KAPSARC Energy Workshop Series

Global shift: The energy productivity transformation

May 2015

KS-1517-WB15A

About KAPSARC

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

Legal notice

Summary of key insights

While their consequences are usually obvious, global shifts are not always apparent until after they have occurred. Most shifts have their roots in local political, technological or economic forces and may interact in some way with the energy system. Globalization amplifies their effects, contributing to the relative prosperity and influence of nations.

This workshop investigated the role changing energy productivity may be having on global energy shifts. Key questions included:

- What are the pathways for policymakers seeking to promote a more sustainably prosperous world through enhanced energy productivity?
- How is changing energy productivity affecting countries around the world, including the GCC?

Countries improving their energy productivity are likely to capture a wide range of social and economic benefits that go far beyond traditional 'conservation' concepts of saving energy. These outcomes include enhanced employment, stronger government finances and improved infrastructure and trade. Progress on energy productivity may also exert downwards pressure on global energy prices if it dampens the pace of energy demand growth.

On the policy front, global initiatives on energy efficiency through the United Nations, G20 and others, suggest that momentum is gathering on this issue. However, multiple domains of international relations intersect with each other, confusing and even deferring global cooperation. Notwithstanding this, we foresee the formation of new global alliances for energy productivity in 2015 as countries adopt new initiatives and seek to enhance their own welfare. Such alliances are not a necessary condition for wider progress but may provide momentum and a framework for policymakers as they develop their own approaches.

By contrast to many other significant economies and blocs, energy productivity in the Arab world – and more particularly among the countries of the Gulf Cooperation Council (GCC) – has been declining in recent years. This performance may result from a variety of factors including:

- an extremely fast pace of economic and infrastructure development
- a concentration on energy intensive growth, amplified by low energy prices and a degree of offshoring from other economies
- an artifact of the data used and methodology for calculating GDP

KAPSARC and the United Nations Economic and Social Commission for West Asia (UNESCWA) have launched an initiative to better understand energy productivity in the Arab world, starting with GCC countries. This will diagnose the reasons for the current performance and provide a roadmap for policymakers to improve performance and set targets. Such targets may have broader significance if governments propose them as part of international negotiations on climate change, set to culminate in Paris later this year.

Background to the workshop

It is relatively straightforward to observe the supply-side of the energy sector: the drilling rigs, power plants, wind turbines, pipelines, cars and other infrastructure that forms the energy economy. However, the energy productivity or efficiency that is distributed across this system is more difficult to see.

With the aim of improving visibility, the IEA has employed a number of methods to estimate global investment in energy efficiency somewhere in the

range of $310-360 billion in 2011. While this is lower than upstream oil ($600 billion invested in 2011) and conventional power industry investments (around $550 billion), it is significant in the context of the overall energy system.

Despite its size, and contribution to global progress, energy productivity is not at all well understood and, as a result, energy efficiency attracts a much lower level of attention from industry analysts and governments than more traditional sources of energy.

The workshops were held over two days, with the first day dedicated to Energy Productivity in the six countries of the Gulf Cooperation Council (GCC) and the second to wider international energy productivity issues. Experts gathered from around the world and across the Arab region to discuss the role energy productivity can play in reshaping energy systems. The workshops also launched a collaborative project between KAPSARC and UNESCWA to explore the energy productivity potential of the Arab region.

What are the pathways for policymakers looking to increase energy productivity?

There is something inherently human about the desire to find new forms of energy and use it more effectively in the pursuit of our goals. However, conventional thinking on energy efficiency has typically been thought of in the fairly narrow terms of its energy saving potential, and more recently its greenhouse gas mitigating capabilities.

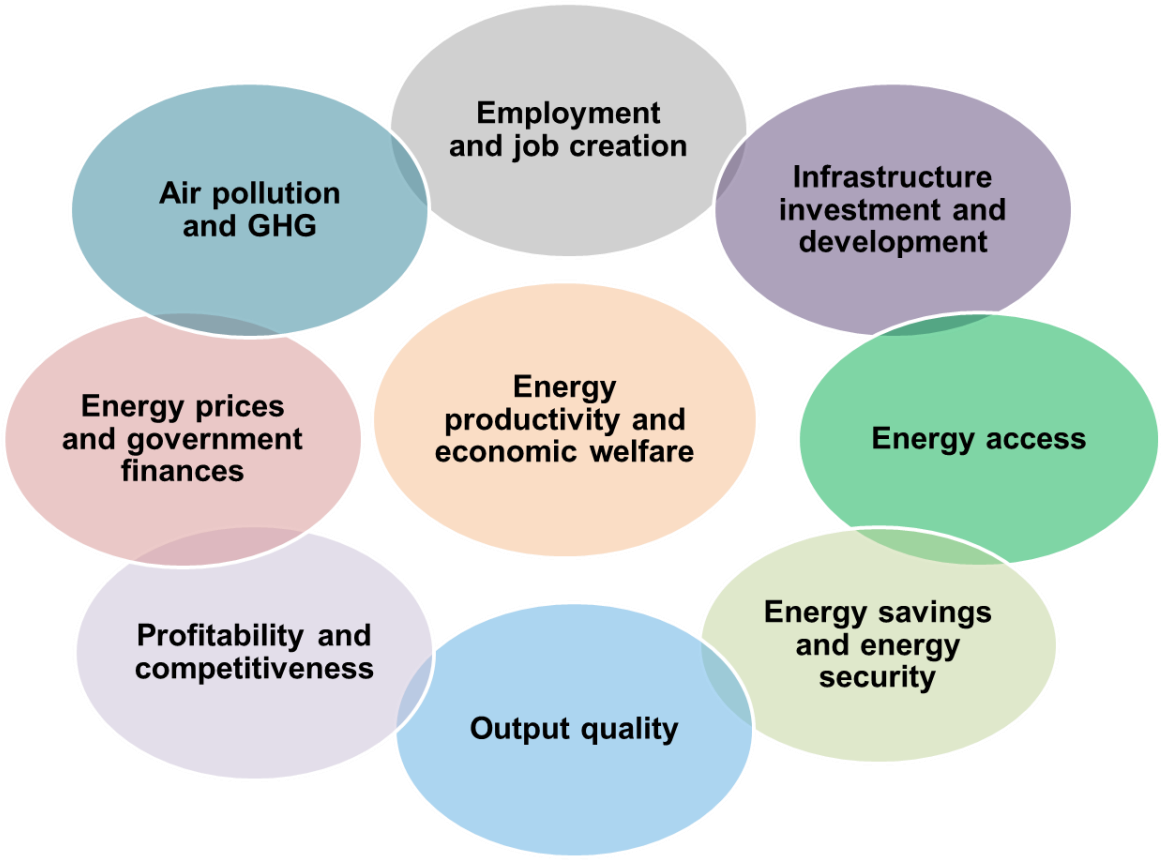


Figure 1: Energy productivity and economic welfare
Source: KAPSARC based on IEA

Positive spillovers of energy efficiency

Many organizations have sought to make the case for policies that support energy efficiency that extend beyond the simple economic returns to the investor. One such example is work undertaken by the IEA in Capturing the Multiple Benefits of Energy Efficiency. It highlights the considerable additional value of social and economic outcomes resulting from energy efficiency investments to date. Benefits include:

- Between 0.25% and 1.1% extra GDP growth per annum from enhanced energy efficiency investment
- A 5% to 30% improvement in the government's financial balance
- 8 -27 jobs per million euros of energy efficiency investment
- Up to a 400% return on investment in insulation including from lower healthcare costs in cool climates
- Profitability gains of between 40% and 250% of the value of energy cost-reductions from energy efficiency investments
- Up to 240% returns on utility investments in consumer energy efficiency

This view is starting to shift, informed by new targets based around the notion of energy productivity. Energy productivity is a concept that reframes the focus of policymakers away from energy conservation and towards how energy can best be used to enhance social welfare.

Targets are typically set relating economic outputs to energy inputs (typically GDP and total primary energy supply). Even so, GDP provides only a partial picture of how effective a society is at using energy to achieve its goals and a range of complimentary measures is required to monitor progress. Shifting from speaking about energy efficiency and intensity to energy productivity across a range of indicators is therefore an important part of the transformation.

It is ironic that while no consumer or government would question the significant social and economic benefits of increasing energy supply, both groups have been less quick to recognize that using energy more productively produces the same benefits, often at below the long run marginal cost of supply side options. Indeed, the IEA estimates only around 20-30% of identified viable energy efficiency potentials have been realized.

While this suggests that a significant potential for energy productivity led economic growth exists, different cultural and market contexts suggest there is little insight in the search for so-called "optimal" methods for implementing substantial energy efficiency.

For example, it is not clear whether energy efficiency can be better advanced by general energy price levels in the economy and organic market adaptation, or by strategic state-driven mandates on the regulatory front backed-up by strong enforcement mechanisms. Debate remains as to what is the primary driver of energy productivity.

Global cooperation on energy efficiency

Since the G8 Gleneagles focus on energy efficiency in 2008, there has been a growth of agencies and programs pursuing energy efficiency. UNSE4All has created a global ambition to double the rate of improvement of energy efficiency by 2030. This has resonated around the world, and through the UN's five regional commissions the SE4ALL initiative is achieving global reach.

The IEA, OECD, RCREEE, KAPSARC and the UNDP Copenhagen Centre for Energy Efficiency among others are providing analytical and policy capability. Energy efficiency is on regional government agendas with both the C40 and Covenant of Mayors processes developing capability in local government. The World Energy Council, Major Economies Forum, Clean Energy Ministerial, COP21, League of Arab States and G20 have each developed a focus on energy efficiency within their broader mandates.

"A key question that should challenge all leaders in all countries is how does energy productivity bear on our prospects for development?"

Energy efficiency cooperation platforms, like the International Partnership for Energy Efficiency Cooperation and the Clean Energy Solutions Centre, are good options for collaborative progress for those countries that are less inclined to engage on global greenhouse gas (GHG) reduction processes. Importantly, the multilateral development banks have also established sustainable energy portfolios that prioritize energy efficiency investments.

The recent expansion of this pool of international bodies, each with a focus on energy efficiency, has led some to call for improved coordination. However, perhaps the greatest priority is to develop capacity within individual countries, so that energy efficiency can contribute to meeting welfare needs and economic development goals.

"Most international processes have lost sight of any overarching objective of global welfare, and as such are not asking the right questions of energy productivity."

From time to time, the idea of global framework of agreed energy efficiency targets is raised. While this is a challenging exercise in a regional context (such as the European Union's energy efficiency target), it is even more difficult in a global context where the sheer diversity of political priorities make alignment and agreement to a target very challenging. It is perhaps more pragmatic to focus on processes that enable innovation, or help accelerate or spread successful energy efficiency practices, than invest political capital in hard to achieve grand goals or gestures.

Rapid progress is already being made in existing commitments to energy productivity by China and the EU. With the focus of US technical innovation capabilities being motivated by the bipartisan energy policy goal to double energy productivity of the US economy by 2030, the scope for energy efficiency cooperation is substantially greater.

The US energy services company (ESCo) market was worth $8 Billion in 2013 and is growing at 20% per year. China's ESCo market is estimated at around $12 billion and growing towards a potential scale of around $100 billion per year. As is often the way, international policy seems likely to follow initiatives at the industry and national level and codify the accepted norms.

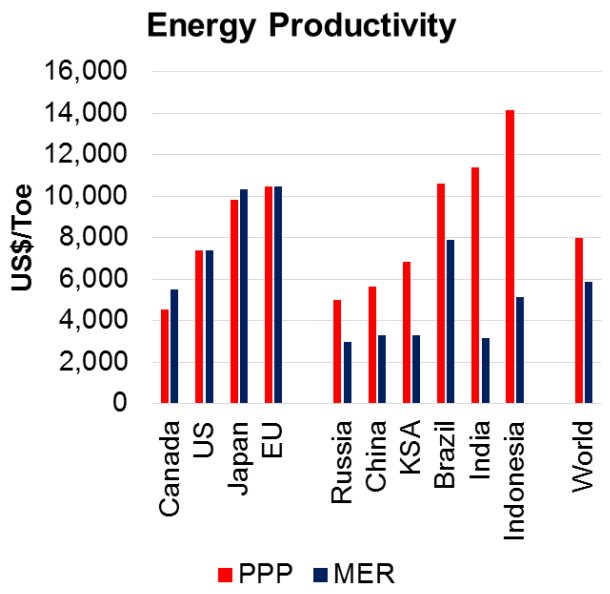
With the interconnected nature of global supply chains and the tendency of innovation to spread from innovating economies to those who adopt rather than generate new technologies, actions in a few major economies can have global ramifications.

"Global agreement on energy productivity targets may not be necessary if a few major countries take strong action and coordinate their standards."

There is a tension between the perspective that constraints in energy supply and global GHG levels necessitate a need to accept lower standards of living and the perspective that increasing energy use will improve the living standards, health and productivity of citizens, especially in developing countries.

There are several analyses of the potential global economic outcomes from energy productivity improvements. For example, in their Efficient World Scenario in the 2012 World Energy Outlook, the IEA identifies a possible boost in global economic output of an additional $18 trillion through to 2035. Additional energy efficiency investment of $11.8 trillion in new, more efficient infrastructure is required to achieve this over the period, but this is more than offset by $17.5 trillion of avoided fuel costs, and $5.9 trillion of avoided supply-side investment.

The IEA's analysis suggests emerging economies benefit most significantly from the global expansion of energy productivity. GDP gains in 2035 are greatest in India (3%) and China (2.1%), while developed countries gain less – US (1.7%) and OECD Europe (1.1%). The implications on energy resources are significant. Avoided demand for oil is estimated at 12.7 million barrels per day in 2035, compared to the business as usual. In practice, this does not mean the world will necessarily consume less oil but that any demand above this scenario will be adding additional value to the global economy.



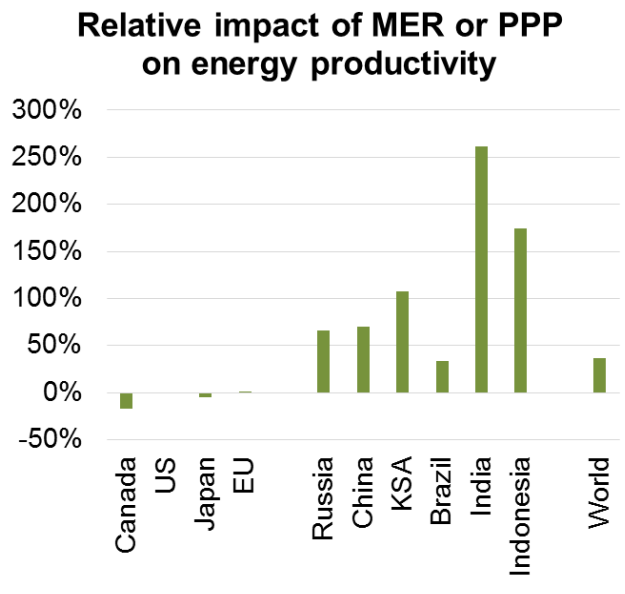


Figure 2: Exchange rate assumptions matter for developing countries
Source: World Bank and BP Statistical Review, KAPSARC analysis

Energy productivity performance is highly sensitive to data conventions

Comparisons of energy productivity between countries requires the conversion of each country's GDP, whether measured in Dollars, Euros, Renminbis or Rupees into consistent units, typically 2005 US dollars in purchasing power parity (PPP) terms (as above). However, the use of PPP compared to market exchange rates (MER) results in major differences in the relative energy productivity of countries, especially those from the developing world.

For example, when using PPP the size of the Chinese economy is much larger than if MERs are used in the conversion. This results in conventional measures of Chinese energy productivity being higher than if MER is used. There are numerous arguments for and against either approach, but it may not matter which out of MER or PPP provides 'truer' picture of the size of GDP between countries for calculating energy productivity. In the longer run, as economies become more developed and open to trade and financial flows, the differences between MER and PPP may become less important. For long term targets, MER may provide the truer comparison and PPP may provide better comparisons of short term performance. However, what matters most is that countries understand their own productivity and potentials, so that they can incorporate sensible lessons learned from comparisons that enjoy general acceptance.

When comparing the performance of economies, it is also important to qualify the widely used energy-GDP or GDP-energy index of energy intensity/ productivity as an expression of aggregate energy efficiency. While valuable as an strategic goal:

- it is too aggregated to be of practical use for specific policy options
- too naïve to express the reality of different social and economic country contexts
- does not adequately expose the driving forces, state or response options that underpin progress in energy efficiency

Many policy analyses find that there is benefit in estimating energy productivity changes by disaggregating energy consumption and activity at a sub-sectoral level, and by factoring out the different structural, environmental and fuel mix changes that underlie energy consumption, taking into account the dynamic evolution of the economy. As yet, few economies have invested in gathering the essential activity and energy demand data to do this well.

Global shift: Managing an energy productivity transformation

Energy productivity can be measured by calculating the amount of economic output produced from a certain quantity of energy inputs. In Figure 3, some of the major shifts in energy productivity are shown for selected countries. The improvements in performance are starkly evident – to a much greater extent than the specific policies that may have been effective in driving them. It is only with the benefit of hindsight that it becomes more obvious how a combination of policies drove such a transformation. Energy prices played a role, as did policies designed to increase energy security and diversity in the fuel mix. There is opportunity for those economies that have not yet set out on the energy productivity improvement journey to incorporate the learnings of others into their own policy prescriptions.

China

China's economic rise is one of the largest proportionate shifts over this time, moving from low energy consumption levels in 1990 to being the world's largest energy consumer by 2012. At the

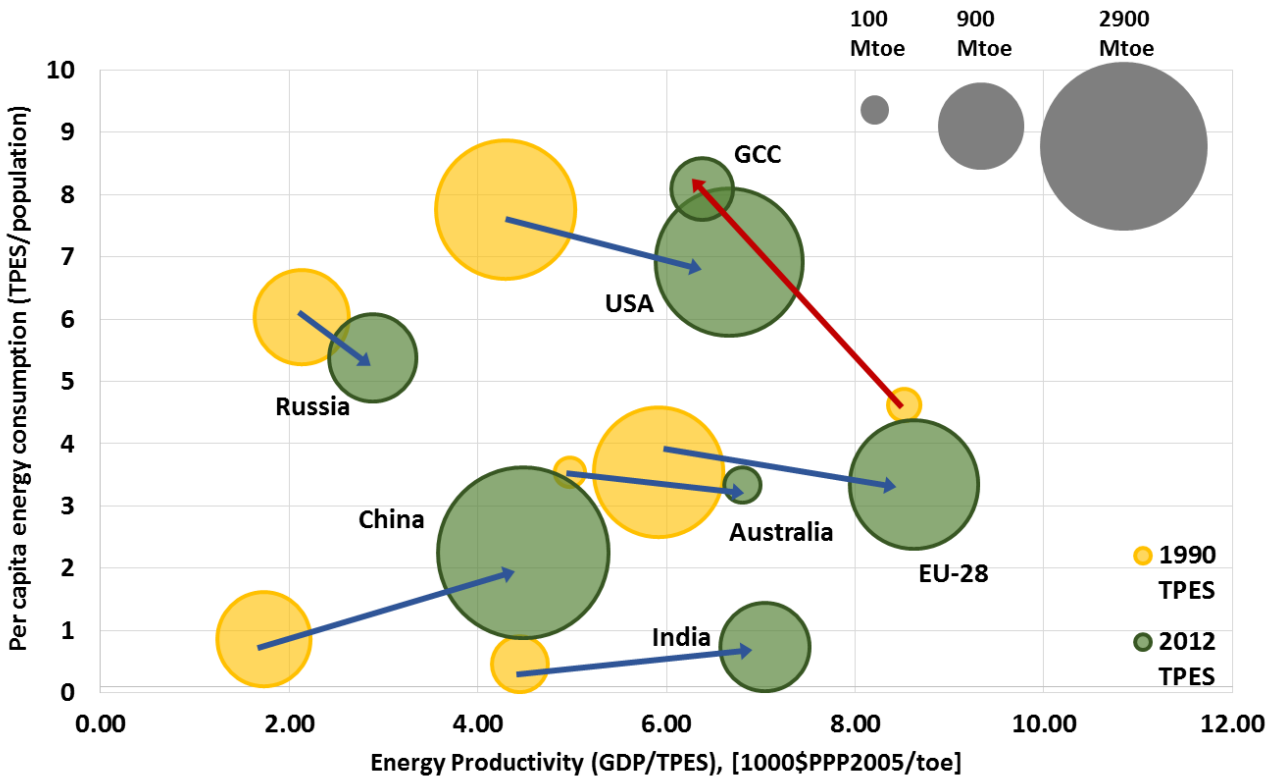


Figure 3: Global shifts in energy productivity. The size of the bubble represents total primary energy supply, while the direction and color of the bubble shows the change between 1990 and 2012.
Source: KAPSARC based on OECD data.

same time, China has more than doubled its energy productivity moving from $1,730 of GDP produced per toe to $4,480.

China also stands out as an emerging economy with a very deliberate implementation of energy efficiency for social and economic development. This highlights the substantial role that energy efficiency can play as a national priority in energy policy, when a country's leadership commits to it.

India

India has achieved more significant relative gains in energy productivity than either the US or Europe over this time. When evaluating this shift, it is important to take into account that they are moving from a significantly different base in terms of their stage economic development.

For example, the US and India have roughly the same level of energy productivity of $6,670 and $7,700 per ton of oil equivalent respectively, but their per capita energy consumption is very different with the US registering seven times India's per capita energy consumption. Energy productivity on its own gives only a partial picture.

With over 400 million people living largely in rural areas unserved by electricity, access to modern energy services remains a constraint on the potential for productivity in India. Because of this, the role of energy efficiency in simultaneously providing necessary energy services through new infrastructure, while enabling the greatest welfare to be gained from the existing energy system, is being elevated up the policy agenda.

"Energy efficiency has a radically different meaning and value when implemented in the context of energy shortages, than when explored in countries not facing such shortages, or indeed enjoy the luxury of capacity margins."

India currently faces around a 40 GW deficit in electricity supply. In this situation, end-use energy efficiency reduces pressure on the existing supply system, and therefore assists by reducing the supply-demand gap and thus reduces the frequency of power cuts and need to rely on the backup of expensive and inefficient diesel generators. This has the advantage of improving the quality and reliability of power supply which, in turn, reduces distribution losses and further improves the efficiency of end-use.

Natural progression or a policy driven path?

Differences between emerging and developed countries can possibly be explained through the notion of energy productivity Kuznets curves (EPKC) shown in Figure 4. The EPKC hypothesis is that at low levels of economic development countries (e.g. India and much of Africa) have energy use and low GDP that can lead to high energy productivity. As economic growth takes hold and the infrastructure of the country is developed along with modern energy sources, energy consumption rises faster than GDP due to the energy intensive nature of this process. Once an economy matures, higher value-added service sectors generally play a greater role and the presence of an existing building stock and transport network means less steel and cement is required for building infrastructure. This results in an "inverted U-shaped" relationship between energy intensity and per capital GDP (or normal U-shape for energy productivity). An empirical investigation of this relationship is shown below.

This analysis suggests that in advanced economies the turning point of per capita income at where energy productivity starts to improve occurs earlier than that for emerging economies. Another observation is that this turning point occurs at a lower level of energy intensity than in emerging nations. As suggested by the EPKC theory, this likely reflects the less energy intensive nature of

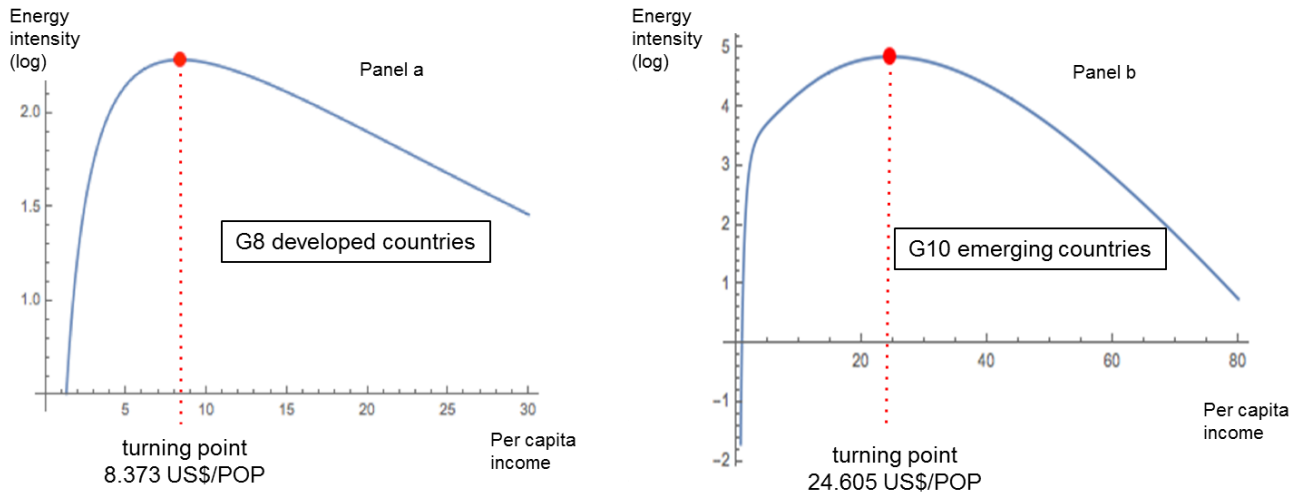


Figure 4: Energy productivity Kuznets curves for the G20
Source: KAPSARC analysis based on OECD data. 2005 US dollars PPP. Note: Russia is not included due to data limitations.

more mature economies, as higher value added services make up more of the economic output.

Of course, the question as to whether energy productivity will follow this pattern in all cases will be an empirical issue. It may be that energy consumption continues to outpace economic growth in some instances because, at high levels of per capita income, energy consumption rises again as people migrate to energy consuming technologies – such as dishwashers and air transport. This would mean that in rich, mature economies the curve may begin to rise again as prosperity increases and the Kuznets function is in fact more of an inverted 'w' shape than an inverted "u".

Care should also be taken not to consider the results of such analysis in one region or country in isolation of its major trading partners. For example, an EPKC in one country might suggest a turning point has been achieved and the economy has reached new levels of productivity, whereas if, in fact, this is being driven by structural change and the import of energy intensive good from other countries, the global welfare benefits are less clear. A global perspective is required.

The energy productivity shift in GCC countries

Hydrocarbons have played, and will continue to play, a dominant role in the GCC economies. Due to the low cost of production in the region, the size of oil and gas rent constitutes a big share of the region's GDP. For decades, oil and gas revenues have been used for financing government spending, the accumulation of national savings, investments in infrastructure, and the expansion of social programs. It can be argued that these revenues have resulted in improvement across a wide range of human development indicators.

As shown in Figure 5, the GCC countries are one of the only regions of the world where energy productivity is deteriorating. Between 1990 and 2012, energy productivity shifted from an average of around $8,520 to $6,380 per toe. While this in large part may be attributed to the movement along the energy productivity Kuznets curve, consistent with the GCC's current phase of economic development, it still represents an important challenge for GCC policymakers who must consider the pressure increasing domestic energy demands place on oil and gas exports and their associated revenues.

Several main forces have shaped energy use and productivity in the GCC:

- The construction of modern infrastructure and rapid economic development
- A specialization in energy intensive industries, building on the region's comparative advantage in energy production
- The energy demand effects of high population growth, including high levels of expatriate labor
- An extreme climate requiring a high dependence on air conditioning, which consumes around 70% of residential electricity
- The need to manufacture potable water with desalination technologies

These forces suggest that the evolution of energy productivity in Gulf states will follow a different path than in other economies. Nevertheless, the energy efficiency imperative is being taken seriously by policymakers. For example, the recent implementation of air conditioner standards, along with building energy efficiency standards in Saudi Arabia, target capacity reductions of 10GW, or a quarter of current electricity demand. The Riyadh metro, already under construction, will offer a transformative mode of mobility with a 178km city-wide efficient rapid transit system to be installed by

2018. The UAE's development as an airline hub is also a logical expansion into a higher value added services sector. Notwithstanding this, there is a strong need to use benchmarking across different sectors of the economy to help make a more effective evaluation of energy productivity performance.

The role that pricing policies can play in driving energy productivity improvements cannot be stressed sufficiently. To the extent that pricing alters energy consumption behaviors at a lower overall social cost than a collage of regulatory mandates, is an important issue. Exploring the implications of potential policy directions in this regard is a very relevant subject for GCC countries.

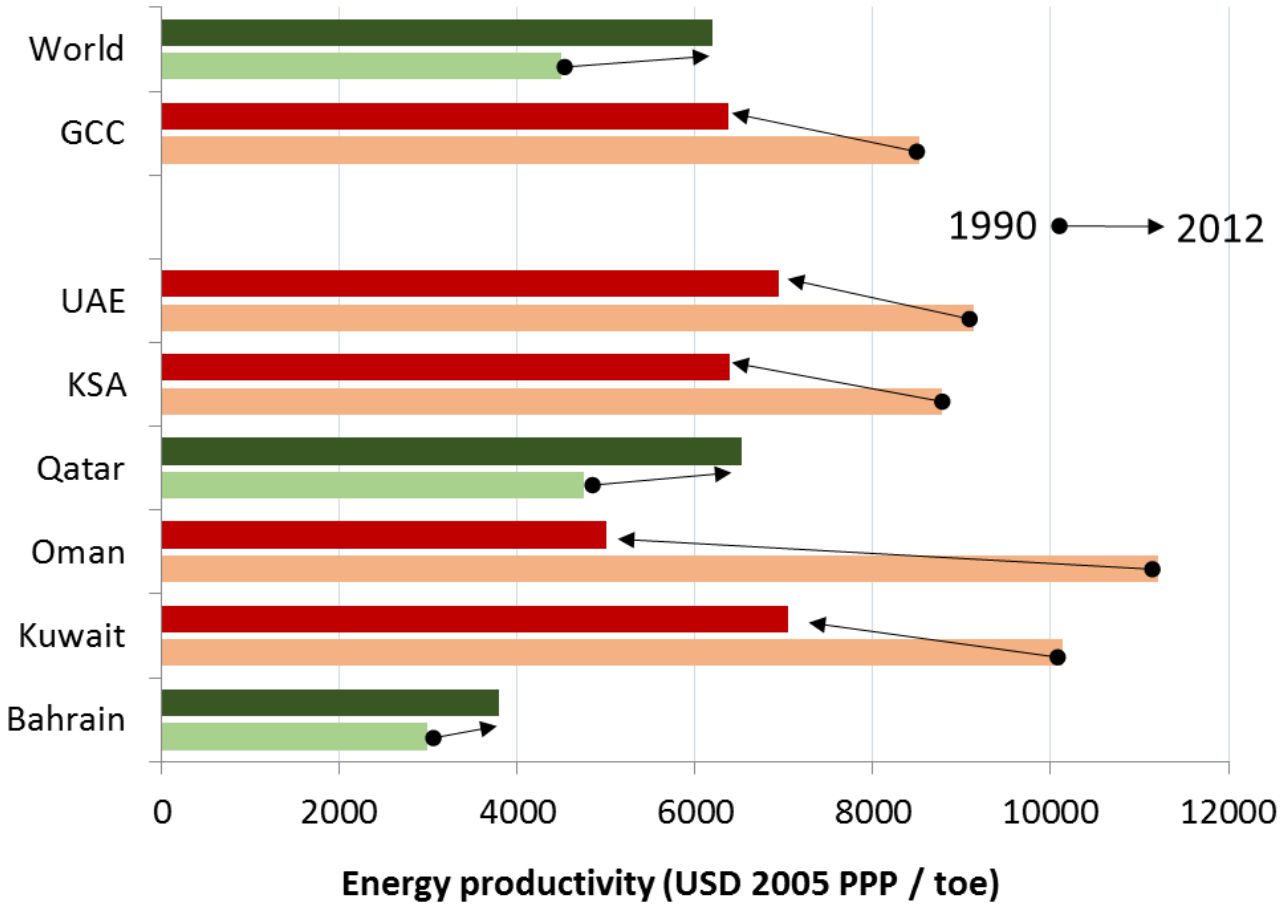


Figure 5: Energy productivity Kuznets curves for the G20
Source: KAPSARC analysis based on OECD data. 2005 US dollars PPP. Note: Russia is not included due to data limitations.

About the workshop

In February 2015, KAPSARC convened the fourth and fifth workshops in its Energy Productivity workshop series. The workshops were held over two days, with the first day dedicated to energy productivity in the six countries of the Gulf Cooperation Council (GCC) and the second to wider international energy productivity issues. The workshops also launched a collaborative project between KAPSARC and UNESCWA to explore the energy productivity potential of the Arab region. The workshop was held under the Chatham House Rule of capturing the discussion on a non-attribution basis. Participants included:

Ibrahim Abdel Gelil – Adjunct Professor of Energy and Environment, Arabian Gulf University, KAPSARC visiting fellow

Hisham Akhonbay – Collaboration Specialist, KAPSARC

Muhammad Akmal – Corporate Planning, Saudi Aramco

H.E. Abdulaziz Al Furaih – Deputy Governor, Saudi Arabian Monetary Agency (SAMA)

Mohammed Al Sahlawi – Professor, King Fahd University of Petroleum and Minerals

H.E. Abdullah Al Shehri – Governor, The Electricity Co-Generation Regulatory Authority

Naif Alabbadi – Director General, Saudi Energy Efficiency Center

Abdulrahman AlAbdulbarim – SASO

Samer AlAshgar – President, KAPSARC

H.E. Saleh Alawaji – Deputy Minister, Saudi Ministry of Water and Electricity

Adel AlBogame – SASO

Walid AlDeghaili – Consultant in Energy (EE&RE)

Abdullah AlGahtani – SASO

Moctar AlHacene – Director Economic Development and Globalization Division, UNESCWA

Fatma Al-Hakmani – Director of Energy Department, The Cooperation Council for the Arab States of the Gulf, Secretariat General

Sadeem Alhosain – Data Analyst, KAPSARC

H.E. Saad O AlKasabi – Governor, Saudi Standards, Metrology and Quality Organization (SASO)

Hani AlOgaili – SASO

H.E. Hamad Al-Sayari – Former Governor, Saudi Arabian Monetary Agency

Mohammed AlShab – SASO

Omar Alubaidly – Director of International Relations & Geopolitics Program, DERASAT - Bahrain Center for Strategic, International and Energy Studies

Mansour Al-Zunaidi – General Manager, Privatization and Commercial Affairs, Saline Water Conversion Corporation

Mohamed Hedi Bchir – Chief, Modeling and Forecasting Section, Economic and Development and Globalization Division, UNESCWA

Leila Benali – Corporate Planning, Saudi Aramco

Mongi Bida – First Economic Affairs Officer, Sustainable Development and Policy Division (SDPD) (ESCWA)

Tyler Bryant – Project Manager, International Energy Agency

Kateri Callahan – President, Alliance to Save Energy

Clark Gordon – Director, Smith School of Enterprise and the Environment

Kankana Dubey – Research Associate, KAPSARC

Habib El Andaloussi – Chief Energy Section, Sustainable Development and Policy Division (SDPD) (ESCWA)

Marzio Galeotti – Professor, University of Milan, KAPSARC Visiting Fellow

Anwar Gassim – Research Associate, KAPSARC

Rebekah Grindlay – Director, Resources and Energy Section, Australian Department of Foreign Affairs and Trade

David Hobbs – Head of Research, KAPSARC

Nicholas Howarth – Research Fellow, KAPSARC

Min Jin – Associate Professor, Renmin University of China, KAPSARC Visiting Fellow

Alessandro Lanza – Euro Mediterranean Center on Climate Change, Italy, FEEM, Italy, and KAPSARC Visiting Fellow

Benoit Lebot – Head, International Partnership for Energy Efficiency Cooperation

Hengwei Liu – Department of Policy and Regulation, National Center for Climate Change Strategy and International Cooperation (NCSC)

Xiaomin Liu – Associate Director, China Coal and Power

David Livingston – Associate, Energy and Climate Program, Carnegie Endowment for Global Peace

Toufic Mezher – Professor, Masdar Institute of Science and Technology

Padu S. Padmanaban – Former World Bank and USAID energy efficiency expert, KAPSARC Visiting Fellow

Axel Pierru – Program Director Economics and Modeling, Senior Research Fellow, KAPSARC

Taoufic Rajhi – African Development Institute, Tunisia

Mohamed Ramady – Professor, King Fahd University of Petroleum and Minerals

Ridha Saidi – Former Minister to the Head of Tunisian Government, in charge of coordination and monitoring of economic affairs

Jayant Sathaye – Founder, International Energy Studies Group, Lawrence Berkeley National Laboratory (LBNL)

Jigar V. Shah – Executive Director, Institute for Industrial Productivity

Adnan Shihab-Eldin – Director General, Kuwait Foundation for the Advancement of Sciences

Mayssam Tamim – Assistant Resident Representative, United Nations Development Program

Robert Tromop – Former Head of Energy Efficiency at the IEA, KAPSARC Visiting Fellow

Abdullah Tuwaijri – Collaboration, KAPSARC

Eric Watkins – Visiting Fellow, KAPSARC

Frank Wouters – CEO, Wouters Ltd

Yan XIA – Associate Professor, Chinese Academy of Sciences, KAPSARC Visiting Fellow

Xu Yuan – Assistant Professor, The Chinese University of Hong Kong

Hanxiong Zhu – Post-doctoral Researcher, School of Social Development and Public Policy, Fudan University

About the team

Tarek Atallah is a Senior Research Analyst evaluating energy productivity investments, economics of energy vulnerability, and the effect of climate on energy consumption patterns.

Patrick Bean is a Senior Research Associate examining new electricity market and business models, in addition to his research on the determinants of energy productivity.

Jorge Blazquez is a Research Fellow specialising in energy and economics. He has a PhD in macroeconomics from Universidad Complutense de Madrid.

Kankana Dubey is a Research Associate working on energy productivity in China and GCC countries. She holds an MSc degree in energy management from the University of Stirling.

Rodrigo Echeverri is a Research Fellow analyzing coal markets. He has worked at Adaro Energy in Indonesia and Cerrejon Coal in Colombia and Europe.

Anwar Gasim is a Research Associate examining the embodied energy in trade and its impact on a country's energy use and productivity. He also works on a number of projects that revolve around energy efficiency.

Berenice Garcia-Tellez is a Senior Research Analyst evaluating the energy use associated with embodied water in the global trade of goods. She holds a Master's degree in environmental engineering from KAUST.

Marzio Galeotti is a KAPSARC visiting fellow collaborating with KAPSARC-UNESCWA on energy productivity in GCC countries. He is a Professor in the Department of Economics at the University of Milan.

Ibrahim A Gelil is a KAPSARC visiting fellow collaborating with KAPSARC-UNESCWA on energy productivity in GCC countries. He is Professor Emeritus and Academic Chair at the Arabian Gulf University.

Frederic Gonand is a KAPSARC visiting fellow collaborating with KAPSARC-UNESCWA on energy productivity in GCC countries. He is a Professor of Economics at University of Paris-Dauphin.

About the team (continued)

Nicholas Howarth is a Research Fellow specializing in technological change, energy and the environment, working on energy productivity in China and GCC countries. He holds a DPhil in applied economics from the University of Oxford.

Lester Hunt is a Senior Research Fellow. His research focuses on energy modeling, energy efficiency, and energy policy. He has a PhD from the University of Surrey.

Min Jin is a KAPSARC Visiting Fellow. She is an Associate Professor at the Renmin University of China. She specializes in energy efficiency in China.

Alessandro Lanza is a Senior Visiting Fellow and an expert in the fields of energy and environmental markets, economics and climate change policy.

Leo Lester is a Research Fellow leading the China Research. Previously working in strategy and portfolio development for an international oil company, he has a PhD and is a CFA and FRM.

Srinivasan Padmanaban is a KAPSARC visiting fellow collaborating with KAPSARC-UNESCWA on energy productivity in GCC countries. He has worked with the World Bank and USAID.

Sa'd Shannak is a Research Associate investigating water-energy nexus and energy and the environment. He holds a PhD in water management from the Texas A&M University.

Robert Tromop is a KAPSARC visiting fellow collaborating with KAPSARC-UNESCWA on energy productivity in GCC countries. He has worked with governments and was Head of Energy Efficiency at IEA.

Xia Yan is a Associate Professor at the Chinese Academy of Science, specializing in multiregional input output and computable general equilibrium modeling of the Chinese economy.