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Growth Through Diversification and Energy Efficiency: Energy Productivity in Saudi Arabia

Consultation Report

November 2017 / KS-2017--DP024

Background to This Study

This report summarizes the main results of a joint KAPSARC-UNESCWA study into energy productivity in the Gulf region, focusing on Saudi Arabia. It would not have been possible without generous contributions provided by participants in KAPSARC's Energy Productivity Workshop Series and a number of expert studies which were conducted for this report, listed under project publications. It is intended as a consultation document to inform discussion around how improving energy productivity in the Kingdom of Saudi Arabia and other GCC countries can contribute to increasing the welfare society obtains from the energy system.

The views and opinions expressed herein are wholly those of the authors and do not necessarily reflect those of KAPSARC or UNESCWA. Please cite this publication as KAPSARC-UNESCWA (2017) Growth Through Diversification and Energy Efficiency: Energy Productivity in Saudi Arabia, KAPSARC-UNESCWA Consultation Report, Riyadh and Beirut. For more information please contact nicholas.howarth@kapsarc.org or Radia Sedaoui: sedaoui@un.org. Comments received will be gratefully acknowledged and will inform further work on this report.

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.

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Key Points

With domestic energy demand in Saudi Arabia expected to potentially double by 2030, managing the relationship between energy consumption and economic growth will be very important for the Kingdom's sustainable development. To assist in this task, this report recommends using energy productivity as an indicator and policy framework to help inform policymakers as to where and how the most value can be achieved from energy use. Key messages include:

- Energy productivity is an economic planning tool that is increasingly being used by leading G20 countries to better manage the energy growth relationship.
- Two of the main elements of energy productivity are achieving structural change in the economy in favor of higher value-added activities and improving energy efficiency.
- These are key features of Saudi Arabia's Vision 2030 which is aimed at delivering more sustainable, socially inclusive and prosperous economic development.
- If Saudi Arabia's efforts to transition towards a more diverse and energy-efficient economy are unsuccessful, then social welfare will remain vulnerable to swings in international oil markets, increasing the risks of declining per capita income over time.
- We believe that the energy productivity planning framework set out in this report can help inform reform initiatives and increase the chances of a successful transition, particularly in the areas of industrial strategy, energy price reform and energy efficiency.

Executive Summary

While Saudi Arabia's Vision 2030 has set clear goals related to its overall objective of transitioning to an economy less reliant on oil exports by lifting non oil private sector growth, the strategy for domestic energy consumption that would deliver this is less clearly mapped out. This report makes the case for using energy productivity as an energy economic indicator and policy framework to address this, helping to inform policymakers managing the interplay between energy consumption and sustainable development. It is set out in five sections:

- What is energy productivity?
- How does energy productivity support Saudi Arabia's Vision 2030 and Sustainable Development Goals?
- The macroeconomic benefits of investments in energy productivity.
- Putting energy productivity into practice.
- Looking to the future: Potential energy productivity pathways for Saudi Arabia.

What is energy productivity?

Energy productivity, or the amount of economic activity per unit of energy consumed, is an indicator that has been used in different contexts around the world to help manage the balance between economic growth and domestic energy consumption. It reflects the level of structural diversification between energy-intensive and non-energy-intensive activities and the overall energy efficiency of the economy.

In addition to being an indicator, energy productivity offers a strong policy framework, especially for industrial strategy, based on the principle of maximizing the value that society obtains from energy use.

How does energy productivity support Saudi Arabia's Vision 2030 and Sustainable Development Goals?

Recognizing the combined risks of an economy that is over-reliant on oil exports, a rapidly growing population with high youth unemployment, and rapidly growing domestic energy consumption, the Kingdom has introduced an ambitious reform program called Vision 2030. This includes major subprograms such as the National Transformation Program and Fiscal Balance Program which, among other goals, aim to diversify the economy, increase energy prices and improve energy efficiency. For example, one key target is the plan to expand the share of private sector non-oil gross domestic product (GDP) from around 40 percent in 2015 to 65 percent by 2030.

Low energy prices and strong growth in the production of relatively low value-added, energy-intensive, basic commodities make improving energy productivity a challenge in Saudi Arabia. Economic diversification to higher value-added activities and increased energy efficiency offers a way forward to reduce the fiscal and economic risks associated with the current oil-based growth model. This structural change could lift per capita incomes and transform the level and composition of long-term domestic energy and economic demand, increasing energy productivity.

Without such a transformation, the Kingdom will remain vulnerable to swings in international energy markets. A low energy productivity growth pathway will make it difficult to maintain or increase growth in per capita incomes in the longer term and to deliver high quality jobs for a young and ambitious population.

The macroeconomic benefits of investments in energy productivity

Some estimates suggest domestic energy consumption could potentially double by 2030 from current levels of around 4.4 million barrels of oil equivalent per day (MBOED). Enhancing energy efficiency in the economy by up to 4 percent per annum could avoid the consumption of as much as 1 MBOED by 2030. This does not include the potential from structural change from diversification strategies. This avoided energy consumption would increase policy flexibility by making extra energy resources available for export, alternative domestic uses, or preserving it for future generations.

KAPSARC estimates the avoided energy consumption from a 4 percent improvement in energy efficiency per annum could be worth between approximately Saudi riyal (SAR) 50 billion and SAR 100 billion per annum in extra revenue to the government by 2030, depending on international oil market conditions.

If reinvested in the economy, this could lift GDP growth by between 0.3 and 0.6 percent per annum by 2030, helping achieve a variety of Vision 2030 goals.

As much of the benefit of enhanced energy efficiency occurs at the system or government level, there is a strong rationale for public subsidies for energy efficiency. For example, incorporating the benefits of selling avoided energy consumption – a barrel of oil not consumed, that is, a ‘nega-barrel’ – on international markets would be a powerful driver for the energy efficiency market.

Putting energy productivity into practice

Current policies in Saudi Arabia can be understood within an energy productivity framework. This can provide a useful way of mapping out future possible development pathways. Identifying energy productivity pathways could also fill a gap in the Saudi Vision 2030 goals by providing a clearer signal as to the desired diversification strategy as well as lifting the profile of energy efficiency policies. Clear shared goals around a common idea, such as energy productivity, can also act as a helpful coordinating instrument between different government agencies and stakeholders across the key reform areas outlined below.

Industrial strategy and diversification

Using energy productivity as a framework for industrial strategy would build on the Kingdom’s competitive advantages by enabling a strong and energy-efficient industrial base of basic commodity production. This could be achieved by ensuring that basic energy-intensive products are produced in the most energy-efficient way, so as to support competitiveness, increase profitability and grow market share.

A comprehensive program to bring companies up to or beyond industry energy efficiency benchmarks should be implemented, with those companies that fail to comply facing a combination of financial penalties, a reduction in their allocation of energy or, in extreme cases, mandated plant closures.

Domestic and international supply chain linkages should be developed in order to create more downstream opportunities in the higher value-added manufacturing and service sectors. At the same time, local capacity building, technology transfer, education and training should be emphasized to ensure local citizens and companies benefit from new investments.

Energy price reform

In response to fiscal pressures imposed by lower oil prices, a window has opened across the Gulf Cooperation Council (GCC) to reform domestic energy prices as part of broader economic restructuring to help make these countries less exposed to swings in international energy markets. In Saudi Arabia, the Fiscal Balance Program that forms part of Vision 2030 has set out energy price reforms which will move domestic energy prices up to international benchmarks by 2020 and beyond. These reforms will play a key role in shaping the Kingdom's future energy efficiency and industrial development.

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.

While the broad directions of the program have been announced, international experience suggests the path forward for successful implementation will need to be carefully managed. Key principles to maximize the chance of successful reforms include:

- Prices should not be increased too rapidly.
- There should be a clear and credible long-term commitment to the strategy.
- Pricing adjustments over the life of the program should be depoliticized as much as possible, though flexibility should be maintained to recognize that low energy prices have historically formed a key part of the Kingdom's implicit social contract.
- Reform objectives and planned mitigating measures should be clearly communicated to citizens and industry.

Using energy productivity as a guiding logic for energy price reform suggests that, on the one hand, energy prices should not rise beyond the level required to maintain Saudi Arabia's competitive advantage in energy-intensive industries. On the other hand, however, they should be close enough to international reference prices to incentivize energy efficiency and enhanced development of higher value-added downstream industries.

The transition to an automatic energy price setting mechanism based on international reference prices, as opposed to the current administered arrangement, could be facilitated by setting up an independent body to administer either a moving average mechanism, or price band mechanism. Such schemes have been used elsewhere and could help provide some recognition of the historical social contract while devolving most technical decisions on prices to a more transparent market oriented process.

Energy efficiency in Saudi Arabia

Saudi Arabia has established a comprehensive energy efficiency program, the Saudi Energy Efficiency Program (SEEP), drawing on international best practice. This covers all major sectors of energy consumption, as well as prioritizing a range of institutional and capacity building aspects. This has included the establishment of a framework for an energy efficiency market involving energy service companies (ESCOs) and a range of regulatory measures to drive the market.

The industrial sector

The industrial sector, including the consumption of energy as a feedstock, or non-energy use, is the largest and fastest growing source of energy demand in the Kingdom comprising around 54 percent of total final energy consumption. This points to where some of the biggest gains from energy efficiency can be made – in the petrochemical sector, which is the largest industrial consumer. Benchmarking of energy efficiency in Saudi Arabia is currently being carried out for around 180 industrial plants in the petrochemical, cement and steel subsectors, involving 59 different production processes. These are the most significant energy-consuming industrial sectors. Aspirational goals have been negotiated for 2019 and overall these are expected to achieve a reduction of around 9 percent of total energy consumption compared with a 2011 baseline.

The transport sector

The transport sector accounts for around 30 percent of total final energy consumption in the Kingdom. While other countries, such as the U.S., have achieved a decoupling of economic growth and transport energy consumption, in Saudi Arabia they are linked virtually on a one-to-one basis. This suggests there is significant scope for energy efficiency in this sector. Improved urban planning, public transport and the implementation of energy efficiency vehicle regulations will play a key role. A ‘cash-for-clunkers’ program is one policy likely to have popular social appeal that could have a significant impact in improving energy efficiency in this sector.

The buildings sector

The residential and services sectors constitute around 16 per cent of total final energy consumption in Saudi Arabia, mostly reflecting energy consumed in buildings. However, given the low electricity prices in the Kingdom, there is little incentive for building owners to invest in energy efficiency. This will likely remain an issue, even after the announced price reforms are fully implemented. However, when the broader social benefits from avoided energy consumption, such as the reduced need to build new electricity generation capacity, are taken into account, energy efficiency investments are highly cost effective.

For example, an investment program of between $10 billion (U.S.) and $207 billion over 10 years could generate between 16,000 and 100,000 GWh/year in avoided energy consumption. This is valued at between $500 million and $10.5 billion per year in reduced energy bills, depending on electricity prices. In terms of avoided generation capacity, this program could provide between 3.7 GW and 22.9 GW, valued at between $2.8 billion and $17.2 billion in reduced capital expenditure (CAPEX). It is also estimated that it could greatly reduce carbon emissions, potentially delivering between 12 million and 76 million metric tons of CO_2 equivalent.

Employment and capacity issues

Implementing Vision 2030 will be as much a human challenge as an economic or technical one. The Kingdom plans to create some 1.2 million new jobs across a range of strategic sectors, including mining, renewable and atomic energy and ICT, among others.

There are currently around 30 million people living in the Kingdom, one-third of whom are expatriates. Half of all Saudis are under the age of

25. This makes addressing youth unemployment and providing good quality jobs a key issue. The Saudi Energy Efficiency Program offers an energy efficiency training course in five different engineering schools, having created an Energy Efficiency Technician degree and Certified Energy Manager qualification in conjunction with the National Power Academy and Association of Energy Engineers.

While it often receives less attention than renewable energy, the job creation potential of increasing energy efficiency is very large. KAPSARC estimates that up to 250,000 jobs could be generated from a deep retrofitting of the Kingdom's building stock alone. The skillset for energy efficiency is also much broader than that for renewable energy, further strengthening the potential contribution of capacity building in this area.

Looking to the future: Potential energy productivity pathways for Saudi Arabia

KAPSARC research suggests that a range of potential Saudi energy productivity pathways exist, ranging from stabilization at current levels through to an increase of around 30 percent by 2030. This compares with U.S. targets to double energy productivity by 2030 relative to 2014, and in Australia to increase it by 40 percent by 2030 relative to 2015.

The future for energy productivity will depend on the choices of policymakers, particularly in terms of economic diversification. While not mutually exclusive, two broad pathways are possible:

> A strong diversification strategy toward sectors such as health, education, IT, media and high-tech manufacturing, combined with strong energy efficiency measures, will have the greatest impact on energy productivity.

> Weaker diversification, emphasizing downstream energy-intensive industries and strong industrial energy efficiency, while still having the scope to increase energy productivity, will mean a lower energy productivity pathway.

Enhancing energy productivity would also strengthen the Kingdom's engagement around a number of key international sustainable development processes. For example, energy productivity has recently been adopted as a framework by the United Nations Sustainable Energy for All (SE4ALL) program. This involves a plan to double the growth rate of energy efficiency worldwide by 2030 in support of the Sustainable Development Goals (SDGs), particularly SDG7 on energy.

Enhancing energy productivity naturally also supports the Kingdom's greenhouse gas target of avoiding emissions of 130 million metric tons of CO_2 equivalent per annum by 2030 under the Paris Accord and related objectives within the Energy and Sustainability Working Group processes of the G20.

Saudi Vision 2030 and its supporting programs are aimed at achieving a substantive transition towards more sustainable growth – economic, social and environmental. Navigating a course toward reform may be easier if the value of improving energy productivity as a metric for measuring progress and supporting decision-making is recognized.

Fact Sheet: Energy Productivity in Saudi Arabia at a Glance

Saudi Arabia's Vision 2030 maps out a plan to move the Kingdom up the global ladder of leading countries from currently being ranked the 19th largest economy in the G20 to top 15 status by 2030. Plans are to achieve this through a combination of growing the economy, increasing jobs and expanding the share of private sector non-oil GDP from around 40 percent in 2015 to 65 percent by 2030. At the same time, some estimates suggest that without structural and energy efficiency reforms domestic energy consumption is set to double from current levels of around 4.4 MBOED to more than 8 MBOED, posing sustainability challenges. Increasing Saudi Arabia's energy productivity can help address this. Key facts drawn from this report as to how this can be done include:

Between 1990 and 2015 energy productivity rose in almost all major economies around the world, but in Saudi Arabia it fell by 29 percent as the strong expansion of energy-intensive heavy industry led growth in domestic energy demand.

Saudi Arabia has historically had very high energy productivity, significantly above the G20 average, due to the strong contribution of oil export revenues to overall GDP. The most recent data suggest Saudi Arabia's energy productivity is around $6,000 per metric ton of oil equivalent, which is roughly in line with the G20 average.

If the oil-based components of GDP are removed, Saudi Arabia's energy productivity falls by around 40 percent to just over $4,000 per ton of oil equivalent, just below that of China.

With this oil-based component removed, Saudi Arabia's energy productivity has remained roughly stable since 1990. This highlights the importance of accounting for structural change in oil-based GDP when calculating energy productivity for major energy exporters.

Enhancing energy efficiency in the economy by up to 4 per cent per year could avoid the consumption of as much as 1 MBOED by 2030. This could be worth between SAR 50 billion and SAR 100 billion per annum in extra revenue to the government depending on international oil market conditions. Depending on how revenue is used, it could lift GDP growth by between 0.3 and 0.6 percent per annum by 2030. Including avoided energy consumption from structural diversification would significantly increase these figures.

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. Impacts on overall inflation so far have been limited, partly due to a strengthening of the local currency.

The industrial sector accounts for 54 percent of total final energy consumption. The largest and fastest growing source of energy demand in the Kingdom, it is driven higher by strong production of petrochemicals, cement, fertilizer and steel production. Energy efficiency benchmarking is now being conducted for 180 plants, covering 59 different industrial processes, and is expected to deliver around a 9 percent reduction in industrial energy demand relative to a 2011 baseline.

Energy consumption in the transport sector is growing at one of the highest rates in the G20 and accounts for around 30 percent of total final energy consumption. It is increasing virtually on a one-to-one basis with economic growth, whereas in other G20 countries transport energy consumption and economic growth has largely decoupled.

Around 16 percent of total final energy consumption is consumed by the Kingdom's building stock. This comprises around 70 percent of total electricity consumption. A 10 year investment program of between $10 billion and $207 billion could generate between 16,000 and 100,000 GWh/year in avoided energy consumption, as well as improve the living standards of residents and productivity of workers. This would be equivalent to a reduction of between $500 million and $10.5 billion per year in energy bills, depending on electricity prices. In terms of avoided electricity generation capacity, such a program could provide between 3.7 and 22.9 GW, valued at between $2.8 billion and $17.2 billion in reduced CAPEX. It could also avoid emitting between 12 million and 76 million metric tons of CO_2 equivalent.

Under Vision 2030, the Kingdom plans to create around 1.2 million new jobs across a range of strategic sectors including mining, renewable and atomic energy and ICT, among others. There are currently around 30 million people living in the Kingdom, one third of whom are expatriates. Half of all Saudis are under the age of 25. Youth unemployment is over 30 percent. KAPSARC estimates up to 250,000 jobs could be created in the energy management sector, focusing on energy efficiency. The potential for employment generation is vast and exceeds that for renewable energy, though this often receives more attention.

KAPSARC research suggests that, depending on the diversification strategy pursued, a range of potential energy productivity pathways exist for Saudi Arabia, ranging from stabilization at current levels through to an increase of around 30 percent by 2030. This compares with U.S. targets of doubling energy productivity by 2030 relative to 2014 and Australian plans to increase it by 40 percent by 2030 relative to 2015.

Under its Nationally Determined Contribution to the United Nations Framework Convention on Climate Change (UNFCCC) under the Paris Accord on Climate Change, Saudi Arabia plans to avoid 130 million metric tons of CO_2 equivalent per year by 2030. Diversification, energy efficiency and renewable energy will contribute significantly to achieving this target.

Energy productivity has recently been adopted as a framework by the United Nations Sustainable Energy for All (SE4ALL) program. This involves a plan to double the rate of energy efficiency worldwide by 2030 in support of the Sustainable Development Goals (SDGs), particularly SDG7 on energy.

What is Energy Productivity?

Energy productivity is both a policy strategy focusing on how energy can best be used to create value in the economy, and an indicator which integrates economic growth with energy consumption.

At the macroeconomic level, energy productivity describes how much GDP can be produced using a specific amount of energy. It is thus both a reflection of the structural makeup of the economy between energy-intensive and non-energy-intensive activities, and of how efficiently energy is used in those activities right across the economy (Figure 1).

At the microeconomic level, energy productivity focuses on how much revenue is produced from economic activities per unit of energy consumption.

This is related to, but distinct from, energy efficiency, which generally focuses on how much physical output is produced per unit of energy consumption.

For example, Patterson (1996) states that energy efficiency generally refers to using less energy to produce the same amount of services or useful output. In the industrial sector, energy efficiency is thus typically measured by the amount of energy required to produce a metric ton of product. The issue then becomes how to precisely define the useful output and the energy input. This gives rise to a number of indicators which have been used to measure energy efficiency. Patterson groups these into four main categories:

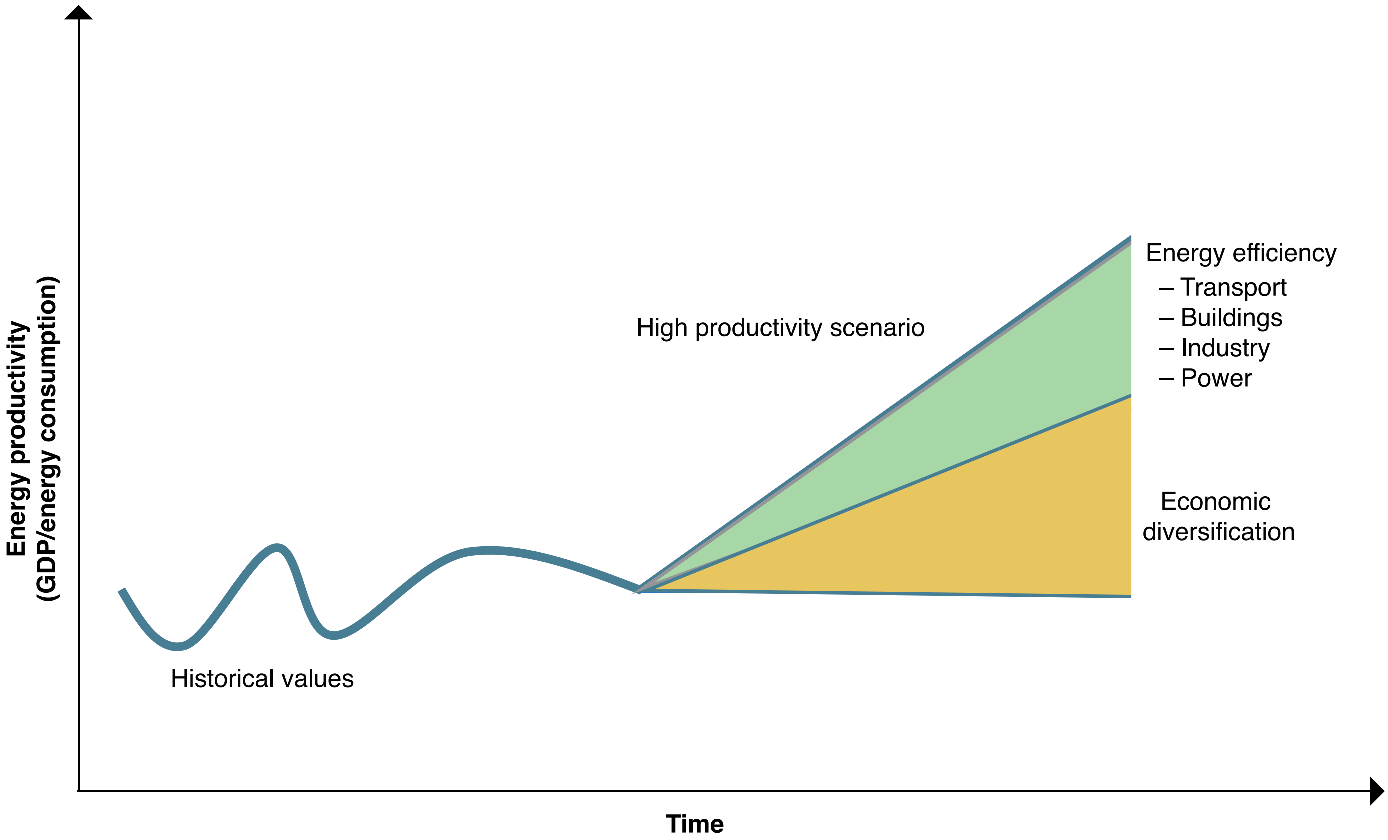

Figure 1. The key drivers of energy productivity.

Source: KAPSARC.

1. **Thermodynamic:** Usually expressed as ratios, these are indicators that relate actual energy use to an 'ideal' process.

2. **Physical-thermodynamic:** Hybrid measures where energy input is measured in thermodynamic units, but energy output is measured in physical units.

3. **Economic-thermodynamic:** Another hybrid indicator where the energy service – output – is measured in terms of market prices, and the input – energy – is measured in terms of thermodynamic units.

4. **Economic:** Both energy input and energy output are measured in terms of market values.

Using this typology, energy productivity, which relates GDP at the macroeconomic level or company revenue at the microeconomic level, to energy, can be thought of as an economic-thermodynamic indicator. Thus, energy-intensive industries, such as petrochemicals and cement, will tend to have much lower energy productivity than sectors such as aerospace, healthcare or automotive manufacturing, irrespective of how energy-efficient individual industries are within their subsector.

Several major countries, most notably Australia and the U.S., have recently set energy productivity at the center of their energy economic planning. The underlying aim of increasing the economic value of each unit of energy consumed is interpreted differently in different national contexts, to reflect national priorities. Emphasis on areas such as economic growth, job creation, regional development, infrastructure, energy access, energy security, electricity market reform, energy efficiency, pollution control and greenhouse gas avoidance, among others, varies across countries.

Managing energy productivity in China: Lessons for policymakers

The experience of China offers valuable lessons for countries looking to integrate energy productivity into their sustainable development strategy. More than any other country, China has used energy-intensity targets as the central objective in its development and climate policies. In order to better manage a period of falling energy productivity, or rising intensity, the country introduced both national and provincial level targets, backed up with sector targets and subsector policies that included rigorous monitoring and evaluation of performance in the highest energy-consuming industrial sectors (Howarth, et al. 2014).

In 2006, in its 11th Five Year Plan (FYP), China set an aggressive target of lowering energy intensity by 20 percent by 2010, relative to 2005 levels. After achieving this, in its 12th FYP it set a new target to reduce energy intensity by 16 percent, relative to 2010, by 2015. A 18.2 percent reduction was achieved. The current 13th FYP includes energy- and carbon-intensity reduction targets of 15 percent and 18 percent, respectively, by 2020, relative to 2015.

Energy related policy narratives have evolved over time, also reflecting different periods and contexts. For example, energy conservation emerged in the U.S. as a result of the 1970s oil crisis. This was demonstrated most famously when President Jimmy Carter appeared in a sweater encouraging people to turn down their heating. Energy efficiency followed, with priority given to ways of reducing the energy required by such things as cars, planes and industrial machinery. The emphasis was on the amount of energy used per piece of equipment per unit of output. On the whole economy scale, the use of energy intensity as an indicator to measure and manage the relationship between economic growth and energy consumption became popular, shifting the focus to how much energy is used per unit of output (GDP). Energy intensity targets have been used, most notably perhaps in China, where reducing the amount of energy consumed for a given amount of output has been the main objective.

Following the 2008 financial crisis, green growth and inclusive green growth became important policy narratives as countries struggled with recovering from recession, growing unemployment and weaker than desired economic performance.

Recently energy productivity, which is the mathematical inverse of energy intensity, has gained traction, particularly with energy economists, as an alternative indicator and more broadly as a policy strategy through which a range of energy and economic policies can be framed.

As an indicator, energy productivity describes how much value, usually measured in GDP, can be produced using a specific amount of energy, usually measured using total primary energy consumption. It reflects how much economic value is created from one barrel of oil or one British thermal unit (Btu) of natural gas. As a policy narrative, it has also been used to provide a framework for energy management decisions. For example, in Australia policymakers use it to focus on how to best support economic competitiveness and growth in energy policy areas as diverse as electricity market reform, greenhouse gas avoidance, the mining sector, freight and passenger transport and agriculture (Australian Alliance for Energy Productivity 2016).

Two broad aims are at the core of an energy productivity approach: improving energy efficiency and pursuing economic diversification to increase the value derived from energy consumption. However, as energy productivity has only really begun to be applied in the last few years as both a policy narrative and indicator, limited attention has been given so far to these issues.

While productivity in the domains of labor and capital has long been recognized as a driver of overall economic productivity and growth, energy productivity has received less attention. There is also increasing recognition that the major means of production are related to one another in terms of productivity and that, consequently, improvements in energy efficiency which involve the modernization of plant or equipment are likely to lead, at the same time, to improved labor and capital productivity. For example, improved energy efficiency can provide better energy services, which can provide better working conditions, such as lighting, air quality and thermal comfort, thus leading to higher overall economic productivity (IEA 2015).

For countries such as Saudi Arabia, where energy is a central driver for much economic activity, there is a strong case for focusing on energy productivity as a way to achieve more sustainable growth. This is particularly the case as avoided domestic energy consumption can increase both the amount of

What is the difference between setting energy productivity and energy intensity targets?

People have debated whether the difference between energy intensity and energy productivity is purely rhetorical. Some argue that energy productivity has a more positive connotation since it focuses on valuing the additional economic output, rather than the shrinking of energy demand (KAPSARC Energy Dialogue 2016). It should also be noted that energy productivity can offer a more straightforward means of comparison across countries at low levels of energy intensity. This is because, at that level, figures may appear to converge towards an asymptotic mean that can, in the long run, create an illusion of equivalent energy economic performance between countries. On the other hand, energy productivity provides numerically higher percentage changes as development and energy efficiency progresses, which allows policymakers to present their targets as more ambitious (KAPSARC 2014a). Energy productivity can also indicate a numerically 'better' performance with respect to a base year, in both relative and absolute terms, for countries that initially started from a less promising energy economic situation. Thus both energy productivity and intensity can give an 'obscured' impression of underlying changes.

For those for whom the primary goal of energy policy is reducing carbon emissions, energy intensity is likely to remain the preferred measure due to its emphasis on reducing energy consumption. Conversely, for those who put a premium on growth, energy productivity is likely to be the preferred metric.

It has also been suggested that there may be a difference in perspective between energy exporters, who view energy consumption growth more positively, and that of energy importers, who look to minimize their energy consumption as part of their energy security goals.

Some argue that people are used to using energy intensity and that this alone is reason to concentrate on this term. However, because energy productivity and energy intensity can be used to focus on different objectives – increasing growth on one hand and reducing energy consumption on the other – what might seem a simple technical distinction can attract a significant amount of debate, and even controversy, over which is most important for public policy.

energy available for export and the potential revenue for government to invest in broader economic growth strategies.

Achieving higher energy productivity results from adopting technologies which increase the size of the economy or improve business profitability, as well as those which reduce energy consumption, through energy efficiency and/or diversification strategies. It is important to see both these actions – promoting growth on the one hand and reducing energy consumption on the other – as key elements of an energy productivity agenda.

A broader view of energy productivity is being developed by the Climate Policy Initiative in conjunction with the South Pole Group and other stakeholders (Figure 2).

This puts forward the idea of 'integrated energy productivity' which incorporates the environmental as well as social benefits attached to energy use, in addition to the economic or 'traditional' components. While economic benefits can always be interpreted in a broader sense, by including these broader elements, the concept of integrated energy productivity applies a stronger focus to additional sources of economic value such as the health benefits from pollution reduction, or any positive employment effects from the development of higher value industries, as well as avoided greenhouse gas emissions.

In summary, energy productivity offers a rich, emerging policy framework by means of which governments can address a wide range of energy policy issues, as well as a specific indicator that can be used to guide energy solutions development. It extends from a narrow focus on how energy can best be used in the economy to maximize GDP through energy efficiency, industrial development and diversification policies, through to broader sources of value such as greenhouse gas mitigation, energy access, employment issues and the health benefits of air quality. Much like the concept of sustainable development, it is an idea which will be interpreted in different contexts in ways appropriate to the needs of the policymakers who use it.

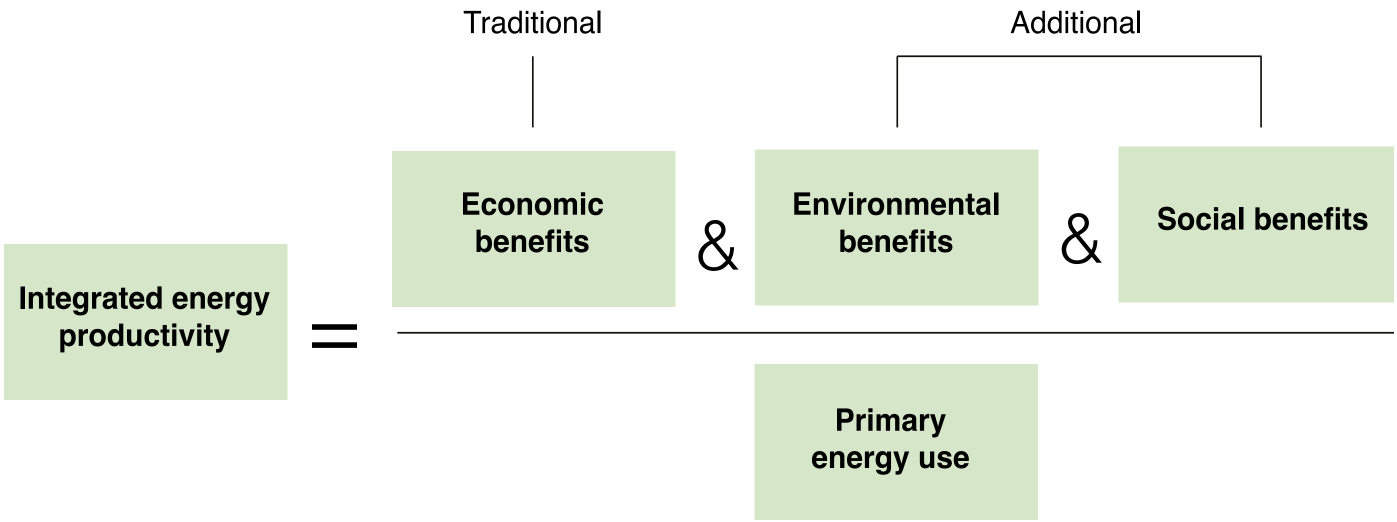

Figure 2. Integrated energy productivity.

Source: Energy Foundation China, based on Climate Policy Initiative.

How Does Energy Productivity Support Saudi Arabia's Vision 2030 and SDGs?

The beginning of the 21st century was a time of unprecedented growth. Saudi Arabia and the countries that make up the Gulf Cooperation Council (GCC) raced ahead, boosted by a commodities super cycle and booming government oil revenues (Figure 3). Today, with weak economic demand in most major economies, governments around the world are confronting the reality that the growth models of the past are no longer appropriate. This raises the question: What new economic strategies can help policymakers address the twin challenges of weak growth and long-term sustainability?

Confronting what could be an extended period of weak international growth and low oil prices, Saudi Arabia has intensified efforts to find a new growth model which will improve the welfare of citizens while reducing the country's economic reliance on oil. Figure 3 shows that while oil-based GDP has historically delivered impressive contributions to growth, it is very volatile and recently has substantially declined as a result of prolonged low oil prices since 2014. Shifting towards more sustained and sustainable growth has justifiably been a top priority for the government. The Kingdom's Vision 2030 is a roadmap for this economic transition.

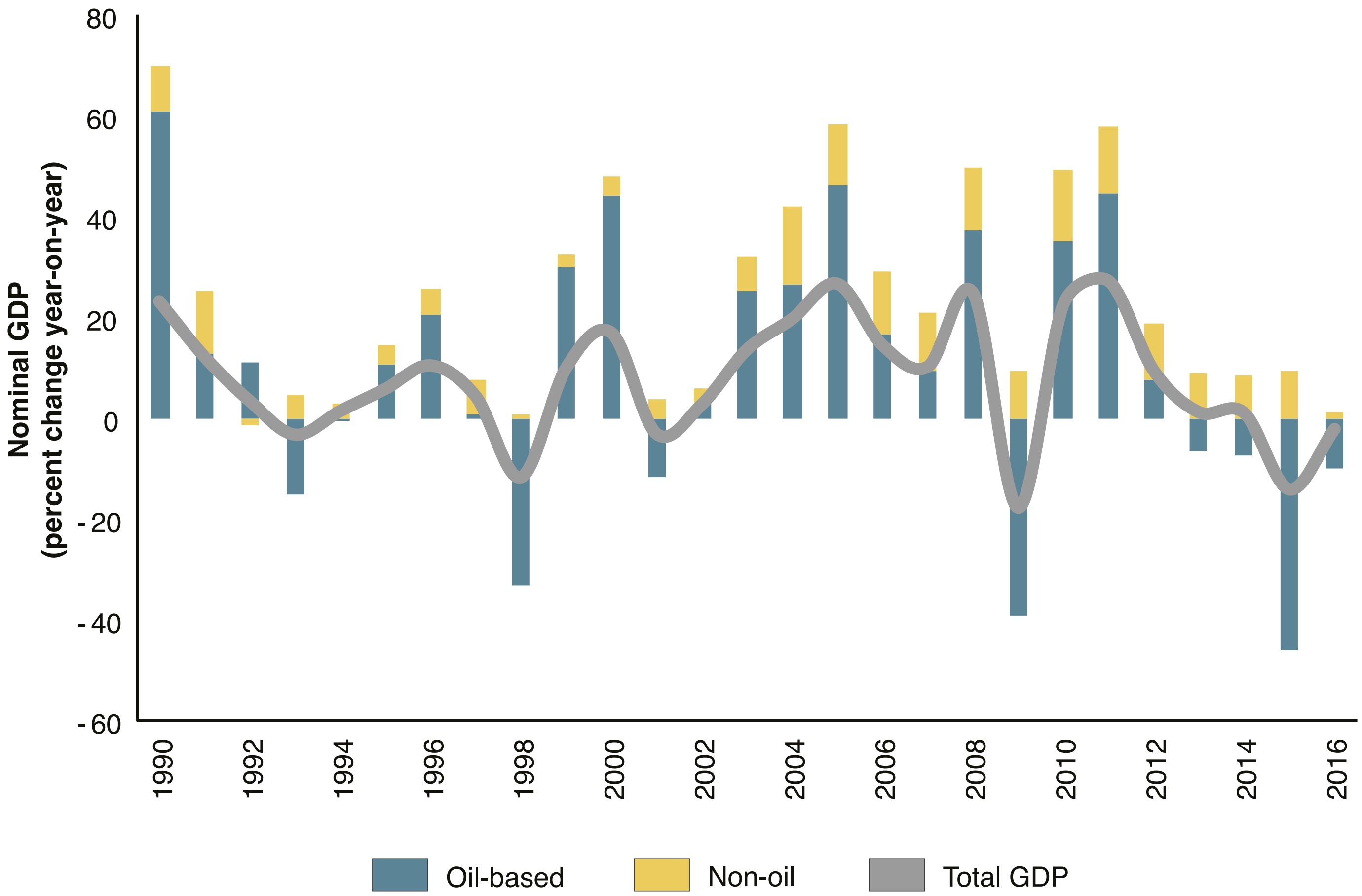

Figure 3. Nominal GDP growth 1990-2016 oil and non-oil (% year-on-year).

Source: KSA General Authority for Statistics.

Historically, in response to down cycles in the oil market, similar calls for reform were made. In the 1980s and 90s diversification responses were accompanied by cuts in government spending and plans for growth in non oil-sectors, but reforms became more muted as oil prices picked up and the fiscal pressure was reduced.

Vision 2030 is perhaps the most systematic response yet of these reform phases. It is driven by the growing recognition that the Kingdom's hydrocarbon resources are not sufficient to support the aspirations of a young and growing population. There are over 30 million people in the Kingdom, two-thirds of whom are Saudi, and there is a large expatriate workforce which fills a significant proportion of employment positions in most sectors. Half the population is under 25 and, to provide high quality employment options, new sectors of growth will need to be created beyond the capital-intensive upstream oil and gas sectors.

Climate change policies around the world have also led to a shift in the peak 'oil' discourse, away from peak availability and toward concerns over peak demand. Taken together, these issues give the current reform phase a sense of being backed by serious resolve.

To support the transition, the Kingdom's Vision 2030 is being implemented through a rollout of substantive subprograms. Major subprograms include: The Fiscal Balance Program, the National Transformation Program, the National Industrial Clusters Development Program, the Saudi Energy Efficiency Program and a renewable energy program. As part of these efforts, the Kingdom is announcing ambitious, public goals which are being transparently shared with the public to create a more open, diverse economy and an accountable system, less reliant on hydrocarbon resources. This includes a significant program involving the privatization of state-owned enterprises, support of the private sector, greater localization and reforms to provide an environment that is attractive to local and international investors. In addition, these plans also have a strong environmental sustainability dimension which will deliver significant greenhouse gas avoidance co-benefits through a combination of energy efficiency, structural diversification and renewable energy investments, among other measures.

In the energy sector, the Kingdom has taken great steps toward prioritizing energy efficiency through the Saudi Energy Efficiency Center, and more recently through its plans for the implementation of 9.5 GW of renewable energy by 2023. However, beyond these programs, what Saudi Vision 2030 means for the overall energy sector is less clearly mapped out. Since domestic energy consumption is expected to roughly double by 2030, it will be very important to closely manage the relationship between growth and energy consumption. This report makes the case for using energy productivity as an indicator and policy strategy to fill this gap, particularly in the area of industrial strategy.

Energy productivity is both a policy agenda, focusing on how energy can best be used to create value in the economy, and an indicator which integrates economic growth with energy consumption. At the macroeconomic level, energy productivity describes how much GDP can be produced using a specific amount of energy.
It is thus both a reflection of the division of the economy between energy-intensive and non-energy-intensive activities, and of how efficiently energy is used in those activities.

Between 1990 and 2015, energy productivity rose in almost all major economies around the world, but in Saudi Arabia it fell by 29 percent (Figure 4). This drop was in part due to Saudi Arabia's stage of economic development, with per capita energy consumption rising from a relatively low base. The Kingdom has also had historically very high energy productivity, lifted by a high proportion of GDP from oil production. As oil extraction generates a lot of revenue for the amount of energy required to produce it, this meant that Saudi energy productivity was exceptionally high in the 1980s and 90s by international standards. Now, if we strip away the oil based components, we see there has been little change in overall energy productivity in the Kingdom since 1990. Without including oil revenues, the absolute level of energy productivity is around 40 percent lower, and well below that in the U.S., which has similar per capita energy consumption. This highlights the importance of distinguishing the oil and non-oil components of GDP when using energy productivity, or energy intensity, as a metric for major energy exporting countries.

More recently, as the non-oil sectors of the economy have expanded, the expansion of energy-intensive heavy industry has acted as a downward force on energy productivity. The downward pressure on

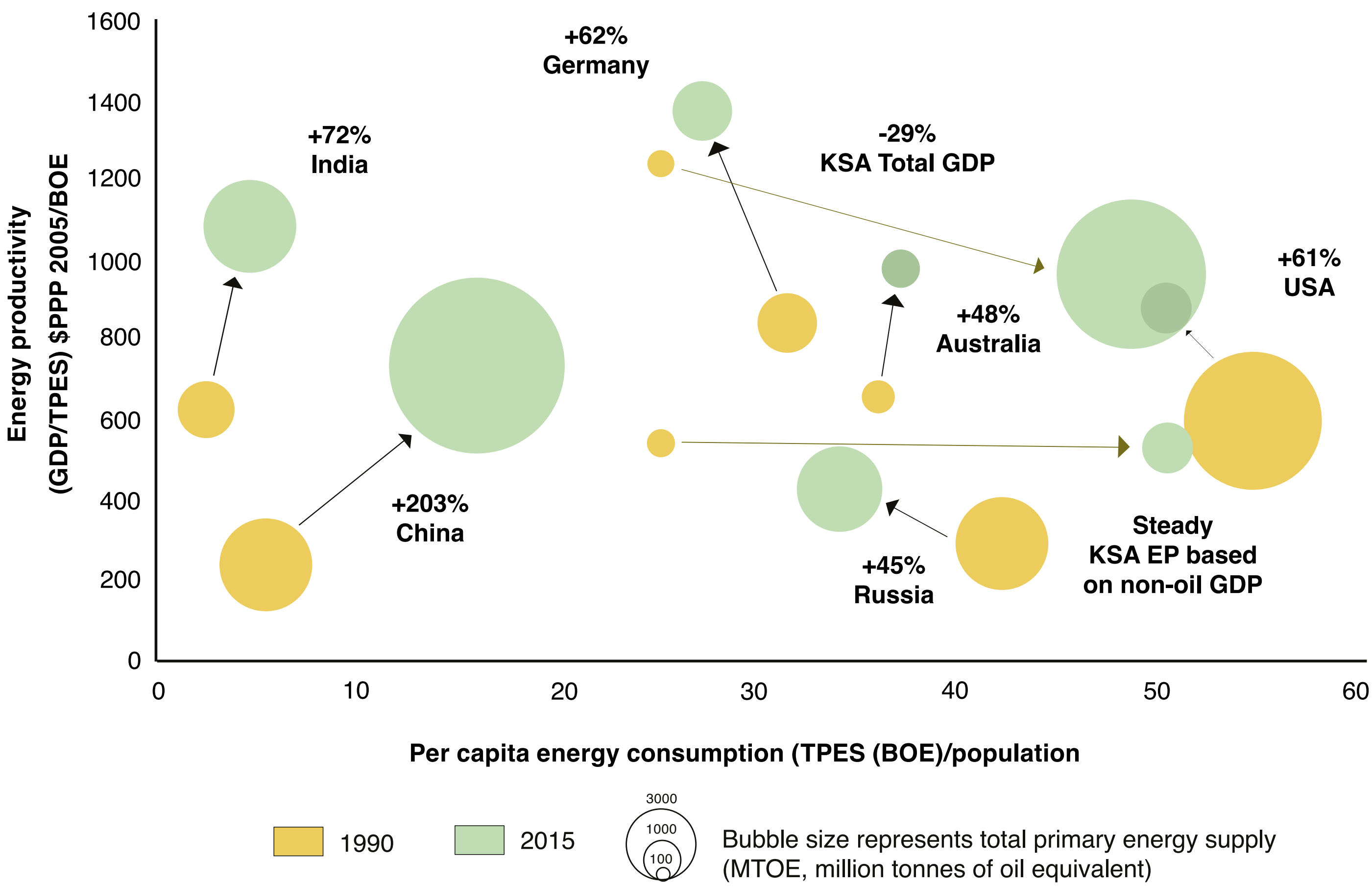

Figure 4. Global shifts in energy productivity: An indicator for diversification and energy efficiency at the national level.

Source: KAPSARC, based on International Energy Agency (IEA) and Enerdata databases.

energy productivity has also been influenced by very low domestic energy prices that have encouraged growth in the production of energy-intensive basic commodities, particularly petrochemicals, and discouraged energy efficiency.

Examining a few of these shifts in greater detail (Figure 5), we see that Saudi Arabia has had some success in stabilizing a declining trend in energy productivity since 2001-03. This reflects a period of massive infrastructure expansion, which both boosted GDP and helped modernize the economy. Such modernization is also typically associated with improving energy efficiency in the overall capital stock, as old or obsolete technologies are replaced by newer more efficient ones (Dubey, et al. 2016)

In addition, the Saudi Energy Efficiency Center (SEEC) was established in 2010 and has made significant progress in building institutional capacity around energy efficiency and implementing major energy efficiency initiatives. In 2012, to coordinate all government action, SEEC led the establishment of the interagency Saudi Energy Efficiency Program (SEEP), which set out guiding principles with a clear strategy for improving energy efficiency, focusing on industry, buildings and transport, covering more than 90 percent of energy consumption.

While SEEC's achievement in terms of stabilizing the Kingdom's energy productivity has been substantial, particularly given the low domestic energy price environment, it is important to view it in its international context (Figure 5). In almost all

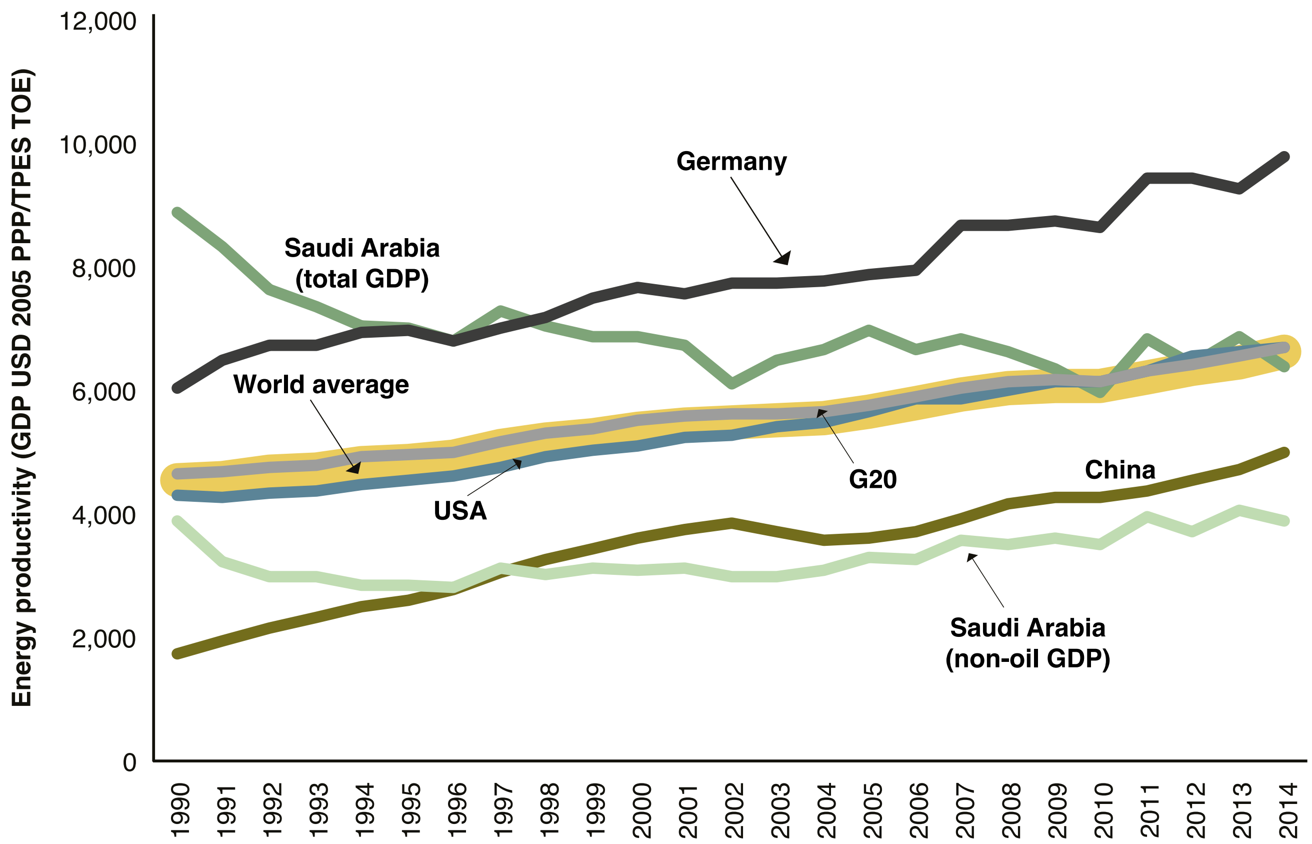

Figure 5. Energy productivity in KSA and global trends.

Source: KAPSARC, based on KSA General Authority of Statistics and IEA and Enerdata databases.

major economies' energy productivity has been increasing and between 1990 and 2014 the G20 and world average energy productivity rose by around 50 percent. While it should be recognized that Saudi Arabia's energy productivity is now the same as the world and G20 averages, it has not been moving in line with global trends and it is boosted by oil production, which accounts for around 42 percent of total GDP.

Comparison with China is particularly interesting, since even though it is a rapidly growing, developing economy dominated by energy-intensive industry, it has managed to grow its economy at a faster rate than its energy consumption over most of its recent history, and at a pace exceeding that of the Kingdom. The lessons from this for Saudi Arabia have been investigated in greater detail by KAPSARC in 'Managing China's energy productivity potential: what are the lessons for policymakers' (Howarth et al. 2014) and are the subject of ongoing collaboration between KAPSARC and the Energy Research Institute of China's National Development and Reform Commission (see KAPSARC Workshop Brief: 'How to Achieve Economic Prosperity Through Industrial Energy Productivity Improvement'). A key lesson from this experience is how China used energy intensity targets at the core of its economic planning to help drive energy efficiency and structural change in the economy.

The structural shift in the economy toward or away from energy-intensive industry, as well as the relative contributions of growth in the overall scale of the economy and underlying energy efficiency, can be examined through a Fisher decomposition of non-residential energy consumption, or, in other words, the sectors which generate value-added (Figure 6).

Here we see that the primary driver of the strong growth in energy consumption from value-added activities (in blue) between 1990 and 2014 has been growth in the overall size of the value-added sectors of the economy (scale, in grey), combining with strong growth in energy-intensive industries (structural change, in yellow).

Slowing this rise in energy consumption, there has been an improvement in the energy efficiency of economy, which started to gather pace from 2003 onwards (shown in green). While the scale and composition effects far outweigh the avoided energy consumption from the energy efficiency effect, this analysis suggests that the modernization associated with the infrastructure investment and energy efficiency programs over the last decade has had a positive effect in avoiding domestic energy consumption.

To understand the dynamics of energy productivity, and in setting targets, it is crucial to recognize that development by its nature is a process which will typically go through different phases (Figure 7).

With Figure 7, we introduce the Kuznets hypothesis (see also Figures 9 and 10.) When related to energy, this hypothesis suggests that, at early stages of economic development, per capita energy consumption is likely to be very low reflecting low levels of income, consumption, industrialization and access to modern energy services such as heating, cooling, entertainment and transport.

This 'inverted U' shaped behavior seen in Figure 7 arises in part because overall per capita energy consumption is a weighted average of the energy consumption within each sector. Structural changes in the economy are a major driver of

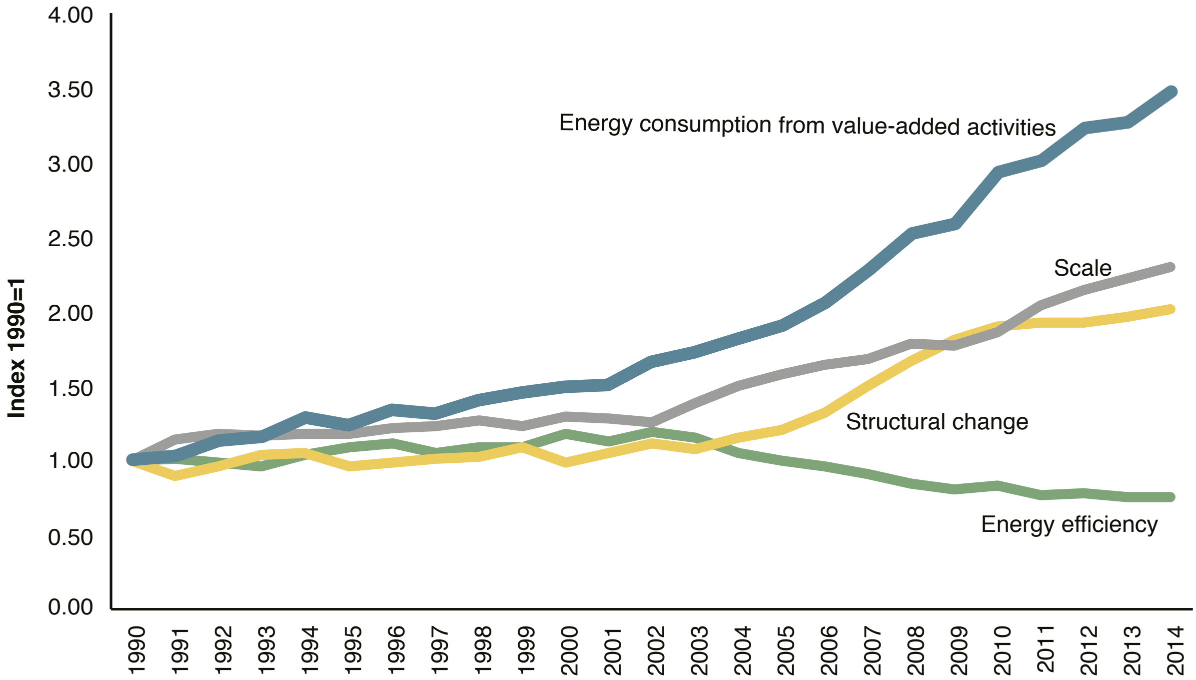

Figure 6. Drivers of energy consumption from value-added activities in Saudi Arabia.

Source: KAPSARC, based on IEA, UNSTAT databases.

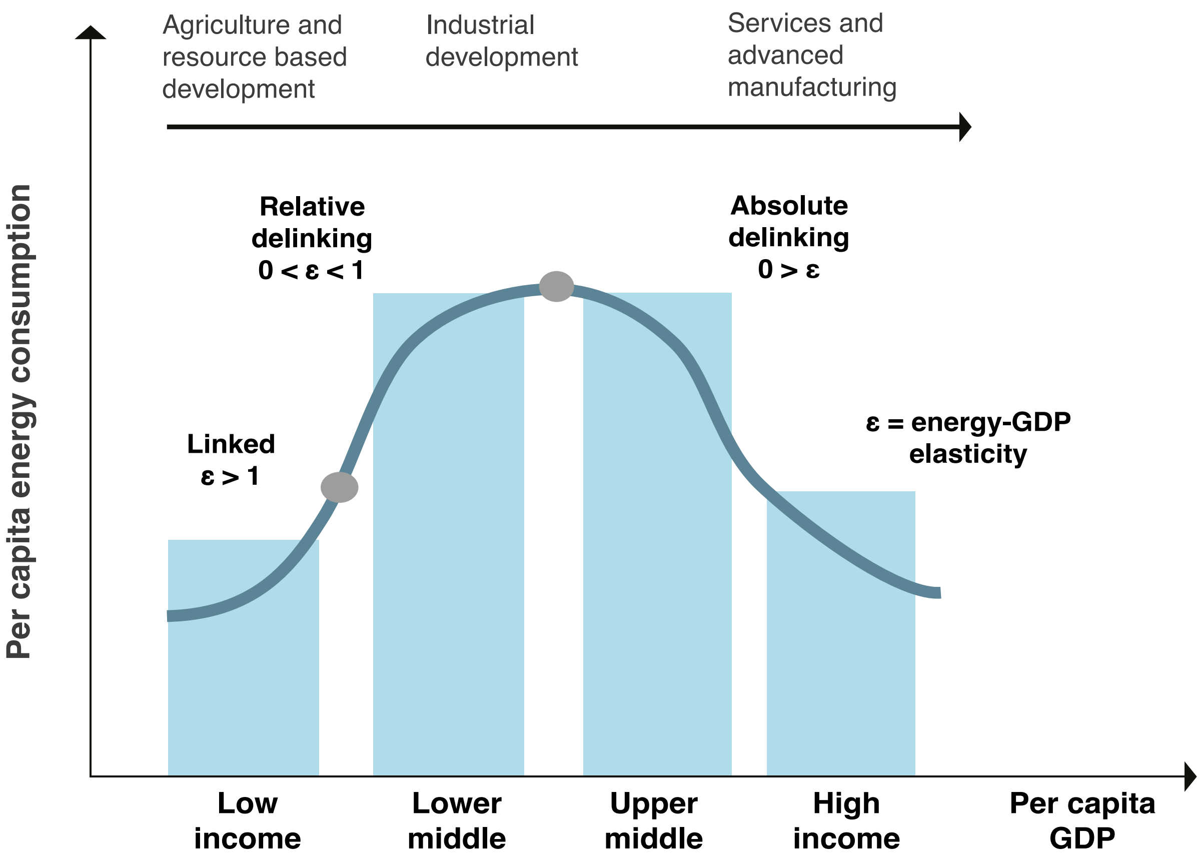

Figure 7. Transition pathway for per capita energy consumption and development.

Source: KAPSARC, based on Kuznets 1971; Galeotti, Howarth and Lanza 2017.

the dynamics of energy-GDP elasticity over time. Figure 8 extends Figure 7 to illustrate some generalized relationships in per capita energy consumption and per capita income for the main energy-consuming sectors.

The key sector driving this energy-GDP relationship is the industrial sector, which shows the greatest shift between low income and high income. In the initial stages of development, the industrial sector grows faster than the other sectors. It then declines as per capita incomes grow and consumer durables – such as air conditioners, refrigerators and cars – and consumer services, including health, education, restaurants and retail, take up a larger share of economic activity. Heavy industry and the production of basic commodities like steel and cement are also activities that tend to be features of countries experiencing rapid development of new infrastructure. As economic development progresses, industrial energy demand is likely to fall as demand from infrastructure expansion declines and industrial activities become more sophisticated. In addition, as countries grow richer and prioritize issues such as air pollution control and greenhouse gas avoidance, there may be a shift away from

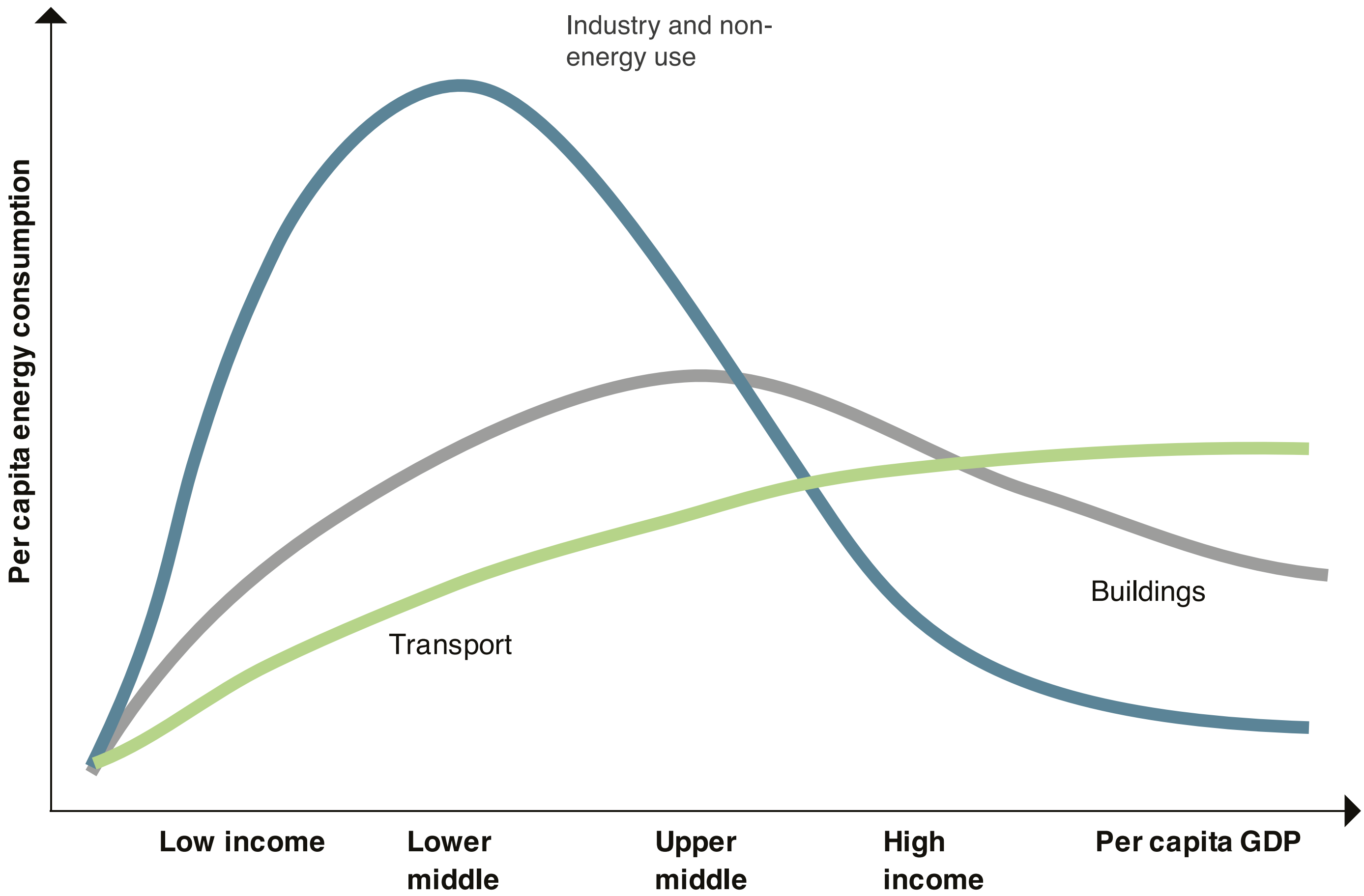

Figure 8. Transition pathways for sectoral energy consumption.

Source: KAPSARC, based on Medlock and Soligo 2001.

producing to importing energy-intensive products, which can amplify this transitional effect in the industrial sector.

As per capita incomes grow and households become saturated with energy-consuming durable goods, the energy-GDP elasticity in the buildings sector falls below one. For example, even if air conditioners are operated 24 hours a day, the per capita growth in energy they consume should eventually reach some upper bound. From that point, advances in technology leading to greater energy efficiency will tend to reduce per capita energy consumption in that sector, putting downward pressure on elasticity. However, one factor working against this saturation effect in the buildings sector is the tendency of people, as their incomes rise, to want to live in larger spaces, which require more energy to heat or cool.

The transportation sector faces similar effects, once the number of vehicles per capita reaches the number which satisfies the population's basic mobility requirements and the number of cars that can be driven. From then on, as per capita incomes grow, the opportunity cost of time also increases and individuals are likely to try to reduce the amount of time spent in transit. One factor that may work against the efficiency saturation effect in the transport sector is the rise in air travel, which typically grows with increasing income and wealth.

In Figures 9 and 10 we take the Kuznets hypothesis

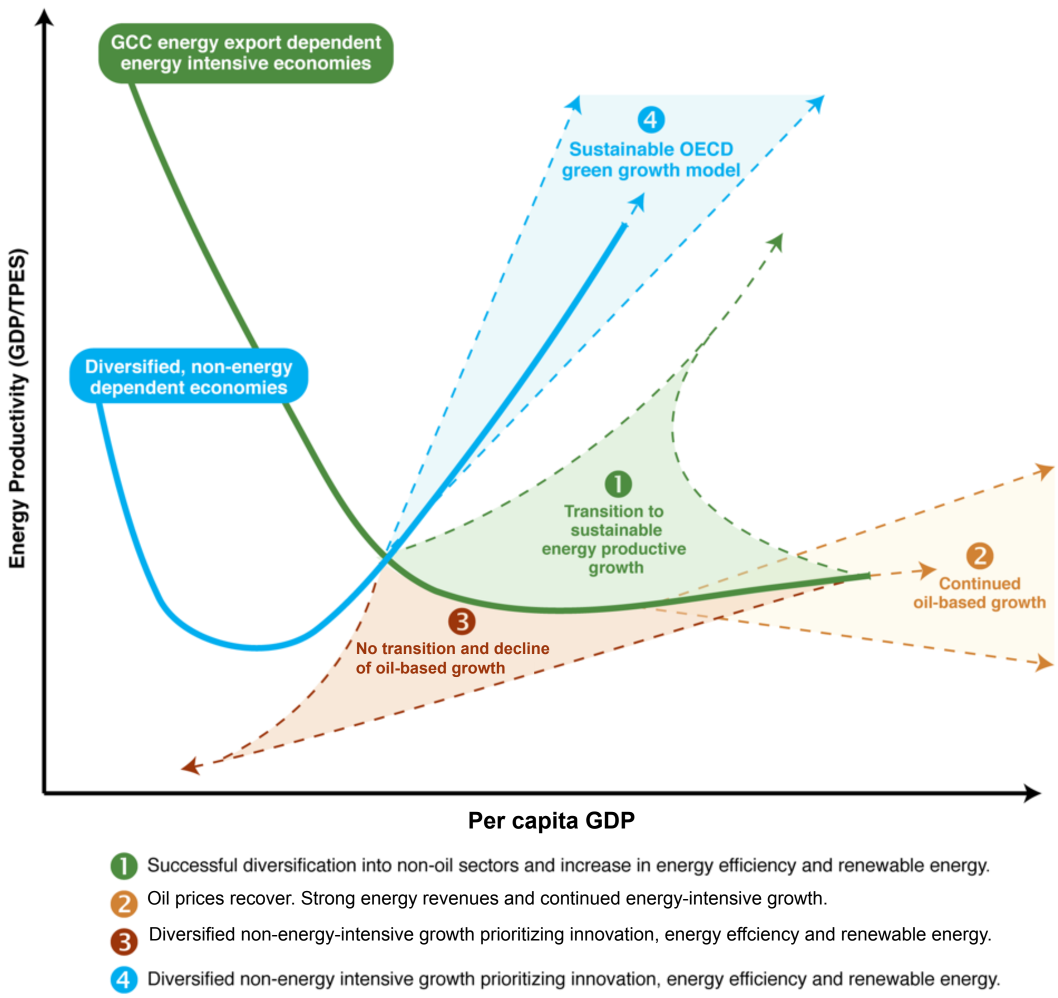

Figure 9. Energy productivity growth models within a Kuznets curve framework.

Source: KAPSARC, based on Galeotti, Howarth and Lanza 2016.

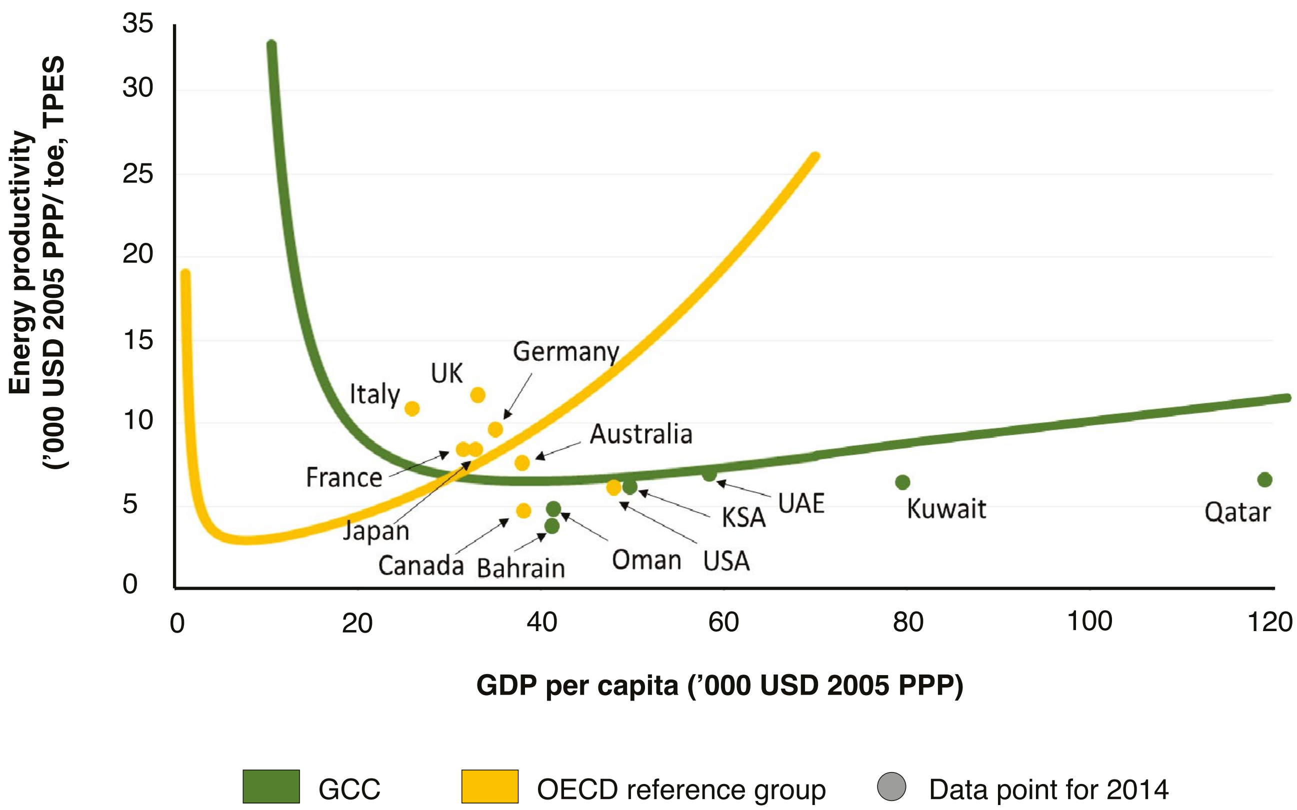

Figure 10. Energy productivity Kuznets curve for GCC and selected advanced economies (1971-2014).

Source: Galeotti, Howarth, & Lanza 2016.

forward within an energy productivity framework. These two charts should be viewed together to show, on the one hand, a generalized set of relationships and possible future scenarios based on our theoretical expectations (Figure 9), coupled with and informed by our empirical observations (Figure 10).

At the early stages of development when the economy is small and energy consumption is relatively low, energy productivity is likely to be high. This is because of the relatively low level of energy-intensive industrialization combined with lower incomes and consumption of energy services. In oil exporting countries we might expect this to be more pronounced because these countries are likely to benefit from higher GDP, and thus higher energy productivity, as a result of oil revenues in the initial stages of development (Figure 9).

As the economy grows, per capita energy consumption increases, along with the installation of new infrastructure and industrialization. This is an energy-intensive process, and the Kuznets hypothesis suggests that we should expect energy productivity to decline during this period, (shown in the downward sloping, left hand part of the curve in Figure 9).

As the economy matures and diversifies and industries move up the value chain of production into a wider range of sectors, including advanced manufacturing and services, the Kuznets theory suggests the level of energy consumption per unit of GDP will start to decline as per capita incomes rise. Energy productivity will enter a phase where it rises with per capita incomes (indicated by the upward sloping, right hand part of the curve in Figure 9). In energy rich or producing countries, we might also expect this transition to be shallower than in energy poor or consumer countries, due to the relative abundance of energy and low energy prices which make specialization in energy-intensive industry more likely.

Policy is also a key driver of this hypothetical Kuznets curve behavior. As per capita incomes rise, we can expect the quality of economic governance to improve as a wider range of social services – including education, health and environmental considerations – is demanded by citizens. Such progress is also likely to lead to stronger diversification and energy efficiency policies, which boost energy productivity, as well as a range of other socio-economic indicators of progress.

For diversified, non energy revenue-dependent countries, such as those in the OECD, a high energy productive development pathway (the sustainable OECD green growth pathway in Figure 9) is likely already to be largely locked in place through policies and economic structures which have prioritized less energy-intensive growth by means of high domestic energy prices and energy efficiency regulations. In this case, the transition to higher per capita income and high energy productivity will likely be relatively consistent with past historical experience (suggested by the solid blue line).

However, for this group of countries, there may be another possibility, apart from the sustainable 'green growth' future. Weak economic growth, or even recession, could mean that instead of moving up the curve, countries stagnate, or move down into the bottom section of the Kuznets 'U'-shaped curve.

For the oil-based economies of the GCC, we have outlined (Figure 9) three hypothetical growth pathways within this framework. These countries enjoy much higher per capita incomes than their OECD counterparts, but face risks and concerns around the long-term sustainability of this growth model. This could be due to any one or a combination of:

- Increasing population, which puts downward pressure on per capita income and lifts domestic energy consumption.
- Declining oil or gas export revenues, resulting from international energy price volatility.
- Carbon constraints, reducing international demand for energy exports.
- Rising domestic energy consumption, reducing the proportion of energy production available for export and the government revenue required to fund public investment to drive growth.

Such concerns are drivers of the economic diversification and transformation plans in the region which, if successful, are likely to lift energy productivity and move these countries into transition zone 1 of 'Sustainable energy productive growth' in Figure 9.

Another development model is illustrated by growth pathway 2, 'Continued oil-based growth' (Figure 9). In this growth paradigm, energy export revenues continue strongly, supporting high per capita incomes, driven by high energy prices and production levels. Reforms to diversify the economy move slowly in this scenario, industrial development remains on a highly energy-intensive path and energy productivity remains low.

The final, and least desirable, development model is shown by zone 3, 'No transition and decline of oil-based growth' (Figure 9), where declining energy export revenues lead to falling per capita incomes. In this model, diversification efforts have not achieved any fundamental structural shift in the economy and growth remains largely dependent on oil exports and predominantly low value-added energy-intensive industrial activities. In this scenario, citizens' social welfare will be significantly diminished.

Figure 10 presents the results of an empirical investigation of these theoretical Kuznets curve growth models. Two groups of countries are analyzed: the six countries of the GCC and a selection of advanced, diversified OECD economies. The two curves reflect the econometric relationship within these groupings over the last 43 years, with the last data point for 2014 included for illustrative purposes (Galeotti, Howarth, & Lanza 2016).

This empirical work supports and has informed the generalized relationships presented in Figure 9. It highlights in a striking way how GCC countries have achieved very high per capita income levels relative to the reference group of OECD countries through a combination of high oil prices and hydrocarbon revenues, which have unambiguously led to great social and economic progress in the region.

The question facing GCC governments, including Saudi Arabia, is to what extent it will likely be possible to continue to use energy export based growth to sustainably drive economic development. For those countries which are very energy rich, with vast energy reserves and small populations, like Qatar and to a lesser extent Kuwait, it may be possible to maintain higher per capita incomes for some time, following an oil-based growth paradigm (pathway 2 in Figure 9). However, the pressures to move from an energy dependent growth model to an alternative will be greater for those countries where:

- Populations are larger and growing faster.
- Per capita incomes are already lower.
- Energy resources are less abundant.
- Domestic energy demand is large relative to production.

In this respect, the UAE and Saudi Arabia are relatively well positioned to move to a higher per capita income and energy productive growth paradigm, while Bahrain and Oman are in more difficult positions with lower per capita incomes.

It will likely be easier to move to a new growth model from a position of strength than to wait until per capita incomes have fallen so far that social pressures create an environment requiring more abrupt shifts. Attempting far-reaching reforms when public budgets are under pressure will likely not have as good a chance of delivering against diversification goals, or of creating new opportunities for employment and generating national wealth, than would have been possible in times of greater strength. This underscores the imperative to press forward with diversification efforts, even if international energy prices rise again and fiscal pressures ease.

These dynamics can be seen in greater detail in Figures 11-13 which illustrate indices for sectoral energy consumption and GDP for a selection of developed and developing countries alongside Saudi Arabia.

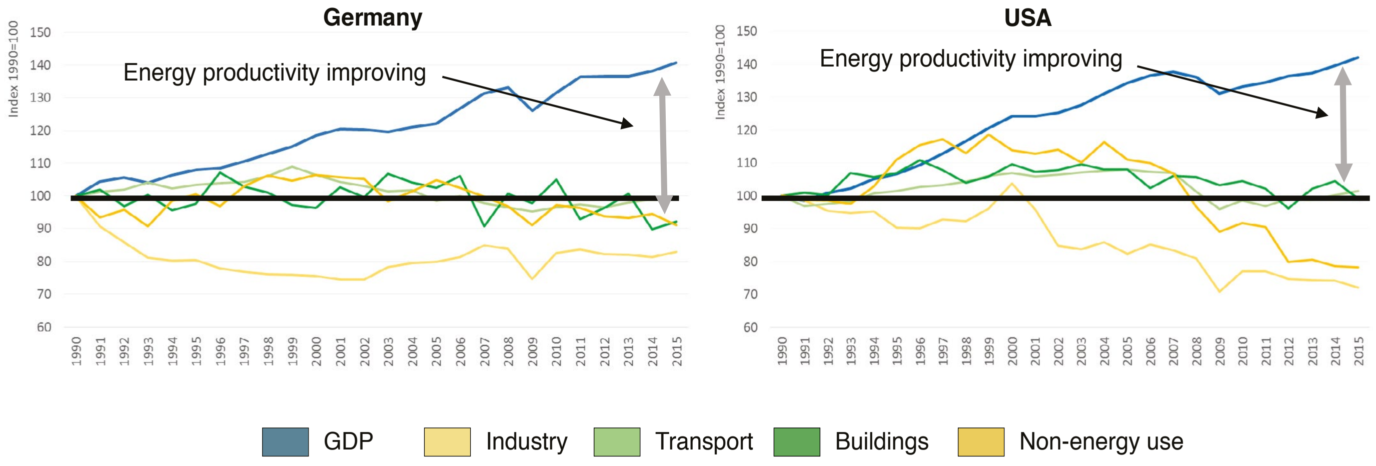

Figure 11. Absolute decoupling: GDP growing while energy consumption falls.

Source: KAPSARC analysis, based on IEA data.

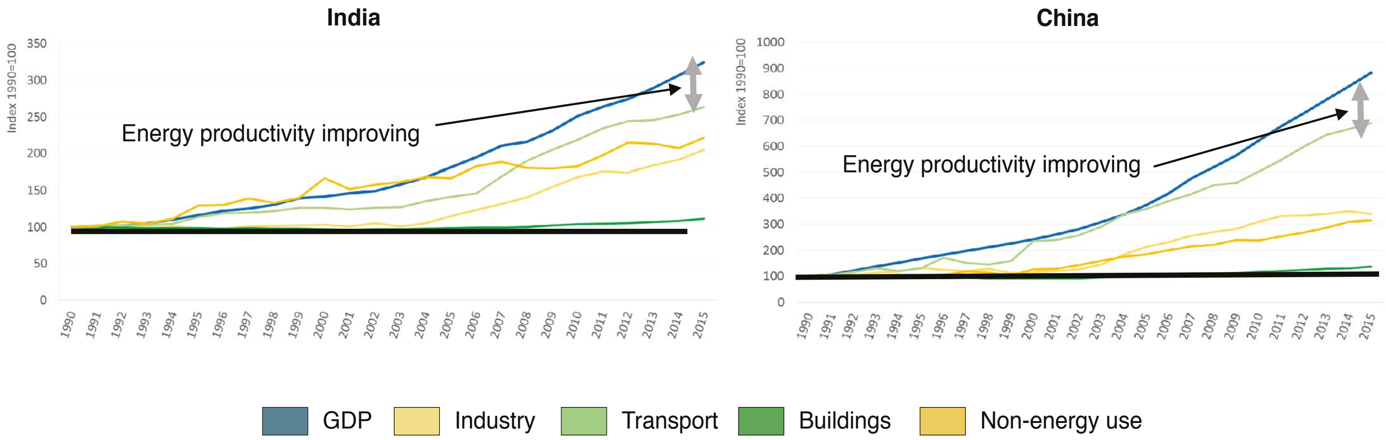

Figure 12. Relative decoupling: GDP rising faster than the increase in energy consumption.

Source: KAPSARC analysis, based on IEA data.

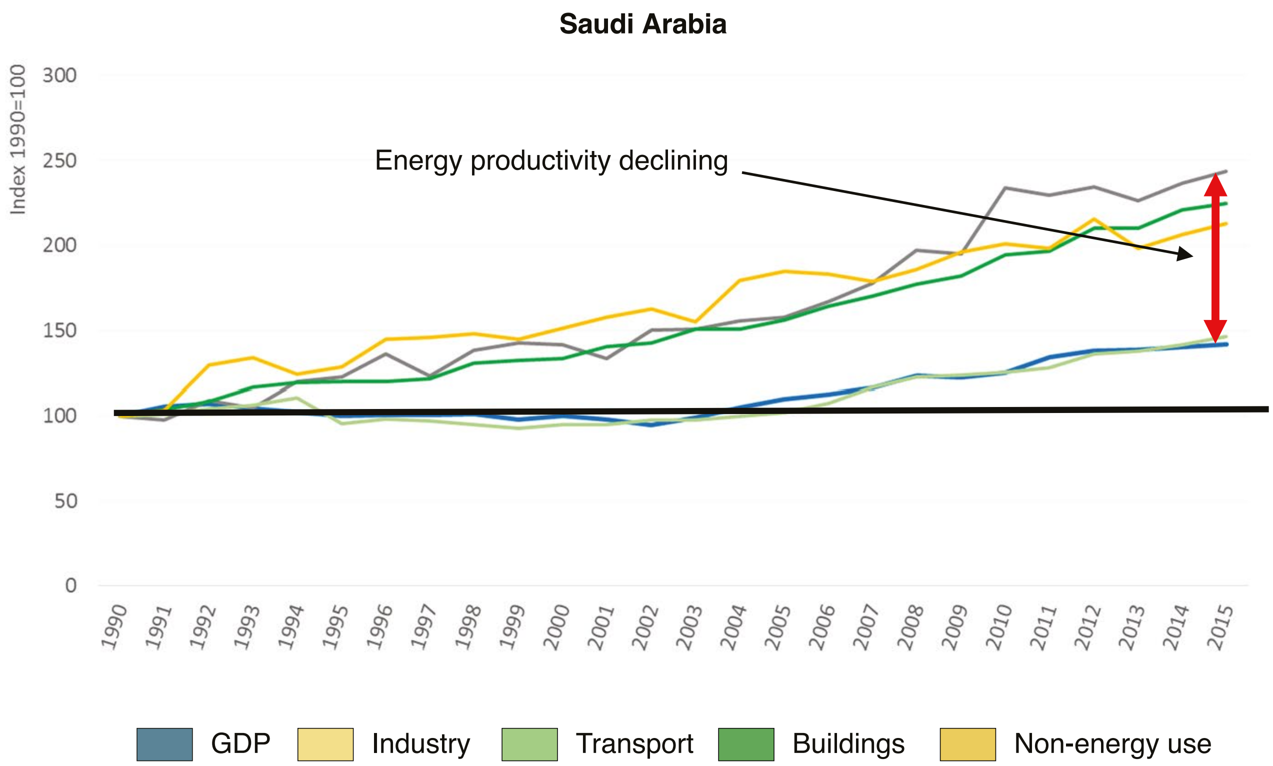

Figure 13. Not decoupled: energy consumption increasing faster than the increase in GDP.

Source: KAPSARC analysis, based on IEA data.

This clearly shows the three different growth paradigms: absolute delinking, where GDP is rising and energy consumption is falling (in Germany and the U.S.); relative delinking, where both GDP and energy consumption are increasing, with GDP rising faster than energy (in India and China); and not decoupled, as is the case in the Kingdom, where energy consumption is increasing faster than economic growth.

The core elements of what will be required to achieve this decoupling of energy consumption and economic growth and increasing energy productivity were set out earlier (Figure 1). The decoupling was the result of two main drivers: the overall energy efficiency of the different sectors of the economy, and the division of the economy between the production of basic energy-intensive commodities and higher value-added manufacturing and services such as health and education.

Saudi Arabia's Vision 2030 has already identified many of these issues as key elements of its domestic economic and energy reform agenda, which sets out a methodology and roadmap for economic and developmental action, establishing the Kingdom's directions, policies, goals and objectives. Many of the core elements of Vision 2030 will shift the country toward more energy-productive growth by boosting GDP and restructuring the economy away from oil-based sectors. However, while these plans identify many key indicators, several targets still need to be set out. There is also space for additional indicators that can better coordinate the energy sector's role in delivering on the established economic directions.

In this context, energy productivity pathways could assist with mapping the desired future course of industrial development and provide a national level focus for improving energy efficiency. A collaborative effort to develop energy productivity targets could also help coordinate actions across government around a shared goal.

Besides serving as an indicator, energy productivity can also provide a decision-making or investment framework to assess the desirability of different development projects, aligned with the government's specific development goals and strategies. These could be stimulating non-oil economic growth and investment, providing local employment or reducing carbon emissions.

In the following sections, this report explores the potential macroeconomic benefits from increasing energy productivity. It also describes how energy productivity can be used as a framework for understanding some of the Kingdom's main energy economic policy objectives and helping inform their attainment.

The Macroeconomic Benefits of Energy Productivity Investment

Two main factors affect energy productivity: the underlying energy efficiency of the economy and its structure. Improving the economy's energy efficiency without any change in its structure will improve energy productivity. Diversifying away from energy-intensive – low energy productivity – industries to less energy-intensive, or higher energy productivity, sectors will also improve energy productivity. Programs to improve productivity should target both energy efficiency and diversification.

Table 1 details four investment categories that improve energy productivity. In the first three, investment is focused on refurbishing existing assets and replacing old assets with new ones, while leaving the structure of the economy largely unchanged. This includes improving energy productivity in energy-intensive industries.

Energy efficiency driven retrofits. This includes retrofitting existing buildings, industrial processes, transport systems or energy systems with the primary purpose of improving energy efficiency. The expenditure in these cases is mainly on energy efficiency equipment and systems.

Modernization of existing assets. This includes refurbishing existing buildings, industrial processes, transport systems or energy systems where the primary purpose is not energy efficiency, but other aims, such as the need to bring old buildings up to modern standards or to improve reliability. In these cases, opportunities to maximize energy efficiency should be exploited to avoid locking in high energy use for the life of the project.

New assets. This includes investments in new buildings, industrial processes, transport systems or energy systems for the existing structure of the economy. In this case the primary purpose is not energy efficiency, but the value or outputs that come from the new building, process or system. New buildings or processes are typically more efficient than older ones, but there are still opportunities to maximize efficiency.

Improving end use energy efficiency can bring direct and valuable benefits in the energy supply system. This is particularly evident in that system, but it also applies to fuel supply. Energy efficiency and demand response programs can reduce power demand, particularly at times of peak demand, and also increase system reliability.

Reducing power demand through energy efficiency can also reduce or defer the need for capital expenditure on new energy generation, transmission and distribution infrastructure. In addition, energy efficiency can also reduce the need for 'hot standby' power plants that, by their nature, continue to consume fuel when they are not called on by the system. Energy efficiency has the potential to become a resource for the electricity system that can be utilized in the same way as power plants.

These benefits occur at three levels. First, at the level of the individual or organization undertaking the investment, then at the utility level and, in the case of an energy-exporting country, also at the national level, where more production becomes available to export. Table 2 summarizes these benefits.

When end users create value in the electricity system by investing in energy efficiency, there is

Table 1. Energy productivity investment by category.

		Buildings and the built environment	Transport	Industry	Utilities
Energy efficiency investments	**Energy efficiency driven retrofit**	Retrofit building structure, systems and controls. Retrofit street lights to LED lamps.	Retrofit vehicles (e.g. aerodynamics, drive train).	Retrofit processes and buildings for energy efficiency reasons e.g. variable speed drives.	Retrofit power plant, transmission and distribution systems for energy efficiency reasons.
Mainstream investments	**Modernization: existing assets**	Refurbishment of a building to make it a modern working environment.	Refurbishment of existing vehicles for non-energy reasons, e.g. refurbishment of buses or trains.	Retrofit/ refurbishment of industrial processes for non-energy efficiency reasons e.g. quality, production output (incorporating some efficiency improvement).	Retrofit/ refurbishment of power plant, transmission and distribution systems for non energy efficiency reasons, e.g. reliability (incorporating some efficiency improvement).
	Modernization: new assets within existing industrial structure	New high efficiency buildings, near zero energy buildings or net energy positive buildings. New street lighting installations.	New high efficiency vehicles.	New high efficiency production plant using same process. New plant using new process for existing industries.	New high efficiency generation, transmission and distribution plant.
	Modernization: new assets driving structural change	Changes in urban planning. Use of buildings as part of the power grid, i.e. smart buildings and smart cities.	New vehicle types, e.g. electric cars, buses and trucks. Modal shifts, e.g. high speed rail links to reduce air transport.	New, less energy-intensive industries.	New technologies, e.g. renewables, nuclear, distributed generation, district heating and cooling.

Source: Dubey et al. 2016.

an argument for appropriate market mechanisms that return some of this value to the end user. This payment could take several forms including grants, access to lower cost capital or ongoing payments for delivered energy efficiency, such as an efficiency feed-in tariff.

Low energy prices lead to low levels of energy productivity in the economy. They also encourage energy-intensive practices and low value energy uses — the antithesis of encouraging energy productivity.

Table 2. Energy productivity benefits: organizational, utility and national value.

	Type of benefits	
Level of benefits	**Energy saved**	**Economic value**
Individual or organization level	Energy cost saving. Reduced exposure to energy price volatility.	Reduced need to expand energy supply infrastructure. Improved productivity through removing bottlenecks, etc. Improved employee satisfaction resulting from better working environment and sense of social responsibility. Better market positioning through being seen as environmentally conscious. Increased sales through increased foot traffic, natural lighting, etc.
Energy supply system level	Reduced primary energy input.	Reduced (or delayed) need to invest in new supply generation, transmission and distribution infrastructure.
National level	Reduced need to import fuel or electricity or reduced domestic fuel use in the case of oil-producing countries. Reduced need for energy subsidies where these are present.	Job creation. Reduced local pollution. Reduced greenhouse gas emissions. Creation of new industries/sectors with higher value-added or lower energy consumption.

Source: Dubey et al. 2016.

The transition to higher energy productivity in the GCC will require economic incentives to encourage higher value uses of energy. Energy price reform has received much attention. Regulations and standards will also play an important role, but they require substantial bureaucratic organization and strong implementation capacity.

The distribution of energy efficiency benefits among end users, the energy system and the national government is very different in the GCC from many other countries. Low domestic energy prices mean that energy efficiency measures are not economic at the organizational level. Nonetheless, a barrel of oil that is not consumed domestically could be sold internationally, creating a large potential benefit at both system and national level from investments enabling reduced domestic consumption. Reducing electricity demand through energy efficiency also has a significant benefit at the utility system level, in terms of lower capital expenditure requirements.

To correct for the imbalance in value, the government could provide a financial payment to individuals and organizations that undertake energy efficiency investments. A unit of energy saved produces economic value for the government in three main ways:

- Increased income through exporting the saved unit of energy.
- Reduced need for energy subsidy payments, if there are any.
- Reduced need for new investment in generation capacity, as utilities in the GCC are mainly publicly owned and operated.

These benefits establish the potential value of a negabarrel, a unit of energy saved through investments that boost energy efficiency or energy productivity. Governments could offer this value to projects that produce negabarrels against a defined baseline. Auctions could be implemented to achieve price discovery and best value for money.

While energy efficiency investments offer the most obvious and immediately feasible sources of investment for negabarrels, this approach could also be extended to areas such as renewable energy or to investments that promote structural change. The key requirements would be that protocols should be defined and the investments should be monitored, verified and certified by accredited energy auditors.

The negabarrel approach would require creation of a government-funded market in reduced energy demand, taking into account the overall value that greater energy productivity creates for society. Although negawatts – more correctly ‘negawatt hours’ for energy – have been discussed for many years in energy efficiency circles, no proper market has yet been established. However, measurement and verification technology, coupled with smart metering, now enable energy efficiency measurement, making such programs more feasible.

A program of that sort can be seen as toward the public financing end of the spectrum of financial instruments used in energy efficiency financing (Figure 14). Experience from the World Bank suggests that the concept of a ‘public energy efficiency financing ladder’ can be useful in designing investment support policies. At low levels of market maturity, higher levels of public financing using instruments such as grants and subsidies and private-public partnerships are most effective in driving investments. As the energy efficiency market matures, to the point where there is an effective price signal, more commercially oriented financing instruments such as energy efficiency loans can drive investment.

In 2012, the Saudi Arabian Energy Efficiency Center developed the framework for the Kingdom’s ESCO (energy service company) market, which will be pivotal in facilitating such investments. In 2015 and 2016, an ESCO project was piloted to retrofit the Ministry of Petroleum and Mineral Resources building, generating energy savings worth 36 percent of annual energy consumption and delivering an estimated five-year payback. Since then, a licensing scheme has been launched, along with a national measurement and verification user guide, which can be used as a reference for calculating energy savings for retrofit projects.

Figure 14. Energy efficiency financing ladder.

Source: World Bank.

The macroeconomic benefits of enhanced energy efficiency investment have been explored by KAPSARC in research which highlights how avoided energy consumption can be used to:

- Boost the amount of oil available for export.
- Increase the availability of energy for alternative domestic uses.
- Enable oil to be kept in the ground for future use.

If sold internationally, the oil from avoided consumption can earn the government significant extra revenue and be used to support investment and economic growth (Impacts of higher energy efficiency on growth and welfare across generations in Saudi Arabia, Gonand 2016).

If the avoided energy consumption from a 4 percent annual increase in energy efficiency were to be sold on international markets and fully recycled through public spending or investment, growth in the Kingdom could be increased by between 0.3 and 0.6 percent per year by 2030, depending on prevailing oil prices. Once rebound and other general equilibrium effects are taken into account, this could increase overall energy productivity in Saudi Arabia by up to 30 percent (What are the macroeconomic consequences of shifts in energy efficiency?, Gonand 2015).

These results are summarized in Figure 15. This work suggests almost 1 million barrels of oil equivalent a day (1 MBOED) of avoided energy could be achieved as a result of increased energy efficiency by 2030, and could potentially generate between SAR 50 billion to SAR 100 billion in extra revenue, depending on the prevailing oil market conditions.

The Saudi Energy Efficiency Program also estimates that it aims to achieve avoided energy consumption of around 1.5 MBOED by 2030, or around a 20 percent reduction in the energy consumption that might be expected without the program (SEEC 2017).

The next section of this report investigates how these macro benefits of energy efficiency investment can be achieved in practice through a number of the key policy areas impacting on energy productivity that have been prioritized by the government.

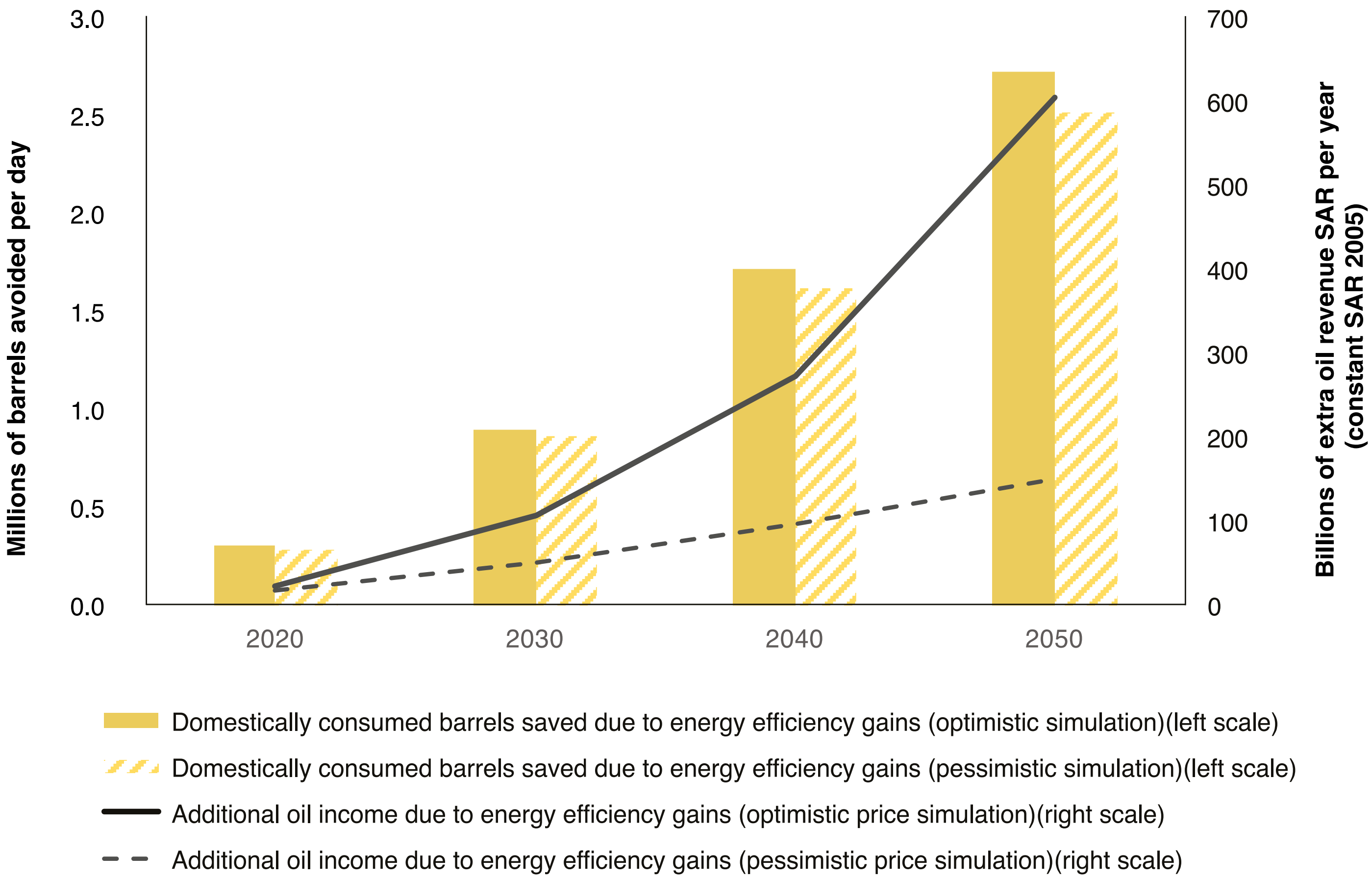

Figure 15. Macroeconomic gains from 4% per annum improved energy efficiency of the economy.

Source: Gonand, Impacts of higher energy efficiency on growth and welfare across generations in Saudi Arabia, 2016.

Putting Energy Productivity into Practice

While Saudi Arabia's Vision 2030 is clear about its overall goal of a transformation to an economy less reliant on oil and gas, the energy consumption pathway that will deliver this is less clearly mapped out. In this report we suggest that the use of energy productivity as an indicator and policy narrative can help to do this.

This section sets out the current set of indicators, targets and policies in Saudi Arabia, and places them in an energy productivity context. The following key focus areas are highlighted:

- Industrial strategy and diversification.
- Energy price reform.
- Energy efficiency in the industrial, transport and buildings sectors.
- Employment and capacity issues.

Saudi Arabia's Vision 2030

Recognizing the risks posed by an economy that is over reliant on oil exports, the government introduced an ambitious whole-of-government reform program entitled Vision 2030. This is being supported and implemented through a rollout of substantive subprograms that include: the Fiscal Balance Program, the National Transformation Program, the National Industrial Clusters Development Program and the Saudi Energy Efficiency Program, among others. To bring these programs about, the Kingdom has announced ambitious public goals that have been transparently shared to create a more open, diverse economy, less reliant on hydrocarbon resources. These include a significant program involving the privatization of state-owned enterprises, support of the private sector, greater localization and reforms aimed at creating an environment that is more attractive for local and international investors.

The plans also have a strong sustainability dimension which should deliver significant greenhouse gas avoidance benefits through a combination of energy efficiency, structural diversification and renewable energy investments, among other measures.

Industrial Strategy and Diversification

The central element of the economic plan in Saudi Vision 2030 is to move the Kingdom up the global ranking of leading economies from being the 19th largest country to top 15 status by 2030. Plans are to achieve this by growing the economy, increasing jobs and expanding the share of private sector non oil GDP from around 40 percent in 2015 to 65 percent by 2030 (see Figures 16 and 17).

In real 2010 values, non-oil GDP accounted for around 58 percent of total GDP at approximately SAR 1,422 billion in 2015. It has represented the main source of growth for the Kingdom since the implementation of the 2003 growth program that accompanied the last oil price boom.

It is important to note that while Figure 16 uses constant 2010 values, in current values the volatility of oil and non-oil GDP is much more pronounced (Figure 17). This highlights the importance of the Kingdom's plan in Vision 2030 to diversify sources of growth toward non-oil sectors which, while still closely related, are less exposed to changes in international energy markets.

Despite progress in increasing the share of non-oil GDP, hydrocarbon and government activities – which are heavily funded by oil revenues – still account for the greater part of total GDP in Saudi Arabia. In addition, economic activity in the non-government and non-oil sectors is also closely related to strength in the oil sector. Other major areas of value-added include the refinery and chemical industries, which derive from the oil industry but may be counted as non-oil GDP for national accounting purposes.

Up till now, Saudi domestic energy consumption has been dominated by the industrial sector, which makes up around 60 percent of total final energy consumption. It includes non-energy use, which accounts for the energy content of fuels used as feedstock to produce petrochemicals and fertilizers (Figure 18). Energy consumption in the transport

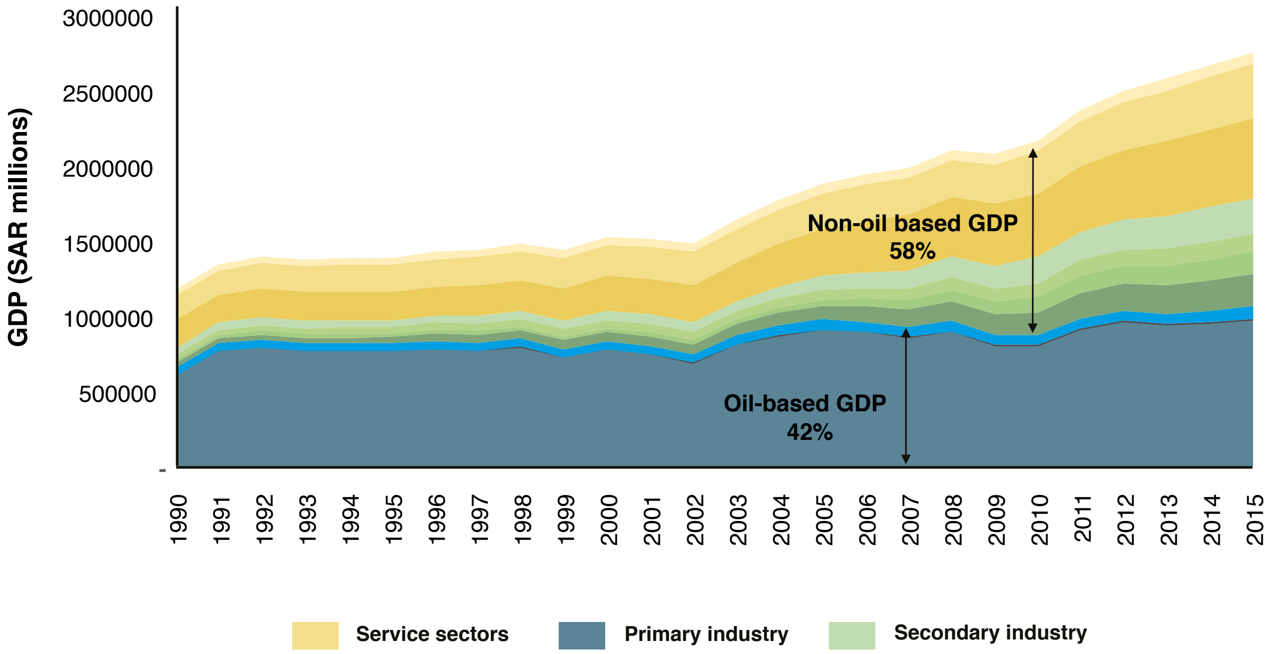

Figure 16. Oil and non-oil GDP (2010, constant prices).

Source: KSA General Authority for Statistics.

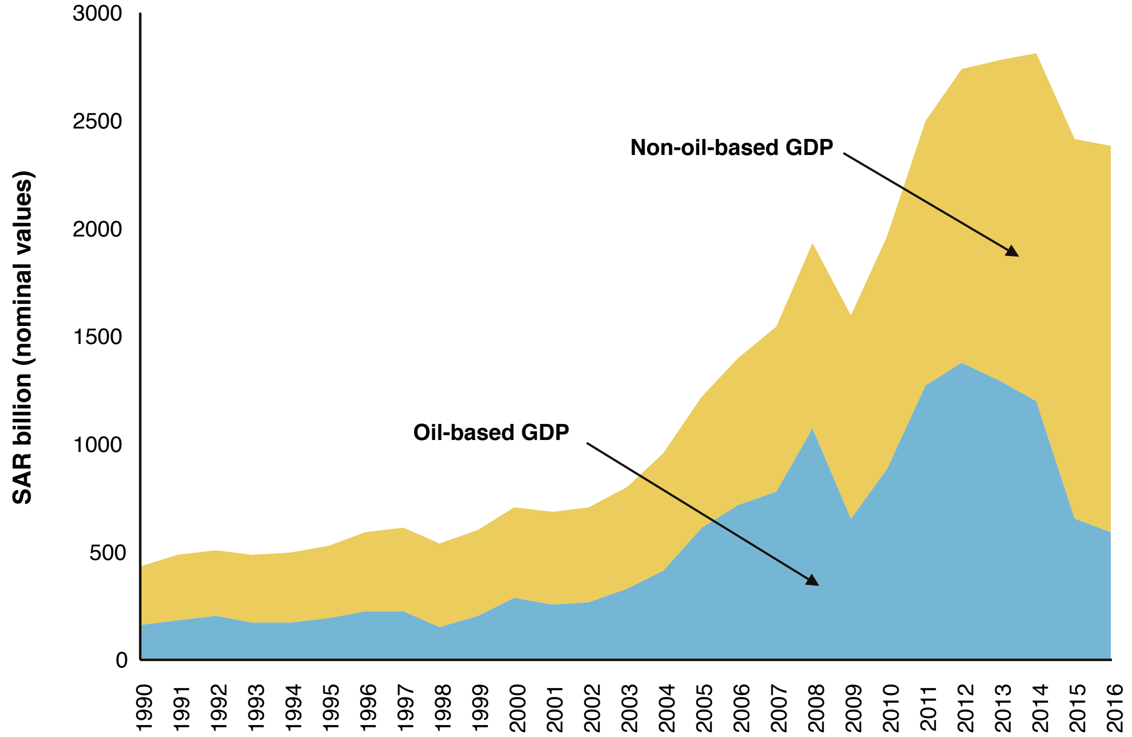

Figure 17. Oil and non-oil GDP 1990-2016 (nominal prices).

Source: KSA General Authority for Statistics.

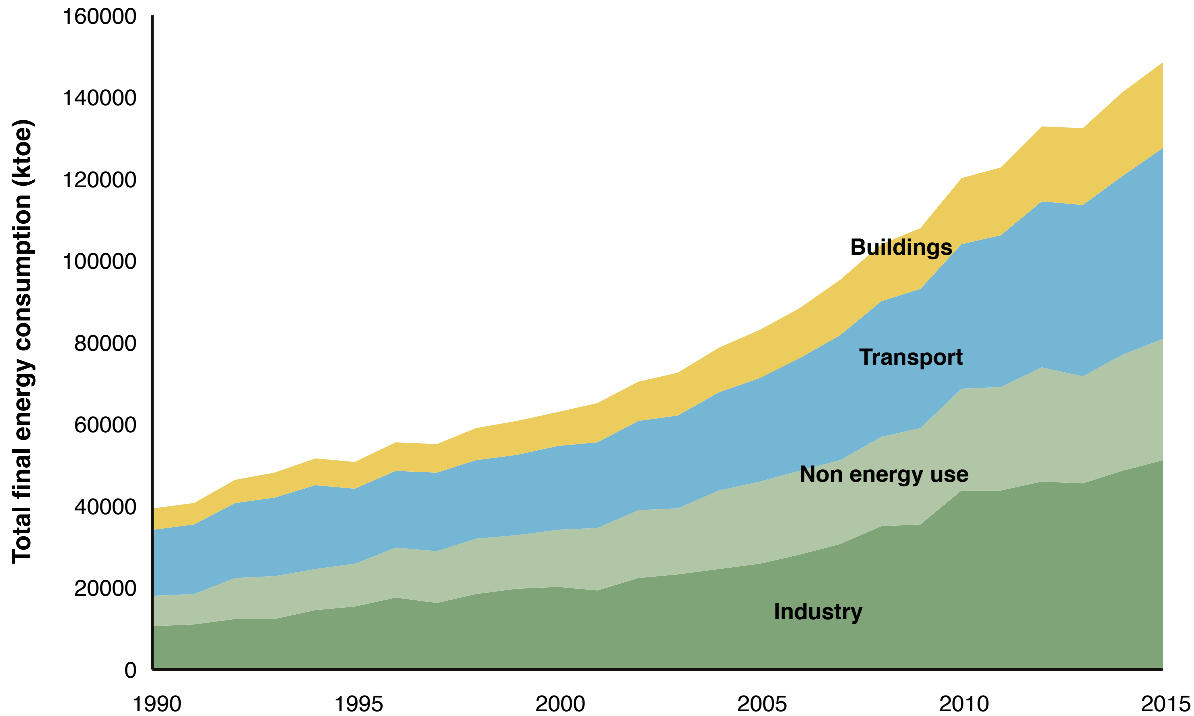

Figure 18. KSA energy consumption trends.

Source: KAPSARC, based on IEA and Enerdata databases.

sector is next highest. The buildings sector, including residential, commercial and government, has the smallest overall share of total final energy consumption. This is unexpected, perhaps, since much attention has been given to the rise in energy consumption in the summer, particularly for air conditioning. Buildings are, on the other hand, the most significant consumer of electricity, accounting for over 70 percent of power demand (Dubey, Howarth, & Krarti 2016).

While a comprehensive industrial strategy is currently under development as part of implementing both Vision 2030 and the Kingdom's National Industrial Clusters Program, Saudi Arabia's Nationally Determined Contribution (NDC) under the Paris Climate Accord outlines two broad development pathways which usefully capture the strategic industry policy choices that must be taken (UNFCCC 2015):

> Accelerated industrialization in energy-intensive sectors, like petrochemicals, steel, aluminum and cement, based on Saudi Arabia's comparative advantage in low cost energy. This would boost domestic energy consumption and result in declining oil exports.

> Substantial diversification into non-energy sectors, such as financial services, medical services, tourism, education, renewable energy and energy efficiency. With this model, the Kingdom would continue to export significant amounts of oil and channel export revenues into investment in these high value-added sectors.

These two strategic options demonstrate the energy productivity choice that policymakers in the Kingdom must confront. On the one hand, exploiting the region's substantial comparative advantage in terms of low cost energy resources and the development of energy-intensive basic industries, and, on the other hand, moving toward a stronger form of diversification into less energy-intensive, higher value-added manufacturing, service sectors and renewable energy. In the former, oil production is diverted to domestic consumption, and, in the latter, government revenues from oil production are maintained or increased.

Figure 19 shows how energy productivity can be used as a framework to manage these issues. The data on revenue and energy consumption is based on the aggregated results of an international analysis of companies grouped into industrial subsectors and ranked according to average revenue generated per barrel of oil equivalent.

The sample of industrial subsectors of the economy has been organized into two groups:

> Basic energy-intensive products and companies, including the energy-intensive heavy industries like steel, aluminum, petrochemical and cement production as well as transport and utilities.

> Higher value-added industries such as specialty chemicals, manufacturing, health care, and service industries such as engineering and ICT (information and communication technology).

Using energy productivity as the overarching theme for industrial strategy would focus on:

1. 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. A comprehensive program to bring companies up to, or beyond, industry energy efficiency benchmarks should be implemented, with those companies that fail to comply facing a combination of financial penalties, a reduction in their allocation of energy or, in extreme cases, mandated plant closures.

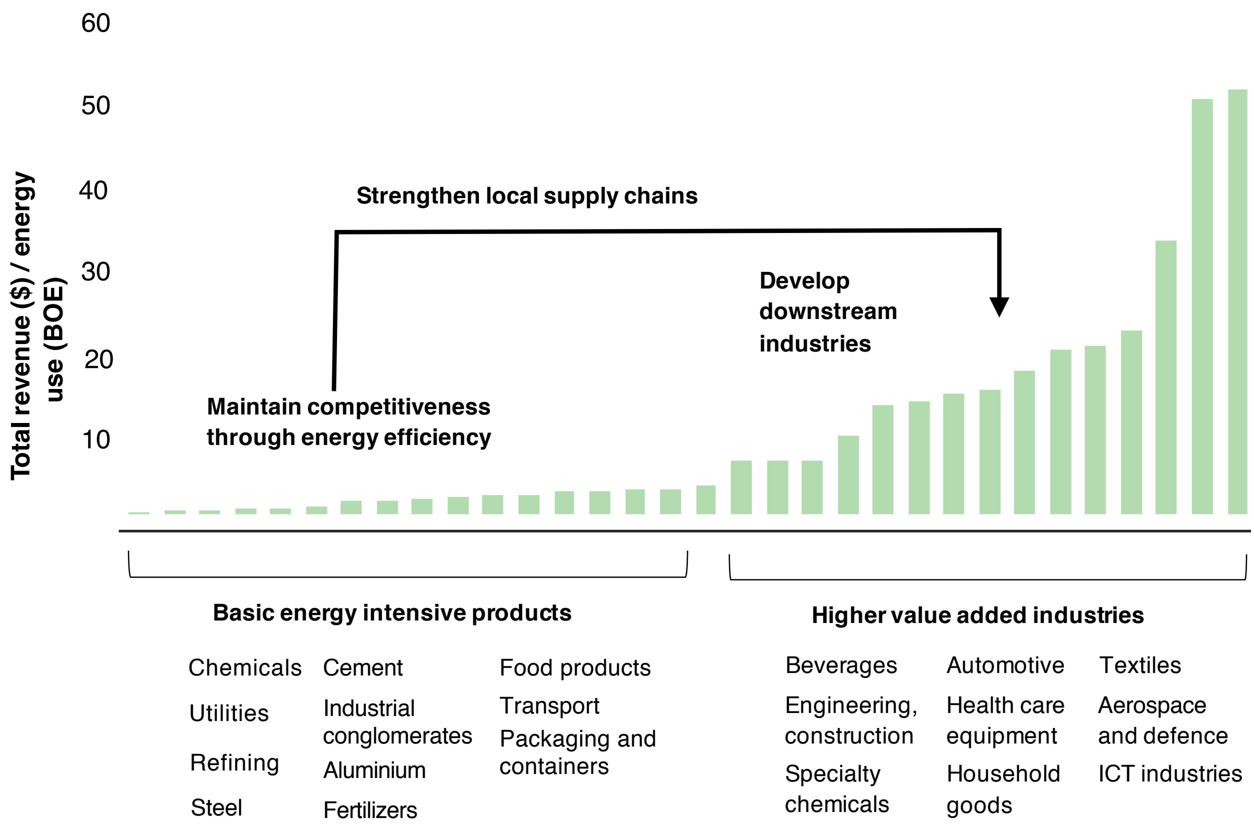

Figure 19. Energy productivity as a framework for industrial strategy.

Source: KAPSARC, based on Climate Works, 2016.

2. Building on a strong and efficient industrial base of basic industries so as to develop the domestic and international supply chain linkages to build downstream higher value-added manufacturing and service sectors.

3. Gradually strengthening advanced higher value-added industries which can build on these competitive advantages through local capacity building, technology transfer, international investment and education and training.

In building industrial strategy using an energy productivity framework, it is important to recognize that just because the basic industrial subsectors generate less revenue per barrel of oil equivalent, this is not a reason to prioritize them lower or penalize them. Most of the higher value-added sectors use basic products in their supply chains, so substantial added value can be created by building on an efficient and internationally competitive heavy industrial base. If such industries are well managed, are energy efficient and competitive, it is preferable to produce energy-intensive commodities domestically, especially in an energy rich economy, than to import them.

For example, the defense and aerospace industries generate around $8 per barrel of oil equivalent (BOE) consumed, while aluminum and chemicals generate less than $1 per BOE. However, these basic products are fundamental to the construction of planes, vehicles and other specialized military equipment. There are also many opportunities along the supply chain from advanced manufacturing, specialty chemicals, plastics and materials, which the Kingdom could exploit using an integrated supply chain approach, focused on maximizing energy productivity.

Of course, higher up the value chain energy efficiency will become a less important driver of competitiveness for the companies involved. This is one reason for prioritizing heavy industry first in an energy productivity industrial strategy, helping it become competitive and creating domestic downstream markets for its products.

"In the pivot to prioritizing high value, non oil private sector activities in the economy, care should be taken not to hollow out energy efficient, energy-intensive industry. It should not be a case of either/or, but rather of maintaining competitive advantage where it exists and building on it to extract more value in the production of downstream high value products and activities."

Quote from KAPSARC Workshop 'How to Achieve Economic Prosperity Through Industrial Energy Productivity Improvement', March 28, 2017.

Looking forward to 2020 and 2030, a number of specific sectoral goals have been identified in the National Transformation Program. Focus areas include expansion of the non-oil and gas production sectors to better exploit the Kingdom's mineral resources, growing them from SAR 64 billion to SAR 97 billion by 2020. The IT industry would be expanded from 1.2 percent to 2.24 percent of non-oil GDP by 2020, while leisure and media would increase from SAR 5.2 billion to SAR 6.6 billion by 2020 and the tourism sector from 2.9 percent of GDP at present to 3.1 percent by 2020. The real estate sector would raise its annual growth from 4 percent to 7 percent by 2020, and over the same period it would lift its share of GDP from 5 percent to 10 percent (National Transformation Program 2016).

Figure 20 shows the structural makeup of Saudi Arabia's non-oil economy, along with annual fixed capital spending based on the Kingdom's annual

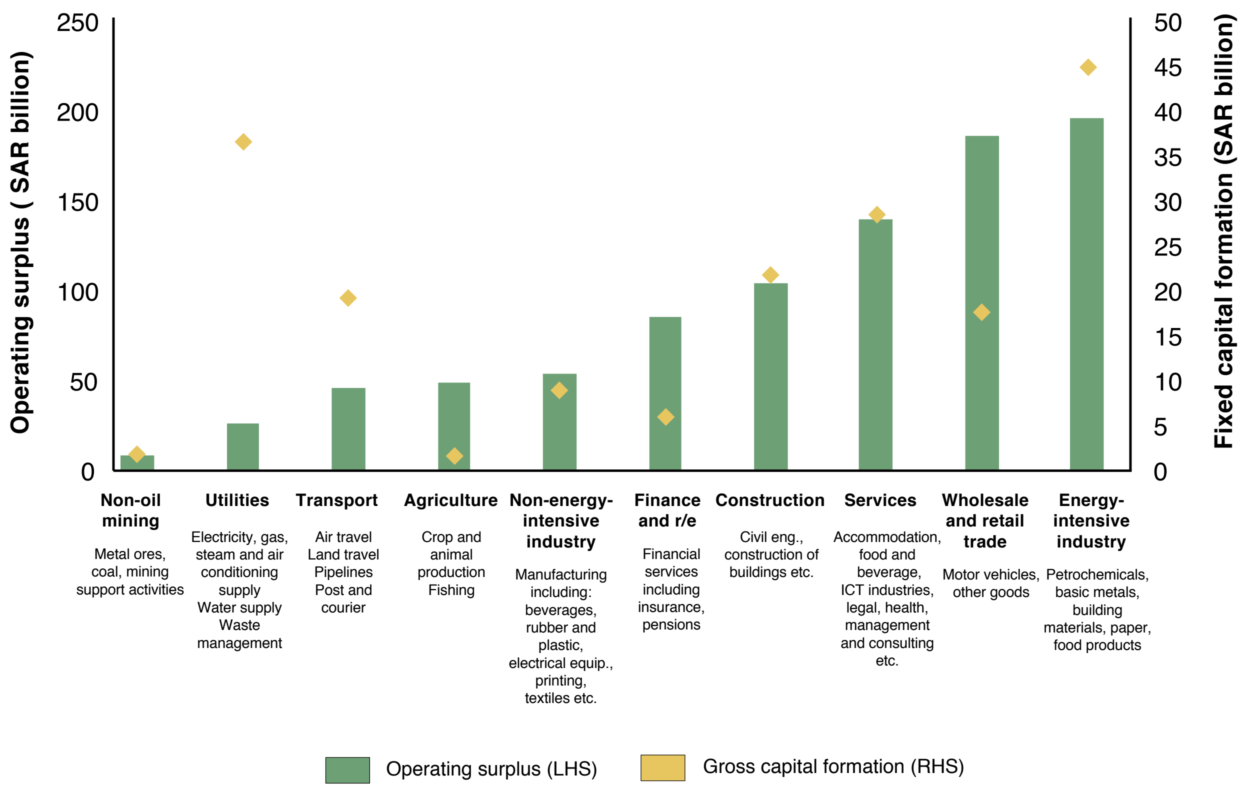

Figure 20. KSA non-oil sectoral operating surplus and fixed capital formation 2015.

Source: KAPSARC, based on KSA Annual Economic Survey 2015.

economic survey. This highlights the importance of energy-intensive industries to the Kingdom, both in terms of generating income (operating surplus) and as a driver of capital investment.

Based on these estimates, increasing investment by around 10 per cent per annum in the non-oil sectors would cost in the vicinity of around SAR 20 million per year, and if this were based on the current economic structure it would focus on the utilities and energy-intensive industries sectors. Because these also have a significant influence on energy productivity they would be considered important priorities in any industrial strategy.

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

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

Five industrial clusters have been identified, 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.

The Advanced Fiber Industries Project (Figure 21) and Synthetic Rubber Conversion Strategy

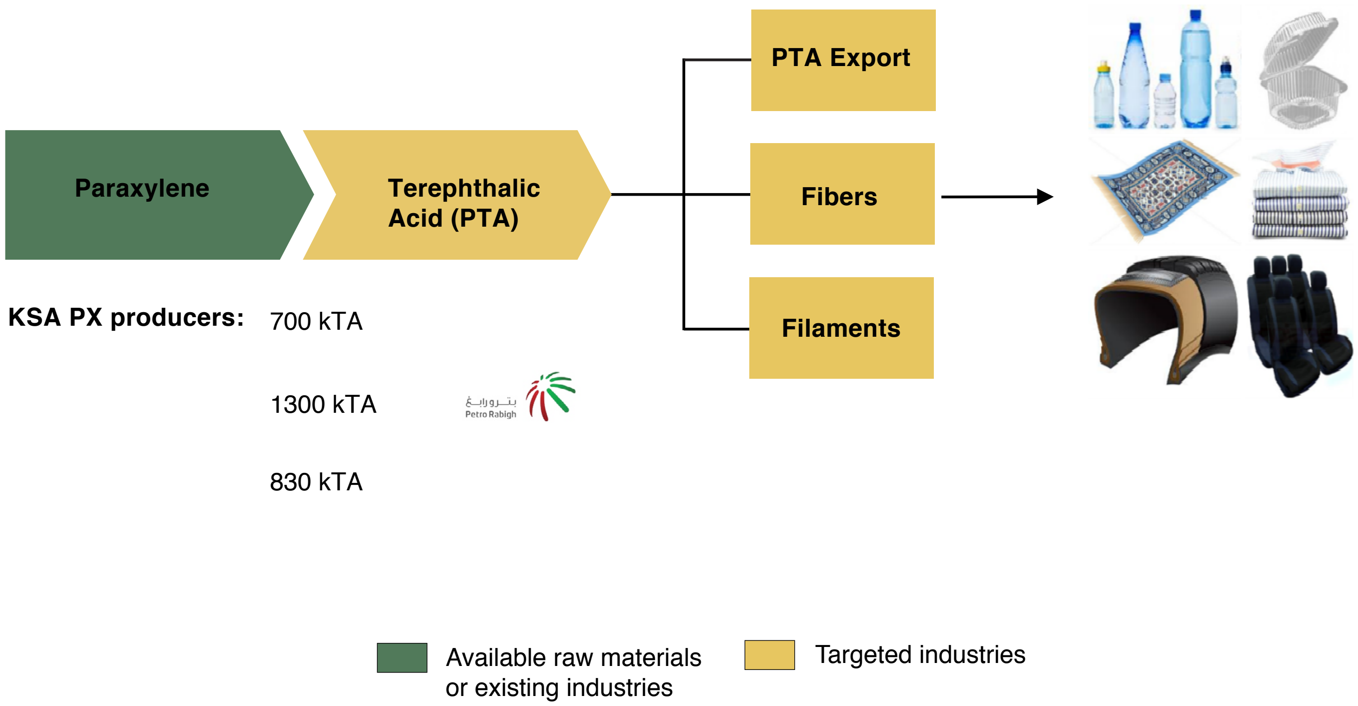

Figure 21. The Advanced Fiber Industries Project at Jazan Economic City.

Source: National Industrial Clusters Program.

(Figure 22) are examples of Saudi Arabia's industrial strategy, which aims to use the Kingdom's basic commodities production to support downstream higher value-added growth opportunities.

Such initiatives fit well with the use of energy productivity as a guiding strategy (see Figure 19) and are creating value through attracting investment, creating jobs and capitalizing on the Kingdom's resource base.

An important part of this plan for diversification into non-oil sectors is the expansion of non-oil exports as a proportion of non-oil GDP from around SAR 185 billion, or 16 percent, to around SAR 330 billion in 2020 and around 50 percent by 2030. This implies non-oil exports are set to become a much larger component of economic activity.

The level of export diversification can be tracked by applying the Herfinahl-Hirshman index to export concentration (Figure 23). This index, a widely accepted measure of market concentration, was mentioned in the National Transformation Program, with an appropriate target for the future still under study.

This measure demonstrates that countries like Australia and Canada have achieved a high level

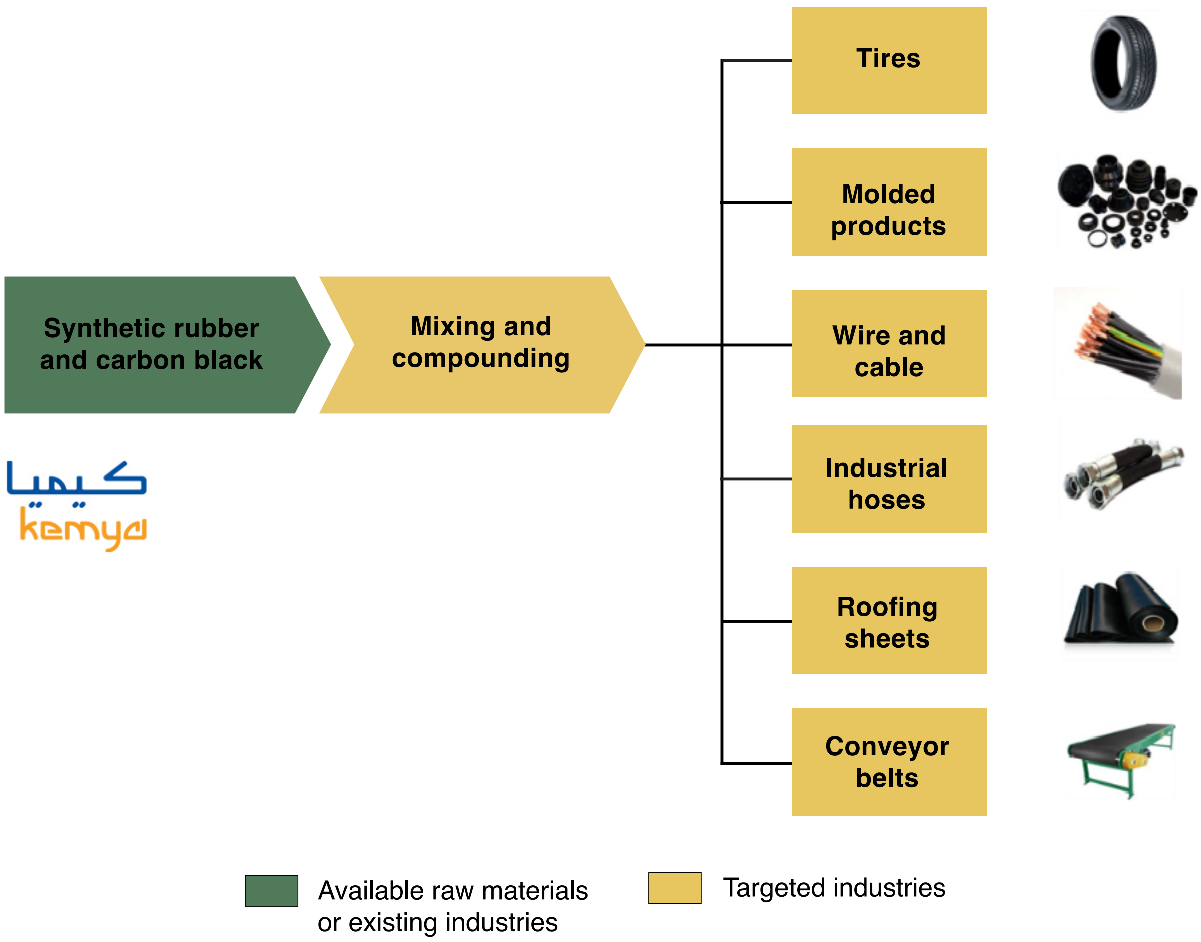

Figure 22. Synthetic rubber conversion at Yanbu Industrial City.

Source: National Industrial Clusters Program.

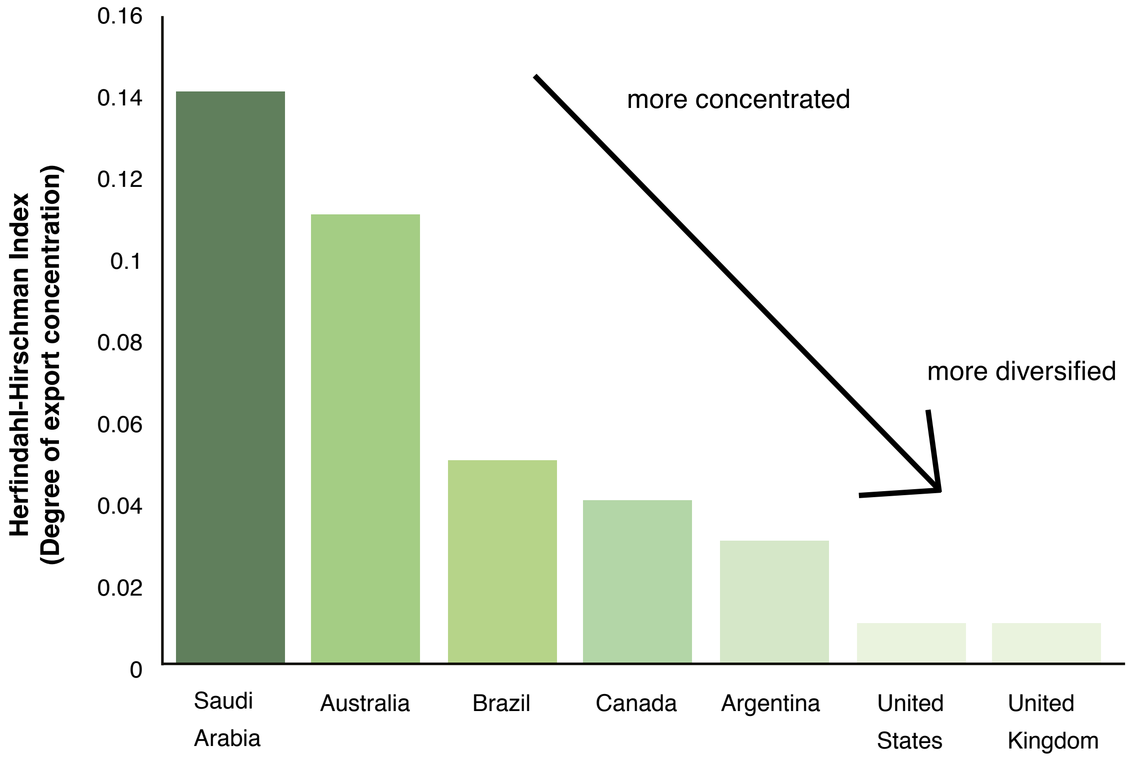

Figure 23. Herfinahl-Hirshman Index and export concentration.

Source: World Bank, 2014, KSA National Transformation Program.

of diversification in their overall economies, yet maintain quite concentrated exports. In their cases, the development and exploitation of natural resources has been able to facilitate broader growth across the economy. This came about through investment in physical infrastructure such as transport networks, as well as legal and investment frameworks in the development of their natural resource wealth – which later provided a foundation for financial and other service sectors (World Bank 2014).

That Canada and Australia have achieved impressive growth rates and maintained their position as leading commodity exporters raises an important question as to the possible direction of industrial diversification in the Kingdom and other Gulf countries:

"Should Saudi Arabia see export concentration as a necessary 'evil' by depending too heavily on external demand for only a few oil-based and energy-intensive products? "

Quote from KAPSARC Workshop 'How to Achieve Economic Prosperity Through Industrial Energy Productivity Improvement', March 28, 2017.

While not entirely clear, evidence suggests that export concentration can increase economic stability risks. However, if revenues from these sectors are reinvested in the right sectors, such as high value-added manufacturing and non-oil-based services, and strong institutions are built, facilitating broader growth in other sectors of the economy, then these risks can be more safely managed.

Energy Price Reform

Faced with rapidly rising energy consumption and increased fiscal pressures due to low oil prices, all GCC countries have recently brought in significant energy price reforms covering transport fuels, natural gas and electricity. In addition to addressing fiscal pressures, these reforms are also aimed at providing the economic signal to support economic diversification and encourage energy efficiency strategies.

Energy subsidies have for a long time been a key element of a social contract, where GCC governments extract their countries' hydrocarbon resources, distributing a part of the rents so as to share the nation's wealth and encourage social participation. However, this implicit social contract has come under substantial pressure since the global oil price collapse of 2014, which squeezed public budgets. Falling oil prices have also created a window to work on broader economic reforms.

A brief survey of the existing literature confirms that there is no universally accepted definition of energy subsidies, although organizations such as the International Energy Agency (IEA), World Trade Organization (WTO), and International Monetary Fund (IMF) have clear definitions of their own. The last of these defines pre-tax subsidies as the difference between the price consumers pay and the cost of supplying energy, and post-tax subsidies as including the estimated cost of environmental damage and foregone consumption taxes that may be applied to energy products. Previous KAPSARC studies have given detailed descriptions of various views on subsidies (El-Katiri 2012).

There are many ways to define and measure energy subsidies. A major part of the subsidy debate concerns the transfer of public benefit to private entities. Depending on the definition used, there can be significant variations in subsidy estimates. The Global Subsidies Initiative (GSI) uses a definition of subsidy based on the WTO's Agreement on Subsidies and Countervailing Measures (ASCM), which is supported by 153 countries. The IEA defines energy subsidies "as any government action that concerns primarily the energy sector (and) that lowers the cost of energy production, raises the price received by energy producers or lowers the price paid by energy consumers" (IEA 2006).

Closely related to the definition of subsidies are different views on what constitutes the appropriate reference price. While the IEA uses prices on international markets, OPEC (Organization of Petroleum Exporting Countries) and many fossil resource rich countries, including those in the GCC region, often argue that the reference price should be related to the cost of production. This suggestion is based on the argument that resource rich countries use their domestic resources, in the production of which they hold a comparative advantage, for economic and social development.

Nevertheless, low pricing of fossil fuels involves an opportunity cost based on international prices – an implicit subsidy – or an implicit transfer. The first of these represents the economic rent/revenue foregone by failing to sell oil at higher international market prices; it involves a transfer from the government to the final consumers without such a transfer appearing explicitly on state oil companies' records or in the government budget (Krane 2013).

Using production costs as the reference price for estimating energy subsidies results in significantly lower subsidies than if a much higher world reference price were used. Implicit subsidies typically occur in oil and gas producing countries, where for the most part National Oil Companies (NOCs) are vertically integrated monopolies that produce, refine and market petroleum products. In the majority of cases, those companies are mandated to sell petroleum products for domestic consumers at below international prices but above production costs. In this case, the NOC does not incur any financial losses, and it will not require any transfer from the public budget to compensate for its losses. Thus, the opportunity cost based on international prices (implicit subsidy) represents the opportunity cost, and entails a transfer from the government to the final consumers without such a transfer appearing explicitly on NOCs' records or in the government budget.

Implicit subsidies are less obvious and are one of the main reasons for continuing debate about what constitutes an energy subsidy. This is easier to establish in the oil market, where there are only three main international benchmarks, which are reasonably aligned. However, the market for natural gas continues to be fragmented and thus the international benchmark prices vary widely. It is certainly difficult to determine what the exact production cost for natural gas is, due to the lack of global benchmarks, and consequently calling this a subsidy is empirically challenging (Boersma & Griffiths 2016). For further discussion of the concept of subsidy in the region see Darbouche (2012) and Lahan (2014).

This appropriate reference price debate has policy implications. For example, in September 2009 the leaders of the G20 – the international body made up of heads of states, finance ministers and central bank governors from the world's leading economies – pledged to "phase out and rationalize over the medium term inefficient fossil fuel subsidies while providing targeted support for the poorest" (G20 2009). However, the Kingdom of Saudi Arabia posited that this proposal does not apply in its case (Koplow 2010), arguing that as long as producers charge their domestic clients a price higher than the cost of production, no subsidy occurs.

In 2015, GCC countries began implementing and accelerating pricing reforms aimed at removing energy subsidies. While the price increases were from a low base and domestic energy prices remain well below international levels and among the cheapest in the world, the recent increases represent a fundamental shift in GCC economic and social policies.

Conversely, low energy prices have resulted in wide distortions and inefficiencies in the GCC economies that have prevented governments from optimizing the use of their natural resources. For example, they have caused rapid growth in domestic energy consumption and a decline in energy productivity, as low energy prices encouraged wasteful consumption and industrial policies biased toward investment in energy-intensive industries such as petrochemicals and aluminum. They are also inequitable, with households in high income brackets, which have relatively higher levels of consumption, capturing most of the benefits from low energy prices. The large differences in the prices of diesel and gasoline have also encouraged smuggling within the GCC region (Fattouh & Sen 2016).

Recent domestic price reforms in GCC countries, however, indicate that change is possible on a step-by-step basis. Given the confluence of interests in reform and increasing economic pressures, most GCC countries have gone beyond the stage of just testing the water. However, possible price reform pitfalls include the impact on the competitiveness of industry and the profit margins of companies as well as trickle-down effects on prices for the final consumer and household budgets.

Nonetheless, these price reforms are significant for global agendas calling for 'getting the price right', whether they be linked to energy and water security, resource efficiency or climate change.

GCC countries are influential in international forums on issues related to energy and sustainability. At the same time, these countries set an example as donors and investors in developing countries and serve as models for other petroleum exporting states, especially through their OPEC role. On a domestic level, the reforms may mark the start of a reshuffling of government support measures that will begin to reorient economies and thus affect business and investment. If this is the case, the most important question will be whether new sectors for growth can be harnessed as old ones decline.

While the recent price rises will help bring down government subsidy bills, they are unlikely to significantly impact fuel demand growth, given the current ratios of energy cost to income. To rationalize fuel use, governments must ensure that a gradual price rise is accompanied by stronger institutional and legislative support for energy efficiency. The question of how to make this dual approach work for business is pertinent to green growth agendas globally (Lahn 2016).

There is sufficient international experience of energy subsidy reform to indicate that reforms can fail when:

- Fuel prices are increased too rapidly.
- Long-term commitment to reform is unclear or lacking.
- Pricing policy decisions are not depoliticized.
- There is a failure to introduce appropriate social safety nets as part of the reforms.
- Reform objectives and planned mitigating measures are not communicated clearly to citizens (IMF 2015).

An additional complexity for the GCC is that policy decisions often cannot be entirely depoliticized, as they form part of the implicit social contract that GCC governments have with their citizens in the redistribution of oil wealth.

International experience proves that governments should pursue policies to deregulate fuel prices in order to make their downstream oil sectors competitive. To achieve social protection and other objectives of price controls, governments need to implement strategies other than exercising control over pricing and fuel allocation. To help the vulnerable group among the population cope with high oil prices, the long-term goal should be to replace fuel price subsidies with an effective social safety net. The most efficient and least distorting approach is arguably to transfer cash as part of an integrated, comprehensive program.

The path to subsidies reform depends on the national circumstances that influence the design and timing of that reform, including: (1) the price gap between the current and market-based price levels, (2) the market structure, (3) the subsidy delivery mechanism, and (4) the mechanism for delivering social protection.

Table 3 compares the advantages and disadvantages of different pricing mechanisms, demonstrating that the first-best solution is to liberalize petroleum prices, which helps depoliticize petroleum product pricing. However, liberalizing prices requires preparation. In countries where the market for petroleum products is dominated by the public sector, as in the case of the GCC, price liberalization also requires liberalizing downstream activities including import and distribution. In order to do this, regulatory frameworks may need to be strengthened, including the capacity to detect and discourage anti-competitive behavior.

Table 3. Advantages and disadvantages of pricing mechanisms.

	Pricing option	Advantages	Disadvantages
Full deregulation	Market pricing.	• Minimize market distortion. • No fiscal burden. • Promote energy productivity.	• High consumer prices. • Oil price volatility is immediately transmitted to consumers.
Automatic adjustment mechanism	Moving average: base retail prices on moving average of past spot prices.	• Prices are relatively stable.	• Oil price volatility is transmitted to consumers but not quickly.
	Trigger rules: prices are only updated if spot prices change by more than a pre-determined trigger amount.	• Prices are stable within a predetermined band.	• Can lead to some subsidies.
	Maximum-minimum: set ceiling and floor at the level of retail prices.	• Avoid large price changes.	• Can lead to some subsidies. • Band should be regularly adjusted.
	Steady, predetermined price increases at regular time intervals till cost recovery levels are reached.	• Each price increase is isolated from international price volatility.	• Could lead to subsidies if world prices increase. • Could become unpopular if world prices decrease.
Stabilization fund	Fund saves revenues when world prices decrease while revenues are used to keep domestic prices low when world prices are high.	• Budget neutral.	• Can cause serious cash flow problems during periods of world prices fluctuations.
Discriminatory pricing	Cross-subsidy of certain fuels.	• Can reduce price risks of sensitive fuels. • Budget neutral.	• Can lead to subsidies. • Can drive fuel switching to the subsidized fuel.
	Remove subsidy from high grade fuels.	• Consumers of high grade fuels are able to bear price risks. • Subsidies are targeting the poor.	• Can drive fuel switching from high grade fuels to the subsidized one.
	Subsidize certain consumer group	• Alleviate price risks of the poor. • Target subsidies.	• Promote corruption and fuel diversion from the entitled group.
Assign quota for subsidized fuels	Charge higher prices outside the quota.	• Limit the amount of subsidies. • Target the poor. • Drive rational consumer behavior.	• Invites corruption and patronage based on political influence.
Establish the total subsidy envelope for the fiscal year	Adjust prices, volume, or both, accordingly.	• Limit the amount of subsidies.	• Highly politicized. • Difficult to implement.

Source: KAPSARC, based on Kojima 2013.

If markets are imperfect or if governments are concerned about excessive price volatility, they can implement an automatic pricing mechanism that adjusts prices regularly in response to changes in international prices. Often the pricing formulas are designed to smooth the pass-through of international prices to domestic prices. It is also desirable that the automatic pricing mechanism be implemented by an independent body. It could also be supported by incorporation of a price smoothing mechanism to ensure pass-through over the medium term but also to avoid sharp increases or decreases in domestic prices (see Box 4) (IMF 2012).

Automatic price setting mechanisms

An automatic price setting mechanism, with technical decisions on prices delegated to an independent body, could pave the way for a fully liberalized pricing regime. Automatic pricing mechanisms are intended to fully transmit price fluctuations in international prices to domestic retail prices. They avoid an ad hoc approach to fuel pricing in which governments change prices at irregular intervals and they could incorporate smoothing rules to avoid excessive price volatility. Implementing an automatic pricing mechanism requires specifying the price structure/pricing formula to link international and domestic prices, the timeline for updating the components of the price structure, and a rule determining when retail prices change and by how much. The most common types of smoothing mechanisms include:

1. Moving average mechanisms (MA): Retail price adjustments are based on changes in the average of past international prices, where the period for which averages are calculated could be set as days, weeks, or months. Longer averaging periods tend to reduce the magnitude of prices changes.

2. Price band mechanisms (PB): A maximum limit, i.e. a cap, is set on the retail price variation. If the required retail price increase exceeds the cap, the maximum allowed increase is implemented. If the implied price increase is below the cap, then the full adjustment is allowed.

Source: IMF (2015), Energy Price Reforms in the GCC – What Can Be Learned From International Experiences? Annual Meeting of Ministers of Finance and Central Bank Governors, Nov. 10, 2015, Doha, Qatar.

Smoothing mechanisms include moving averages, price adjustment caps and/or triggers and price bands. Countries that have implemented formula-based mechanisms include UAE, Oman, and Qatar, while Kuwait, Bahrain and Saudi Arabia have historically adopted an ad hoc price setting process, in which price changes are announced by government decrees.

However, subsidized prices are not the only way to share resource wealth; there are other less distorting options to do so, including:

Compensatory cash transfers to all households, irrespective of income or wealth. This could be another policy choice to distribute oil wealth as part of the social contract. Cash transfers could also be targeted to reach specific population groups, e.g., poor segments. For example, Jordan offered cash transfers to families below a certain income threshold – which represent 70 percent of the population – if oil prices rise above $100 per barrel. In fact, though, studies showed that in most cases rich segments of the population benefit more than the poor when subsidies are offered universally, as is the case in all GCC countries.

Investing money in pension funds: Norway provides a good example of how a country can manage the wealth created by natural resources. Such funds could pay yearly dividends, depending on their performance, to all nationals.

Corporatization of the NOCs so they become more profit oriented and push governments to reform market distortions. Improving the efficiency of NOCs reduces the fiscal burden of the energy sector and could help to address public concerns about lack of government credibility and administrative capacity. The UAE is a good example of this.

The Current Round of Energy Price Reforms in Saudi Arabia

In Saudi Arabia's Vision 2030 and the National Transformation Program there are clear targets to lift the share of non-oil government revenue from the current levels of around SAR 163 billion, or around 23 percent of total government revenue, to SAR 530 billion by 2020 and SAR 1 trillion by 2030.

The implementation plan for these targets was set out in a comprehensive Fiscal Balance Program which outlines plans for meeting ongoing public spending objectives in a lower oil price environment by increasing non-oil revenues and achieving public sector efficiencies (Fiscal Balance Program 2016).

As a result of sustained low oil prices, in 2015 the government announced the highest deficit in its budget at around SAR 366 billion, a fiscal balance swing from a surplus of SAR 180 billion over just two years. Public debt increased from SAR 44 billion in 2015 to SAR 316 billion in 2016 and reduced the government account balances at the Saudi Monetary Authority from around SAR 1,413 billion in 2015 to SAR 577 billion in 2016 (Fiscal Balance Program 2016). In such an environment, a key priority is to ensure the maintenance of fiscal space to support the public spending programs required to support growth (Figure 24).

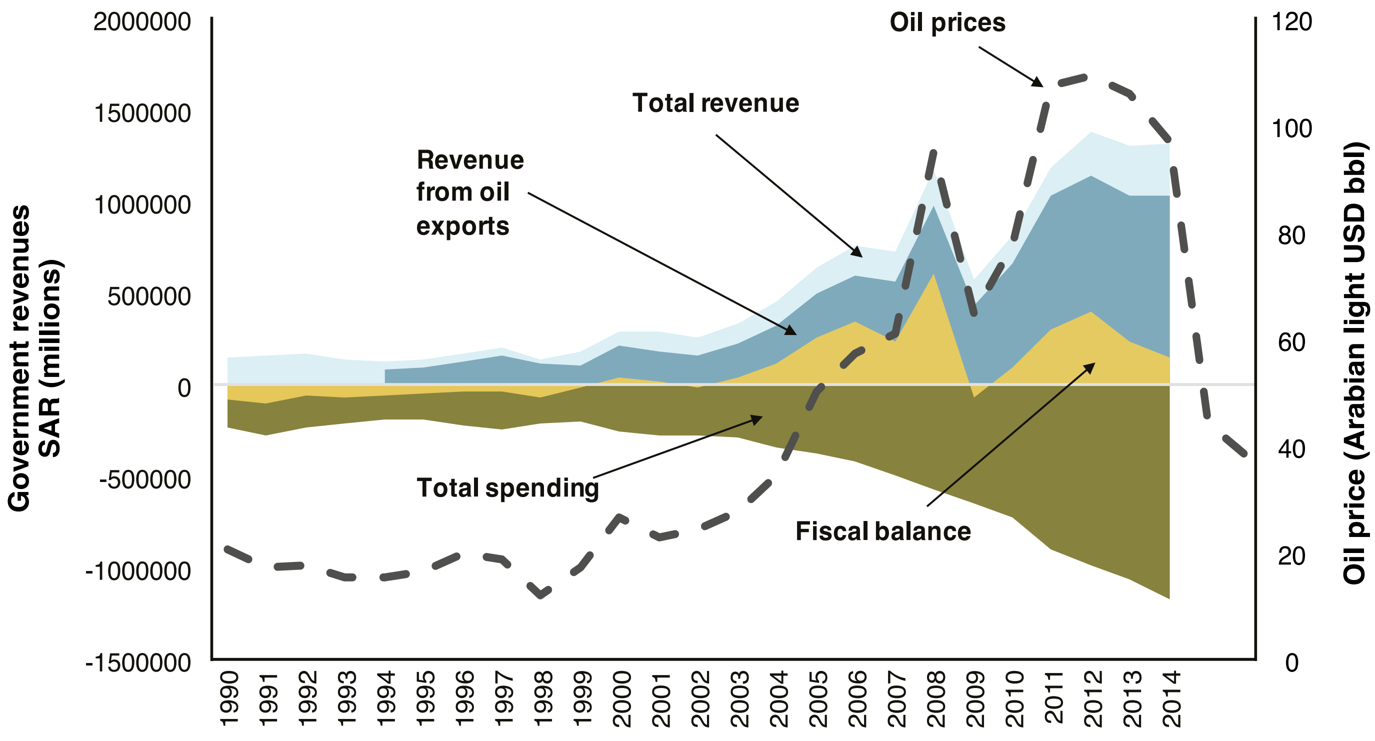

Figure 24. Fiscal balance in KSA and oil prices.

Source: IMF.

In light of these challenges and the potential negative consequences of a long-term fiscal imbalance, the Fiscal Balance Program proposes achieving fiscal balance by 2020 through:

- Growing non-oil revenue, including energy price reforms and the introduction of a value-added tax.
- Reducing public capital and operational expenditure.
- Eliminating subsidies and empowering consumers to choose and consume responsibly.
- Privatization of state assets.
- Accessing international debt markets.
- Sustaining economic growth in the private sector and household spending through compensatory stimulus measures.

One area that aligns these fiscal goals with the agenda to increase energy productivity is domestic energy price reform. Debate has focused on the removal of inefficient subsidies. However, the Kingdom has long argued that there is no subsidy because, while prices are low, this is simply a reflection of the low cost of domestic production of oil and gas. However, irrespective of this debate, significant foregone government revenue results from not pricing energy at a level consistent with international reference prices.

In Saudi Arabia, the first phase of energy and water price reform was implemented in 2016 for two categories: households, and industry and other entities. These reforms are outlined in Table 4.

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

Table 4. 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/litre)	0.45-0.60	0.75-0.90	Diesel USD/ barrel	Transport	10.6	19.10
				Industry	9.12	14.00
Electricity (SAR/kWh)	0.05-0.26	0.05-0.30	Industrial		0.14	0.18
			Commercial		0.14-0.26	0.18-0.30
			Governmental		0.26	0.32
Water (SAR/m_3)	0.10-6.00	0.15-9.00			0.1-6.0	0.15-9.0
			Gas (methane) (USD/MMBtu)		0.75	1.25
			Ethane (USD/MMBtu)		0.75	1.75
			HFO 380 (USD/barrel)		2.08	3.80

Source: Fiscal Balance Program 2016.

from 3.5 percent in the first half of 2015 to 1.7 percent in the first half of 2016 (Fiscal Balance Program 2016). The inflationary effects of these reforms, while significant for energy products, have been somewhat mitigated due to lower import prices for some goods. This is because the riyal, which is pegged to the U.S. dollar, has risen along with higher U.S. interest rates, making many imported goods cheaper in local currency terms.

The proposed second phase of reform will begin in 2017, with a steady change in prices from 2017 to 2020. Domestic energy product prices will be linked as a percentage to the reference export price of the respective product, and at full implementation will fluctuate with changes in international markets (Fiscal Balance Program 2016).

Three main reasons have been cited for the reforms:

1. The large opportunity cost associated with foregone revenue from fuel sales, calculated at SAR 300 billion in 2015.

2. Concerns over wasteful and unsustainable growth in domestic energy consumption.

3. Social equity considerations, like the current system disproportionately benefiting more affluent consumers rather than lower income households.

Phase two of the energy and water price reforms is scheduled to be implemented from mid-2017 through to 2020 at differing times for households and non households (see Table 5).

Taken together, phases one and two of the energy price reform package are expected to generate SAR 209 billion by 2020 (Figure 25). Taking 2015 international energy prices as a guide, this would imply that the opportunity cost of energy benefits to consumers would fall from SAR 300 billion per year in 2015 to SAR 91 billion by 2020 under the energy price reform plan.

As part of the implementation of energy price reform, the government plans to bring in targeted assistance to households and industry. Households will be split into five income categories, with the lowest income groups receiving full compensation for the rise in energy prices and the highest income earners no extra allowances. Individuals have been

Table 5. Implementation of phase 2 energy price reforms.

	Households	Industry and others
2017	Link electricity 100% to reference prices.	
2018		Link electricity 100% to reference prices.
2019	Based on the readiness of water infrastructure, gradually link water prices to reach reference prices.	
		Gradually link all unpegged products to reach reference prices, except for butane, propane and natural gas.
2020	Bring all products to reach 100% of reference prices.	

Source: Fiscal Balance Program 2016.

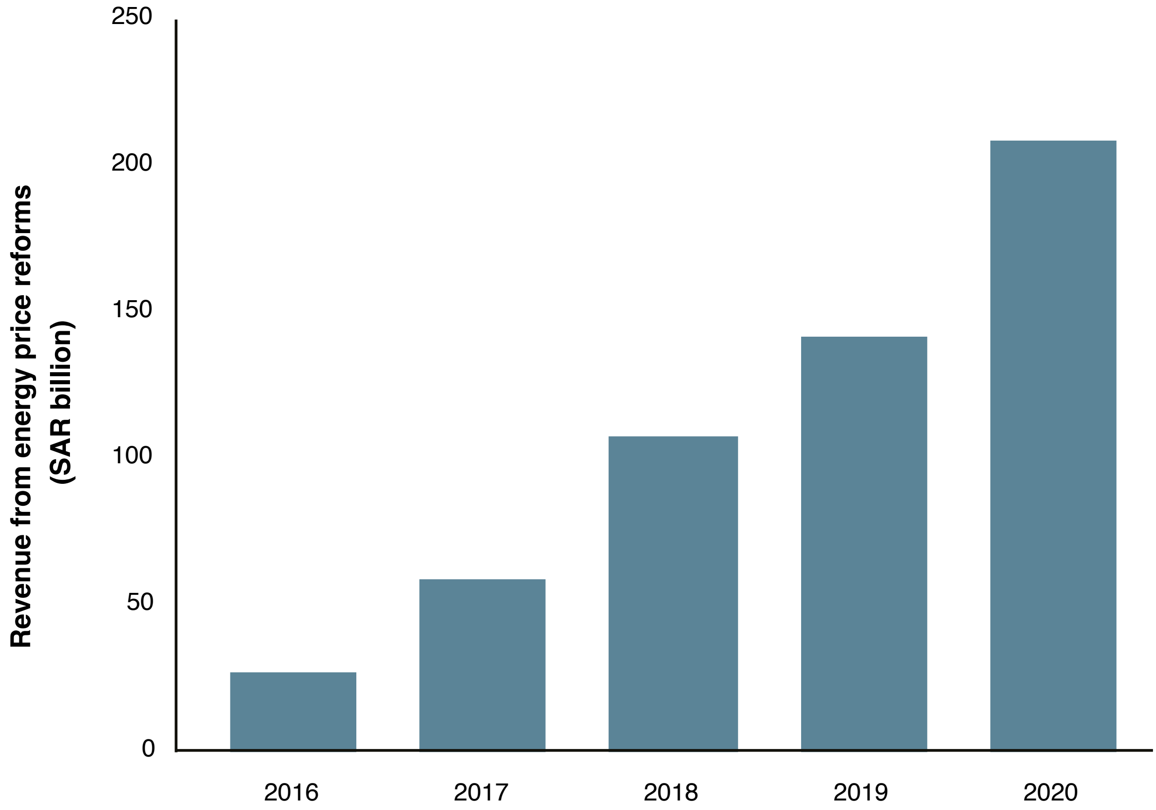

Figure 25. Gross revenue from planned energy and water price reforms.

Source: Fiscal Balance Program 2016.

requested to register for the Household Allowance Program which will deliver direct cash payments to a special citizens' account beginning in mid-2017, ahead of the start of the second round of reforms. According to the Fiscal Balance Program, disbursements will start from SAR 22.5 billion in 2017 and reach SAR 65 billion in 2020.

The government has also signaled that in addition to households, industries that have a strategic importance, with a strong global export outlook and which can build on the Kingdom's areas of competitive advantage, will be offered support through a SAR 200 billion industry stimulus package in support of Vision 2030 objectives (Fiscal Balance Program 2016). In terms of impact, the petrochemical industry is the largest energy-consuming industrial sector, and one which has been highlighted for concentrated support. This is one potential reason why the price rises for natural gas, ethane and LPG are not scheduled until 2020, to give time for businesses to plan and adapt (Jadwa Investment 2017).

While the stimulus program is being developed to support the industry strategy as part of Vision 2030, measures potentially include temporary support, facilitating infrastructure designed to achieve a competitive advantage and the promotion of energy and operational efficiency.

While the strategic direction of policy has been set, there is an urgent need for research into what implementation strategies are most likely to be successful in delivering the planned reforms. This should take into account that increasing energy prices represents a significant shift in the social contract between government, industry and citizens.

Energy price reform should aim to preserve the competitive advantage of energy-intensive industries in the Kingdom, but be high enough to incentivize energy efficiency in line with international benchmarks. Providing households with assistance will help with implementation and improve the social equity dimensions of how hydrocarbon wealth is shared in the Kingdom.

Quote from KAPSARC Workshop 'How to Achieve Economic Prosperity Through Industrial Energy Productivity Improvement', March 28, 2017.

One of the lessons from international experience of energy price reform is that the pace and magnitude of the reform process should be gradual and signaled as much in advance as possible.

Figure 26 shows the relationship between energy productivity and energy prices, using the proxy of gasoline prices across a range of OECD and non-OECD countries. This research suggests that at low energy prices there is little relationship between changes in energy prices and economy-wide energy productivity but, at higher prices, changes in energy prices explain a significant proportion of changes in energy productivity (Gelil, Howarth, & Lanza 2016).

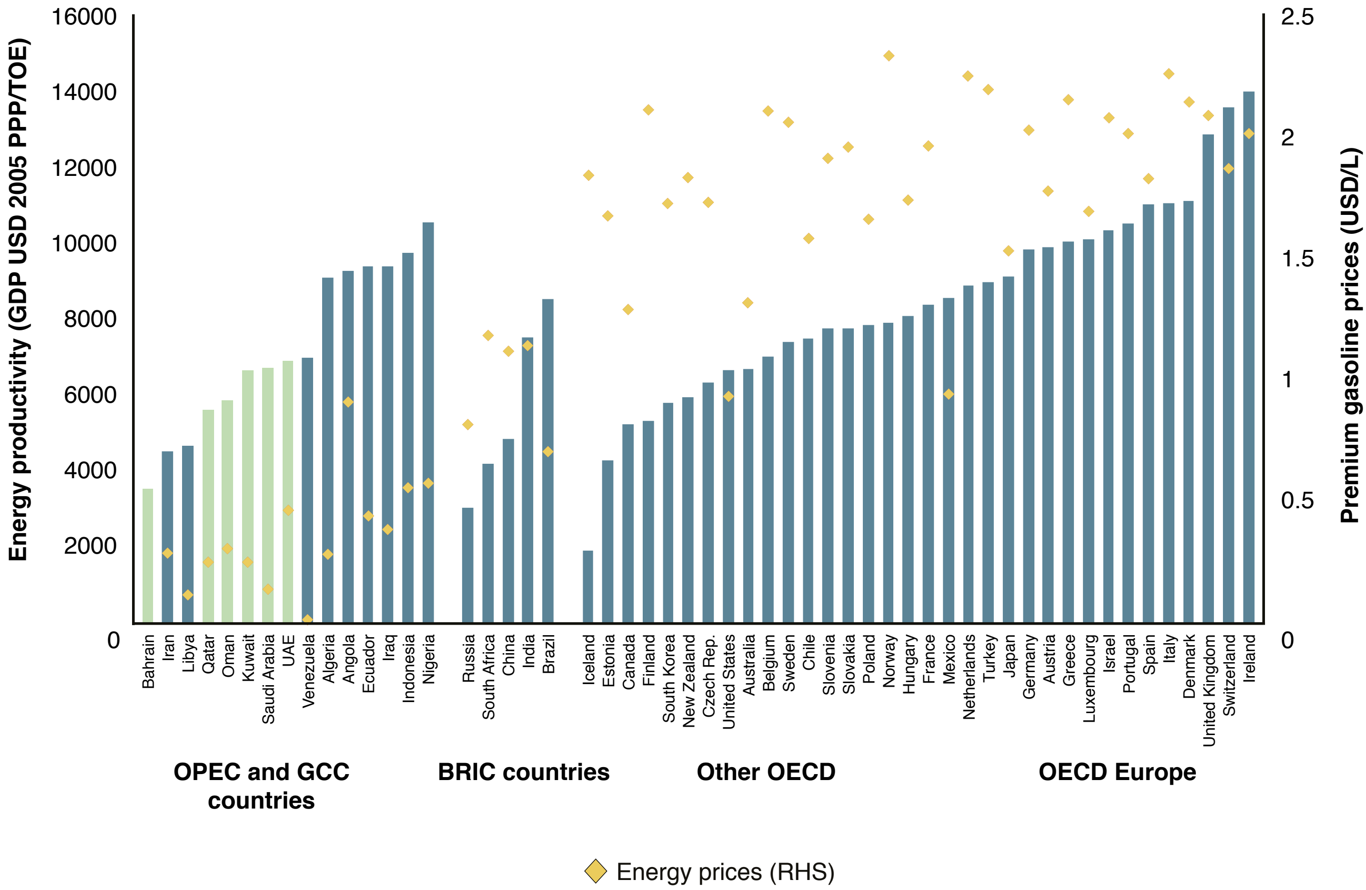

Figure 26. Energy prices and energy productivity.

Source: KAPSARC analysis, based on IEA and Enerdata.

Given the low costs of energy product production in Saudi Arabia and the reforms announced in the Fiscal Balance Program, it may be time to move beyond the energy subsidy debate to focus on what the most beneficial price reform pathways would be from a social perspective. Energy price reform will be crucial to helping meet Saudi Vision 2030 goals, including diversification of fiscal revenue to more non-oil sources as well as rebalancing of the Saudi economy towards less energy-intensive non-oil-based growth.

The core idea behind energy productivity in terms of energy price reform is that when items are priced higher, society values them more and puts them to higher value uses. This may be a more compelling domestic narrative than removing subsidies, which may help avoid potential complications in the World Trade Organization when implementing price reform. In the following section on energy efficiency, energy pricing is discussed further in the context of each relevant sector.

Energy Efficiency in Saudi Arabia

If diversification is one arm of energy productivity planning, enhancing energy efficiency is the other. The Saudi Energy Efficiency Center was established in 2010 to develop the Kingdom's energy efficiency policy. In 2012, this developed into an interagency effort through the launch of the Saudi Energy Efficiency Program (SEEP), which outlined guiding principles with strong participatory governance among key implementation agencies. These were focused on the building, transport and industry sectors and covered around 90 percent of energy consumption in the Kingdom, as summarized in Figure 27.

Today SEEP is a fully fledged program with 12 teams and 150 professionals spread over 30 implementation and policy entities, involving 84 initiatives at different stages of feasibility, design and execution. The approach adopted is to develop baseline and fact base for setting policies, establish performance relative to international benchmarks, prioritize initiatives based on potential impact, achieve consensus and coordination among implementation agencies, and establish execution teams and the enabling policy environment. Then, finally, to monitor and evaluate progress, with a view to registering feedback into the design of the overall approach.

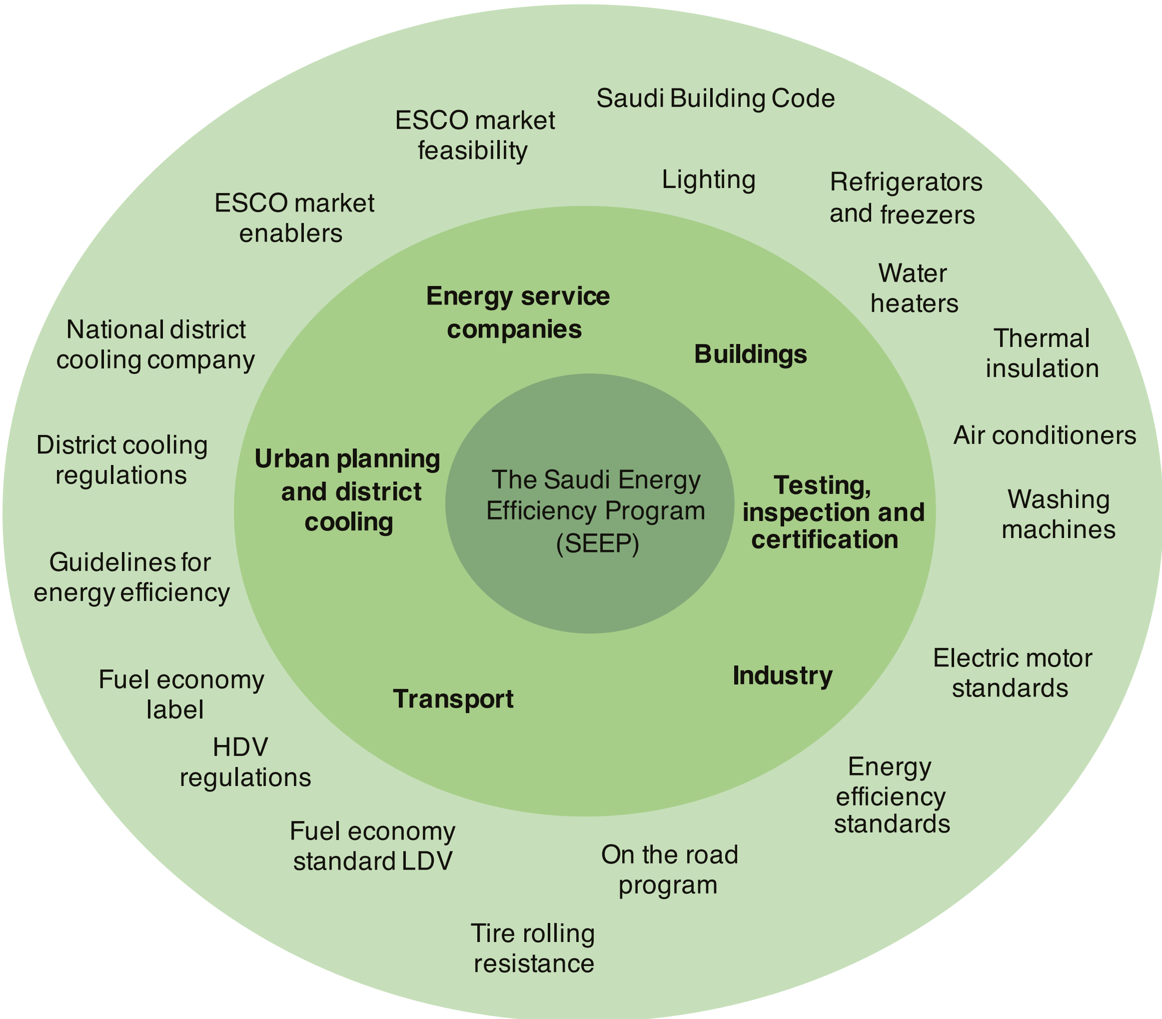

Figure 27. Saudi Arabia's Energy Efficiency Program.

Source: KAPSARC, based on Saudi Arabian Energy Efficiency Center.

The Industrial Sector

As the largest and fastest growing sector of Saudi Arabia's domestic energy economy, energy efficiency in the industrial sector represents the area with the greatest potential impact for government in terms of managing the Kingdom's overall energy productivity.

The relationship between economic growth and industrial energy consumption can give an initial indication of the level of energy efficiency in the sector.

Comparing Saudi Arabia and the GCC countries (Figures 28 and 30) with the reference group of OECD countries (Figures 29 and 31) shows industrial energy consumption is rising much faster than GDP in all GCC countries, whereas it is rising slower in the OECD group, or even falling.

These trends are the two key drivers of energy productivity – on the one hand, structural change in the economy away from energy-intensive industry and, on the other, energy-efficiency in

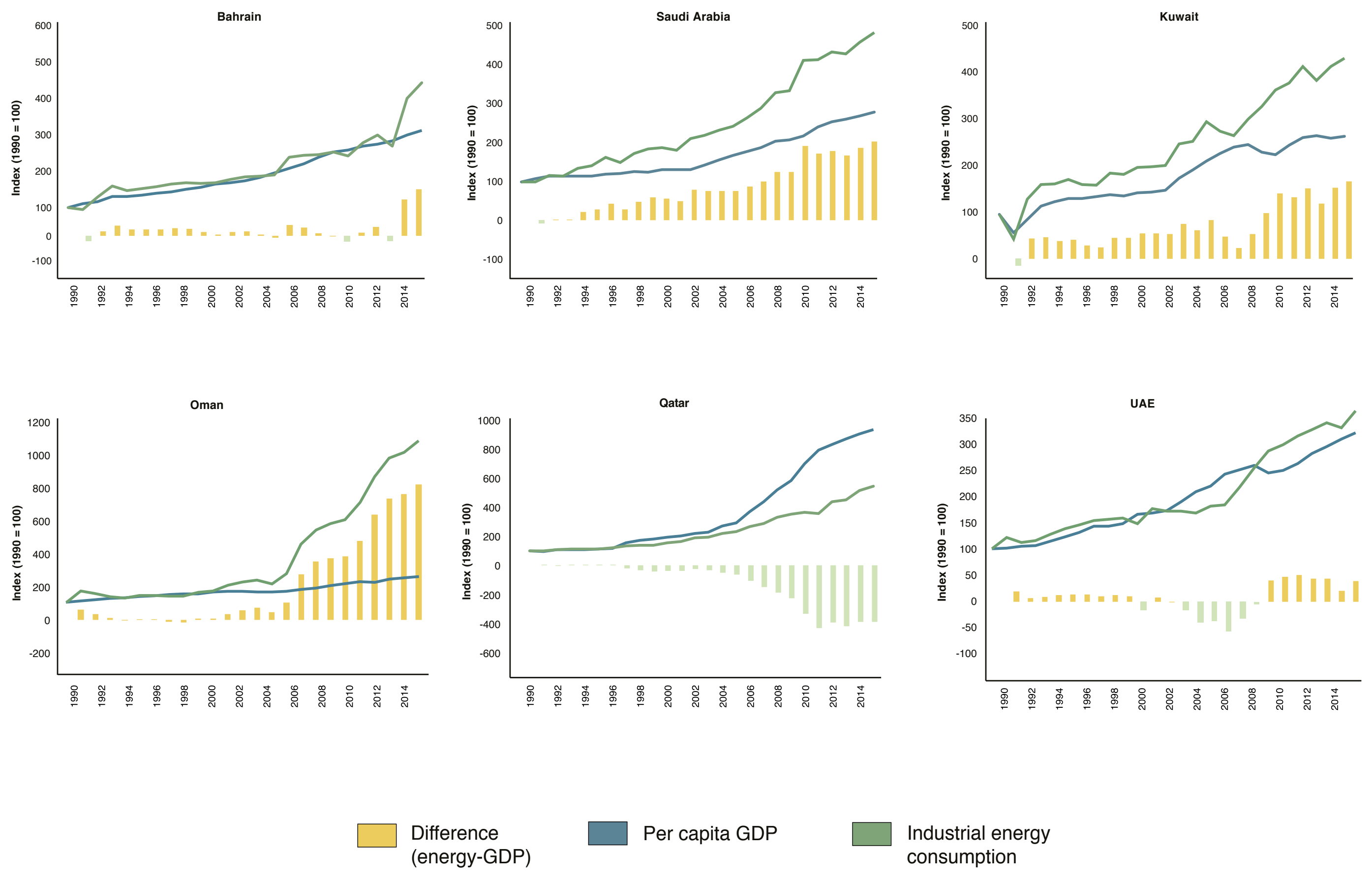

Figure 28. Industrial energy consumption and GDP (1990=100): GCC group.

Source: KAPSARC analysis, based on IEA data (not including non-energy use).

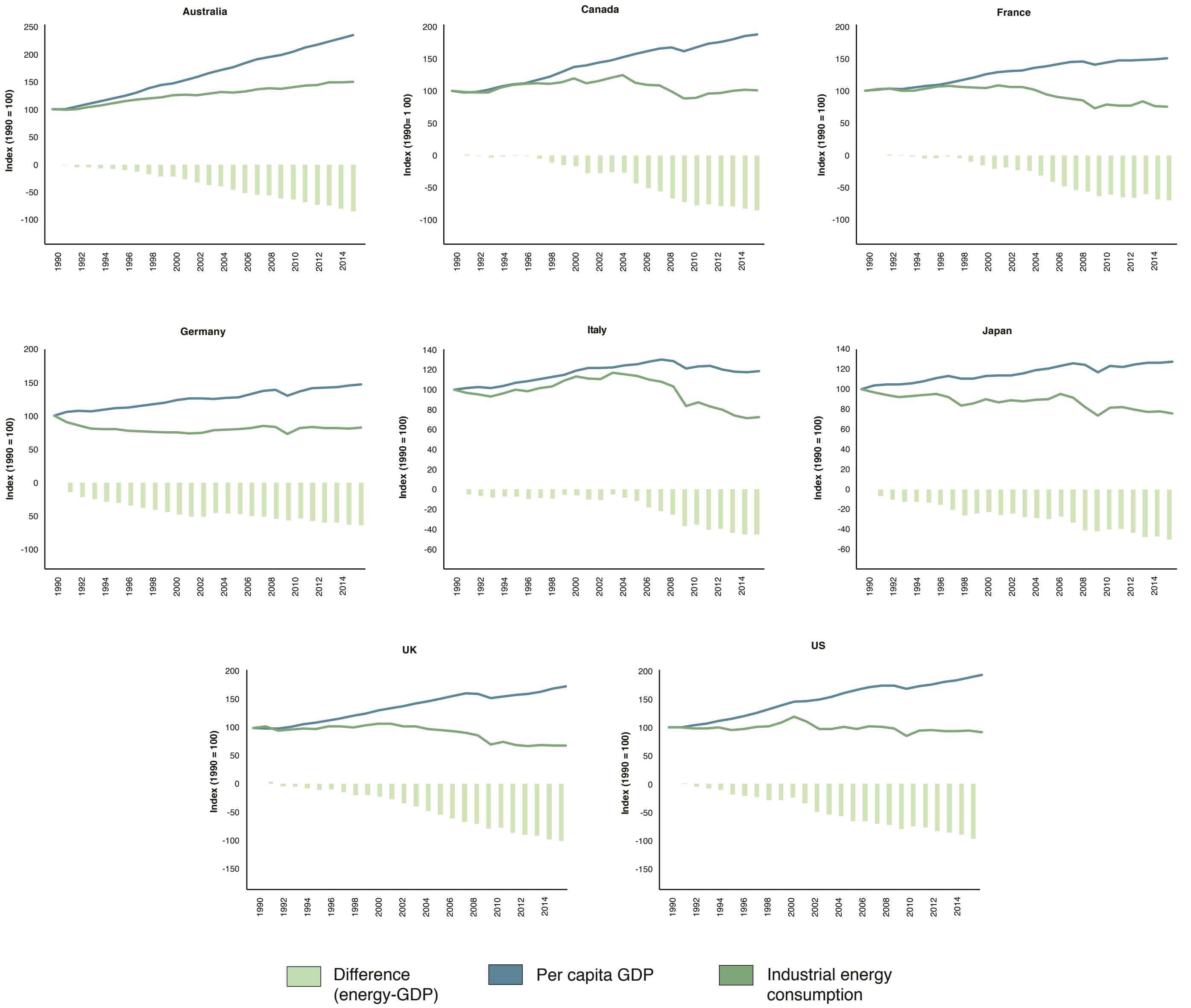

Figure 29. Industrial energy consumption and GDP (1990=100): OECD reference group.

Source: KAPSARC analysis, based on IEA data (not including non-energy use).

energy-intensive industry. While much of the shift in industrial energy consumption can be attributed to structural changes in the OECD, the generally stable or lower trend in industrial energy consumption also supports a transition to more efficient industrial plant processes. Similarly, with energy consumption rising strongly in the GCC, an argument can be made that energy efficiency in the industrial sector should be an area of concern for policymakers.

To obtain a more detailed view of industrial energy efficiency, the energy performance at the

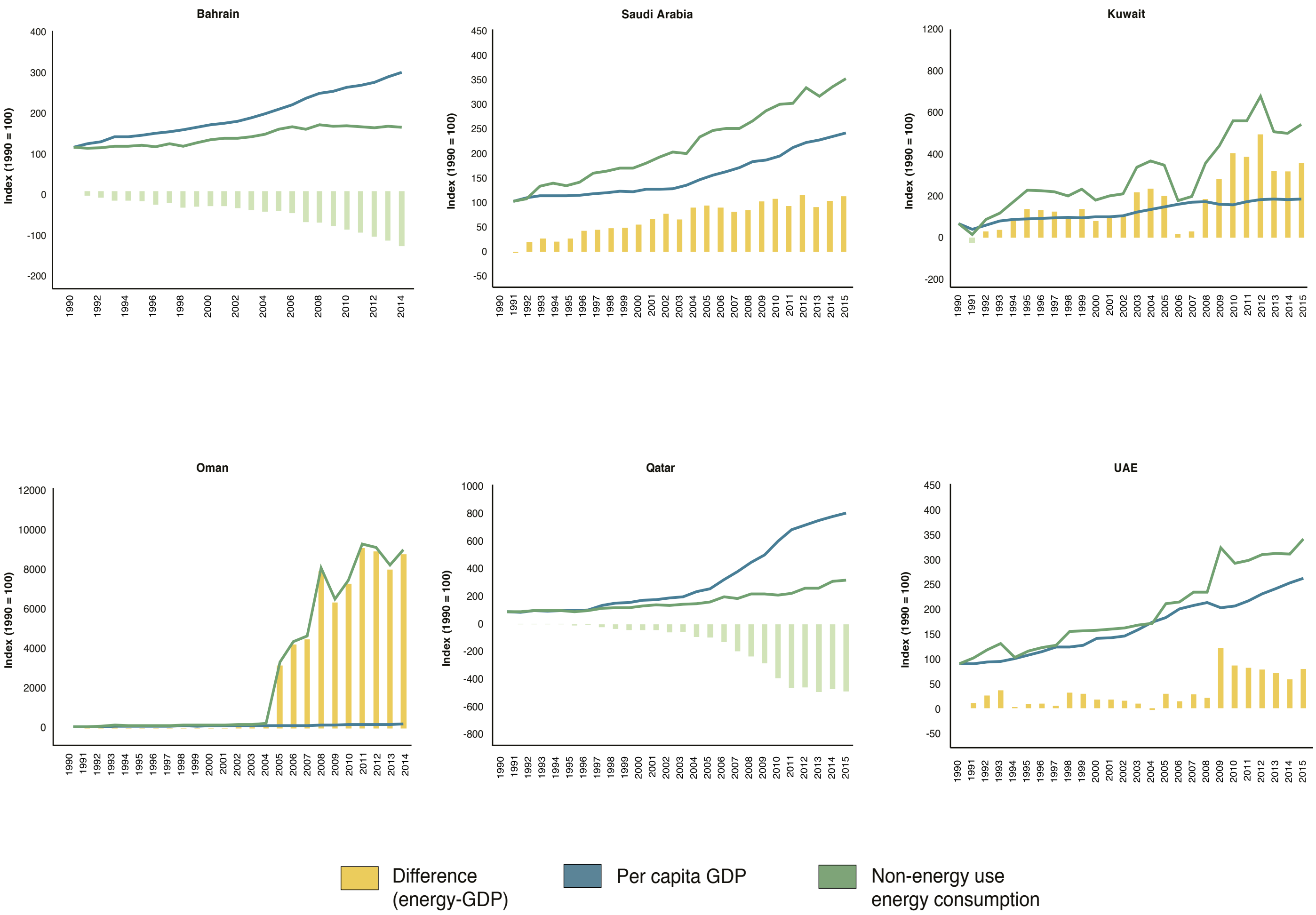

Figure 30. Non-energy use, energy consumption and GDP (1990=100): GCC group.

Source: KAPSARC analysis, based on IEA data.

subsector level can be compared with international benchmarks. Unfortunately, publicly available subsectoral energy consumption data is limited but, in general terms, the petrochemical sector is by far the largest industrial energy consumer in the Kingdom in terms of direct energy and feedstock, followed by the production of cement, fertilizers, steel and aluminum. Though very energy-intensive, aluminum production accounts for only a small volume of the Kingdom's overall industrial energy consumption, together with a range of other products such as ceramics, paper and glass production.

Because of Saudi Arabia's Vision 2030 and the associated energy price reform process, there is a strong demand from policymakers for benchmark energy efficiency analysis for key industrial sectors.

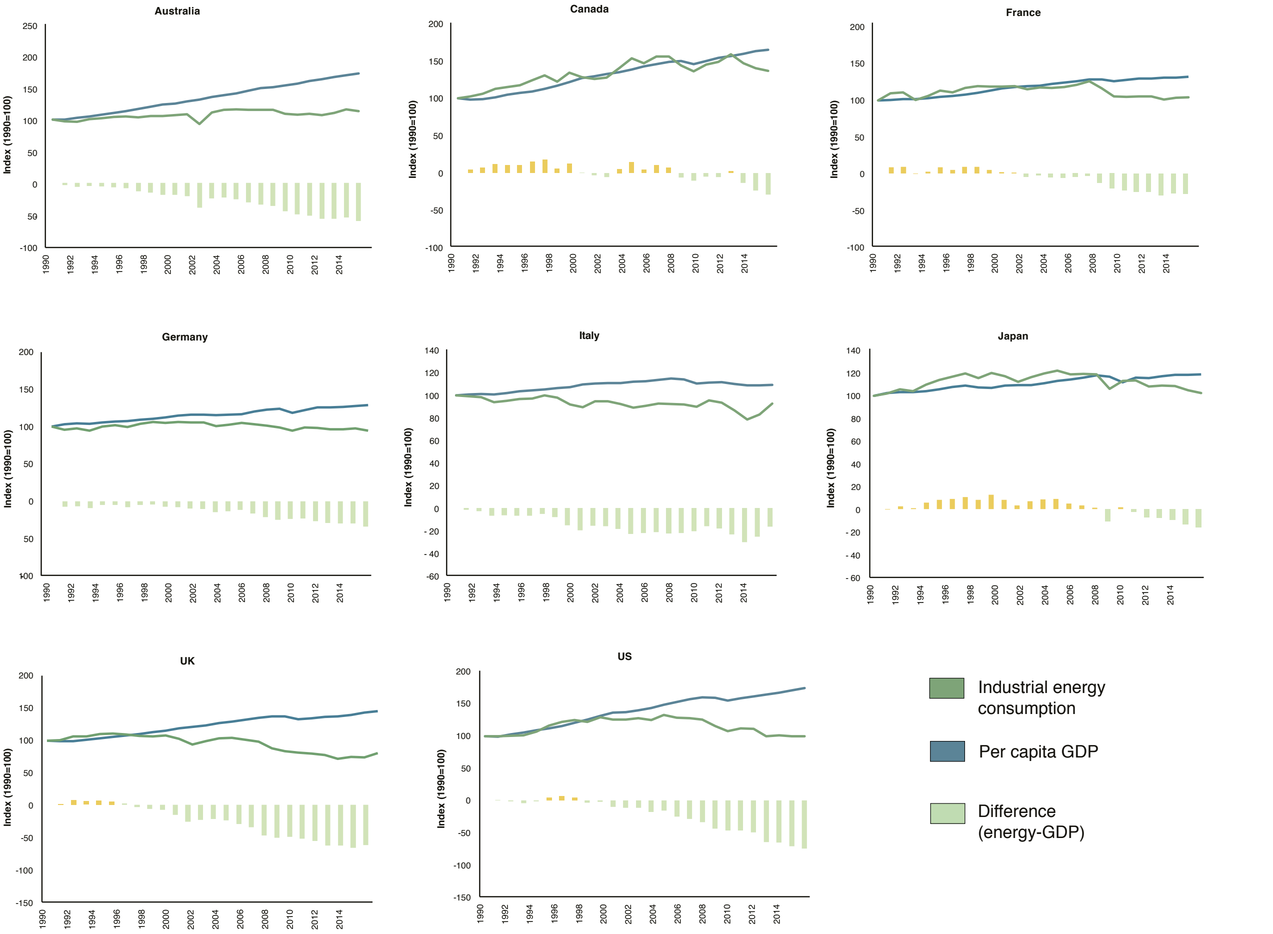

Figure 31. Non-energy use, energy consumption and GDP (1990=100): OECD reference group.

Source: KAPSARC analysis, based on IEA data.

With energy soon to be priced in reference to international energy benchmark prices, energy costs for fuel and feedstocks are expected to substantially increase by 2020, depending on prevailing international market conditions and the formulae for calculating reference prices.

For example, in January 2016, Saudi Arabia raised the price of gas (methane, or sales gas) for power generation from 0.75 cents per MMBtu to $1.25 per MMBtu. In neighboring Bahrain, in 2015 the government increased gas prices from $2.25 per MMBtu to $2.5 per MMBtu and established a process by which the price is set to rise by 25 cents each year on April 1 until it reaches $4 per MMBtu by 2022. Oman also significantly increased gas prices from $1.5 per MMBtu to $3 per MMBtu.

January 2016 saw the ethane price rise in Saudi Arabia from $0.75 per MMBtu to $1.75 per MMBtu, or by 133 percent, although the price rise was introduced in stages and volumes sold under older contracts continued to be charged at old prices (Chatham House 2016).

Compared with international prices, current prices for methane are still below the U.S. Henry Hub spot price, which is a commonly cited international benchmark (Figure 32). However, establishing international reference prices for natural gas is not

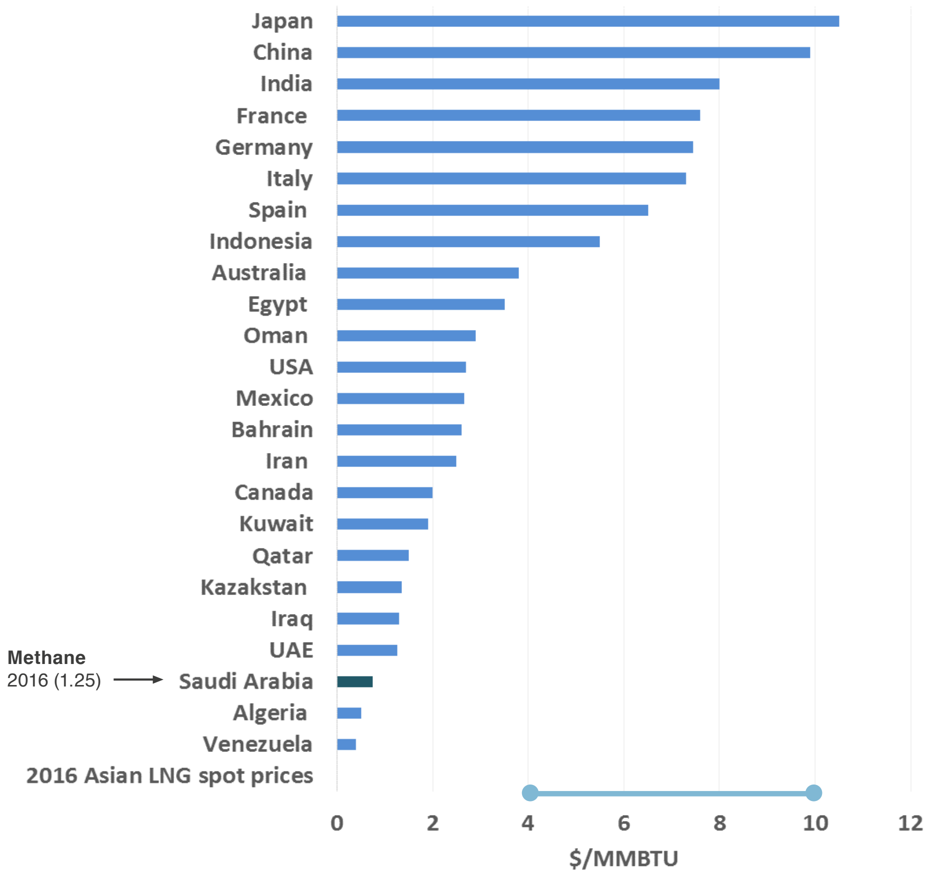

Figure 32. 2015 wholesale gas and Asian LNG spot prices.

Source: KAPSARC based on International Gas Union.

as straightforward as for oil, which is a much more actively internationally traded commodity. Liquefied natural gas (LNG) prices offer an alternative reference based on different regional prices. LNG can trade at much higher prices, though, for example between $4 and $10 per MMBtu in 2016.

Using an energy productivity framework for setting prices would suggest that the reference price should be set at the maximum level which still maintains the Kingdom's international competitive advantage based on its low costs of production, but which also fully incentivizes energy efficiency and diversification into higher value downstream products such as specialty chemicals.

"In setting future prices, it is also worth referring to the price levels and experience of other countries in the GCC, especially the United Arab Emirates, which has employed a similar logic of successfully benchmarking to international reference prices."

Quote from KAPSARC Workshop 'How to Achieve Economic Prosperity Through Industrial Energy Productivity Improvement', March 28, 2017.

Higher natural gas prices will also be the major determinant of higher electricity prices in the future environment after the introduction of the second phase of energy price reforms (Figure 33).

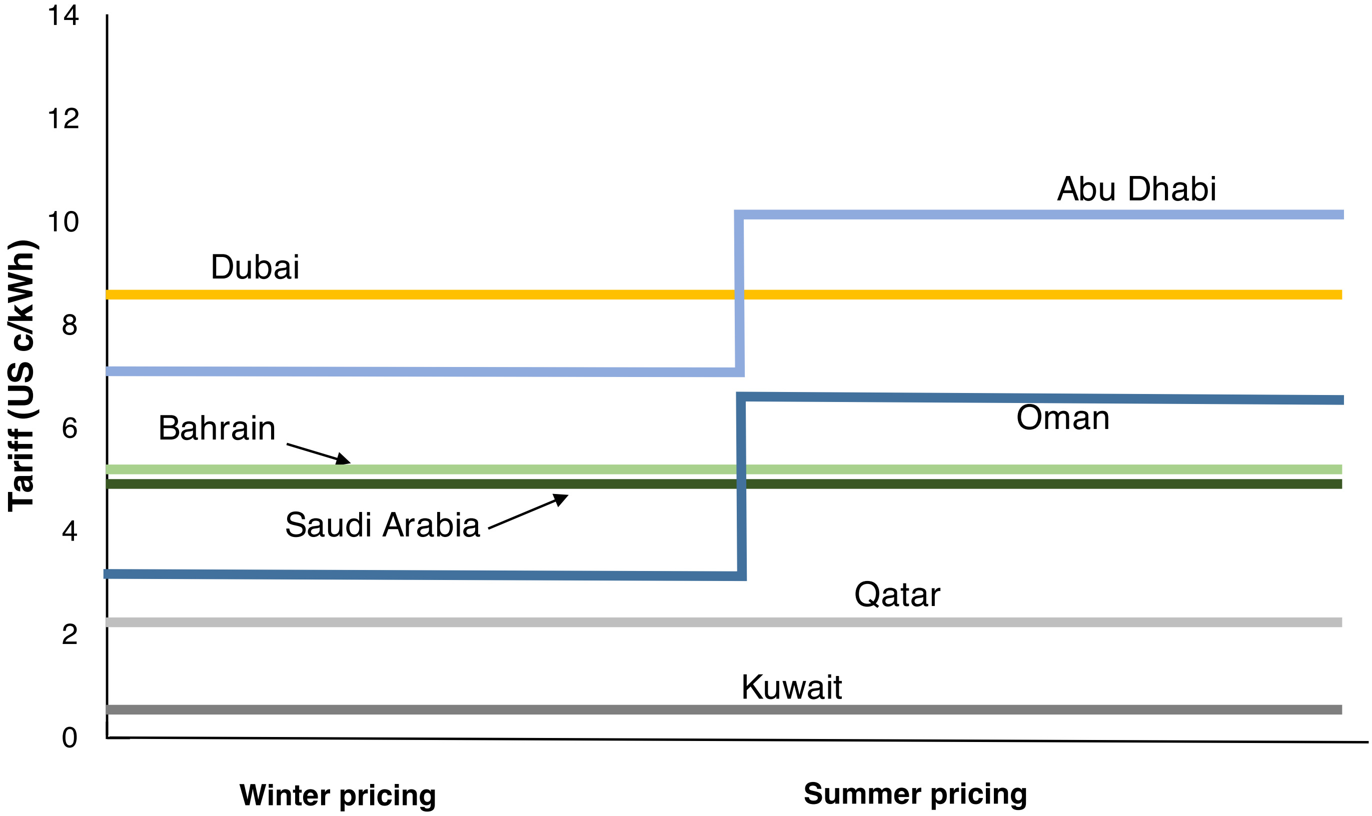

Figure 33. Regional benchmarking of electricity prices for industry.

Source: KAPSARC, based on Chatham House 2016.

Note: Seasonal industrial electricity pricing in Oman and Abu Dhabi. Peak tariffs in Abu Dhabi only apply to consumption over 1 MW. Bahrain has a slab tariff, which sets rates for consumption of 5,000 kWh/month and 250,000 kWh/month. The Dubai tariff is for up to 10,000 kWh/month consumption.

However, for the petrochemical sector, direct energy consumption such as electricity is a smaller element of its cost structure than the cost of feedstock.

Saudi Arabia currently has industrial electricity prices around the average level in the GCC, above prices in Qatar and Kuwait, but below those in the UAE. During the reform process care will need to be taken to allow industry to adapt to any price reforms so as to maintain competitiveness. In addition to better coordination of energy pricing across GCC countries, one strategy which has been applied to mitigate the effect on industry is seasonal pricing. It takes into account the large excess generation capacities that are available in the winter months when lower demand for air conditioning reduces peak power demand to about half its summer levels. Such innovative policy could improve coordination of industrial demand with other consumers and improve the overall value generated from the electricity sector.

One of the key policy tools emphasized in the Fiscal Balance Program which will be used in concert with the transition to higher energy prices is support to industry to encourage it to operate at or above international benchmark standards of energy efficiency. This is based on the logic that in the long run local industries should be internationally competitive with companies which face similar or higher energy input costs. Firms which have lower energy efficiency resulting from the old energy price regime should be provided with support and time to adjust but, ultimately, if energy is to be valued at its true opportunity cost to the Kingdom, best available technologies should be employed.

In terms of regulation, the Saudi Energy Efficiency Center set its standard for electric motors in 2013 (SASO IEC 60034-30) and has begun the process of establishing baselines and benchmarking frameworks for over 180 industrial plants which have 59 different production processes. Aspirational energy efficiency targets have been agreed for 2019 and energy efficiency improvement plans reviewed for 42 companies. Overall, these initiatives are expected to save around 9 percent of total industrial energy consumption by 2019 compared with a 2011 baseline (KAPSARC Energy Productivity Workshop 2017).

Saudi Arabia is focusing on three sectors. The petrochemical sector, with the largest share of industrial energy consumption, has been a major and early focus of the program. Benchmarking is being conducted across 55 separate production processes used by 115 plants and 24 companies. Results from 2011 to 2015 suggest improved energy intensity in the petrochemicals subsector of 2 percent (KAPSARC Energy Productivity Workshop 2017).

The second focus sector is cement, where two production processes are being benchmarked, involving 36 plants and 15 companies. Results from the program suggest an improvement in energy intensity of around 3 percent. The third focus sector is steel, where two production process are being benchmarked across 14 plants and three companies.

A total of 11 government entities have signed joint agreements to help plants achieve their goals. The results from this program feed into a benchmark analysis which forms the basis for managing industrial energy efficiency improvement, the general approach to which is set out in Figure 34.

For the purposes of this report, to obtain benchmarks based on average Specific Energy Consumption (SEC) we have drawn on a sample of firms from across the GCC region to increase our sample, rather than just for Saudi Arabia (Figure 35). We drew on a sample of industry plant level data from the IHS midstream database and research on publicly available company data. Global statistics on specific energy consumption for the industry subsectors were taken from IEA World Energy Statistics 2014.

Using this admittedly limited data, in terms of indicative efficiency, fertilizer production compares favorably to global benchmarks. Dry process cement production across the GCC has a higher SEC than the global average and best available technology. From the sectors examined, cement should thus be made a priority target for energy efficiency policy intervention, as well as petrochemicals, the largest energy consumer. Improvement can also be achieved in the iron and steel sector; however, given the smaller overall energy consumption in this subsector, measures here would have less overall impact on energy productivity at the national level. Aluminum production compares very well with international benchmarks, based on our study.

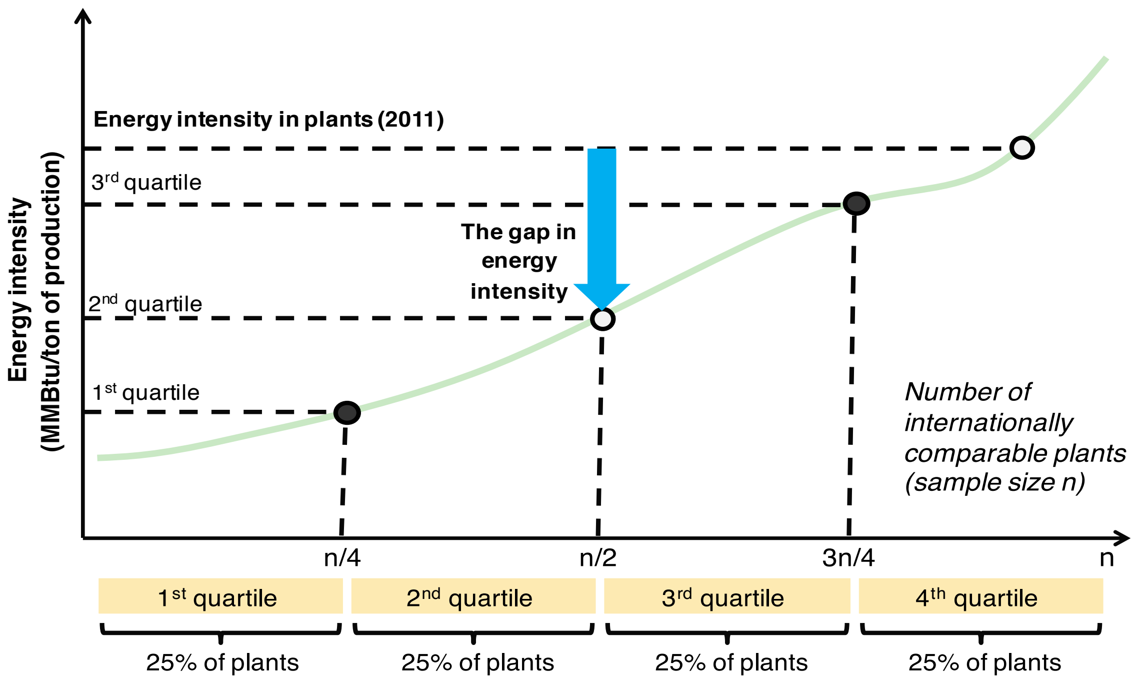

Figure 34. General approach for benchmarking energy efficiency in Saudi Arabia.

Source: Saudi Energy Efficiency Center.

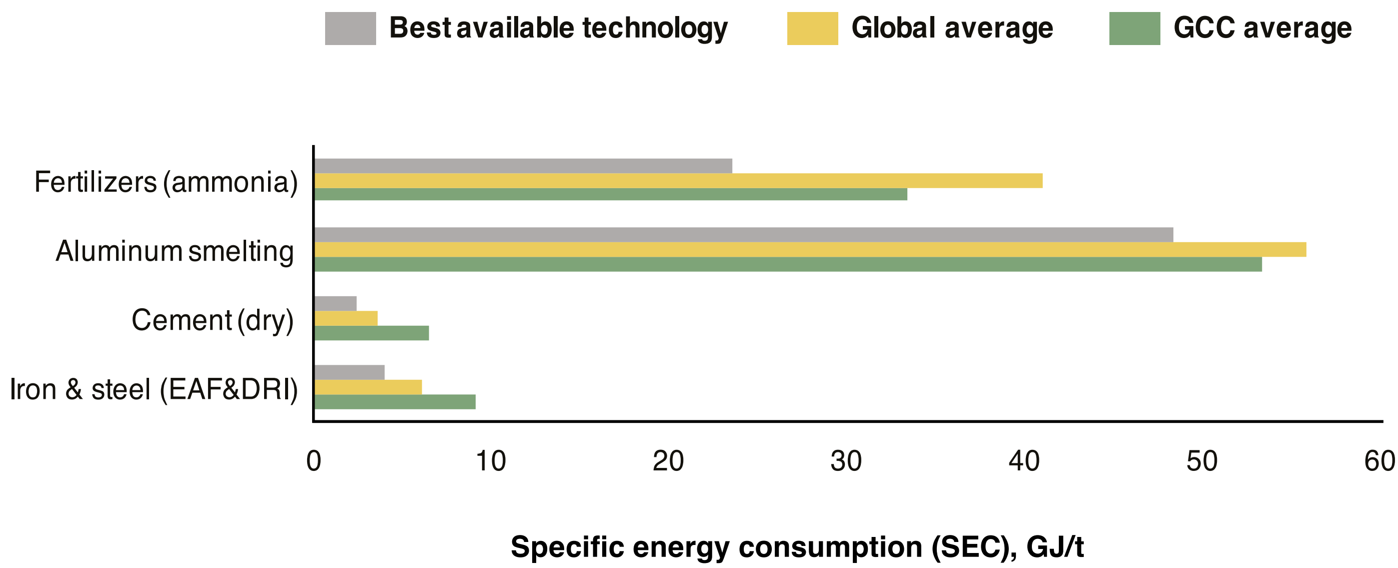

Figure 35. Specific energy consumption for key industrial sectors in the GCC.

Source: KAPSARC, IEA and IHS data.

Industrial energy efficiency benchmarking*

"Energy benchmarking is part of a much wider use of benchmarking as a management tool. The results of sectoral benchmark studies can be summarized in benchmark curves, in which the energy use of individual plants is plotted as a dependent variable from the most efficient to the least efficient plant, either as a function of cumulative production or of the number of plants. The information from benchmark curves can be used to assess the relative performance of individual plants. It can also, where sufficient specific information is available and the coverage of the benchmark curve is fairly comprehensive, be used to estimate the aggregate energy savings potential at the level of an individual country, a region, or worldwide.

A benchmark curve contains valuable information about best practice technologies (BPT), i.e. technologies that are energy efficient and already applied in practice. The most energy efficient plants in the benchmark curves are not, however, necessarily users of the most efficient technologies. They may, rather, be plants that benefit from exceptionally favourable feedstock quality or other non-technology-related factors. Detailed information on the reasons for the position of a plant on the curve cannot be obtained from the benchmark curve itself.

Even where benchmark curves are publicly available, it is often impossible to identify individual plants based on the information given. Plant data are often confidential because of antitrust regulations and market sensitivities. It is not therefore often possible to develop detailed efficiency investment programs based on a benchmark curve because it remains unknown which plants exactly are the ones with the high savings potential. Information from additional sources is needed to complement benchmark curves if governments or other organizations are seeking to target investments in energy efficiency."

*Source: Extracted from UNIDO 2010.

Oil and gas rich GCC countries are a hub for the refining, chemicals and petrochemical industries. For the refinery sector it is not possible to derive a meaningful single SEC value due to the numerous processes involved, each with their own best process technology values. To deal with this, energy efficiency benchmarking requires refining to be typically classified into 13 main refinery 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 sulfur. See Solomon Associates, as reported in Matthes et al. (2008).

The chemical and petrochemical industries are highly diverse and complex, which makes benchmarking energy efficiency in the sector less straightforward than in others. In addition, more than half of the total fuel inputs to this subsector are accounted for by feedstocks, i.e., non-energy consumption. Steam cracking is by far the largest energy user in the sector, accounting for more than one-third of the sector's final energy consumption, including feedstock. Benchmark information is reported for steam cracking for the production of ethylene and other high value chemicals – propylene, butadiene, benzene and hydrogen – and ammonia production by UNIDO (2010) for 2005 (Figures 36-37).

While these benchmarks can provide an indication of each country's position and its energy efficiency improvement potential, given their age and the qualifications to their construction, further research and collaboration is needed to update and increase confidence in the resulting estimates. Solomon Associates is one group which is working closely with stakeholders in this area in the Kingdom, and it was instrumental in the UNIDO report which produced the benchmarks above.

That type of work requires the careful management of confidential information, such as through the application of an anonymized energy information database. This could then be used by policymakers, and potentially made publicly available in an aggregated form to improve transparency around the achievement of targets.

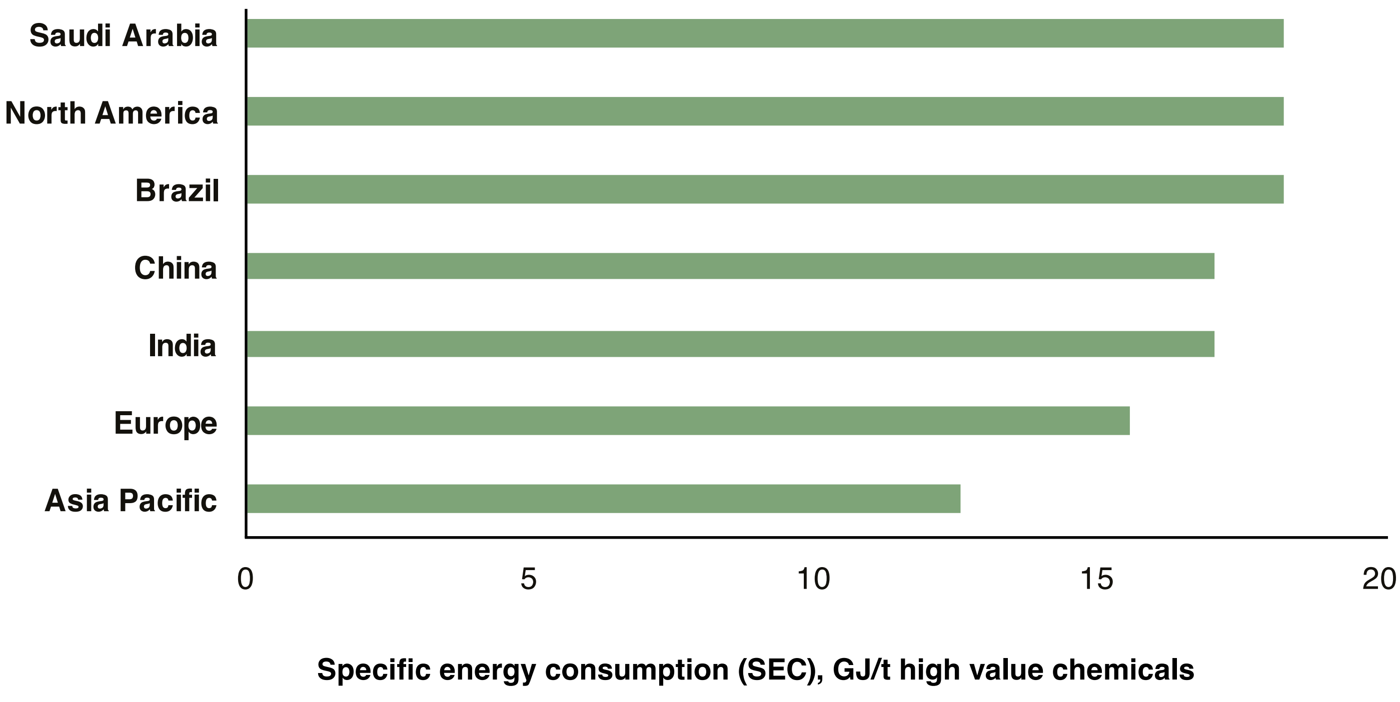

Figure 36. Estimated specific energy consumption (SEC) for steam cracking to produce high value chemicals (HVC) (2005).

Source: UNIDO 2010.

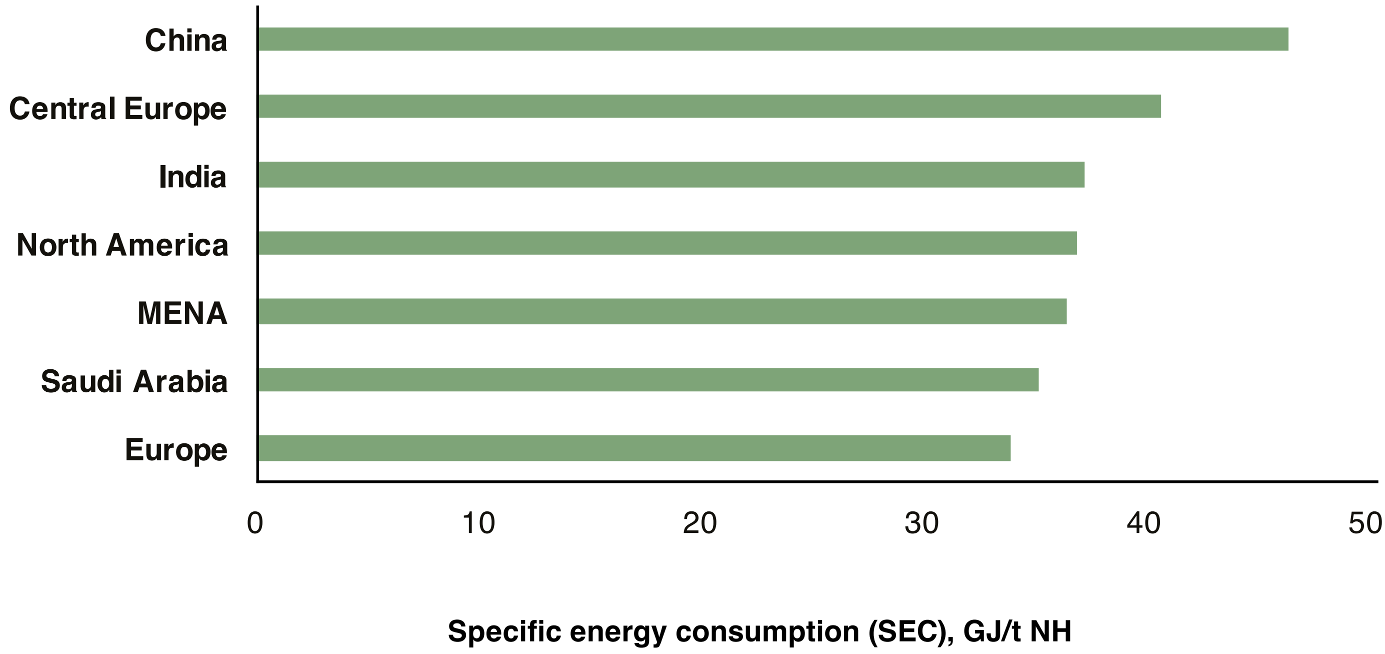

Figure 37. Estimated Specific Energy Consumption (SEC) for ammonia industry (2007).

Source: UNIDO 2010.

Transport

As the second largest energy-consuming sector after industry, increasing energy efficiency in the transport sector has the next largest potential to raise overall energy productivity. To discuss transport sector energy efficiency and productivity is complicated, mainly because transport is not demanded in its own right but acts as an enabler of economic activity by providing adequate mobility to passengers and goods.

Hence it is essential that making transport more energy efficient does not come at the expense of economic growth. Priority must be given to providing people with access to the necessary economic activities that transport enables and to moving goods at a competitive cost and speed.

Another important aspect to consider is that transport is strongly dependent on oil-derived fuels and consequently high demand for transport fuels in Saudi Arabia could potentially impact long-term oil export revenues. These revenues in turn are key to fostering investment in the economic diversification efforts that support transition in the economy to higher value uses. The balance that needs to be struck is between supporting the increased demand for transport services that economic growth requires and ensuring that transport sector energy consumption is not wasteful.

To provide an indicative benchmark of energy efficiency in the sector, transport energy consumption per capita for road transport can be compared across a range of countries (Figure 38). It

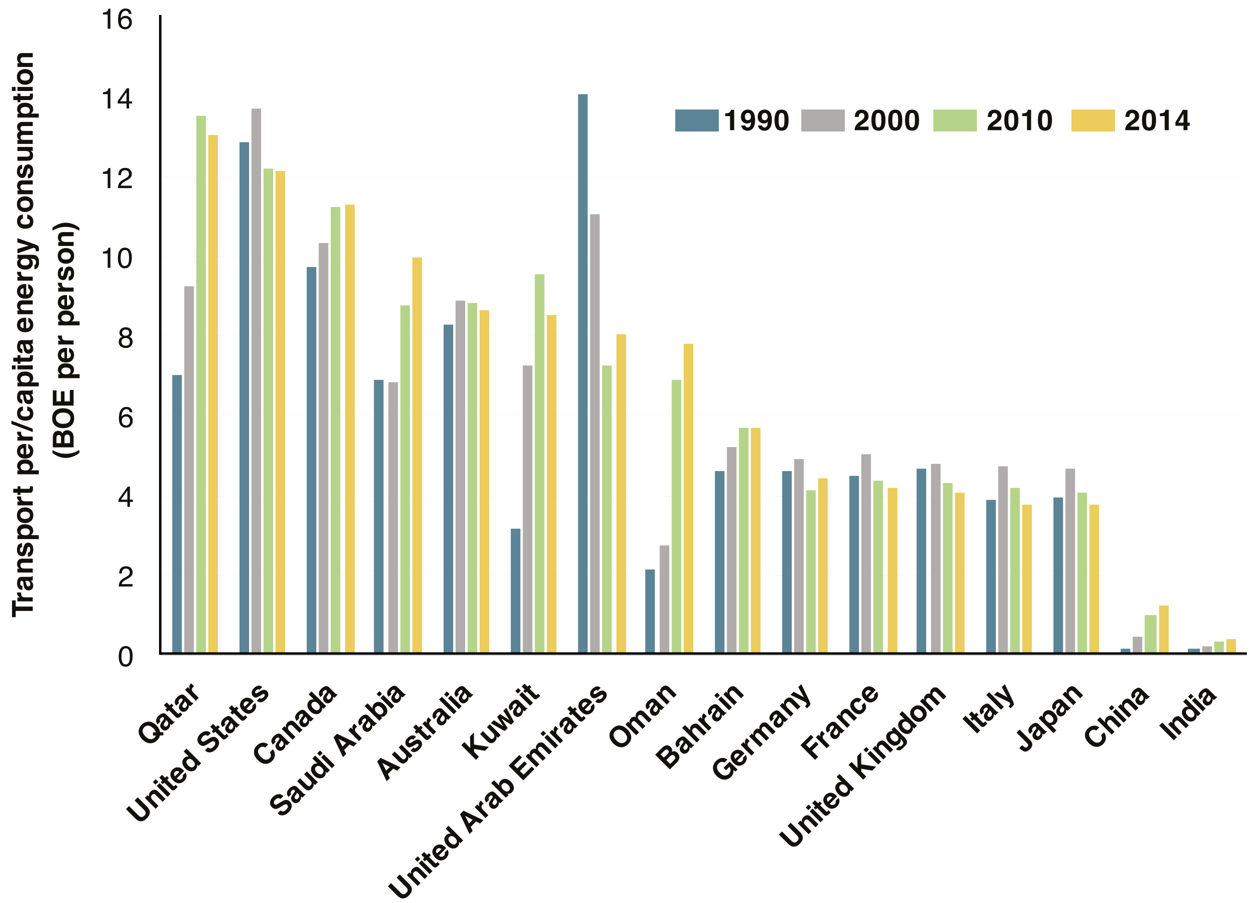

Figure 38. Transport energy consumption per person.

Source: Enerdata.

will be noted that while per capita transport energy consumption is relatively high in Saudi Arabia, it is still lower than in Canada and the U.S. However, the major difference is that per capita transport energy consumption is stable or declining in most OECD countries, whereas in Saudi Arabia it has been growing strongly.

The potential for decoupling transport energy consumption and economic growth is illustrated in Figures 39 and 40. For example, Saudi Arabia and the U.S. are two countries with similar levels of per capita transport energy consumption and per capita incomes. However, the relationship between economic growth and transport energy consumption is very different.

In the U.S., GDP is growing at a much faster rate than transport energy consumption, suggesting that economic growth has decoupled from transport energy consumption. In Saudi Arabia, however, transport energy consumption and economic growth rise hand in hand, implying that as the economy grows, transport energy consumption will also rise. All other things being equal, this suggests that overall the transport sector is positively contributing to energy productivity in the U.S., whereas in Saudi Arabia there is room for improvement.

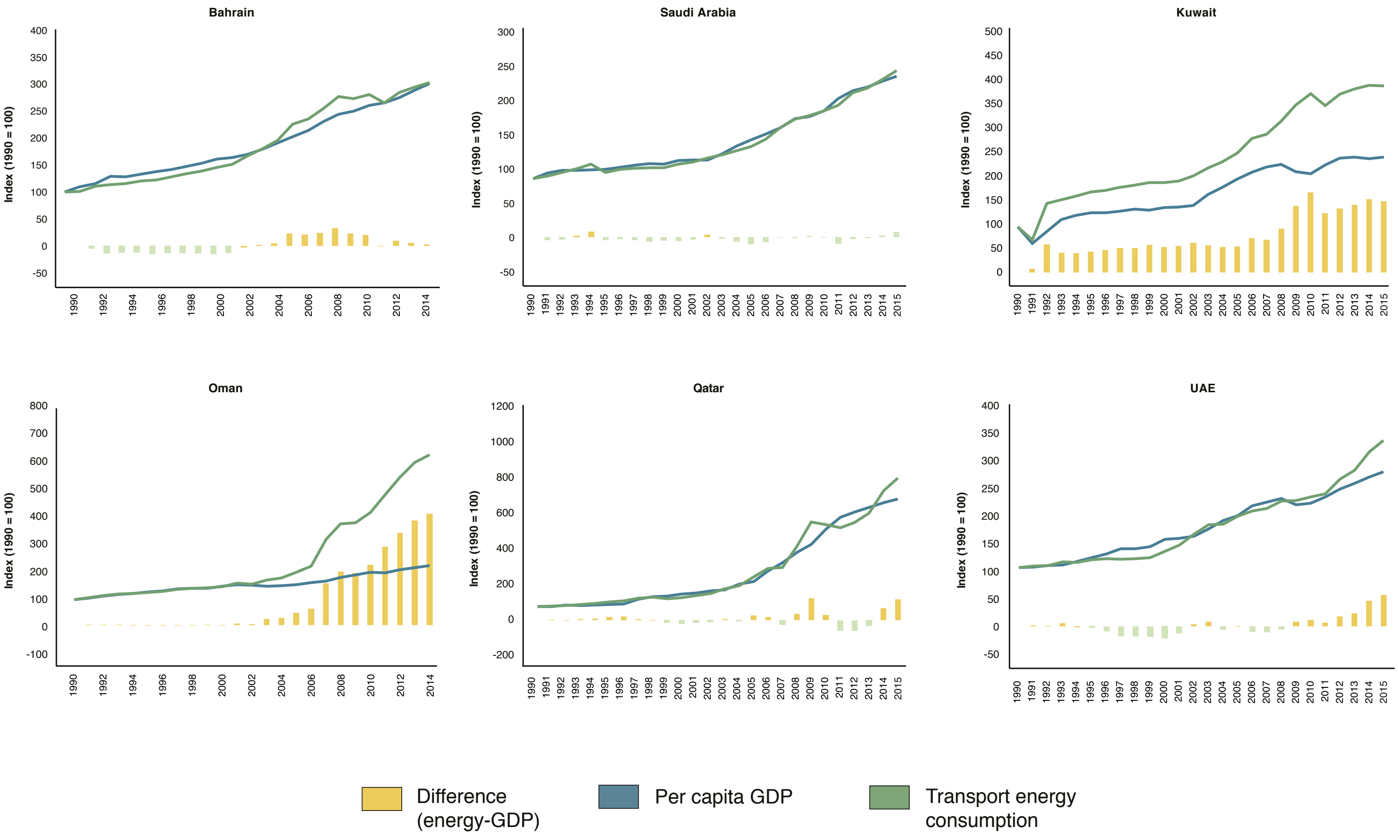

Figure 39. Transport energy consumption and GDP (1990=100): GCC countries.

Source: KAPSARC analysis, based on IEA data.

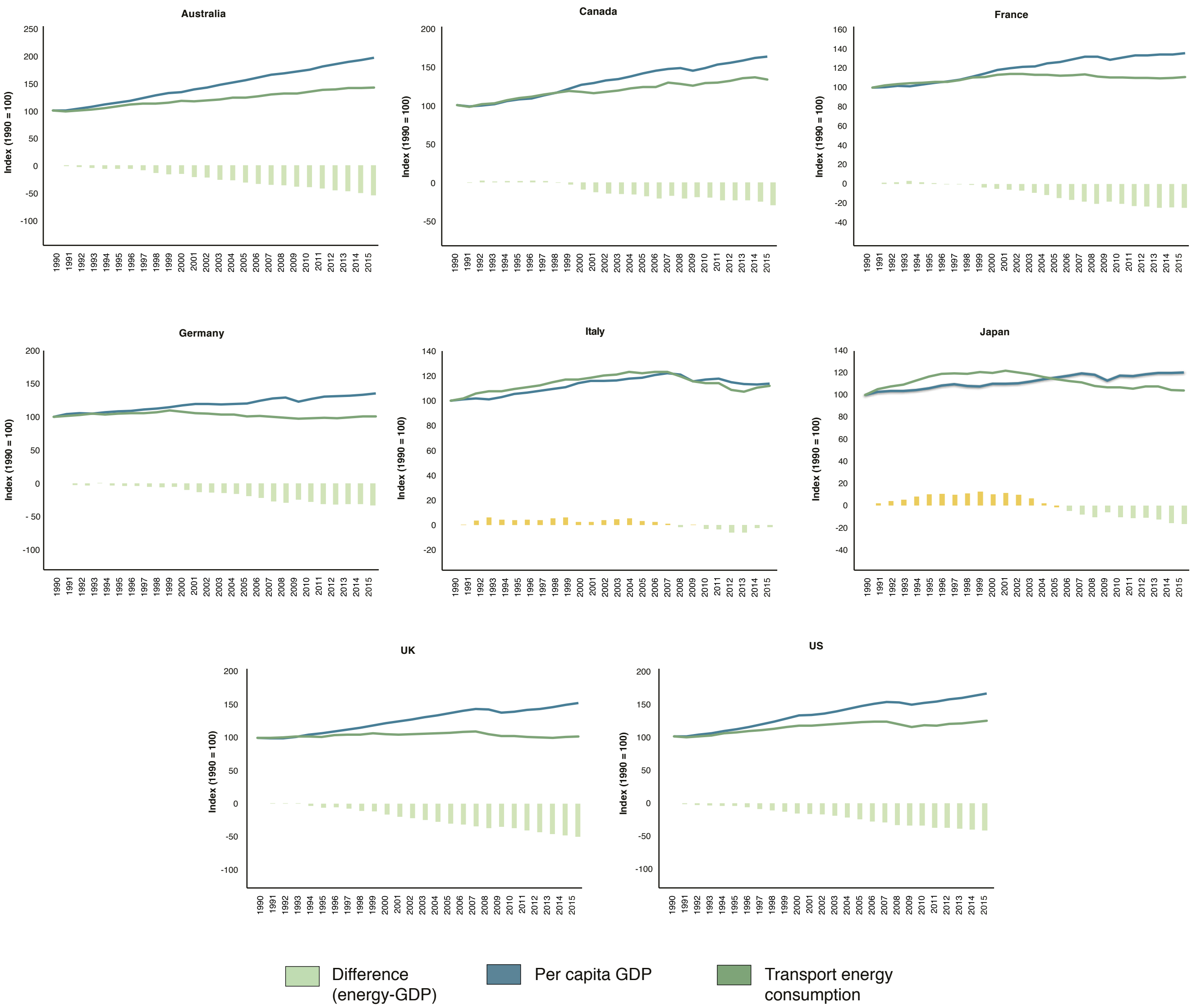

Figure 40. Transport energy consumption and GDP (1990=100): OECD reference countries.

Source: KAPSARC analysis, based on IEA data.

According to the Avoid-Shift-Improve paradigm – designed to achieve more sustainable transportation – energy efficiency in transport can be enhanced in three ways. First, by reducing transport demand through urban planning and information technology; then by shifting transport of passenger and goods away from more energy-intensive modes, such as road, to less intensive means, such as public transportation for passengers and rail and sea for goods; and finally by improving the fuel economy of the vehicles used, be they road vehicles, aircraft, trains or ships.

In Saudi Arabia, all three transportation options are being pursued, with high density urban areas being planned, a metro system being constructed in Riyadh and nationwide railway infrastructure also under development.

In terms of energy efficiency regulations, SEEC issued its fuel economy standard for passenger cars in November 2014, using the U.S. NHTSA CAFE standards as a reference, and has established a fuel economy testing lab for monitoring and evaluating actual performance against this standard. SEEC passenger car regulations also include a requirement for vehicle fuel efficiency labels and a low rolling resistance tire standard. In addition, fuel economy standards for heavy duty vehicles and a 'cash for clunkers' vehicle scrapping scheme are under development. For example, Egypt's Greater Cairo Region Old Vehicles Scrapping and Recycling Program is one example which involved replacing old taxis with compressed natural gas (CNG) fueled vehicles.

Fuel price reform is also crucial to improving energy efficiency and productivity in transportation. As can be seen in Figures 41 and 42, Saudi Arabia currently enjoys the lowest prices in the GCC for transport fuels, which are already among the lowest in the world. Though consistent with the local costs of production of gasoline, this represents a substantial opportunity cost in terms of potential government revenues. It also acts as a disincentive to purchasing more fuel-efficient vehicle models and shifting to more efficient modes of transportation, where available (Gelil, Howarth, & Lanza 2016). Moving toward international benchmarks would help increase energy efficiency in the sector and be consistent with the pricing policies adopted by other GCC countries.

Figure 44 shows the results obtained by taking a price gap approach to comparing the pump prices for transport fuels in each GCC country to their cost of production.

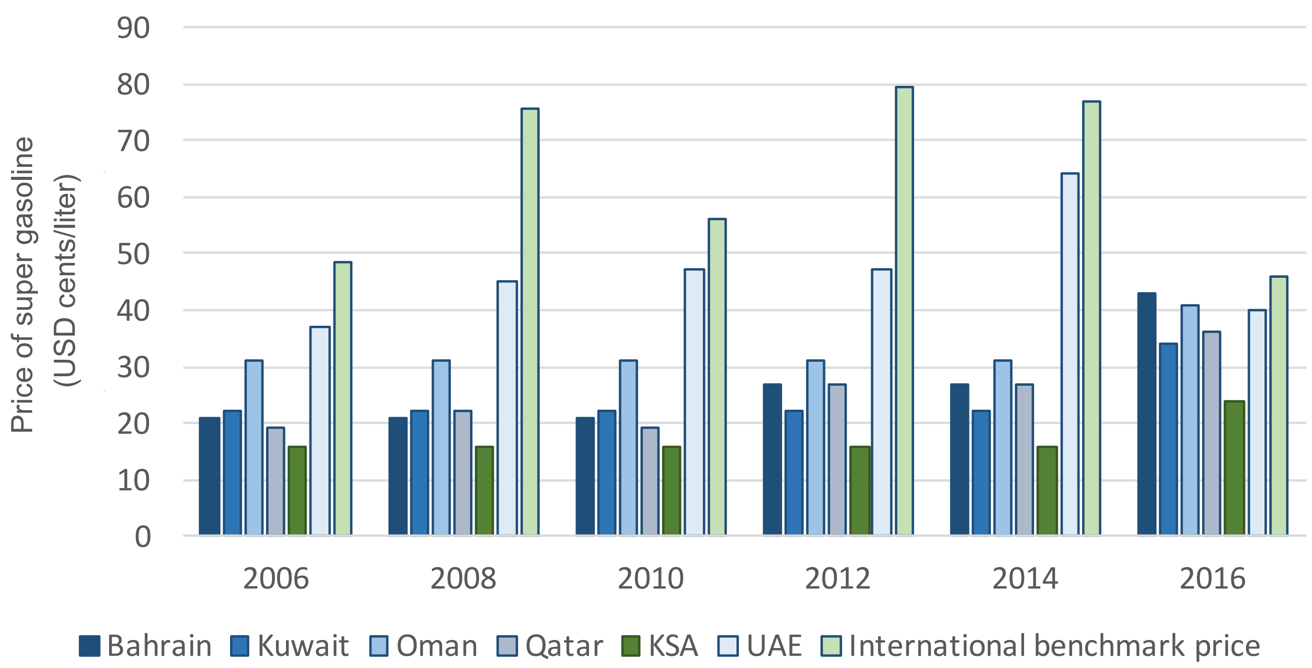

Figure 41. Regional benchmarking of petrol prices in the GCC.

Source: KAPSARC based on GSI and IISD 2014; GIZ 2014 and national country authorities.

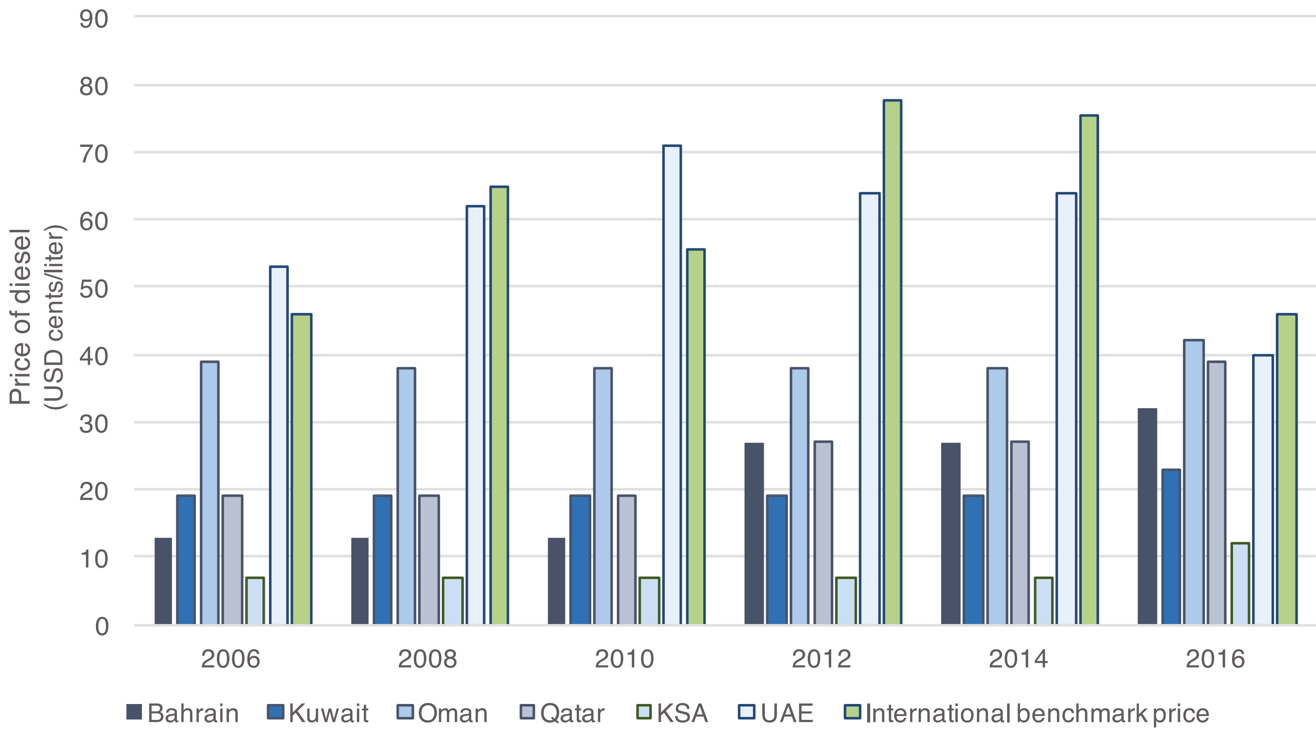

Figure 42. Regional benchmarking of diesel prices in the GCC.

Source: KAPSARC based on GSI and IISD 2014; GIZ 2014 and national country authorities.

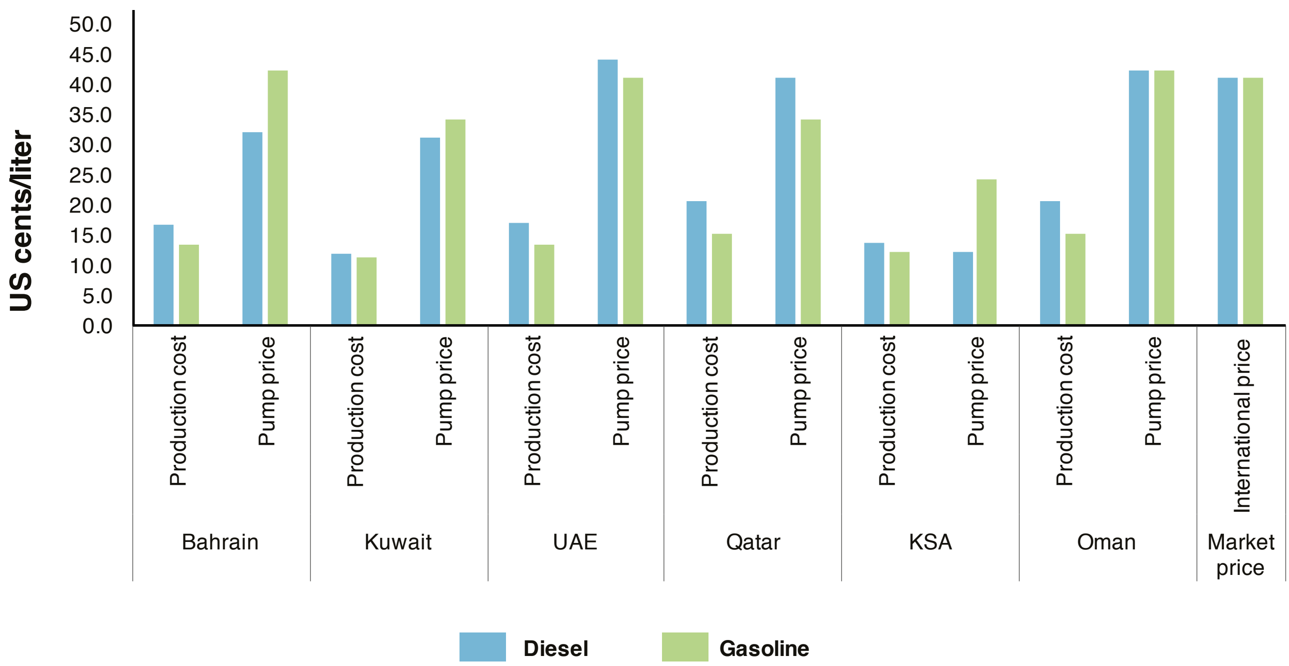

Figure 43. Price comparison of transport fuels (2016) (US cents/liter).

Source: KAPSARC analysis, based on Knoema 2016 and personal communications.

The cost components of production of transport fuels (Figure 43) are based on the breakdown of refining, distribution and marketing and crude oil taken from the U.S. Energy Information Agency (2016), adjusted to remove the effect of tax. The ratios are then applied to the GCC, to show (Figures 44 and 45) the breakeven costs of supplying liquid fuels and the current pump prices of gasoline and diesel. This analysis suggests transportation fuel prices are higher than their costs of production in all the GCC countries. Thus, under the current pricing schemes, there are no explicit subsidies being offered, though there is a high opportunity cost relating to what prices could rise to if international oil prices were taken as a reference price, i.e., 56 and 58 cents per liter for gasoline and diesel, respectively.

The analysis shows that significant revenue is not achieved – forgone – because these fuels are being sold in the domestic markets instead of exporting them to the international markets at much higher levels. The total forgone revenue from gasoline and diesel sold in the GCC in 2014 can be estimated at around $46 billion – and this value has more than tripled since 2006. Indeed, even after the price reforms of January 2016, transportation fuel prices in Saudi Arabia are the lowest in the GCC, contributing about 75 percent and 87 percent of the total opportunity cost of revenues foregone

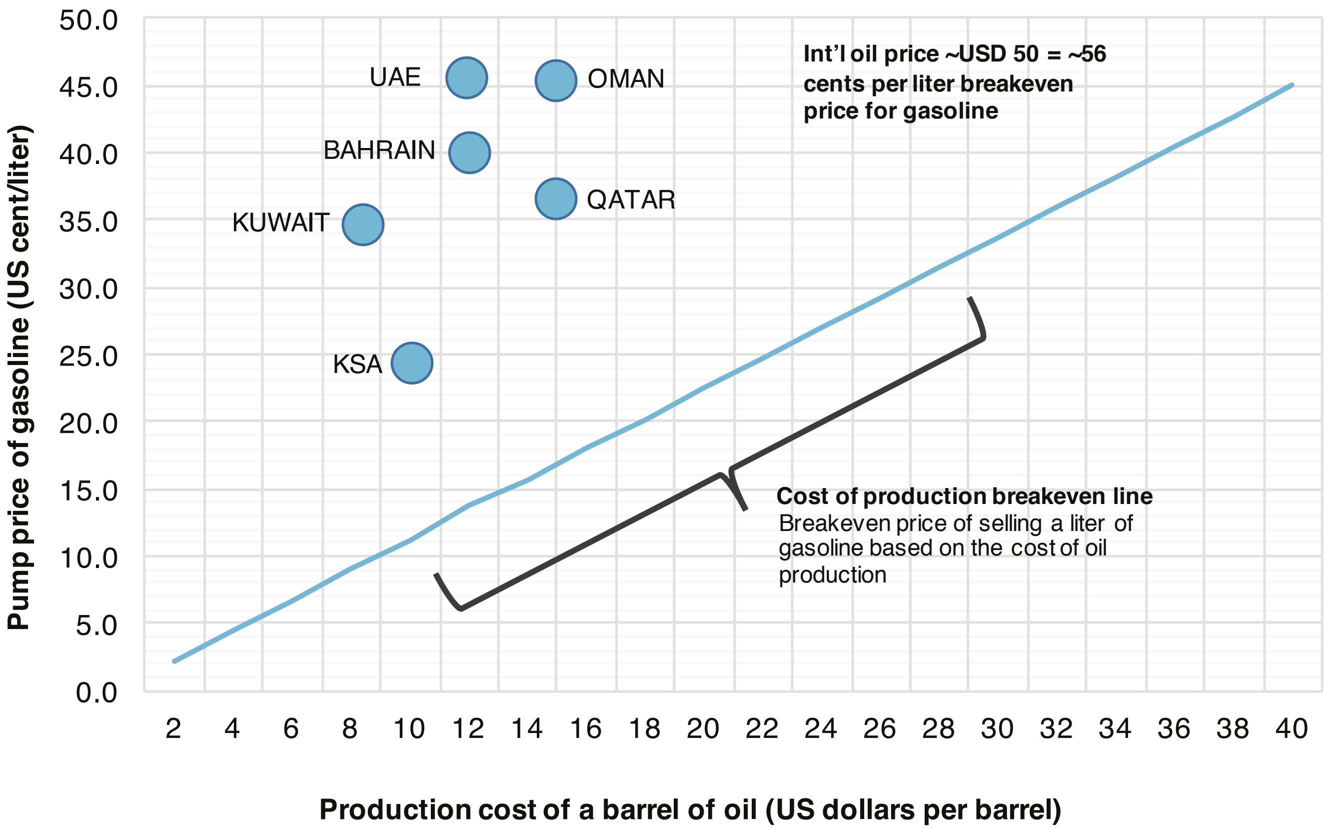

Figure 44. Gap between pump prices of gasoline and cost of production at different oil production costs.

Source: KAPSARC analysis, based on Knoema 2016 and personal communications.

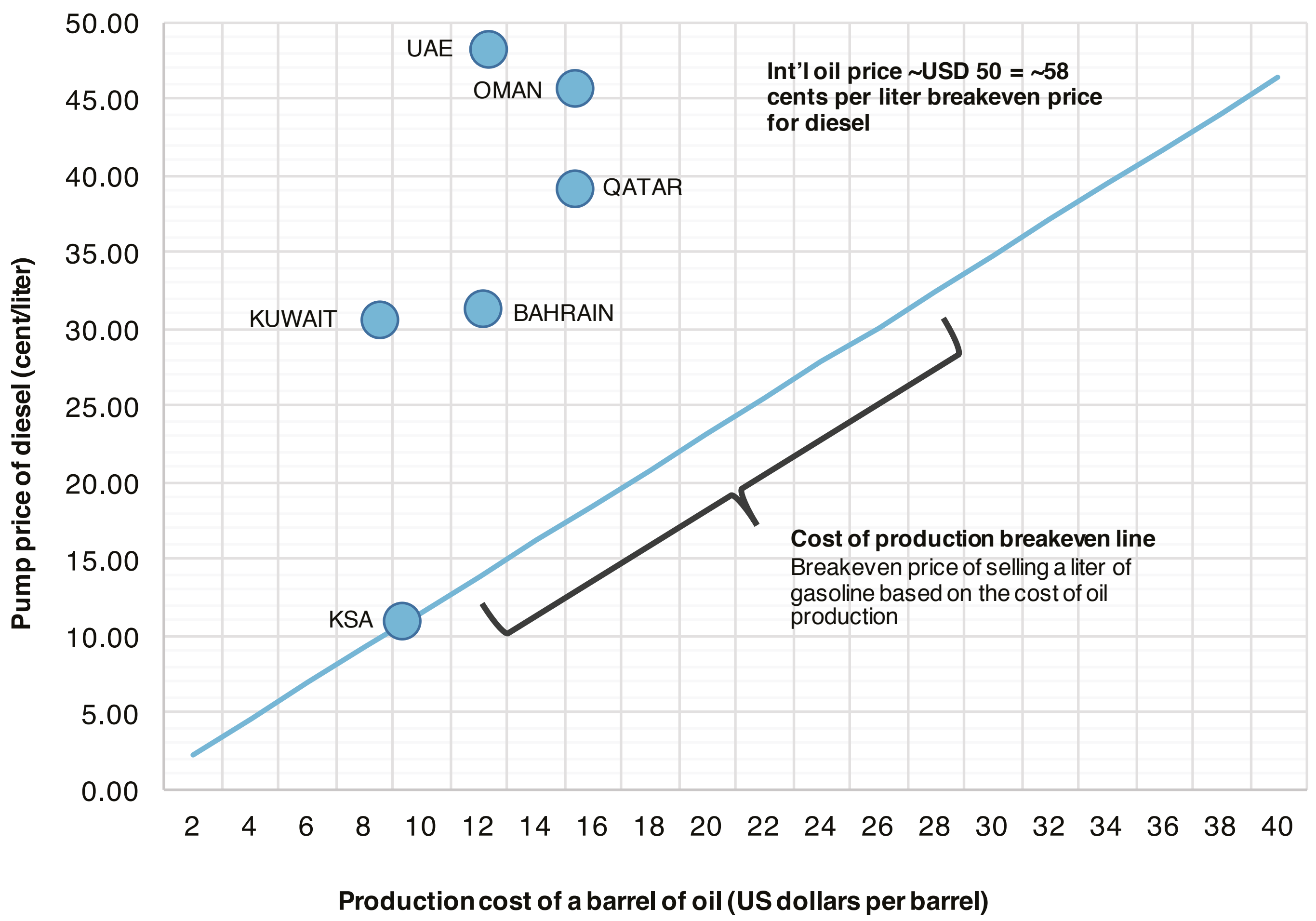

Figure 45. Gap between pump prices of diesel and cost of production at different oil production costs.

Source: KAPSARC analysis based on Knoema 2016 and personal communications.

in the GCC region respectively (Gelil, Howarth, & Lanza 2016).

KAPSARC's ongoing research on transportation energy productivity aims to complement existing studies conducted by SEEC and other national stakeholders by assessing the impact of current and possible future policy measures on oil consumption from the transportation sector in Saudi Arabia, and to formulate policy recommendations as to how more value could be achieved from domestic use of transport fuels.

Buildings

As an emerging economy, Saudi Arabia and the other countries that make up the GCC are characterized by rapidly rising per capita energy consumption from buildings. This compares with OECD averages, in which per capita buildings energy consumption is generally flat or declining (Figure 47). The other notable feature of this chart (Figure 47, below) is that per capita energy consumption in the buildings sector in Saudi Arabia, and most countries in the GCC, is between 0.75 and 1 metric ton of oil equivalent (TOE) per person per year, which is either similar to, or lower than, our reference group of OECD countries. There the figure is also between 0.75 and 1.5 TOE per person per year.

It may seem surprising that per capita energy consumption in Saudi Arabia is the same as, or generally lower than, countries such as the U.S., Canada, the U.K. or even Australia, as the GCC region is often seen as having very high buildings sector energy consumption because of its high use of air conditioning in summer.

This misconception can, in part, be explained by comparing total buildings sector per capita energy consumption (Figure 46) with per capita electricity consumption in the residential sector (Figure 47). The high temperatures in the Gulf region mean that GCC countries have a much greater requirement for air conditioning for cooling than that of the

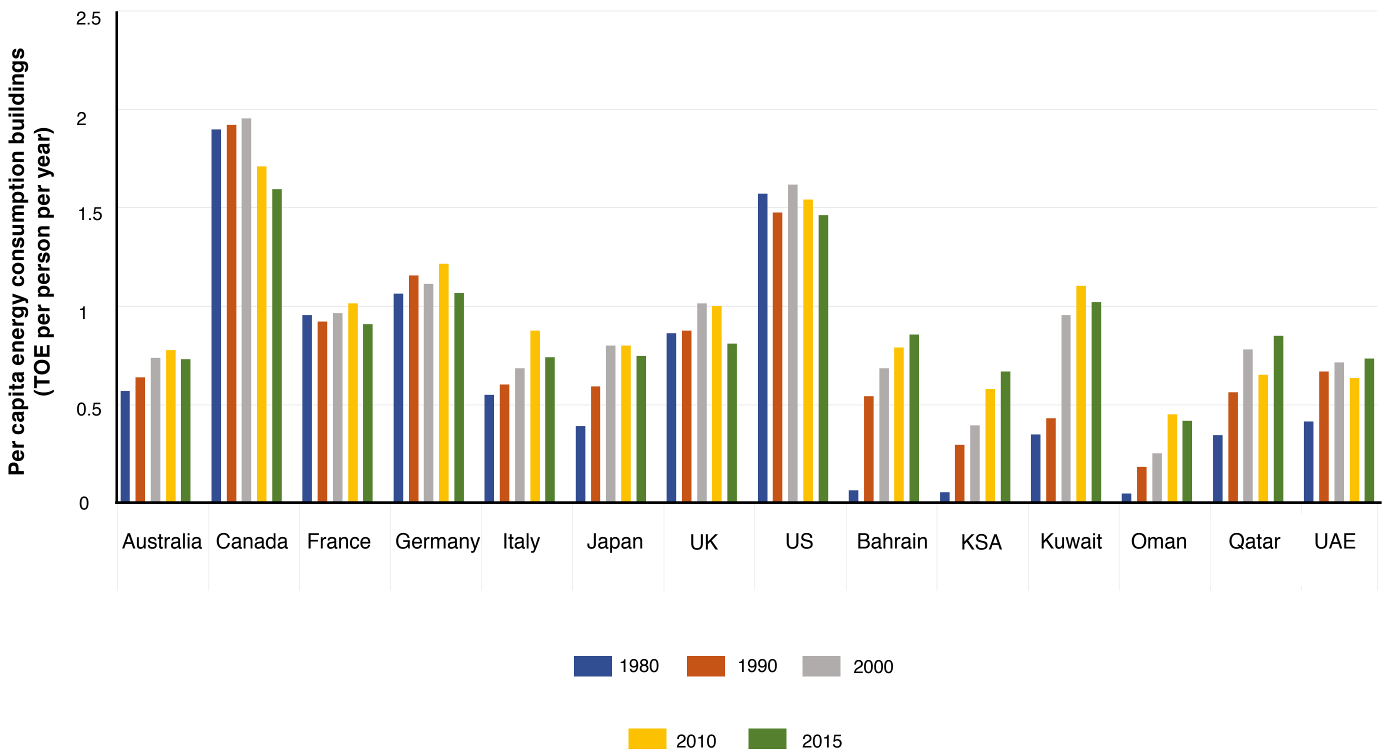

Figure 46. Building sector per capita energy consumption in the GCC and OECD reference countries (1980-2015).

Source: KAPSARC analysis, based on IEA data.

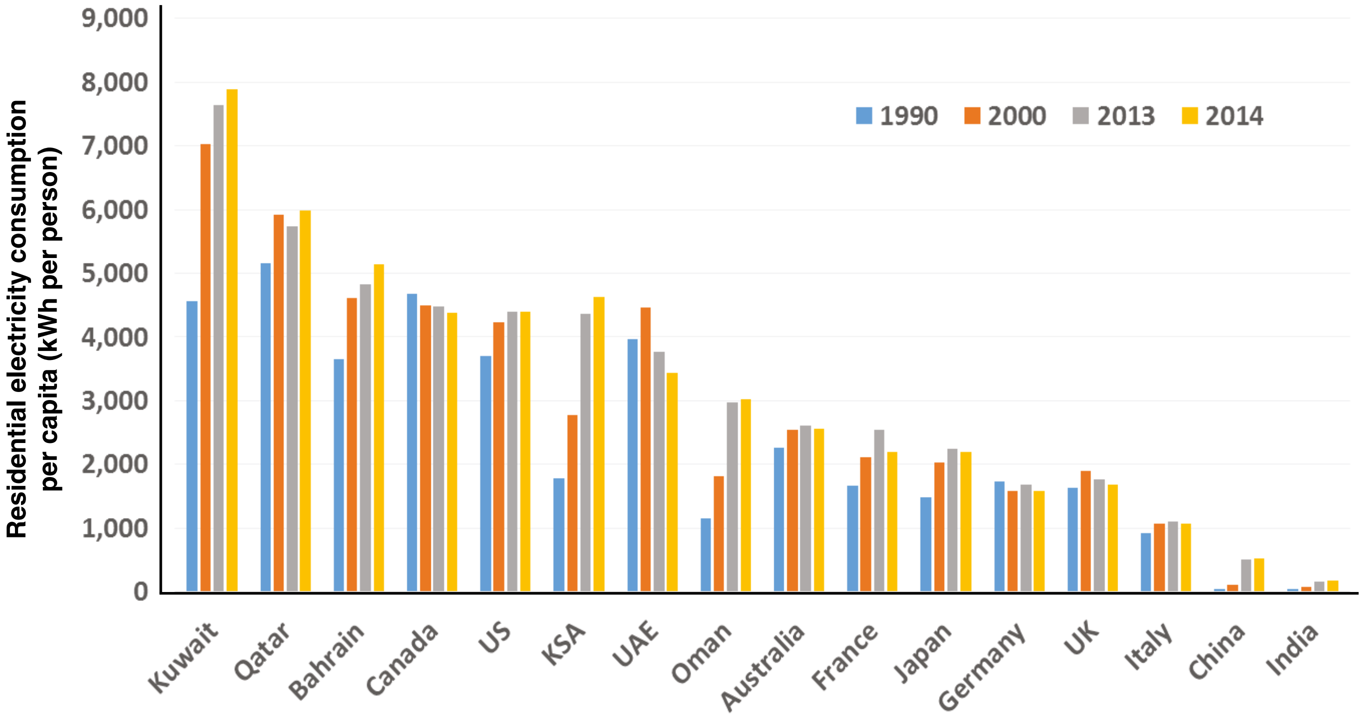

Figure 47. Residential electricity consumption per person.

Source: Enerdata.

OECD reference group, reflected in their very high per capita electricity consumption. By contrast, OECD countries require much more heating in winter, which can be delivered through a variety of energy sources other than electricity.

For example, when comparing per capita electricity consumption in the GCC countries to Europe, care must be taken, as in Europe a significant amount of energy is consumed in heating, where gas is the predominant fuel rather than electricity. Once this is factored in, overall energy residential consumption in the Gulf region is much more in line with other countries.

These trends can also be examined by examining the index measures for energy consumption in the buildings sector in each country relative to GDP. This can give a sense of how far each country has gone in terms of decoupling energy consumption in the sector and of economic growth, which is a useful indicator of sectoral energy efficiency (Figure 48-49).

We see that in almost all GCC countries energy consumption in the buildings sector is rising much faster than general GDP growth. This contrasts with the OECD reference group, where energy consumption in building is generally increasing much slower than GDP, or even falling.

While the buildings sector represents a relatively small share of total energy consumption in the Kingdom – 16 percent – it is still the largest consumer of electricity, with around 70 percent

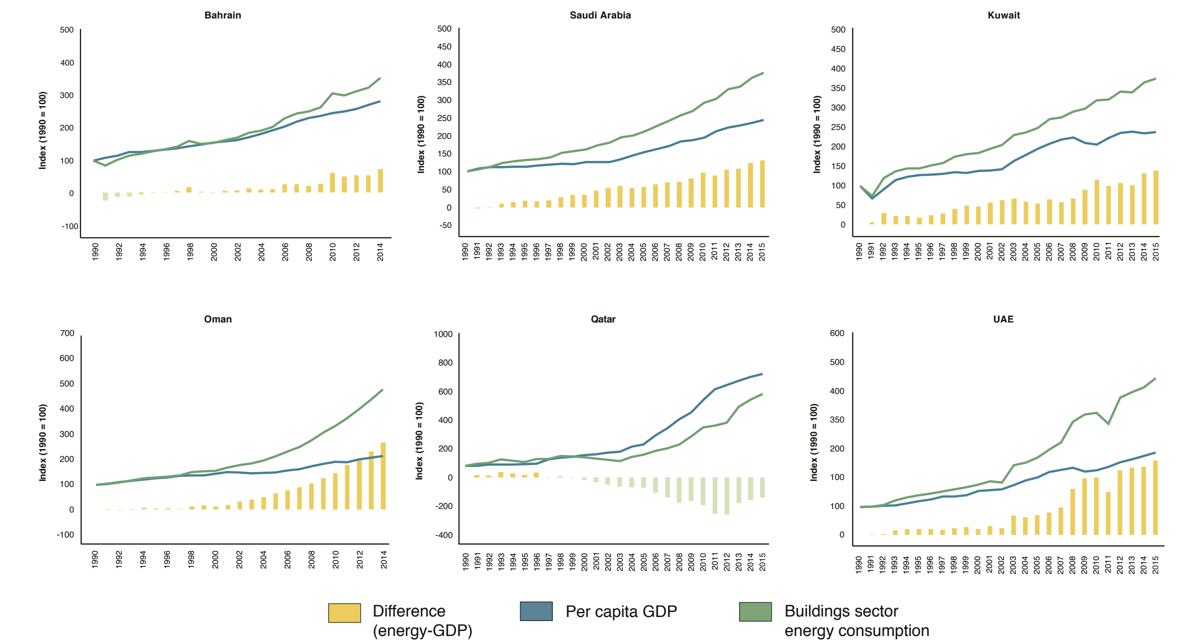

Figure 48. Energy consumption in the buildings sector and GDP (100=1990): GCC countries.

Source: KAPSARC analysis, based on IEA data.

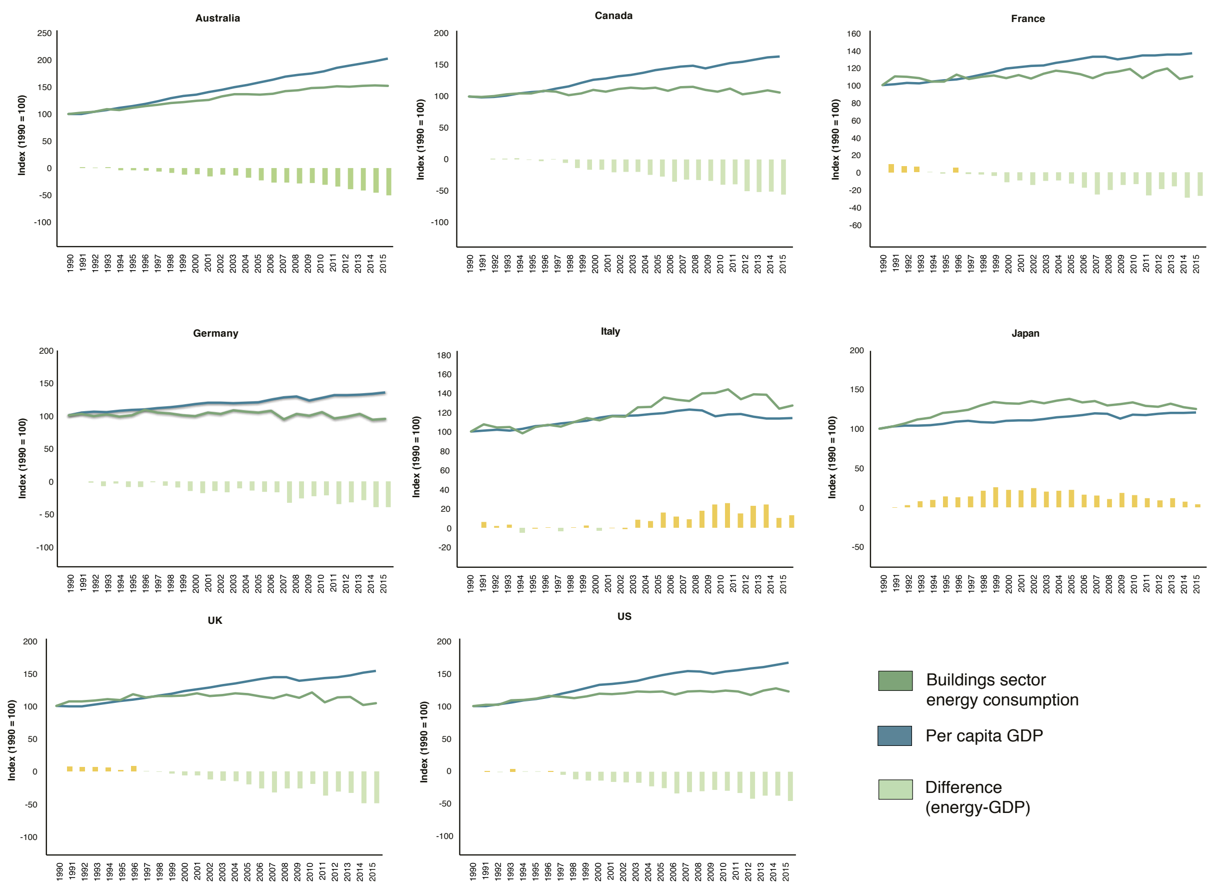

Figure 49. Energy consumption in the buildings sector and GDP (100=1990): GCC countries.

Source: KAPSARC analysis based on IEA data.

of consumption when residential, commercial and governmental use (Figure 50) are included.

Buildings – and especially air conditioning – have also been a priority focus for the Kingdom's energy efficiency program, and one of the earliest target areas for the Saudi Energy Efficiency Corporation (SEEC). High air conditioning use results from the Kingdom's extreme average ambient temperatures in summer, when electricity demand is double that in the winter (Figure 51). Saudi Arabia has a combined power generation capacity of 66 GW, with peak demand of around 57 GW as of 2014 (Saudi Electricity Company 2000-2013). The average annual growth rate of peak demand over 2000-2014 was 7.1 percent. Projections for 2019 include around 69 GW for generation capacity, 352 TWh for total generation and 324 TWh for net consumption (BMI Research 2015). This strong growth in generation capacity means that energy efficiency measures can have a significant impact on reducing the need for additional capital expenditure if they result in lower growth in electricity demand. These benefits are estimated in 'Evaluating Building Energy Efficiency Investment Options for Saudi Arabia', Dubey, Howarth, & Krarti (2016).

KAPSARC research has shown that from an economic perspective, given the low electricity prices in Saudi Arabia, it makes little sense for households and other private organizations to invest in energy efficiency (Figure 52).

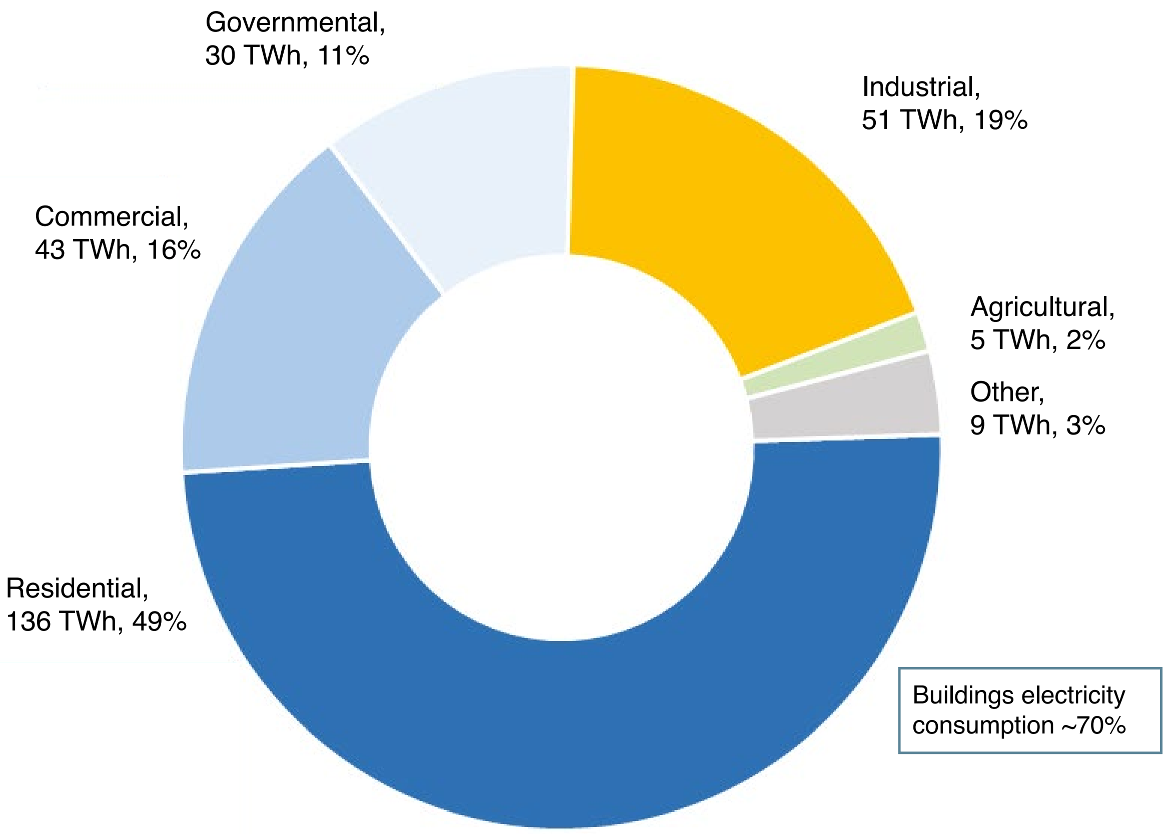

Figure 50. Electricity consumption in KSA by end use sector.

Source: SEC 2015.

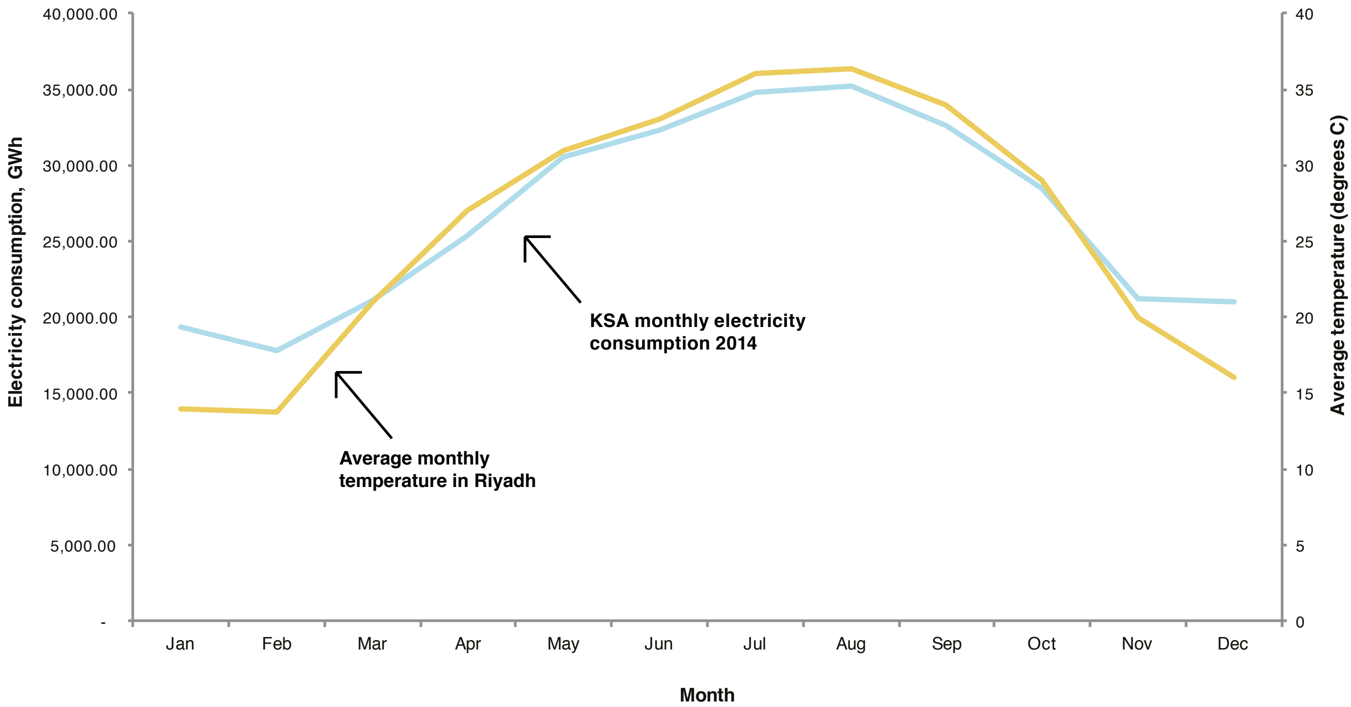

Figure 51. Average monthly temperature and energy consumption (2014).

Source: KAPSARC, based on SEC, 2015.

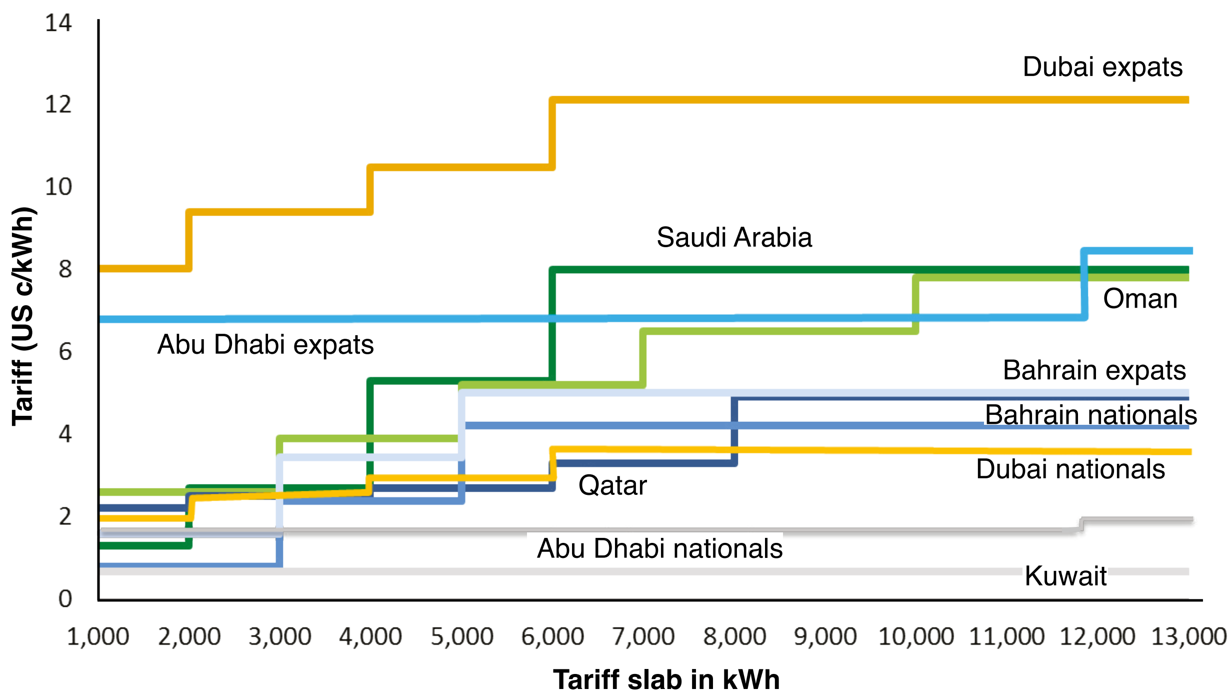

Figure 52. Regional benchmarking of residential electricity prices in the GCC.

Source: KAPSARC, based on Chatham House 2016.

However, when the system-wide benefits from avoided fuel consumption and the reduced need for electricity generation capacity are incorporated (Figure 53), energy efficiency investments become highly cost effective, especially for residential buildings (Evaluating Building Energy Efficiency Investment Options for Saudi Arabia, Dubey, Howarth, & Krarti 2016).

A basic energy retrofit program based on easy to implement energy efficiency measures for the existing building stock and implemented for residential buildings could reduce electricity consumption by about 10 TWh/year, peak demand by 2 GW and carbon emissions by 7.6 million metric tons per year. Such a program is highly cost effective, with an investment payback period of less than a year, driven by a reduced need for power generation capacity, totaling $2.7 billion over the lifetime of the program, and an avoided cost of electricity consumption of between $500 million and $1.7 billion per year, depending on the assumed power tariff.

Level 1 is a basic retrofit, including very basic measures such as installing LED lighting and weatherization of the building shell to limit air leakage. Level 2 includes all the same measures as Level one, plus the use of energy efficient cooling systems and appliances. Level 3 is a deep retrofit, which in addition to all the alterations of Level 2 requires a detailed energy audit and

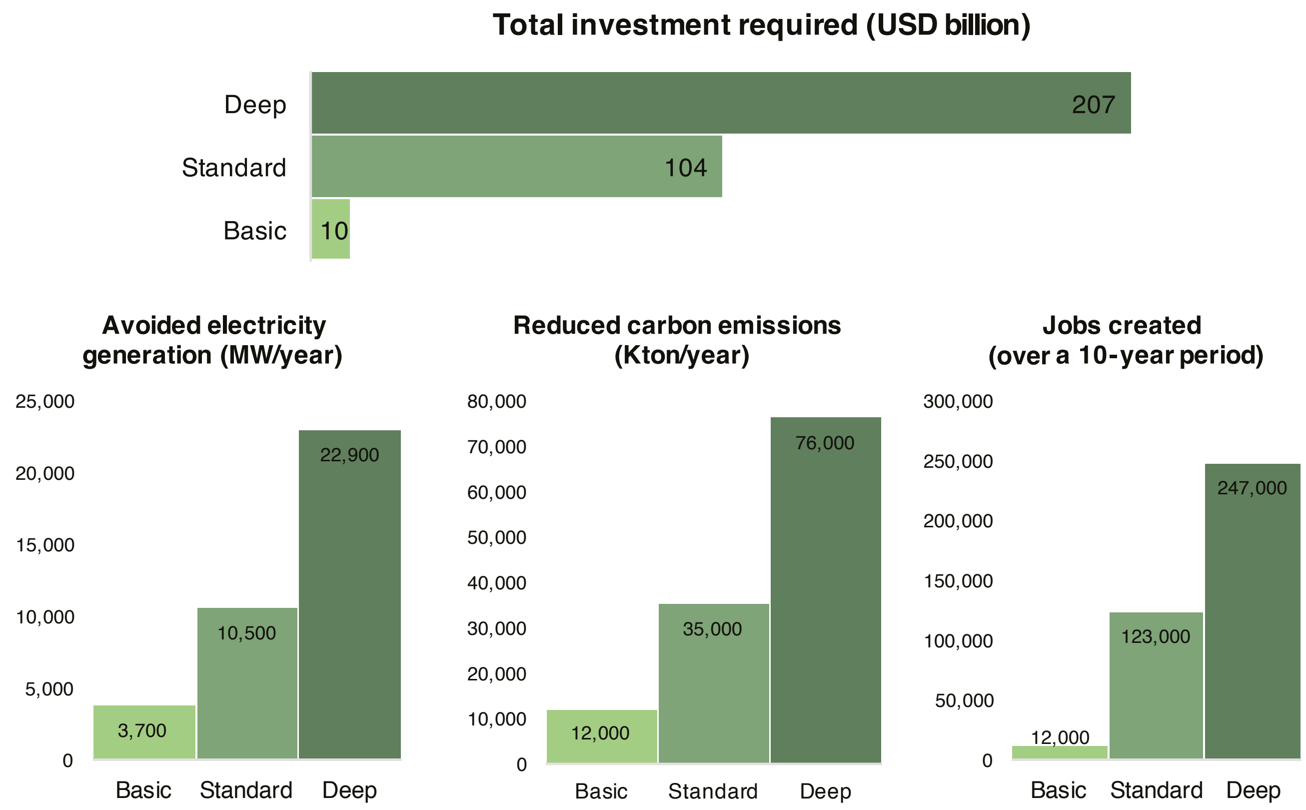

Figure 53. Estimated investment and benefits from energy efficiency investment in KSA.

Source: Evaluating building energy efficiency investment options for Saudi Arabia, Dubey, Howarth, & Krarti 2016.

tougher measures such as window and cooling system replacement and the installation of daylight architectural design elements.

As might be expected, the benefits from energy efficiency investments are boosted when retail electricity prices are higher. In KAPSARC's study, the benefits from energy efficiency investments are calculated using a range of prices from current average tariffs after the recent round of price reforms of approximately $0.05 per kWh, up to an electricity price of around $0.17 per kWh.

Deeper retrofits for residential buildings are shown still to be cost effective within a reasonable payback period, but their attractiveness is significantly influenced by electricity tariffs, highlighting the importance of further price reforms in the Kingdom. This analysis suggests that the most cost effective investments are to be found within the residential building stock, rather than the commercial or government sectors. However, the bulk of recent state investments have focused mostly on public buildings. This may reflect the relative ease of implementation of retrofitting government facilities rather than private homes, where cultural resistance to the disruption of home life makes more extensive household refurbishments a less attractive proposition for some families.

Taking a broader view of the potential benefits by incorporating the value of avoided energy consumption, in terms of oil that could be sold on international markets and using a value of avoided energy of $35 per barrel, another KAPSARC study showed that net present values for energy efficiency investments can be even more cost effective (Figure 54).

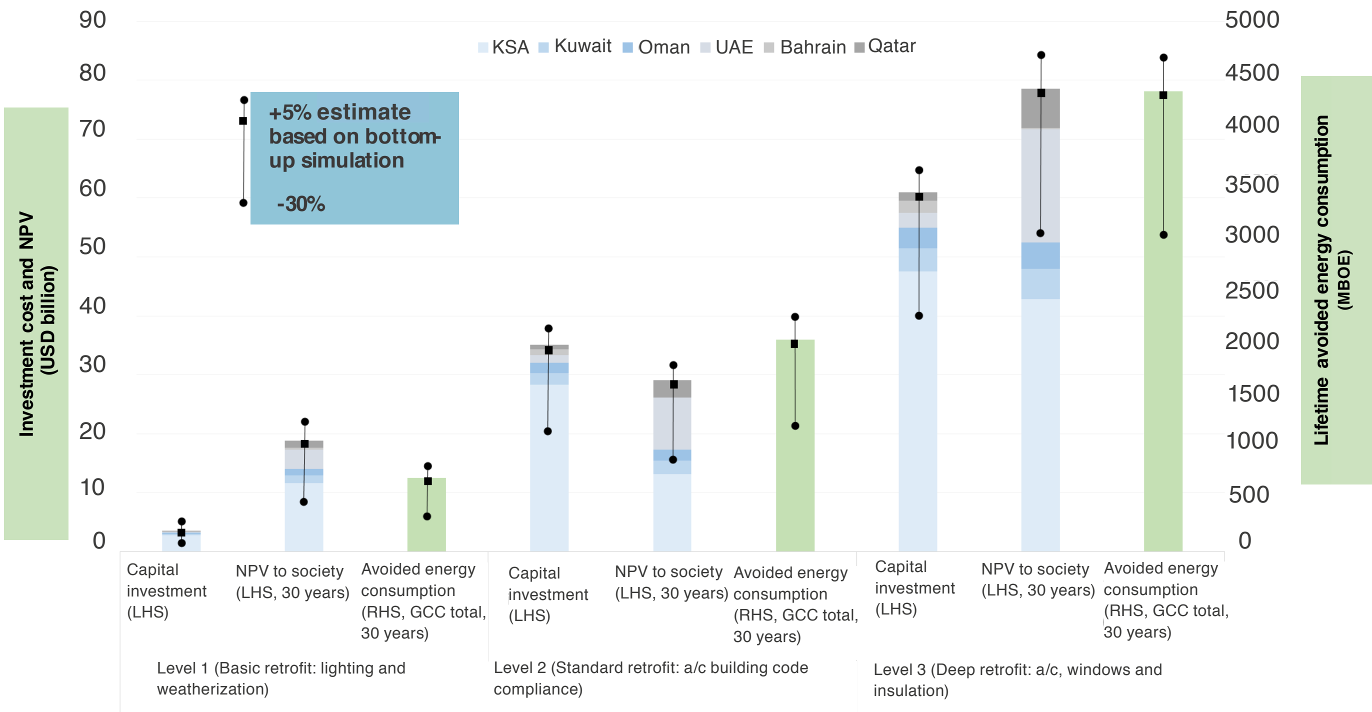

Figure 54. Energy efficiency Investment NPV factoring-in potential revenues from avoided energy consumption in the GCC.

Source: Dubey, Fawkes, Howarth, Krarti, & Padmanabhan 2016.

This analysis assumes a 10-year investment implementation period, 30-year project period and a 3 percent discount rate. Benefits to society include the full value of avoided oil equivalent – not consumed domestically – being exported at $35 per barrel, and avoided electrical generation capacity totaling 3,787 MW for Level 1, 10,889 MW for Level 2 and 23,673 MW for Level 3, calculated using $1,700 for reduced electricity (CAPEX per kW).

Saudi Arabia has a comprehensive buildings energy efficiency code, developed by SEEC in conjunction with the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE). In 2012 SEEC issued the small AC standard according to ASHRAE values and in the following year it began its enforcement program. AC standards are under continual development, with the large AC standard approved in the first half of 2016 and due to come into effect in Q3 2017.

There are 13 thermal insulation standards, which have been issued along with one for new buildings in collaboration with ASHRAE. Standards for refrigerators and freezers as well as for washing machines were issued in 2013, with enforcement commencing in 2015. Standards for energy efficient lighting were approved by the Saudi Arabian Standards Organisation's board in June 2015 and these began to be enforced in August 2016. A standard for hot water heaters is also being developed.

Employment and Capacity Issues

Implementing Vision 2030 will be as much a human challenge as a technical or economic one. Perhaps one of the most important parts of the Kingdom's transition strategy is to create some 1.2 million new jobs by 2020 to address unemployment and ensure local Saudis can participate more than they do today in the wealth created in the economy. Key employment targets are shown in Figure 55, with 2015 sectoral employment in Figure 56.

The scale of this challenge is substantial, as foreign workers currently make up the majority of the labor force in most sectors. Indeed, while nationals in the GCC filled over 70 percent of public sector jobs, around 88 percent of 5.4 million private sector jobs created between 2000 and 2010 were filled by foreign workers, with around 85 percent of these in low skilled positions (IMF 2016). This large pool of low skill labor creates a potential productivity barrier as the low cost of labor reduces the incentive to invest in capital substitution. Low skill labor to capital substitution is likely to have a significant effect on overall energy productivity, both on a technical level as new capital is likely to increase energy efficiency, and by reducing overall energy demand in the economy because there are fewer people resident in the country.

In support of these goals, the Saudi Energy Efficiency Program is supporting local capabilities by offering an energy efficiency course in five different engineering schools in the Kingdom and creating an energy efficiency technician

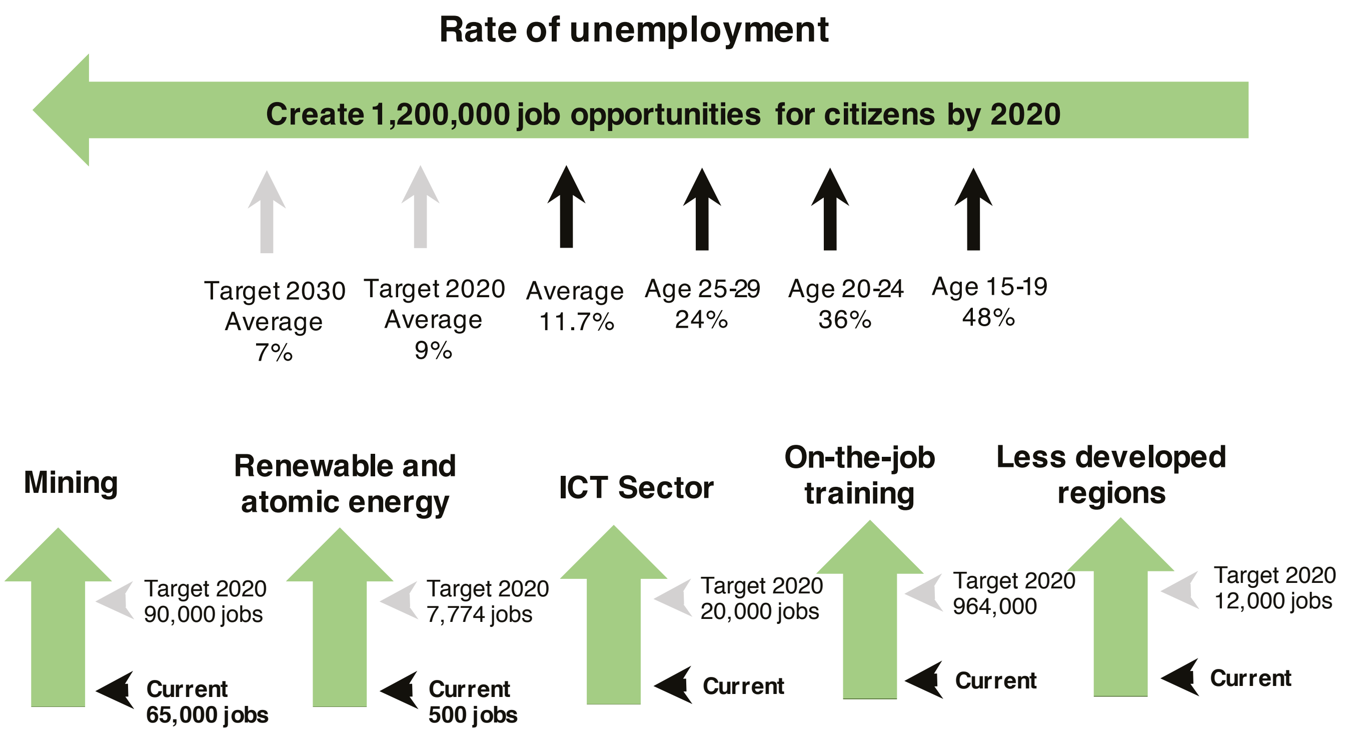

Figure 55. Current rates of unemployment and related Vision 2030 employment targets.

Source: Saudi General Authority for Statistics; National Transformation Program.

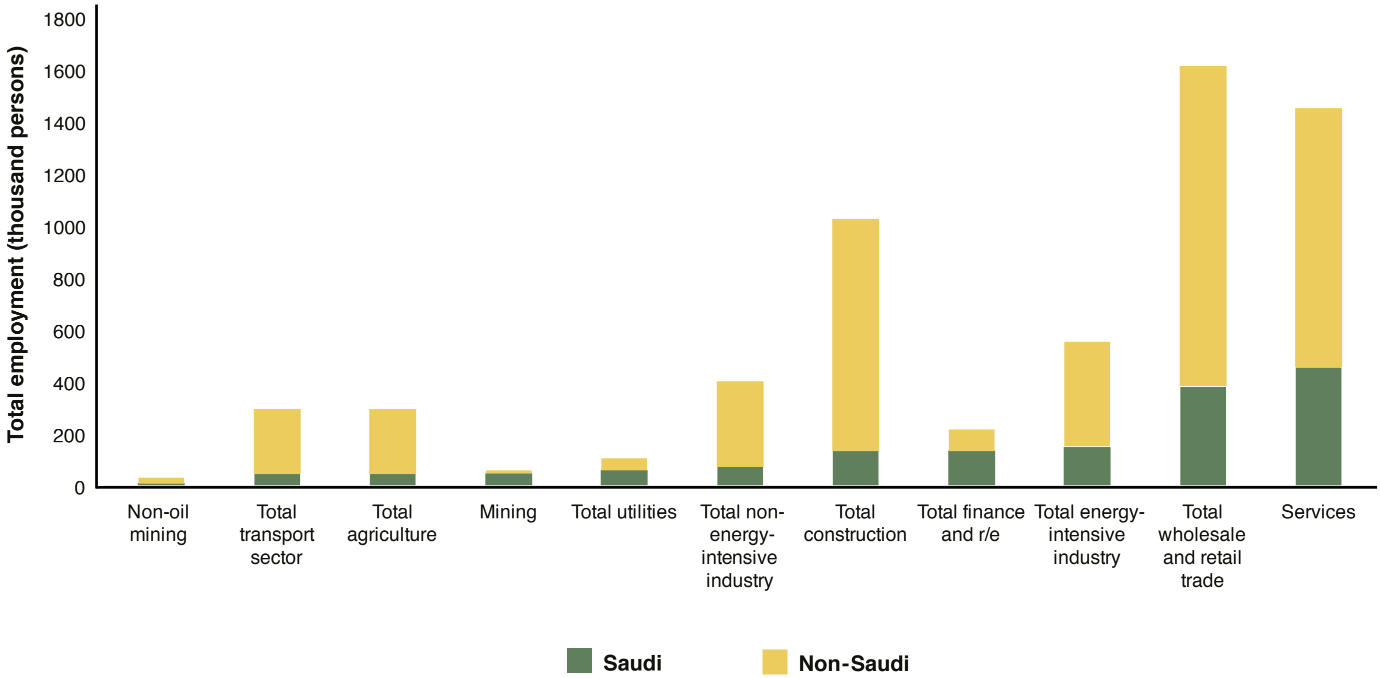

Figure 56. Saudi and non-Saudi employment (2015).

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

degree through the National Power Academy and a Certified Energy Manager qualification in conjunction with Association of Energy Engineers.

The potential for employment creation in the energy efficiency sector is large, with the possibility of creating up to 250,000 jobs through a deep retrofitting of the Kingdom's building stock (KAPSARC 2016c). Inclusion of energy efficiency professionals in employment targets could provide a useful addition to the Kingdom's plans.

Looking to the Future

Potential energy productivity pathways for Saudi Arabia

If the Kingdom is to achieve its economic diversification and energy efficiency goals, moving to a higher energy productivity development pathway will be necessary. To do so will require an adaptive, forward-looking set of policies that can capture the synergies among the respective economic sectors, while building on Saudi Arabia's dominant competitive advantage in low cost energy.

A growing number of countries are using energy productivity pathways as a way of managing their economic, energy and climate goals. The idea is also spreading through initiatives such as EP100 – a program to get large corporations to commit to doubling their energy productivity by 2030. Australia and the U.S. have already set national energy productivity targets and are using these as organizing logic for their energy and economic planning (Figure 57). Germany has also established an energy productivity target of doubling its energy productivity by 2020 compared with 1990 (IEA 2006).

The evidence base in this paper highlights the particular challenges that make increasing energy productivity more difficult in Saudi Arabia than it is other countries. However, as outlined in the two scenarios in the Kingdom's NDC, the nature of the economic development pathway chosen by the Kingdom will have a significant impact. Two possibilities are:

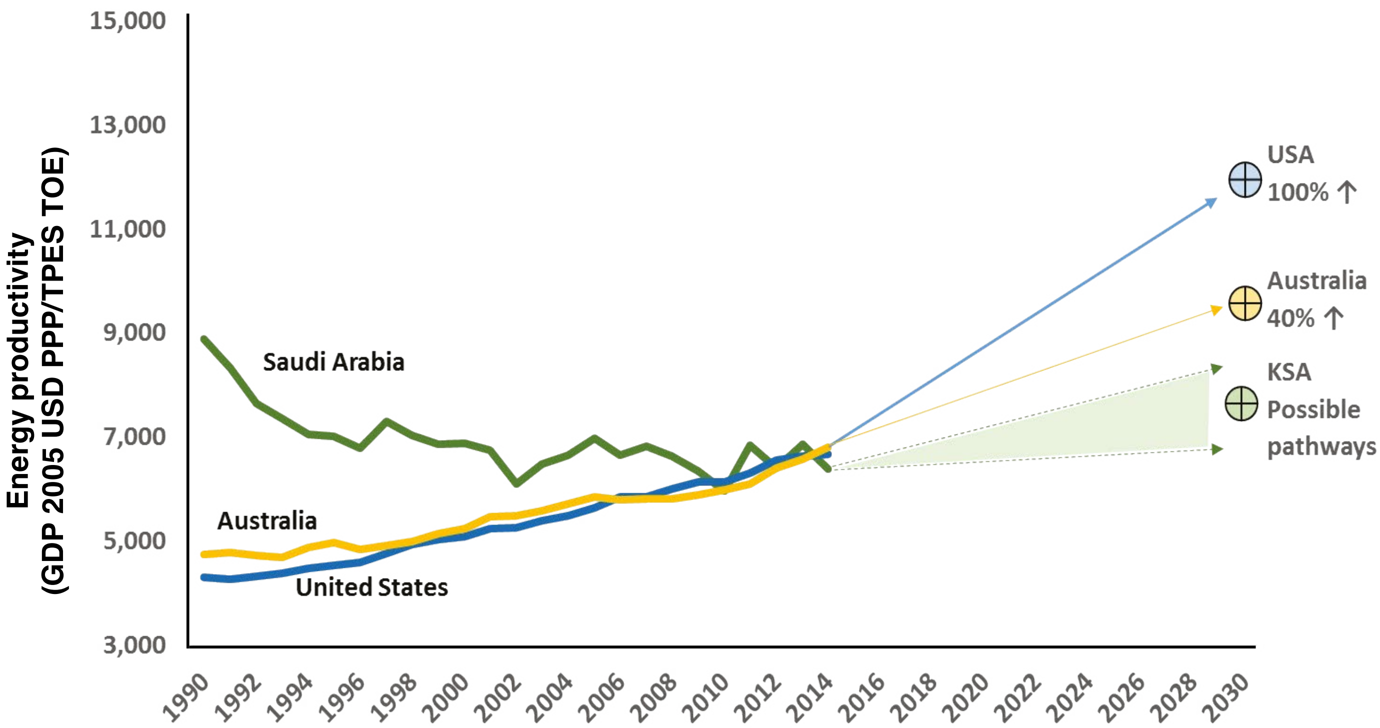

Figure 57. Energy productivity policy pathways.

Source: IEA and Enerdata, US Department of Energy, 2016 Australian Government, 2016.

> A strong diversification outcome toward sectors such as health, education, IT, media and high tech manufacturing, combined with strong energy efficiency measures, which will have the greatest impact on energy productivity.

> Weaker diversification, emphasizing energy-intensive downstream industries while still having scope to increase energy productivity, which will mean a lower energy productivity pathway will be achieved.

Figure 58 illustrates these two scenarios in the context of the Kingdom's plan to avoid 130 million metric tons of CO_2 equivalent per annum relative to a dynamic baseline, contingent on which development pathways are pursued.

In both scenarios, increasing energy efficiency will be very important. The key sectors to focus on, based on their energy consumption, are industry and, most importantly, petrochemicals and cement, followed by transport and the buildings sector, which consumes the majority of the Kingdom's electricity.

Depending on the mix of the two broad industrial diversification strategies that may be pursued and the stringency and success of energy efficiency measures, a reasonable target range for energy productivity lies somewhere between stabilization at current levels and an increase of 30 percent by 2030.

Quote from KAPSARC Workshop 'How to Achieve Economic Prosperity Through Industrial Energy Productivity Improvement', March 28, 2017.

Increasing energy efficiency in power generation is already reflected in the Kingdom's National Transformation Program which aims to increase

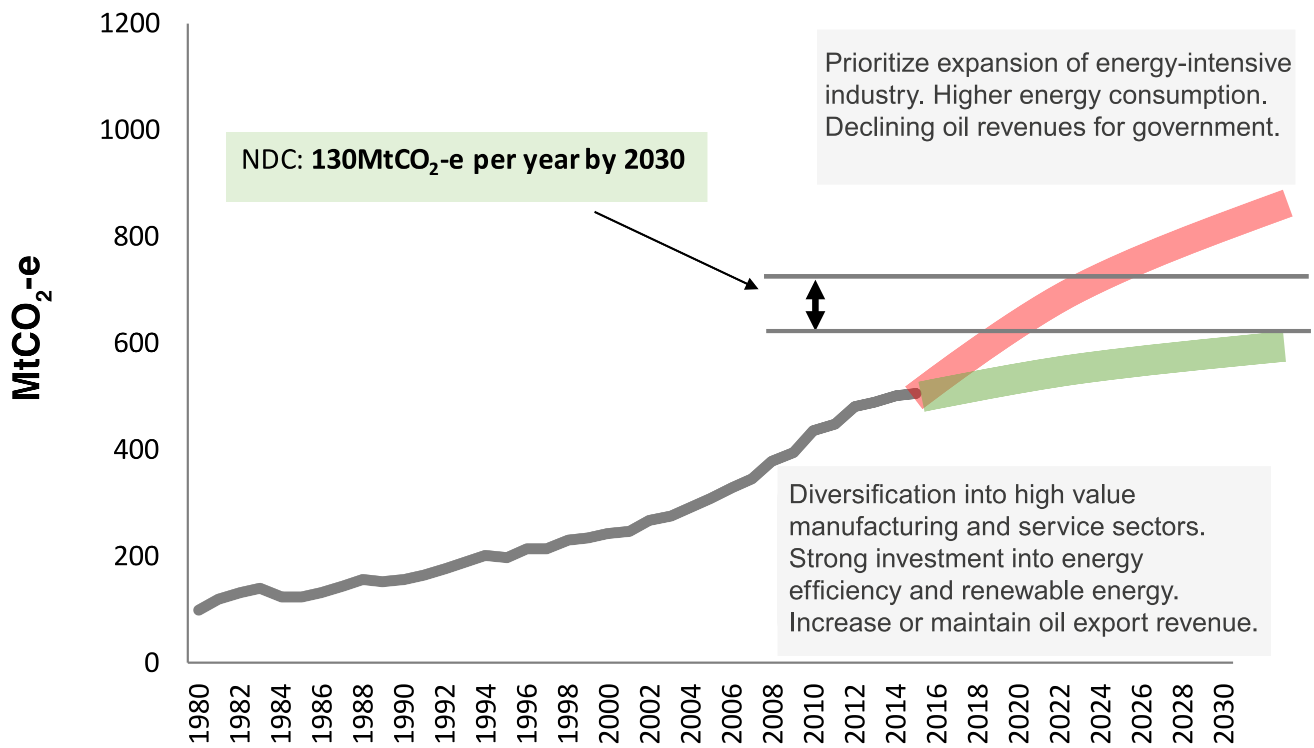

Figure 58. Saudi Arabia's greenhouse gas emissions and possible diversification pathways.

Source: KAPSARC based on IEA data and Saudi Arabia's NDC to the UNFCCC.

the efficiency of fuel use of all Saudi power plants from 33 percent to 40 percent by 2020. However, it is surprising that more sectoral energy efficiency targets have not been publicly announced in support of Vision 2030.

Given the priority placed on energy efficiency and the strong performance of SEEC in implementing programs in cooperation with major stakeholders, there is a good case to include sector-based energy efficiency targets, especially for the industrial sectors of the economy which are among the biggest energy consumers. While transparent targets can be useful to coordinate and focus effort, it is also important to bear in mind the key drivers of change will be the enabling policies and effective implementation instruments, including appropriate financing schemes.

Energy productivity in practice

United States

In September 2014, responding to the presidential call for action to double energy productivity by 2030, U.S. Secretary of Energy Dr. Ernest Moniz announced the Accelerate Energy Productivity 2030 initiative. The U.S. Department of Energy (DOE) partnered with the Council on Competitiveness and the Alliance to Save Energy in a series of public dialogues and executive roundtables to raise awareness, galvanize support and develop the strategies necessary to double U.S. energy productivity by 2030. This initiative requires investment in all sectors of the economy, with the aims of stimulating innovation, optimizing domestic industry practices, supporting domestic energy production and boosting job creation.

Australia

At its December 2015 meeting, the Energy Council of the Council of Australian Governments (COAG) agreed to a national, cooperative effort to better integrate energy and climate policy. A key part of this is the Council's National Energy Productivity Plan (NEPP). It provides a framework and an economy-wide work plan designed to accelerate action to deliver a 40 per cent improvement in Australia's energy productivity by 2030. The potential improvements are to be achieved by improving the way energy is used in the economy through the adoption of more energy efficient technologies and processes, a shift to electricity for certain activities, and the optimization of systems and continued structural shifts in the economy towards less energy- intensive activities.

Source: U.S. Department of Energy; Australian Department of the Environment and Energy.

Besides Australia and the U.S., Germany has also set a target to increase energy productivity by 2.1 per cent per year as part of its Energiewende strategy. This is complemented by targets to decrease primary energy demand by 20 percent by 2020 and 50 percent by 2050 compared with 2008 levels, and a planned reduction in greenhouse gas emissions of 80-95 percent by 2050 relative to 1990. The current reduction is around 26-28 per cent (Federal Ministry for Economic Affairs and Energy 2017).

An important practical consideration for setting energy productivity targets in a major oil-producing country is to distinguish between oil-based GDP and non-oil GDP in the setting of targets (Figure 59).

The main driver of the declining trend in the Kingdom's overall energy productivity since the 1990s has been the steep fall in total GDP-based energy productivity, contrasting with the situation for non-oil-based GDP energy productivity, which has been much more stable, showing an improving trend over the last 12 years (Figure 60). Setting the domestic energy productivity target using GDP, which is not influenced by fluctuating oil prices, is likely to give a more accurate view of actual energy productivity. In addition, domestic energy consumption data, which are not currently publicly available, should be used rather than the IEA energy balance. A project that will focus on energy intensity targets for the overall economy is already reported to be under consideration by

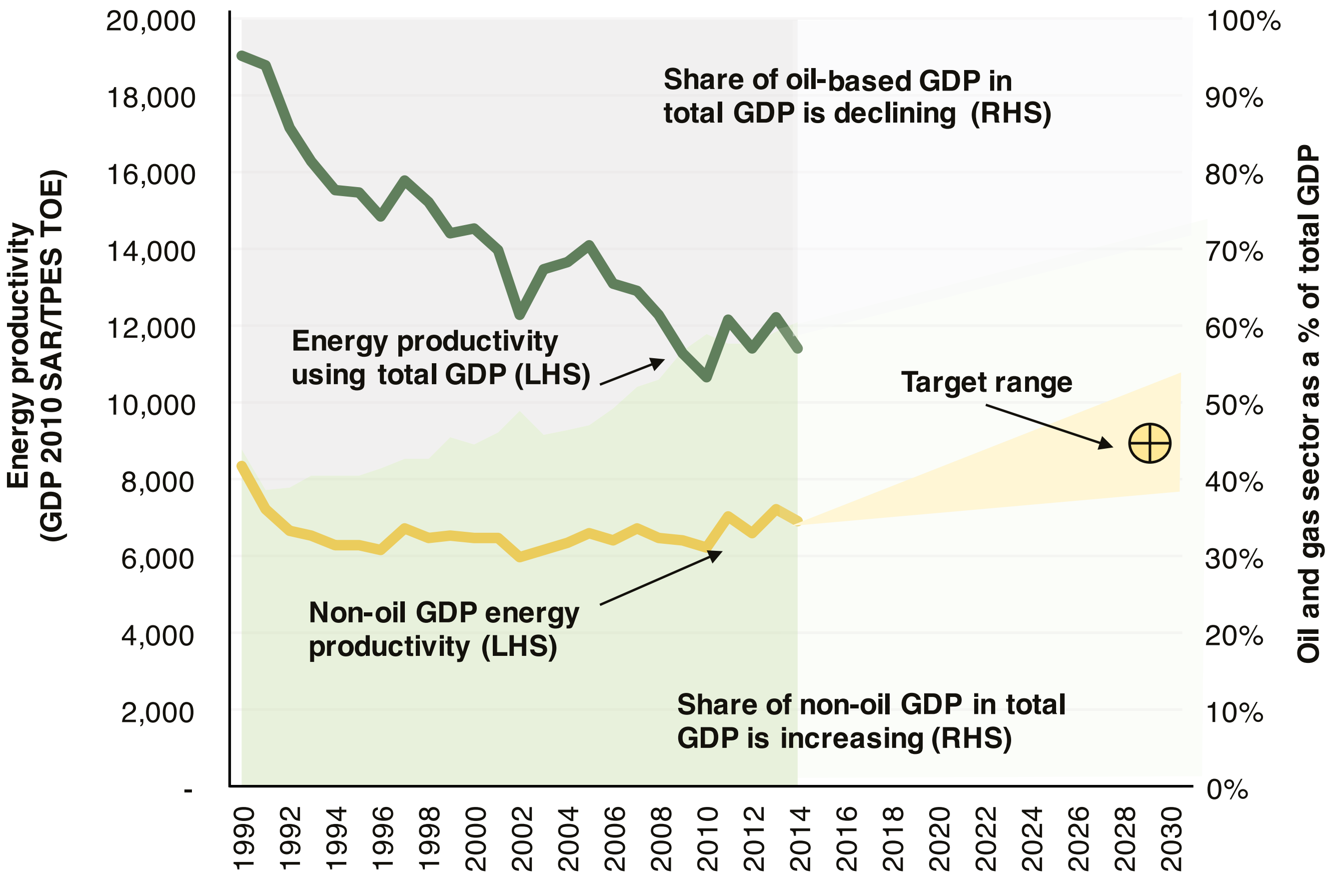

Figure 59. Non-oil and total GDP-based energy productivity targets for KSA.

Source: TPES (IEA), GDP (Saudi General Authority of Statistics).

SEEC (Jadwa Investment 2017). Further work could also examine setting energy efficiency targets at the sector level, based on an assessment of their potential for improvement.

With energy productivity being increasingly used by governments, how it can be integrated with other policy narratives such as sustainable development, energy efficiency as the 'first fuel', or green growth may become an issue for some stakeholders. While the focus on encouraging greater value from energy consumption is universal among those adopting energy productivity as a policy strategy, one important insight from international experience is that the details of such a strategy will depend on the policy priorities of those who apply it.

In this respect, energy productivity can be thought of as both a specific indicator used to measure the level of energy efficiency and structural diversification in the economy and as an integrating policy narrative to support sustainable development (Figure 60).

For instance, enhancing energy productivity relates particularly to the Global Agenda 2030 for Sustainable Development and to the Sustainable Development Goals (SDGs):

> Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all.

> Target 3: Doubling the global rate of improvement in energy efficiency by 2030.

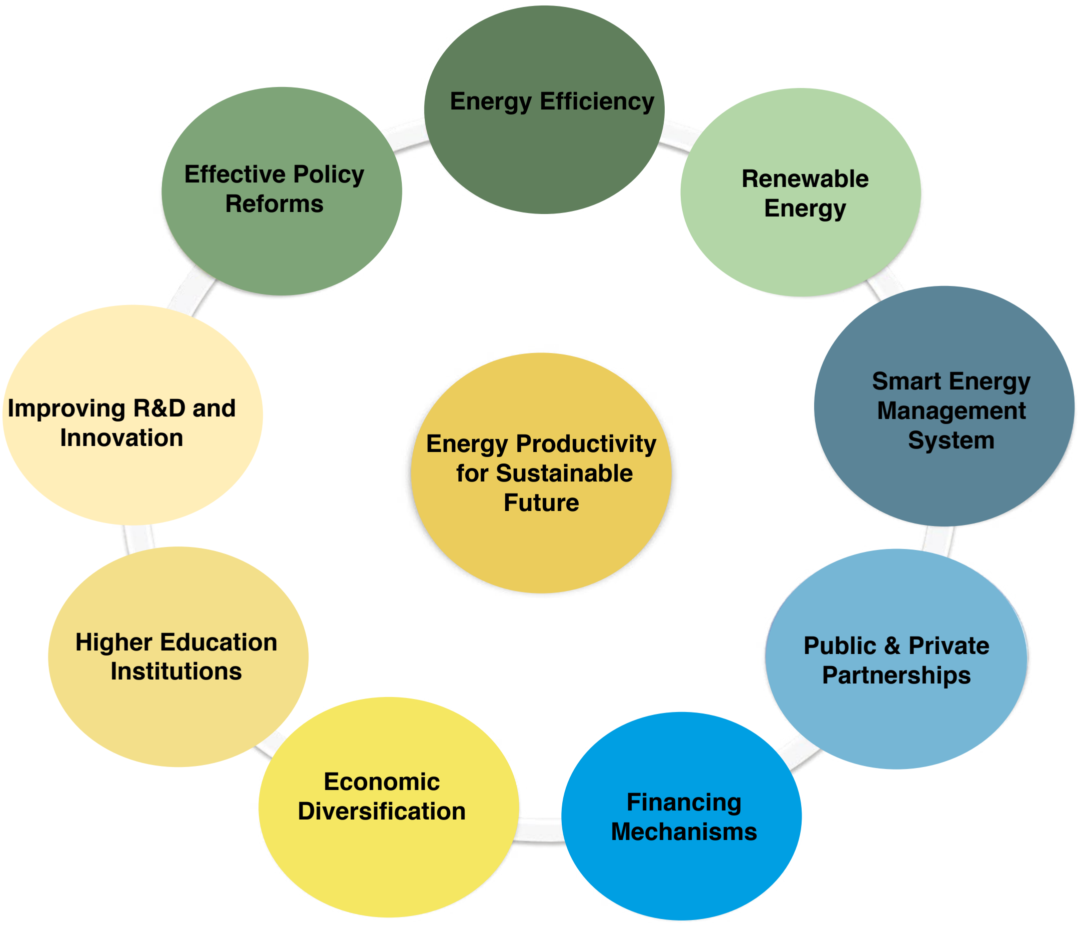

Figure 60. Energy productivity as an integrating policy narrative for sustainable development.

Source: UNESCWA, KAPSARC Energy Dialogue 2016.

- Goal 9: Industry, innovation and infrastructure.
- Goal 12: Ensure sustainable consumption and production patterns.
- Goal 13: Take urgent action to combat climate change and its impacts.

It also relates directly to the work program of the United Nations Secretary General's Sustainable Energy for All (SE4ALL) initiative, especially its energy efficiency theme. Indeed the Special Representative of the UN's SE4ALL program is also the Chair of the Global Alliance for Energy Productivity (Global Alliance for Energy Productivity 2017).

Energy productivity, besides being a good framework for integrating economic, energy and environmental policies, allows for a whole-of-government approach. Energy efficiency is an important element of energy productivity strategies, but it is a narrower term. Energy productivity encompasses a much wider agenda, focused on economic development and diversification. While, ultimately, the objectives of such an approach can be achieved through setting equivalent energy intensity targets, in this paper we have made the case for preferring energy productivity, due to its stronger, more positive message and greater relevance for industrial competitiveness at the microeconomic level (see section 'What is energy productivity?').

Energy is a key ingredient for development. Particularly for countries which are characterized by low per capita energy consumption, increasing the quality energy supply and the consumption of modern energy services is a major priority. This, however, requires a wide range of investments that go beyond energy efficiency, which largely focuses on optimizing the existing, and in many cases already modern, capital stock. Using energy to drive development, such as through improved energy access, is one of the policy avenues that can be focused on when an energy productivity strategy is used.

Energy productivity may be gaining traction around the world because it reflects the current priorities of governments. At a time of weak growth, governments seek, as a first priority, to stimulate their economies. Out of the three main policy tools available to them – monetary policy, fiscal policy and productivity enhancing microeconomic reform – many countries lack fiscal resources and have relied too much on their central banks. An agenda to boost productivity clearly responds to one of the key anxieties of the day.

Shifting the needle on energy productivity will require a range of policy measures, many of which are already underway in the Kingdom. However, international experience suggests that identifying clear reform pathways can be a valuable mechanism to coordinate action and achieve successful policy implementation. The possible elements of an energy productivity policy roadmap for the Kingdom are outlined in Table 6.

Drawing on initiatives already underway or under discussion in the Kingdom, some of the key elements of a possible policy roadmap to achieve any national energy productivity target are highlighted. These have been organized around the two key themes of economic diversification and energy efficiency, the main drivers of change in energy productivity at the national level. If adopted as a target in support of Vision 2030, more work can be done in using energy productivity as a framework for organizing energy economy planning policies, especially within the Ministry for Energy, Industry and Mineral Resources (MIEM).

Table 5. Implementation of phase 2 energy price reforms.

Investments and policy interventions evaluated on value created per unit of energy					
	Energy price reform	**Investment support**	**Regulatory changes**	**Education, training, and employment programs**	**Market access and demand**
Diversification to higher value-added activities	Higher prices incentivize higher value uses of energy. Not too high or too fast to avoid negative impact on growth and inflation.	Low interest rate loans and investment assistance. Privatization and FDI facilitation. Localization potential. Boost SIDF capabilities.	Ease of doing business. Company setup. Small business. Relax trade and investment restrictions. Price allocation for energy rather than quantity.	Education for key skill areas. Labor market efficiency. Labor force participation for women. Saudization targets.	Local content strategy. Free trade agreements. Marketing of Saudi brands. Export development. Public procurement.
Energy efficiency	Prices while above cost of production should be at or just below international benchmarks.	ESCO and Super ESCO. EE funds. Market for avoided energy. National district cooling co.	EE standards. Appliance and equipment regulations. Urban planning guidelines.	University courses. Technical and vocational training. CEM certification.	Public sector implementation of EE retrofits. Energy efficient labelling.

Source: Fiscal Balance Program 2016.

If adopted as a strategic goal by government, developing detailed energy productivity assessment tools will be an important area for collaboration with stakeholders to establish energy productivity as a government and industry priority. As an extension of energy productivity, there could also be a compelling case for taking carbon productivity as an indicator and policy framework for achieving climate goals. This could be an area for future research. This intersects closely with the 'carbon-to-value' agenda that is under discussion in the Kingdom and which focuses on using carbon dioxide to produce useful chemicals and other applications.

In addition, the degree to which one of the two policy scenarios in the Kingdom's NDC is favored over the other is not clearly mapped out. As part of the process of developing the Kingdom's industrial strategy, currently under revision since Vision 2030, these issues can be explored through devising potential energy productivity pathways.

Looking to the Future

Saudi Vision 2030 and its supporting programs are aimed at achieving a substantive transition towards more sustainable growth – economic, social and environmental. The reform pathway will likely be navigated more securely if its implementation recognizes the value of improving energy productivity as a metric for measuring progress and supporting decision-making.

It has been said that a vision without a plan is only a dream. Saudi Arabia's Nationally Determined Contribution to the Paris Accord, National Transformation Program and Fiscal Balance Program have all made important progress in setting out the detailed programs to support the transformation of the Kingdom's economy. Targeting energy productivity as an indicator and policy framework as part of these plans can further assist the Kingdom to fulfill its ambitions.

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Notes

About the Team

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Marcello is a research fellow at KAPSARC, working on innovation and energy transitions policy, with particular emphasis on road transport technology. He holds an M.Sc. in Chemistry from the University of Rome, and an M.Sc. in Environmental Technology and a Ph.D. in Energy Policy and Technology from Imperial College London.

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Kankana is a senior research associate at KAPSARC, working on energy productivity in the GCC and macroeconomic perspectives on energy and economic development in India. Her work focuses on energy productivity, energy efficiency, economic growth and developing energy policy tool kits for government action, particularly in the building sector. Kankana has an M.Sc. in Energy Management from the University of Stirling, UK.

Steven Fawkes

Steven has over 30 years' experience in energy efficiency, with particular expertise in financing. His main focus is financing energy efficiency. He has published extensively on energy efficiency, including more than 250 papers and articles, three books and a regular blog: www.onlyelevenpercent.com

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Marzio is a visiting researcher at KAPSARC. He is professor of environmental and energy economics at the Università degli Studi di Milano, and a research fellow at IEFE, Università Bocconi, Milan. He holds a M.Phil. and Ph.D. in Economics from New York University.

Ibrahim Abdel Gelil

Ibrahim is a visiting fellow at KAPSARC and an adjunct professor of energy and environment at the Arabian Gulf University in Bahrain. He was previously the Chairman of the Energy Planning agency of Egypt (OEP) and the CEO of the Egyptian Environmental Affairs Agency (EEAA). His current research focus is on energy and environmental policies of the GCC.

About the Team

Frédéric Gonand

Frédéric is a visiting fellow at KAPSARC and professor of economics (adjunct, full-time) at University Paris-Dauphine, France. He was previously commissioner of the French Energy Regulation Authority and advisor to the French Minister of the Economy. His research focuses on general equilibrium models with energy and overlapping generations.

Nicholas Howarth

Nicholas is a research fellow at KAPSARC, leading the Center's work on energy productivity. He is an applied economist with 20 years of experience working with governments and industry. He has a D.Phil. from Oxford University in economic geography, specializing in energy, technological change and climate change.

Moncef Krarti

Moncef is a visiting research fellow at KAPSARC, with over 30 years of experience in designing, testing, and assessing innovative energy efficiency and renewable energy technologies applied to buildings. He is a professor and coordinator of the Building Systems Program, Civil, Environment and Architectural Department at the University of Colorado.

Alessandro Lanza

Alessandro is a visiting researcher at KAPSARC. He is Professor of Energy and Environmental Policy at LUISS University, Rome, and a member of the Board of Directors of ENEA, Italy. He holds a Ph.D. in Economics from University College London.

Padu S. Padmanabhan

Padu is a visiting researcher at KAPSARC and is the former program director of the South Asia Regional Initiative for Energy Integration (SARI/EI) and senior energy advisor for USAID/India's bilateral economic assistance program. He has also worked with the World Bank in Washington DC.

About the Project

This project focuses on how shifting to a growth model based around higher energy productivity can benefit Saudi Arabia and the countries of the Gulf Cooperation Council (GCC). Energy productivity is both a policy agenda focusing on how energy can best be used to create value in the economy, and an indicator which integrates economic growth with energy consumption. At the macroeconomic level, energy productivity describes how much gross domestic product (GDP) can be produced using a specific amount of energy. It is the mathematical inverse of energy intensity and is both a reflection of what activities energy is used for (the structural makeup for the economy), and of how well energy is used in specific activities (the level of energy efficiency). At the microeconomic level, energy productivity focuses on how much revenue is produced from economic activities per unit of energy consumption. This is related to, but distinct from, energy efficiency, which focuses on how much physical output is produced per unit of energy consumption.

KAPSARC and UNESCWA have initiated this project to explore the energy productivity potential of the countries of the Gulf Cooperation Council. Aimed at policymakers, the project sets out to highlight the social gains from energy productivity investments, where countries are currently at in each sector, and to articulate options for achieving an improved energy productivity performance.

Acknowledgements

This report provides a synthesis of the results of the joint KAPSARC-UNESCWA project 'Energy Productivity in the GCC'. Nicholas Howarth coordinated the project and authored the report along with members of the project team and with the helpful input of the UNESCWA Energy Section team in the Sustainable Development and Policies Division. Special thanks go to the project team for their work across the project and in developing the papers and analysis upon which much of this paper draws. Thanks also go to David Hobbs, Eloise Logan, Sylvain Cote and Samantha Gross who provided editorial advice. Additionally, a debt of gratitude is owed to Glada Lahn from Chatham House, Zoe Lagarde from IPEEC, Robert Tromop (independent consultant), and Murray Birt from Deutsche Bank, as well as many colleagues from KAPSARC who offered advice, contributed material and reviewed material. Finally, this paper was also able to draw on a rich bank of insights and inputs from participants in KAPSARC's Energy Productivity Workshop Series, which continues to provide a valuable network for the discussion and development of the energy productivity agenda.

Energy Productivity Workshop Series

1. **How to Achieve Economic Prosperity Through Industrial Energy Productivity Improvement?**
   March 2017, KAPSARC Workshop Brief

2. **Energy Productivity as a New Growth Paradigm in the GCC**
   October 2016, KAPSARC Energy Dialogue Summary:
   https://www.kapsarc.org/wp-content/uploads/2017/04/KS-2017-WB04-Energy-Dialogue-2016-Summary1.pdf

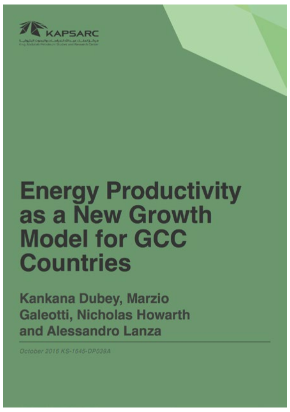
3. **Global Shift: The Energy Productivity Transformation**
May 2015, KAPSARC Workshop Brief
https://www.kapsarc.org/wp-content/uploads/2015/10/KS-1517-WB15A-Global-shift_The-energy-productivity-transformation.pdf

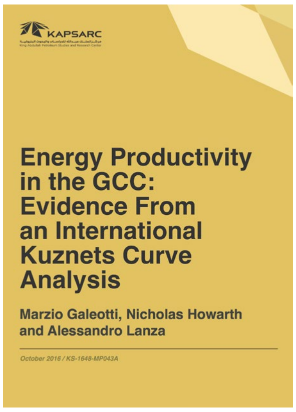
4. **Energy Productivity: From Policy Goal to Reality**
February 2015, KAPSARC Workshop Brief
https://www.kapsarc.org/wp-content/uploads/2015/10/KS-1514-WB12A-Energy-Productivity_From-Policy-Goal-to-Reality.pdf

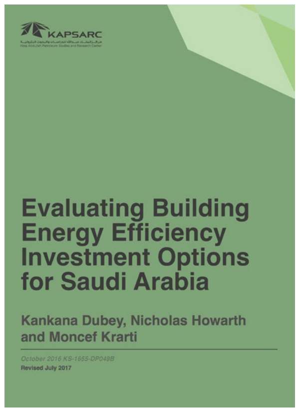
5. **Energy Productivity: Aligning Global Agendas**
October 2014, KAPSARC Workshop Brief
https://www.kapsarc.org/wp-content/uploads/2015/10/KS-1409-WB07A-Energy-ProductivityAligning.pdf

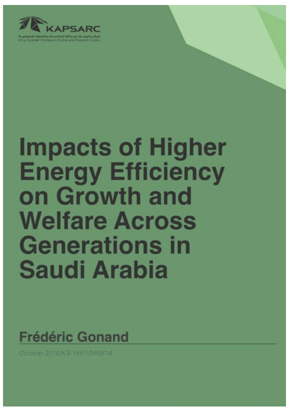
6. **Measuring the Energy Intensity of Nations: Towards a Framework for Transparent Comparisons**
December 2013, KAPSARC Workshop Brief
https://www.kapsarc.org/wp-content/uploads/2015/10/KS1301WB01C_energy_productivity_workshop_policy_brief.pdf

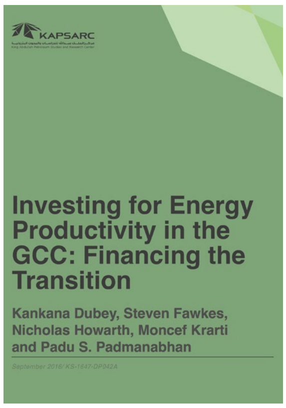
Project Publications

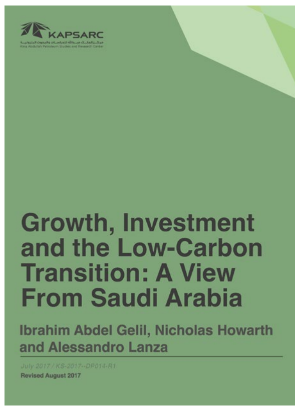












Background papers in process which have informed this report

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