KAPSARC Energy Workshop Series

Energy productivity: From policy goal to reality

February 2015

KS-1514-WB12A

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 for policymakers

Energy productivity, at the national level, has emerged as a valuable indicator for a number of reasons. It accommodates economic growth, linking energy use to gross domestic product. It is more than conceptually tied to energy efficiency; seen by policymakers as a solution to a wide range of energy -related issues. It captures both the energy saved through profitable energy efficiency improvements and the ensuing economic benefits, including higher economic growth and employment. This makes it useful to both OECD and non-OECD countries, despite their sometimes divergent energy policy agendas.

Many governments set national targets based on commonly used indicators, which include energy consumption, energy savings, and energy productivity. The US and Germany, for example, have recently set targets based on energy productivity, with the US aiming to double its productivity by 2030.

When designing targets, governments may find it useful to account for the embodied energy in international trade, if they are not to meet their targets by exporting energy-intensive activities to others, only to re-import the resulting goods for final consumption. For example, energy productivity in the US has improved in part because of the "offshoring" of energy-intensive industries. This has limited the global benefits of the improvement in productivity for the US. Furthermore, if those energy -intensive industries return to the US over the next decade to take advantage of the shale gas boom, there will be downward pressure on US energy productivity. Accounting for inter-regional embodied energy flows within a country also provides key insights to policymakers, especially in countries such as China where targets are designed at a provincial level.

Obstacles to improving energy efficiency include:

- Removing energy subsidies. The normally accepted policy approach is to remove them gradually whenever it appears politically feasible. In the absence of popular support for such measures, some governments look towards "second-best" policies including subsidizing energy efficient appliances or mandating minimum energy efficiency standards. These latter approaches will normally impose a greater societal burden than allowing price signals to modify behaviors, but they are, perhaps perversely, easier to sell to a population because the costs are less transparent.

- Perceived difficulties in financing energy efficiency investments. There is value in standardizing the way energy efficiency projects are measured, validated, and invested in. Reducing the transactional friction that arises when each (relatively small) project requires custom evaluation frameworks can allow for syndication of portfolios of projects, thereby unlocking greater investment flows.

It will require a combination of policies to overcome the barriers to improving energy efficiency and allow governments to meet their energy policy objectives.

Background to the workshop

In September 2014, KAPSARC hosted the third in its Energy Workshop Series on Energy Productivity. Discussions revolved around moving energy productivity from a policy goal to a reality, elevating it from an indicator of past performance to an actionable policy tool that encourages and recognizes both reductions in energy use and the wider economic benefits arising from energy efficiency improvements.

Previous workshops in the series had focused on making consistent comparisons of energy productivity between nations and how energy productivity can help align global agendas. This workshop focused on the following topics:

- The use of targets in energy policymaking
- Insights for policymakers from a deeper analysis of the embodied energy in trade
- Unlocking greater levels of financing for energy efficiency projects
- Tackling energy subsidies
- Energy efficiency opportunities along the supply chain

Monitoring energy efficiency at a national level

Governments seek to improve energy efficiency for different reasons. Energy importing countries see energy efficiency as a tool that can cushion the negative impacts of high energy costs on consumers and reduce persistent trade deficits. Energy-exporting countries see energy efficiency as a key to maintaining export capacity by curbing the growth of domestic energy demand. Energy efficiency has also emerged as one of the central measures to tackling climate change. Regardless of the goal, energy efficiency features prominently in policy debates as a solution to a wide range of issues.

Energy indicators are used by policymakers to monitor progress towards national energy policy objectives. OECD governments typically focus on energy consumption and energy savings. Their use has largely been driven by the objective of mitigating anthropogenic climate change. More recently, energy intensity and its inverse, energy productivity, have become valuable indicators for emerging economies because of the way they accommodate economic growth and the resulting energy demand growth – rather than a simple focus on demand reduction. Energy productivity has even started to find support within the OECD, with the US just announcing its target to double its energy productivity by 2030.

The advantages to having a national target

Many countries set a national energy policy target based on one of the commonly used indicators (Figure 1). Such targets play an important role: they allow governments to create a level of shared accountability, monitor the success of various energy policies, send long-term signals to investors, and coordinate actions with other governments and stakeholders.

An overarching national target can help align different stakeholders

Although some countries have not set an overarching national target, most have adopted a smaller basket of targets for pollution reduction, air quality improvement, economic development, energy efficiency enhancement, and/or greater energy security. Some of these sub-targets may not align, and may even involve trade-offs against one another. An overarching national target can help align the different stakeholders that are responsible for meeting their sub-targets and prevent unintended consequences.

Australia, Canada, and Saudi Arabia present examples of countries that have not yet set a national energy policy target. In the case of Saudi Arabia, there are a number of smaller targets and programs across both the supply and demand sides that aim to improve energy efficiency and sustainability. For example:

- The Saudi Energy Efficiency Center, which is responsible for suggesting, implementing, and monitoring programs that aim to raise energy efficiency on the demand side, has recently implemented a program that requires all new buildings to be thermally insulated. In addition, they have raised the minimum energy efficiency ratio for air-conditioners. Other programs that target the transportation sector, the commercial sector, and lighting are under examination.

- The King Abdullah City for Atomic and Renewable Energy has been established to develop renewable and nuclear energy in the Kingdom. It aims to have 50% of all electricity generated in 2032 come from non-fossil fuel sources – chiefly solar, wind, and nuclear.

- The Electricity and Cogeneration Regulatory Authority, the Ministry of Water and Electricity, and the Saudi Electric Company are working on instituting higher energy efficiency measures for new and existing power plants. The aim is to increase fleet efficiency to more than 45%. Among the programs that will help achieve this objective is the conversion of all inefficient single-cycle gas turbines into combined-cycle units.

The responsibility for improving energy efficiency and productivity in Saudi Arabia is shared by a number of different organizations. Although there are advantages to having different organizations specialize in one particular energy-related issue, an overarching national target can help facilitate greater dialogue and cooperation between the different organizations.

This also applies to countries such as Canada, where energy policy tends to be fragmented among the provinces. Although regional variations mean that provinces may be better equipped to understand which energy policies can be most effective, an overarching national target would likely unlock greater cooperation between provinces.

The most suitable indicator for setting national targets

The IEA recently published a paper titled *Spreading the Net: The Multiple Benefits of Energy Efficiency Improvements*. The paper investigates the wider benefits that are obtained from energy efficiency, moving beyond simply looking at the energy savings. In particular, the focus lies on the macroeconomic benefits, such as higher levels of GDP and employment.

It is common for policies aimed at improving energy efficiency to be framed in terms of energy demand reduction. Because of this, the rebound effect may create perceptions that such a policy has failed. Sometimes known as the Jevons' Paradox, the rebound effect describes a situation where a factor is used more efficiently and so consumers use more of the service provided by that factor, or more of that factor in the additional goods and services they can now afford because of the income freed up by the efficiency improvement.

The rebound effect reduces the potential energy savings from an energy efficiency improvement through a number of mechanisms. However, this also enhances economic growth. For example, a cost -effective improvement in the energy efficiency of a factory will reduce the marginal cost of production. This will encourage the producer to increase output, thereby reducing the energy savings from where

they would have been otherwise. While the reduction in energy savings as a result of rebound may limit the improvement in energy productivity, it is offset by the increase in output. Furthermore, if rebound occurs in a high productivity sector of the economy, then the positive effect it has on energy productivity will be even greater.

If efficiency leads to greater economic growth, it will come with greater energy consumption

Energy-related indicators respond to the rebound effect in different ways. Energy consumption and energy savings portray the rebound effect as an adverse phenomenon that needs to be mitigated, even though it is usually welfare-enhancing. In contrast, energy intensity and productivity will normally improve in the presence of rebound, as they capture the wider welfare benefits in the form of increased GDP and employment that result from energy efficiency.

Although energy intensity and productivity share many positive attributes, increasing energy productivity – "producing more with what you have"– is likely to enroll more support than reducing energy intensity – "using less to produce the same amount". Furthermore, the definition of energy productivity is consistent with that of energy efficiency, both measured in units of output per unit of input, and is more intuitive to policymakers and the wider public.

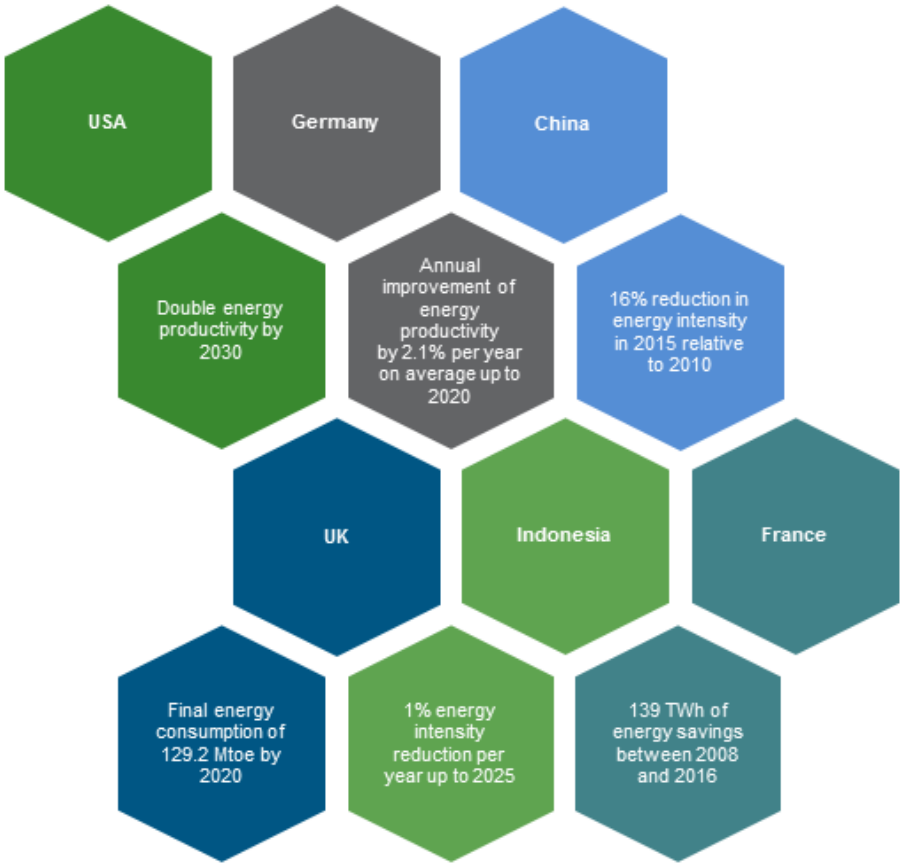

Figure 1: Some of the national targets that have been adopted. Sources: ABB Country Reports (2013), European Commission Energy Efficiency Targets Country Reports (2013), and KAPSARC analysis.

The embodied energy in trade: A blind spot

Countries that "offshore" their energy-intensive industries and then import the resulting products may see an increase in their energy productivity, but the energy productivity of the country that absorbed the energy-intensive industries may fall. Furthermore, if the country that absorbed the energy -intensive industries is less efficient at production, then global energy productivity will likely decrease. Accounting for the embodied energy in international trade can help highlight such issues to policymakers.

If cheap natural gas drives reshoring of US manufacturing, production-based targets will be harder to meet.

The embodied energy in trade has implications on how countries design their targets. Focusing on the US, it has managed to increase its energy productivity because of a degree of offshoring, as the US has consistently been a large net importer of embodied energy. Although there are other reasons why the US is a net importer of embodied energy, such as its trade deficit, offshoring has played a substantial role. This has implications on the US target of doubling energy productivity by 2030. Because of the recent fall in natural gas prices unlocked by horizontal drilling and fracking, basic manufacturing has been undergoing a renaissance. As the US economy adjusts towards more basic manufacturing over the next decade, downward pressure will be exerted on its energy productivity as a greater portion of its output becomes more energy-intensive. This structural shift will make it more difficult for the US to meet its target, even if the intended net global benefit is exceeded. By accounting for the embodied energy in trade, such insights can inform policymakers when designing targets.

Although existing studies have largely focused on examining the embodied energy and emissions in international trade, the inter-regional flows within a country can also provide useful insights to policymakers. Looking at interprovincial embodied energy flows in China (Figure 2), several patterns emerge. The industrialized provinces in Eastern China are large net importers of embodied energy, while the less industrialized provinces in the central region are large net exporters. These patterns carry implications for China's provincial energy intensity targets. Some coastal provinces that appear to be meeting their targets may be doing so by importing embodied energy, while the central provinces that are exporting the energy-intensive goods to the coastal provinces may find it difficult to meet their targets – even if they do improve their energy efficiency substantially. Embodied energy linkages may inform the way each province adapts to its target. Having both an overarching national target and monitoring interprovincial embodied energy flows can unlock increased coordination between provinces as they cooperate to meet the national target.

Overcoming barriers to energy efficiency

There are several obstacles preventing economies from reaching higher levels of energy efficiency. These include:

- Energy subsidies that cause under-investment in energy efficiency by reducing the value of the resulting benefits
- Imperfect information, split incentives, and inattention that lead to the "energy efficiency gap"
- The missing link between profitable, large-scale energy efficiency opportunities and the finance needed to realize them

Some analyses of energy efficiency opportunities suggest that there are free, or even negative-cost, improvements that are left untapped because of market failures caused by environmental externalities, in addition to the above referenced obstacles. The critique of such negative costs has been well-addressed elsewhere.

Energy subsidies

In the presence of energy subsidies, it is likely that the level of energy efficiency in an economy will be lower than optimal because households and firms lack the incentives needed to invest in energy efficiency. For example, subsidized electricity reduces the monetary savings that a household would secure if it invested in a more efficient air-conditioning unit. As a result, the household may not make that investment even though it is optimal from the economy's perspective.

Abolishing subsidies remains the best long-term approach to raising energy efficiency levels in an economy. However, it may appear politically infeasible because policymakers worry about the social implications of higher energy prices –

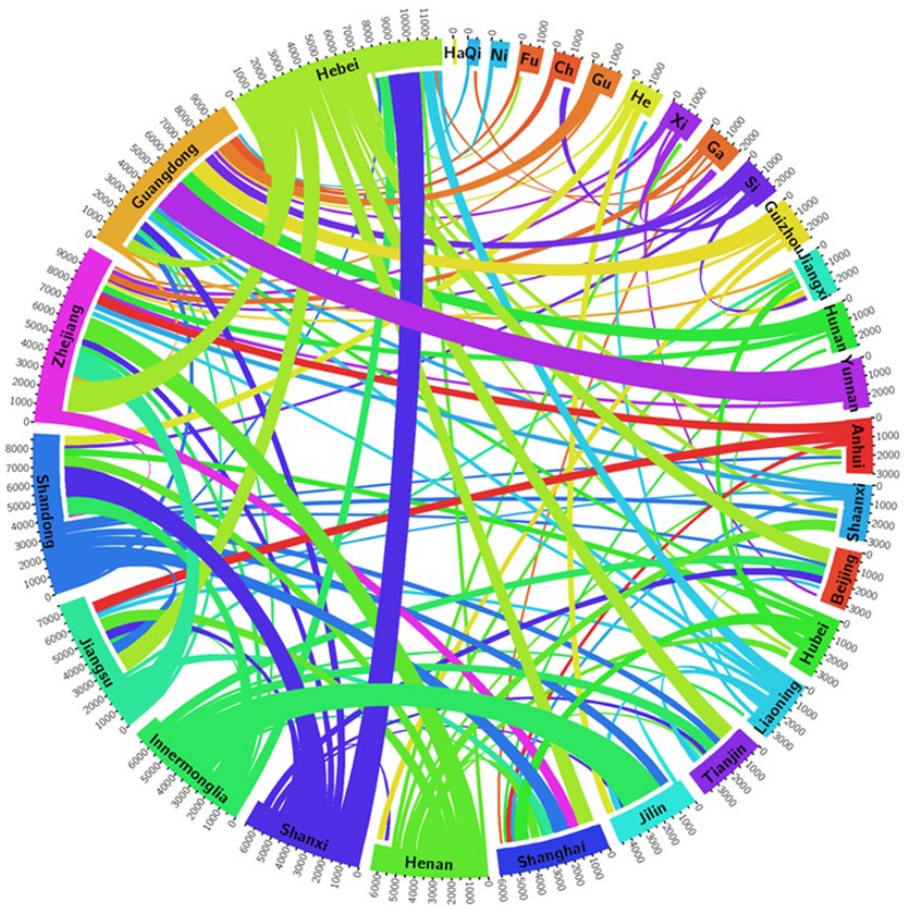

Figure 2: Interprovincial flows of embodied energy in China (Year: 2007; Units: million tonnes of coal equivalent). Bands touching the edge of the circular diagram denote the origin of the embodied energy flow (exports). Conversely, when a band finishes at a non-connected section of the circular boundary, it denotes embodied energy flows into that region (imports). The outer circle denotes the percentage share of embodied energy imports and exports for each region. Width of the bands indicates volume of flows. Sources: Chinese Statistical Year Book and Energy Statistical Year Book (2008 and 2013), Chinese Academy of Sciences, KAPSARC Analysis.

particularly for lower-income households that feel entitled to cheap energy. To gain people's buy-in and abolish subsidies in the long run, governments may look towards a gradual removal, support for low-income households, and a program that educates the wider public about the corrosive impacts of subsidies.

Economically second-best policies – such as subsidizing energy efficient goods and mandating minimum standards – can be used to help governments achieve their targets, an approach also used in unsubsidized markets to bridge the energy efficiency gap. Given that governments ultimately pay for energy subsidies – whether explicitly through budget expenditures or implicitly through lost opportunity costs – the savings that the government realizes from improved energy efficiency in the economy can indirectly be used to pay for the costs of subsidizing energy efficient goods or mandating minimum standards.

Mexico and Saudi Arabia, two countries with subsidized electricity, provide examples where second-best policies are being implemented successfully. In Mexico, a program where the government would give away free energy efficient LED-LCD televisions to households that return their inefficient analogue televisions has been designed. It has been shown that this program could save 2.9 TWh per year and provide the Mexican government with a net profit of $560 million. Meanwhile, Saudi Arabia provides a good example for the successful implementation of minimum standards. Analyses have shown that the Saudi Energy Efficiency Center's initiative for lifting the minimum energy efficiency ratio for air-conditioners in the Kingdom results in benefits that exceed the costs by a factor of five.

The energy efficiency gap

Even in countries where energy is not subsidized, the level of energy efficiency in an economy may be sub-optimal. Regardless of one's views of the 2010 McKinsey and Company study suggesting that that the US could reduce its annual energy consumption in 2020 by 23 percent through energy efficiency investments with negative costs, investments in energy efficiency would be necessary for the US to meet its target of doubling energy productivity by 2030.

Imperfect information, split incentives, and inattention are believed to contribute to the energy efficiency gap. Although evidence on the size of the energy efficiency gap is mixed, there are policies that can be implemented to capture whatever profitable energy efficiency opportunities are present in an economy. Educating the public about the availability and benefits of energy efficient goods, subsidizing those goods, or mandating minimum energy efficiency standards, are some of the policies that governments may implement to close the gap.

The missing link between finance and energy efficiency

Financing an energy efficiency project, such as installing more energy efficient infrastructure in a building, may be a large investment in the eyes of the owner, but small in the eyes of financial investors. While more efficient infrastructure often appears profitable in a cost-benefit analysis, its profitability becomes even greater when environmental externalities are taken into account. Because the investments flowing into large-scale energy efficiency projects are not as numerous as the identified opportunities, there are concerns over the attainment of energy policy targets.

The problem is not so much the lack of finance, but in facilitating the improved linking of projects to investors. Owners seeking to undertake large-scale energy efficiency projects believe a lack of finance to be their major obstacle. On the other side, investors see a shortage of suitable projects. All of this points to a missing channel between projects and investors.

Some investors ignore energy efficiency because it does not slot into an asset class that they are accustomed to. This makes it difficult for them to invest in an energy efficiency project when compared to a real-estate project, for example. Furthermore, an investor looking at multiple energy efficiency projects may find it difficult to discern which is the most profitable because of the different organizations and procedures that are used to measure and validate the benefits of each project. The lack of standardization makes comparisons of projects difficult to the investor, increasing the risk of choosing just one or gauging the risk profile of a syndicated pool of such investments.

Companies don't invest in more efficient supply chains because they are altruistic. They are seeking a financial return.

Recently, energy efficiency investments have started to emerge as a new asset class, helped by initiatives such as the Investor Confidence Project (ICP). The ICP works on standardizing the way energy efficiency projects are measured and validated, allowing investors to make comparisons. This reduces risk by clearly revealing to investors which opportunities among several are the most profitable, potentially unlocking greater flows of investment into energy efficiency.

Small-to-medium size enterprises (SMEs), which form the base of the industrial sector in many countries, generally find it difficult to obtain loans for energy efficiency. Another initiative that can help remedy this problem is the engagement of leading companies, such as Ikea, Pepsi, Tesco, and Walmart, to identify and pilot energy efficiency projects along their supply chains. By piloting demonstration projects, leading companies highlight to their suppliers, most of which are SMEs, the costs and paybacks of different energy efficiency projects. Success stories of projects that resulted in significantly larger savings than costs would thereby spread among suppliers and investors. Although such initiatives come at a cost, they can ultimately benefit leading companies by enhancing their brands, in addition to reducing their input costs in the long run.

Conclusion

Focusing on the interrelated subjects of energy efficiency and energy productivity, KAPSARC's workshop highlighted how energy productivity at the macro-level is a useful indicator that captures the reductions in energy use and the economic benefits that ensue from improvements in energy efficiency. Many countries have started to adopt national targets based on energy productivity, with the US and Germany being two leading examples.

Understanding how the embodied energy in trade influences a nation's energy use is critical for designing targets, not only at the national level but also on a regional or provincial level. Embodied energy flows can reveal whether countries or provinces have only achieved their targets by offshoring energy-intensive industries.

Obstacles that countries face when trying to improve energy efficiency, such as energy subsidies and access to financing, may be susceptible to tailored policy measures. In the case of subsidies, a pragmatic policy measure is gradual price reform. If price reform appears politically infeasible, then second-best policies such as subsidizing energy efficient goods and mandating minimum energy efficiency standards can be implemented successfully. In the case of financing issues, standardization and communication are two measures that can underpin programs to unlock greater levels of finance for energy efficiency.

About the workshop

The workshop was attended by leading energy efficiency and productivity experts from academia, industry, government, and non-governmental organizations. The workshop was held under the Chatham House Rule, where the discussions can be captured on a non-attribution basis. Participants included:

Naif Alabbadi, Director General, Saudi Energy Efficiency Center

Hisham Akhonaby, Collaboration Specialist, KAPSARC

Juan Alario, Head of Division, Renewable Energy and Energy Efficiency, European Investment Bank

Samer AlAshgar, President, KAPSARC

Tarek Atallah, Senior Research Analyst, KAPSARC

Panama Bartholomy, Director, Investor Confidence Project Europe

Mongi Bida, First Economic Affairs Officer, Sustainable Development and Productivity Division, United Nations Economic and Social Commission for Western Asia

Nils Borg, Executive Director, European Council for an Energy Efficient Economy

Tyler Bryant, Energy Policy Analyst, International Energy Agency

Stefen Buettner, Senior Parliamentary Advisor and Researcher, Office Manager to David Torrance MSP

Gabrielle Dreyfus, Policy Analyst, International Climate Change Policy and Technology, Office of International Affairs

Marzio Galeotti, Professor, Università degli Studi di Milano

Anwar Gasim, Research Associate, KAPSARC

Patrice Geoffron, Professor of Economics, Université Paris Dauphine

David Hobbs, Head of Research, KAPSARC

Nicholas Howarth, Research Fellow, KAPSARC

Alessandro Lanza, Independent Consultant, CMCC Italy

Benoit Lebot, Head, International Partnership for Energy Efficiency Cooperation

HelmutMayer, Head of Section, Environmental-Economic Accounting, Federal Statistical Office of Germany

Devin McDaniels, Economic Affairs Officer, World Trade Organization

Steve Nadel, Executive Director, American Council for an Energy-Efficient Economy

Christopher Napoli, Senior Research Associate, KAPSARC

Richard Newell, Professor, Duke University

ZitouniOuld-Dada, Head of Technology Unit, United Nations Environment Programme

Padu Padmanaban, Independent Consultant

Mohamed Ramady, Professor, King Fahd University for Petroleum and Minerals

HamadAl-Sayari, Former Governor, Saudi Arabian Monetary Agency

Jigar Shah, Executive Director, Institute for Industrial Productivity

Abdullah Al-Shehri, Governor, Electricity and Co-Generation Regulatory Authority

Elizabeth Tate, Director of Government Relations, Alliance to Save Energy

Abdullah AlTuwaijri, Director, Energy Data Development and Regional Collaboration, KAPSARC

Zhongxiang Zhang, Distinguished Professor and Chairman of the Department of Public Economics, 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 energy productivity changes and performance. He has a MEM degree in energy and environmental resources from Duke University.

Kankana Dubey is a Research Associate investigating patterns of energy consumption in the water supply chain. She holds a MS degree from the University of Stirling.

Anwar Gasim is a Research Associate examining embodied energy flows in international trade and energy efficiency. He holds a MS degree from KAUST.

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

Nicholas Howarth is a Research Fellow coordinating KAPSARC's Energy Productivity research, especially global investment. He holds a PhD degree from Oxford University.

Christopher Napoli is a Senior Research Associate. His research focuses on natural resource economics and energy policy. He has a PhD from the University of Kent.

About the Energy Productivity Project

The well-established link between economic growth and energy usage presents a conundrum for policymakers that can be resolved by focusing on energy productivity to promote greater societal welfare. Energy productivity focuses attention on how energy resources can be put to their best use, augmenting scarce energy resources, and how energy efficiency can lift economic growth.

The goal of this research project is to provide a deeper understanding on energy productivity. This understanding will enable policymakers to make consistent comparisons of energy productivity between countries and develop better energy policy targets.

The program is global, but also focuses particularly on China and the Arab world. It investigates how energy productivity has changed, what have been the drivers, and how policies might be best designed to maximize the economic welfare extracted from the energy system.

In line with KAPSARC's overall objectives, this research project seeks to provide insights to policymakers that can be used to inform energy and environmental policies at both a national and an international level.

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