller and the buyer. However, if the gas is pumped from a long-distance pipeline, the reference of a city-gate price will be applied for final sale, or an additional fee will be charged for pipeline transmission.

Gas pricing reform in China has experienced three major stages (Figure 35). During the first stage (pre-1982) uniform price setting by the central government, mainly developed in Sichuan province, helped maintain a very low and stable price for natural gas.

During the second stage (1983 to 2005), which coincided with the rapid development of the oil and gas industry, China introduced a differential gas pricing regime within and outside the government plan. It involved a cost-plus and wellhead controlled pricing system, with prices differentiated for industrial, fertilizer, commercial and residential end users. Both government-set prices and government-guided prices existed in the pricing system at this stage.

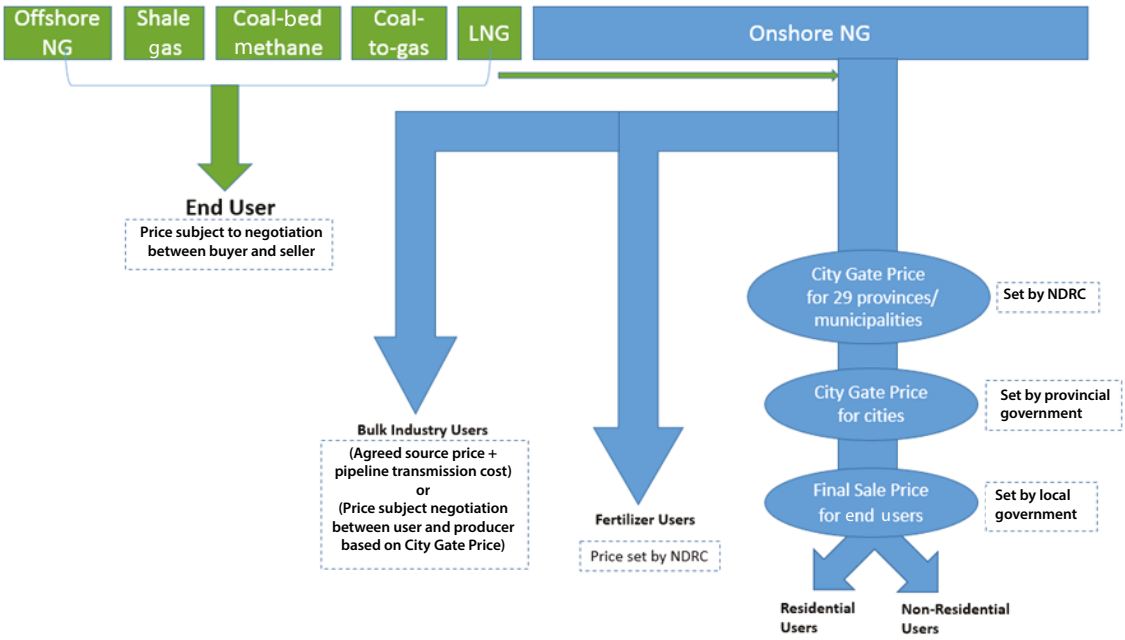

Figure 34. Natural gas price setting system in China.

Source: KAPSARC based on Chinese government policy papers.

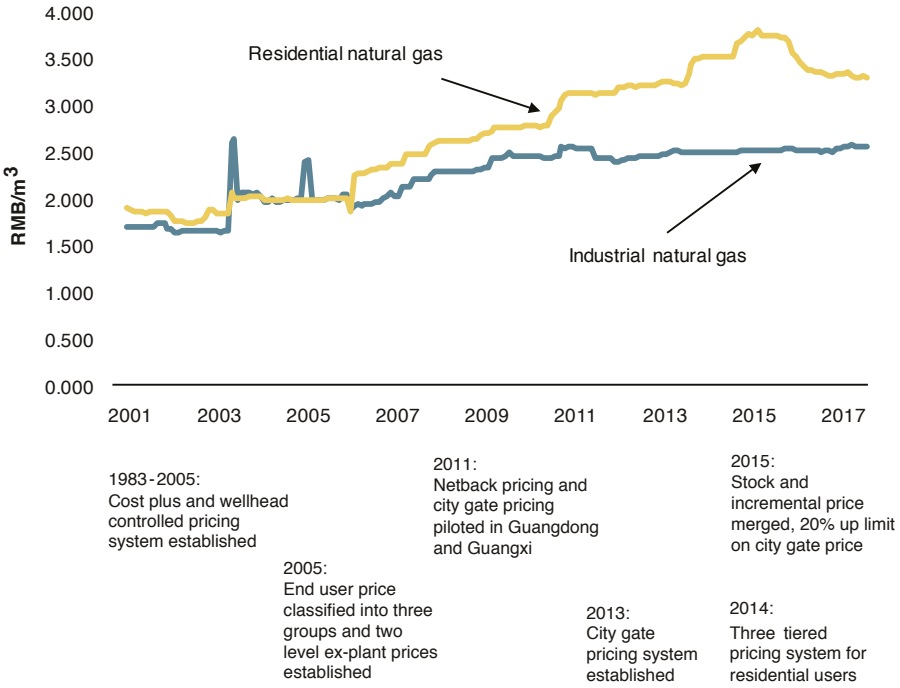

Figure 35. China natural gas prices and energy price reforms.

Source: KAPSARC based on CEIC and Chinese government policy papers.

The gas pricing system moved into the third stage in 2005 once China abolished the government-set price and the gap between government-guided pricing and international fuel price gradually narrowed.

In 2005, the government simplified price classification for end users to industrial, commercial and municipal users (NDRC 2005). China developed dual level ex-plant prices, each with a different scope for adjustment. The change of level prices was linked to price changes of crude oil, LPG and coal at a five-year moving average.

In 2011, China launched a pilot program for natural gas price reform in Guangdong and Guangxi. The program incorporated a netback market value pricing method to better reflect market changes and the scarcity of resources, linking the city gate reference price to the market prices of alternative fuel sources.

In 2013, the government replaced the ex-plant pricing system with the city gate price system, which set the price ceiling for negotiation between buyer and seller (NDRC 2013). Different price adjustment strategies determined the cost of stock gas and incremental gas, with a netback pricing method used for incremental gas.

In 2014, China implemented a three-tiered gas pricing system for residential users.

In 2015, the government merged the stock gas and incremental gas prices. Instead of capping the price, the city gate price provided a reference for bulk industry users, excluding fertilizer users. The final agreed price after negotiation should not be more than 20 percent above the city gate price.

Industrial fuel and chemicals production accounted for the largest share of gas consumption, at around 41 percent in 2014. The price of such gas is usually high and increasingly subject to negotiations between

industry users and producers. Fertilizer producers have paid around 30 percent less than industrial users as part of support to the agricultural sector. The lowest gas price for residential users has increased the use of gas in the residential sector beyond that of the industrial sector. This scenario contrasts with a global gas pricing practice that usually provides lowest gas prices for industrial users to support the industry's competitiveness.

At the end of 2015, around 71 percent of existing long-distance gas pipeline networks were controlled by PetroChina. With state-owned oil enterprises owning more than 97 percent of long-distance gas pipelines, the participation of the private sector is limited. Future price reform is likely to be continuously focused on the price regulation of pipeline transmission and distribution, while the price of gas production and final sale is completely left to market forces, as envisaged in the 13th FYP.

Coal accounted for 72 percent of primary energy production in China in 2015. Power utilities and industries, mainly chemicals, building material, and iron and steel, consumed about 80 percent of the coal. Coal pricing was among the earliest reform steps that enabled China to adopt a more market-oriented regulatory approach. Given the critical and primary position of coal for the country's energy security, caution was exercised at every step of the price reform process to minimize potential damage to industrial competitiveness and economic stability.

The market and price reform of coal went through three important stages. During the first stage (pre-1990s) it followed a dual-track pricing system that gave physical quotas to end users and adopted government guided prices. In some situations, there was also scope outside of the government plan for price negotiation within a prescribed range between the buyer and the seller.

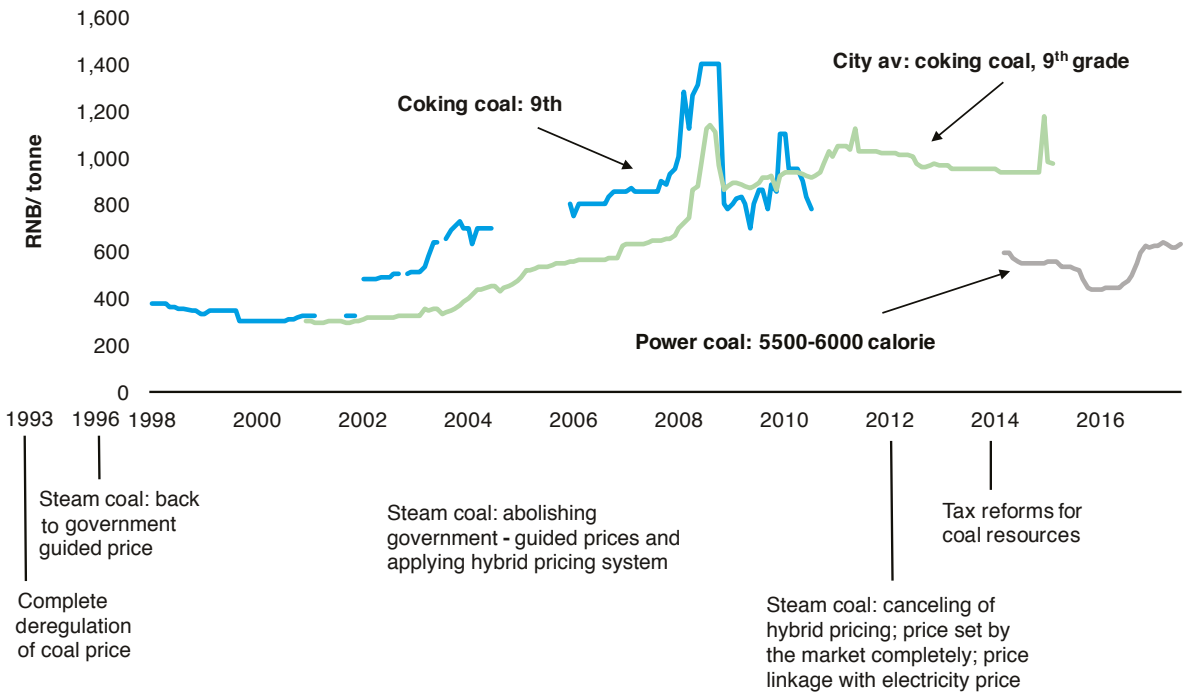

Figure 36. China coal price reforms.

Source: KAPSARC based on the Chinese government policy papers.

Note: Coking coal is only a small part of Chinese coal consumption; coal used in power generation is much bigger. These data limitations should be kept in mind when interpreting this figure.

The second phase of reform (1992 to 2013) saw coal pricing transitioning to market forces. China has swung between government regulation and applying market forces, especially in steam coal pricing (Figure 36). Even though the government deregulated steam coal prices in 2012, the coal-power price linking system has had to strike a fine balance between the open market price of coal and the regulated price of power. Despite this, liberalization of domestic coal prices is a very significant achievement of price reform.

In the third stage of coal price reform, tax reforms were pursued to better reflect the scarcity of resources and advance industrial upgrading and modernization. In 2014, the shift from specific to an ad valorem structure for the coal resource tax levy helped increase the market price of coal and also reshape the fiscal and tax relations between the central and local governments. The tax rate ranged between 2 percent to 10 percent and local governments were provided greater autonomy for approving taxes.

China's power sector has been characterized by strict regulation, an inflexible pricing system and a monopoly in the transmission and dispatch of electricity. Electricity prices at the stages of generation, transmission and distribution and end-user retail are all set and controlled in a centralized manner, with different rates set for different consumers.

With continuous electricity price reforms (Figure 37), China has been steadily building the platform for market competition through:

- Establishing a price bidding mechanism for generation and retail business.
- Price setting for transmission and distribution in all provinces.
- A new electricity market capacity trading mechanism, currently under experimentation.

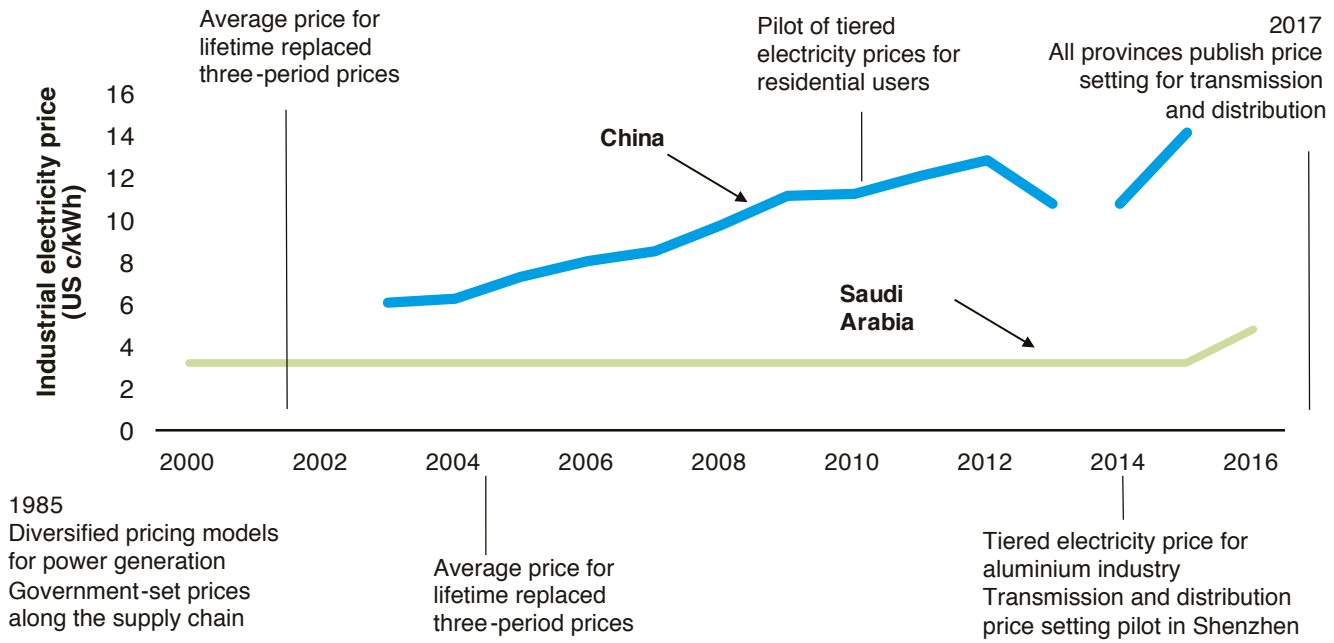

Figure 37. China electricity price reforms.

Source: Enerdata, KAPSARC, Chinese National Bureau of Statistics, NDRC Policy Papers.

Under centralized planning, China had vertically integrated power generation, transmission, distribution and retail. Under this system it administered retail tariffs for bulk industries, ordinary industries and non-industries.

China introduced initial reform in 1985 to deal with serious power shortages, which were occurring across the country due to the slow growth of the power sector. It created diversified pricing models for power generation. The government formulated its set prices on the basis of capital investment, finance costs and a reasonable level of profit across three different time periods. These included the construction period, payback period and post-payback period (State Council 1985). China provided differentiated price guidance for various types of plants, such as newly built plants, collectively constructed plants and foreign-invested plants, to encourage investment from different sources. Energy-intensive industries and agriculture enjoyed relatively low tariffs in this period in comparison to other industries.

During the second stage of electricity price reforms (from 1997 to 2002) the national power shortage was greatly alleviated. During this time, an average tariff-setting formulae for the whole lifetime of the plant replaced tariff setting across the three different periods. The cost-plus profit model was still the basis for tariff setting. Cross-subsidies continued to be prevalent between retail end users.

In the third stage, electricity price reform moved with broader electricity market reform. This phase involved the separation of generation, transmission and distribution businesses, the integration of renewable energy into the energy supply mix and the opening up of the retail market. Notably, the price reform on transmission and distribution started with the pilot program in Shenzhen in 2014, then rolled out to west of Inner Mongolia, Anhui, Hubei, Ningxia, Yunnan and Guizhou in 2015, and to all provincial grids in 2017. It's estimated that price reform on transmission and distribution has reduced the cost of RMB 38 billion for demand side in the first half of 2017 (China Government Web 2017).

Actions on air pollution control and carbon emission reduction have a growing impact on electricity price setting. China first formulated a desulfurization tariff for coal power plants in 2007. Based on the success of this policy, in 2013 the government further developed its denitrification tariff policy and promoted it nationwide as the implementing measure under the Air Pollution Prevention and Control Action Plan. The Ministry of Environment Protection (2013) estimated that RMB 10 billion of government subsidy was provided to coal power plants for the construction and operation of denitrification facilities in 2012 according to the pilot standards 0.8 cents RMB/kWh in addition to the normal price.

A differential electricity pricing policy was first piloted in 2004 to phase out the outdated capacity of energy-intensive industries, which included aluminum, ferroalloy, calcium carbide, caustic soda, cement, iron and steel. In 2006 it was rolled out to eight industries with clearly defined classification and criteria that set out which industrial plants were to be eliminated, restricted, permitted or encouraged. The government developed and updated detailed standards of differential electricity prices for each category (Table 4).

From 2006 this practice was further strengthened to improve the specific energy performance and reduce the environmental impact of energy-intensive industries. In 2014 tiered electricity pricing was introduced in the aluminum industry, thereafter in 2015 in the cement industry and in 2016 in the iron and steel industry.

Table 4. Differential electricity pricing for energy-intensive industry.

Additional price standards for energy-intensive industry (RMB/kWh)							
Aluminum, calcium carbide, caustic soda, cement, iron and steel phosphorous, zinc							
	2006	2006	2007	2008	2010	→	2017*
Eliminated (Low efficiency)	+0.05	+0.10	+0.15	+0.20	+0.30	→	0.50
Restricted (Average efficiency)	+0,02	+0.03	+0.04	+0.05	+0.10	→	0.10
High efficiency	No penalty						

Source: KAPSARC based on NDRC Policy Papers.

Note: *2017 increase for iron and steel only.

During this period China established a coal and power price linking mechanism in 2004 to deal with the long-standing conflict between coal and power generation. Since then they have made more than 14 price adjustments either to on-grid tariffs or retail prices. Even today, the time window and the extent to which the government will adjust the electricity price relative to changes in coal prices is not predictable. In general, electricity prices have been much more stable than underlying fuel input prices (Figure 38).

Energy Pricing Reforms in Saudi Arabia

As part of Saudi Arabia's Vision 2030, in December 2016 the government in Saudi Arabia announced a Fiscal Balance Program which incorporated plans to increase domestic energy prices in the Kingdom from levels consistent with the costs of production to levels more reflective of the opportunity costs of international benchmarks. Consequently, energy costs are likely to significantly increase to an amount that will ultimately depend on prevailing international market conditions and the reference prices used.

The energy price reform program will play a central role in aligning economic incentives toward greater energy efficiency and the allocation of capital toward higher value activities in the economy. It will also help stabilize the fiscal balance by increasing non-oil government revenue. The program is scheduled to be phased in gradually, to provide sufficient time for industry and households to adapt.

While energy price reform will unambiguously support long-term energy efficiency in energy-intensive industries, its impact on energy productivity (revenues per unit of energy consumed) for these industries is less certain. Higher energy prices will result in a loss in competitiveness in energy-intensive industries. As a result, domestic firms may lose market share, especially for internationally traded goods. If this occurs and corporate revenues fall faster

than any decline in energy consumption, energy productivity in the energy-intensive sectors will also fall. Consequently, it is important to take a broad perspective which incorporates all sectors of the Saudi economy. Policies that maintain the economic contribution of current industries while growing new industries are equally important.

Using energy productivity as a framework for energy price reform suggests price rises should preserve the competitive advantage of energy-intensive industries, but be high enough to incentivize energy efficiency in line with international benchmarks.

The government implemented the first phase of energy and water price reform in 2016 for households and non-households (industry and others). These reforms are summarized in Table 5.

The reported impacts of the reforms already implemented include increased revenue from fuel sales of SAR 27-29 billion in 2016 and a reduction in the annualized rate of growth of energy consumption from 3.5 percent in the first half of 2015 to 1.7 percent in the first half of 2016. Saudi Arabia has achieved this while not inducing any negative impact on inflation and foreign investment (Government of Saudi Arabia 2016).

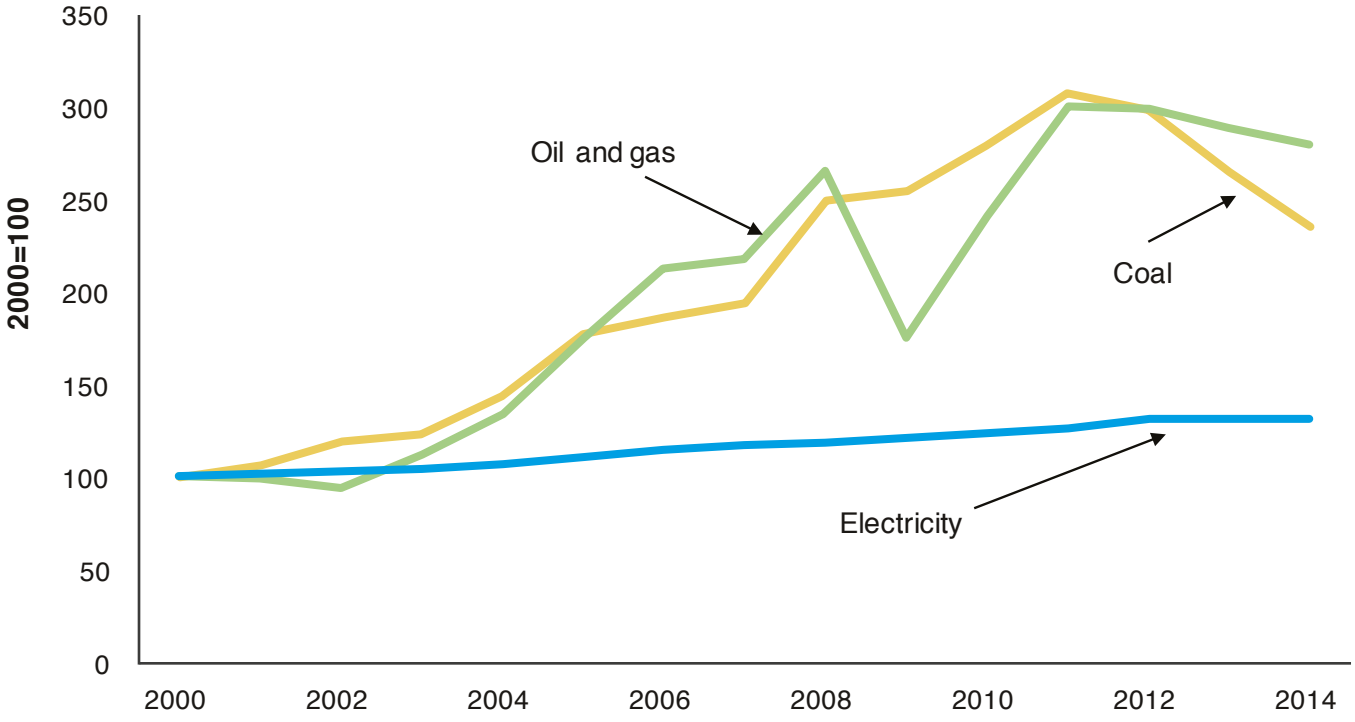

Figure 38. Comparative ex-plant price change of electricity, coal, oil and gas.

Source: National Bureau of Statistics, China.

Table 5. Implementation of phase 1 energy price reforms in Saudi Arabia.

	Households	Industry and others				
	Pre-2016 prices	Current prices (March 2017)			Pre-2016 prices	Current prices (March 2017)
Gasoline (SAR/liter)	0.45-0.60 (0.12-0.16)	0.75-0.90 (0.2-0.24)	Diesel ($/barrel)	Transport	10.6	19.10
				Industry	9.12	14.00
			Industrial		0.14 (0.03)	0.18 (0.04)
Electricity (SAR/kWh)	0.05-0.26 (0.013-0.069)	0.05-0.30 (0.13-0.08)	Commercial		0.14-0.26 (0.03-0.07)	0.18-0.30 (0.04-0.08)
			Governmental		0.26 (0.07)	0.32 (0.09)
Water (SAR/m^3)	0.10-6.00 (0.026-1.6)	0.15-9.00 (0.04-2.4)			0.1-6.0 (0.026-1.6)	0.15-9.0 (0.026—1.6)
			Gas (methane) ($/MMBtu)		0.75	1.25
			Ethane ($/MMBtu)		0.75	1.75
			HFO 380 ($/barrel)		2.08	3.80

Source: Government of Saudi Arabia 2016 (US$ in parenthesis, unless otherwise specified in SAR).

The second phase of reform is currently underway. It will link domestic prices of energy products to the reference export price as a percentage of the respective product. At full implementation, the government intends to move these prices with changes in international markets (Government of Saudi Arabia 2016).

The Fiscal Balance Program cited three main reasons for the reforms:

- The large opportunity cost, or foregone revenue, calculated at SAR 300 billion in 2015 from energy prices set according to the cost of supply, rather than based on international benchmarks.
- Concerns around wasteful and unsustainable growth in domestic energy consumption.
- Social equity considerations, as the current system may benefit more affluent consumers compared with lower income households than arrangements after the reforms.

Phase one and two of the energy price reform package taken together, the 2016 Fiscal Balance Program suggested that higher energy prices would raise around SAR 209 billion in extra revenue for the government. As part of the implementation of these energy price reforms, the government plans to bring in targeted assistance for households and industry.

In December 2017, the government updated its Fiscal Balance Program to accommodate a more expansionary stance. This included the largest ever budget expenditure of SAR 978 billion in 2018, compared with 2017's budget of SAR 890 billion. Based on revenues of SAR 783 billion the

government is planning for a deficit of around SAR 195 billion. The government has budgeted for non-oil revenue to reach SAR 291 billion in 2018, an increase of 14 percent on 2017 actuals. Continued energy price reform is expected to contribute to government revenue with announced increases to electricity tariffs forecast to add around SAR 14 billion in 2018 (Jadwa Investment 2017). The start of January 2018 also saw prices for gasoline raised with 91-octane priced at SAR 1.37 ($0.37) per liter, up from 75 halalas ($0.20) and 95-octane up to SAR 2.04 ($0.54) per liter up from 90 halalas ($0.24). These price increases also include the imposition of a new 5 percent value-added tax, implemented on January 1, 2018. The government is expected to announce further energy price changes in 2018 (Jadwa Investment 2017).

Conclusion

Efforts to share international experiences on industrial energy productivity can help achieve greater prosperity and sustainable development goals. Areas for exchange between China and Saudi Arabia are particularly rich. They include energy price reform and energy efficiency, benchmarking, establishing an industrial ESCO market, district cooling initiatives and policy approaches to building competitive high-value industrial ecosystems.

The economic transformation desired by both China and Saudi Arabia will involve a transformation of their energy sectors. China is managing this process through a systematic program of national and provincial energy intensity targets, energy efficiency benchmarking at the technology and process levels, energy price and market reform and policies to drive structural change and industrial upgrading. While their starting points are very different, there is clear scope for exchange and policy learning between both countries, especially as they enter this deeper phase of bilateral engagement.

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Appendix 1. Implementation Plan for Top Ten Energy Efficiency Program

	Key targets and focal actions
Industrial boiler and furnace energy efficiency retrofitting	Replacing low efficiency boilers with higher efficiency system. Phasing out outdated industrial kilns, e.g. shaft kiln and wet kiln production process in cement sector. Retrofitting pellet rotary kiln and limestone kiln in iron and steel production. Promoting the use of energy efficiency tunnel kiln and other advanced technology in building material production. The operation efficiency of industrial boiler and furnace was to increase 5 percent and 2 percent respectively by 2015 comparing that of 2010.
Oil conservation and substation	Improving the system efficiency in oil extraction, replacing the use of fuel oil with byproduct gas. Promoting production of high efficiency oil-based vehicle, and clean fuel vehicle like electric vehicle and gas-based vehicle. Promoting the electrification of train transport, and intelligent and flexible city transport system. Oil efficiency in internal combustion engine system was to increase 10 percent by 2015 comparing that of 2010.
Motor system energy efficiency retrofitting	Phasing out the production and use of low efficiency motor products. Promoting the use of advanced and high efficiency technology, e.g. variable speed control and permanent magnet control, to improve the overall efficiency of motor system. Expediting retrofitting of motor system through energy performance contract and equipment leasing. The electricity efficiency was to increase 2-3% by 2015 compared to that of 2010.
Waste heat and waste pressure recovery	Promoting waste heat and waste pressure recovery for power generation in iron and steel, cement, glass, nonferrous metal, petrochemical and other industrial sectors. Promoting the use of technology and equipment for byproduct gas and low heat-value gas recovery.
Combined heat and power (CHP) generation	Replacing small-size coal-fired boiler with CHP and increasing the share of CHP in city's heat supply system. Promoting CHP in industrial park for heat supply, with special encouragement of back pressure heating unit. Encouraging the construction of combined cooling heating and power (CCHP) projects.
Energy system optimization	Improve the overall energy efficiency of production in petrochemical, chemical, iron and steel through integrated use of heat and gas, system optimization design, and centralized energy management in production process.

Appendix 1. Implementation Plan for Top Ten Energy Efficiency Program

Building energy efficiency	Initiating the heat supply system reform and promoting meter-based payment. Demonstrating the application of renewable energy and new types of construction material. Enforcing the implementation of 50% energy efficiency standards for newly built buildings at national level and 65% energy efficiency standards in north China.
Green lighting	Upgrading the production of energy efficiency lighting products. Promoting the use of energy efficiency lighting products through public purchase, demand side management, and energy performance contract. Retrofitting the traffic lighting system and promoting the use of LED in landscape.
Energy conservation in government Institutes	Retrofitting the building envelop, central air conditioner system, heating and lighting system. Promoting government purchase for energy efficiency products. Building information platform to collect and track the energy consumption data in government buildings.
Energy efficiency supervision and technical service	Improving the capacity of local administrations on energy efficiency. Providing energy audit services for key enterprises. Developing energy efficiency benchmarking and labeling standards. Promoting ESCOs. Incubating the industrialization bases for energy efficiency equipment industry. Energy equipment industry grows at 15 percent per year, and more than 1000 energy service companies incubated with high competency by 2015.

Source: NDRC.

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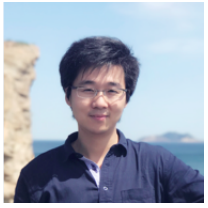

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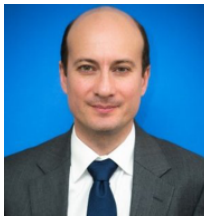

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Notes

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