The Potentials for Energy Savings in the GCC Economies

Mustafa Babiker

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Abstract

Energy efficiency measures and policies are on the rise globally. The Gulf Cooperative Council (GCC) states are witnessing significant growth in domestic energy needs to meet growing demographic pressures and an accelerated energy-intensive industrialization drive. These domestic energy requirements are bringing to surface challenging implications and trade-offs on the development and allocation of hydrocarbon resources between export and domestic demands. Energy efficiency is seen in the GCC as a primary candidate to deal with these challenges. This study is an attempt to examine closely the energy efficiency question in the GCC economies. The two major outcomes of the paper are a detailed assessment of energy intensities of the GCC economies in relation to those of other world economies and a quantification of energy-saving potentials in the GCC based on this assessment.

فرص توفير الطاقة في اقتصادات مجلس التعاون الخليجي

مصطفى بابكر

ملخص

هناك تزايد في الإجراءات والسياسات المتعلقة بترشيد استخدام الطاقة على مستوى العالم. تشهد دول مجلس التعاون نمواً كبيراً في الاحتياجات المحلية للطاقة وذلك لمقابلة الضغوط السكانية المتزايدة ووتائر النمو المتسارع للصناعات كثيفة الاستخدام للطاقة. وتبرز هذه التطورات في دول المجلس إلى السطح جملة من التداعيات والمفاضلات على صعيد تنمية وتوظيف الموارد الكاربهيدروجينية بين أهداف التصدير ومقابلة الطلب المحلي، الأمر الذي يجعل ترشيد الطاقة وتحسين كفاءة الاستخدام تمثلان الخيار الاساسي للتعامل مع مثل هذه التحديات. في ضوء ذلك تجيء هذه الدراسة كمحاولة عن قرب لفحص مسألة ترشيد الطاقة في إقتصادات دول مجلس التعاون الخليجي. ويتمثل أهم مخرجين لهذه الدراسة في التقييم التفصيلي لمعدلات كثافة استخدام الطاقة في دول المجلس مقارنة بدول العالم الاخرى والتحديد الكمي لفرص توفير الطاقة في دول المجلس بناء على هذا التقييم.

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Introduction

Industrialization and modernization have been spreading over the last three decades, albeit at differing paces and with differing consequences. The most important of these consequences are an increased demand for energy and an increased drive for energy efficiency worldwide. The early quest for energy efficiency in the developed world was inspired by the 1973 oil shock and was aimed at achieving supply security and energy independence. The energy price fluctuations and their balance of payment repercussions in developing countries during the 1980s have added to this initial drive, mainly through measures targeting the energy import bill. Nevertheless, the strongest stimulus to energy efficiency measures and policies in the world has emerged with increased environmental concerns in the 1990s, particularly of global warming and the strong calls for sustainable development following the publication of the United Nations Millennium Development Goals (MDGs), (UN, 2000). This, however, is not limited to energy-poor countries alone, but the case for energy efficiency is also taking shape in energy-rich countries particularly with the increasing pressures on budgets and resources to meet their growing domestic energy needs.

This global drive for energy efficiency is manifested in a number of dimensions, including:

- An average annual decline in world energy intensity of 1.5% over the 1995-2005 decade, implying a gradual pattern of decoupling between economic growth and the growth of energy consumption (Expert Group, 2007);
- Rapid development of energy efficiency institutions in almost every country in the world has established a national agency and put forth policies, measures, and national action plans for energy efficiency;
- Many countries and regions have declared very ambitious national and/ or sectoral targets for energy efficiency to be achieved within the next 5-25 years (Appendix, Table A1);
- An increasing involvement of international institutions such as the United Nations Development Program (UNDP), the Global Environmental Facility (GEF), and the World Bank in capacity-building efforts and

funding of energy efficiency projects in developing countries, with the World Bank Group alone extending a funding of 447 million dollars for energy efficiency during the fiscal year 2006 (World Bank Group, 2006); and

- A growing stock of experience in energy efficiency policies and practices from pilot and demonstration projects worldwide that can serve as blue prints for countries embarking on the road of energy efficiency.

At the Gulf Cooperative Council (GCC) level, domestic energy needs are currently growing at high rates and are expected to grow at even higher rates over the near future. The main drivers of growth in energy use are seen to be economic growth, energy-intensive industrialization, population growth, modernization, and harsh climate conditions. These factors are increasingly steering demands for industry feedstock, power generation and transport fuels, giving rise to challenging implications and trade-offs on the allocation of hydrocarbon resources between export and domestic demands.

On one hand, considering the comparative advantages of the GCC economies in hydrocarbon resources, growth in domestic demand for energy on its own may not pose any concern when supported by sound economics. On the other hand, there is the fear that the very low domestic energy prices may encourage inefficiencies and wastage. Furthermore, like in many other countries, there is a growing awareness in the GCC of the need to conserve depletable resources and optimize energy use for clear economic, environmental and social reasons. This awareness has resulted in various efforts and measures aiming at the rational use of energy while achieving the goal of sustainable economic development.

This study is an attempt to examine closely the energy efficiency question in the GCC economies. Two major objectives of the paper are to assess energy intensities of the GCC economies in relation to those of other world economies and to quantify energy saving potentials in the GCC based on the assessment of energy intensities.

Energy Intensity Patterns

Energy Intensity vs. Energy Efficiency: Definitions and Conceptual Issues

Energy intensity is defined as the amount of energy consumed per unit of economic activity. At the aggregate level of the economy, energy intensity is usually expressed in terms of Gross Domestic Product (GDP) units, e.g. BTU (British Thermal Unit) per dollar of real GDP. At the sectoral level, it is usually expressed in terms of gross output, e.g. BTU per ton of output or BTU per dollar of real output.

In contrast, energy efficiency is a rather narrower concept. In economic terms, it refers to increasing energy productivity through raising the cost-effectiveness of energy inputs in the production process. Hence, energy intensity is not the same thing as energy efficiency, e.g., a decline in energy intensity does not necessarily imply an improvement in energy efficiency since that decline could be the result of a change in the general economic structure or the particular production process without involving any explicit energy efficiency action.

Nonetheless, from a conceptual perspective, the observed cross-country differences in energy intensities provide a good indication on differences in energy efficiencies, when aspects unrelated to energy efficiency such as cross-country differences in national currencies purchasing power parity (PPP), economic structure, energy prices, demographic structure and climatic conditions are factored out in such comparisons.

Another conceptual issue in computing energy intensity relates to primary vs. secondary energy form. Intensities may either be computed from the primary energy supply side (the direct fuels use in the economy) or from the final energy side (the direct and the indirect final use of energy in the economy), with the difference between the two measures being the transmission losses. The convention is to compute primary energy intensities at the aggregate national level and the final energy intensities at the sectoral or end-use, i.e. residential, commercial, transport and industrial level.

Primary Energy Intensity: Cross-country Comparisons

The International Energy Agency (IEA) compiles annual energy statistics for about 140 countries. In this exercise, the IEA 2005 statistics for 137 countries (IEA, 2006) were used to compute economy-wide primary energy intensities. Total primary energy supply (TPES) refers to the aggregate consumption of primary fuels (from both renewable and non-renewable sources) in the economy. The index of total primary energy intensity is expressed as BTU per unit of GDP measured in 2000 prices and adjusted for cross-country differences in PPP (1).

Among the 137 countries, Bahrain ranks 8th; Qatar ranks 12th; Kuwait ranks 15th; UAE ranks 21st; Saudi Arabia ranks 24th; and Oman ranks 26th on the index ─ which in turn, indicates a relatively high energy intensiveness of the GCC economies.

To help visualize and to yield more meaningful comparisons of primary energy intensities, focus is concentrated to a sample of 50 countries including the major world economies plus countries and regions of interest to the GCC. The PPP-corrected primary energy intensities for this sample are shown in Figure 1.

Firstly, there are three general features to note at the outset:

- Primary energy intensities are uniformly higher for energy-exporting countries when compared to other countries. The only exceptions to this pattern are seen to be Norway, Australia and to some extent, Canada ─ an indication that low energy prices are major contributors to this phenomenon;
- The Former Soviet economies of Russia and the Caspian Sea have remarkably very high energy intensities, which may be due to the heavy heritage of energy inefficiency from the Soviet era; and
- Despite their industrialization and modernization patterns, the European economies and Japan have particularly low primary energy intensities, which is partially the result of their early embarkation on explicit energy efficiency measures and policies.

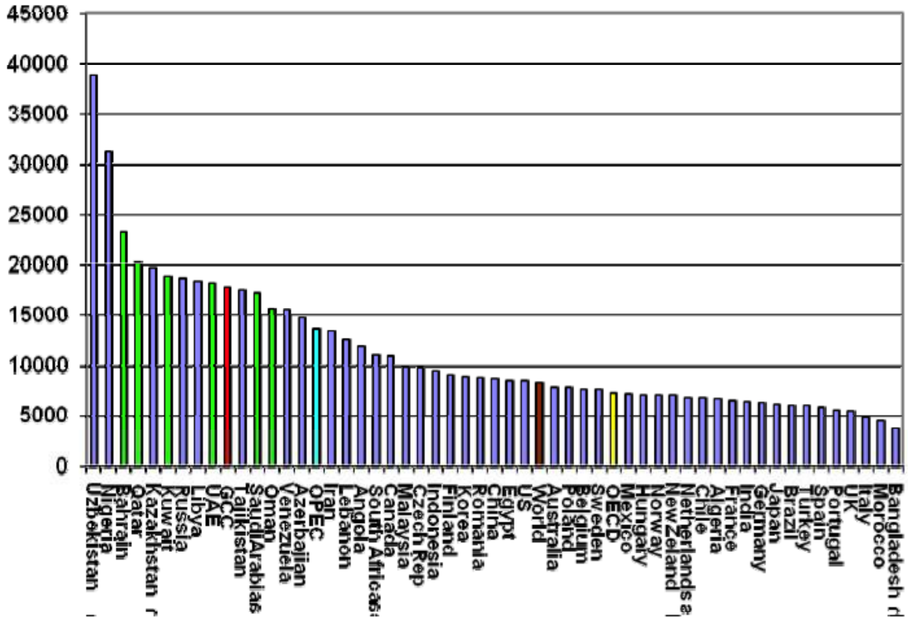

Figure 1. Cross-country comparisons of primary energy intensities in 2005 (BTU/PPP).

Source: Author's calculations

Secondly, with respect to the GCC position in relation to other countries and regions in Figure 1, one might note the following observations:

- The GCC's primary energy intensity is more towards the upper tail, lying within the top 25% of the sample distribution and uniformly higher than all non-oil exporting countries;
- The high magnitude of the primary energy intensities of the GCC economies is more pronounced when compared to the Organization for Economic Co-operation and Development (OECD) and the world averages. In particular, the overall GCC energy intensity seems to be more than twice as much as that of the world and about three times as high when compared to the OECD average; and
- The GCC's energy intensity is about 15% higher than that of the overall Organization of Petroleum Exporting Countries (OPEC) group.

Thirdly, among GCC countries, Oman has particularly low energy intensity whereas Bahrain has a strikingly high one. In contrast, the rest of the GCC countries have similar intensities lying in the range of 17000 to 20000 BTU/PPP.

The cross-country analysis of primary energy intensities clearly suggests that the GCC energy intensities are high. To investigate whether the high GCC energy intensities are warranted or are just the outcome of wastes and consumption inefficiencies, the analysis needs to take on board all the factors that may explain cross-country variations in energy intensity.

Cross-country Variations in Energy Intensities: The Econometric Approach

Like any other normal economic good, the demand for energy is primarily driven by price and income. Yet, given its climate-sensitiveness, energy demand also depends on climatic conditions. Further, at the national aggregate level, variations in energy demand across countries may also be linked to structural factors, such as economic structure, demographic structure, and the country's development stage. Given the definitional correspondence between energy use and energy intensity, the latter may equally be thought of as jointly determined by these factors.

Literature shows two approaches to econometric modeling of energy intensity. The Divisia Decomposition approach breaks down the intensity index into its socioeconomic and structural components using ratios analysis and then assesses econometrically the contribution of the various drivers, e.g. Sun (1998), Roca and Alcantara (2001), and Cornillie and Fankhauser (2004). The other approach applies economic theory of household and firm behavior to identify the drivers of energy intensity and to guide the specification of its econometric estimation. Hang and Tu (2007) analyze energy intensity at the household level, deriving its functional relations from a utility maximization framework. The key determinants of intensity in such framework are identified to be energy prices and household income.

Sue Wing (2008) analyzes energy intensity at the firm level, deriving its functional relations from a cost minimization problem. He specifies a restricted Translog cost function from which he derived the conditional input demand functions for energy products using Shephard Lemma[2]. The main derivers of energy intensity in this framework are suggested to include output, prices, and structural variables such as technology. The empirical specification of the model in this study is consistent with the scale up of the household and the firm variables in the theoretical approach to the national level. Energy prices are represented by the domestic gasoline price, income by per-capita GDP, and structural/technology variables by GDP composition, weather and the stage of economic development.

Mathematically, the specified model is defined by the stochastic equation:

$$I_i = \beta' x_i + \mu_i ; \qquad i=1,2, \ldots\ldots, N \qquad \text{(Equation 1)}$$

Where I is energy intensity, x is a vector of explanatory variables, μ is a stochastic error term, and N is the size of the sample. In estimating the equation, I is represented by the PPP-corrected total primary energy intensity. The vector X is represented by the following variables:

- The domestic price of gasoline as a proxy to energy prices
- Per-capita real GDP in PPP terms to capture income and population effects
- The total annual number of heating and cooling degree days to represent climatic conditions
- The value share of services in GDP to proxy economic structure (level of industrialization)
- Life expectancy at birth to measure the stage of economic development.

This analysis makes use of the same IEA data (op. cit), suitably augmented with economic and climate data from various international sources (IEA, 2006; World Metrological Organization (WMO), 2007; and the World Bank, 2006). Comparable 2005 data on the above variables were collected from these sources for the full sample of 137 countries. A summary of the main statistical features of the data is provided in Table 1.

Table 1. Summary Statistics on Major Energy-Intensity Drivers

	Per-cap GDP (000PPP)	Gasoline Price ($/ litre)	Number of heat/cooling degree days	Services share in GDP (%)	Life Expectancy (years)
Sample Mean	11.35	0.95	2975	54.4	69.0
GCC Range	13.80-38.60	0.16-0.37	3298-3657	18.1-58.5	72.6-79.2
Sample Minimum	0.64	0.02	726	18.1	45.0
Sample Maximum	56.26	1.90	6763	90.7	82.1
Sample Standard deviation	11.21	0.43	970	14.6	11.1

The statistical summary reveals wide variations across the sample, particularly with respect to per capita income and energy prices as indicated by the size of standard deviations relative to means. Compared to the sample averages, the GCC economies seem to score higher on income and life expectancy; considerably higher on climatic conditions; considerably lower on services share; and significantly lower on energy prices. Hence, relative to the sample, the statistics would suggest the crucial drivers of energy intensity in GCC to be the very low energy prices, the harsh climatic conditions, and the larger non-small services sector.

Econometrically, the relationship between primary energy intensity and its suggested drivers is estimated over the full sample using Ordinary Least Squares (OLS). The estimated coefficients along with their significance and implied elasticities are reported in Table 2.

Table 2. Regression Results on Energy Intensity (full sample)

Variable	Coefficient	Test-Statistic	Elasticity at Mean
Gasoline price	-4418.0	-2.73**	-0.38
Per capita GDP	27.1	0.42	0.03
Heat/cooling DD	2.1	3.49**	0.56
Services share	-116.9	-2.18*	-0.58
Life Expectancy	-155.4	-2.36*	-0.98
R-Square (R^2)	0.6	F-test 12.52**	

* 5% significance level
** 1% significance level

Ensuring the satisfaction of the usual statistical diagnoses, the regression model shows a considerably high explanatory power for a typical cross-sectional context. In particular, the five suggested factors ─ Gasoline price, Per capita GDP, Heat/cooling DD, Services share, and Life expectancy ─ together explain about 60% of the cross-country observed variation in primary energy intensity. In addition, all the estimated coefficients have the right expected sign and all of them, except that for per capita income, are statistically significant. Indeed, for the per-capita income variable, the regression results neither support the Kuznets hypothesis(3) nor a significant impact of income on energy intensity. The result on income, however, may be due to the heterogeneity of the sample in the sense that the sample contains a large number of rich developing countries whose energy intensities are growing with income and a large number of advanced rich countries whose energy intensities are falling with income growth.

Leaving income aside, the regression results suggest that energy prices, climatic conditions, economic structure, and the stage of economic development are important drivers of energy intensity. The degree of significance of these factors is indicated by the test-statistic column in Table 2, according to which climatic conditions come first, followed by Gasoline price, Services share, and Life expectancy in the respective order. In contrast, the magnitudes of the impacts of these drivers on energy intensity are reflected on the elasticity column in Table 2. These elasticities suggest that 1% increase in gasoline price will reduce primary energy intensity by about 0.4%(4); 1% increase in the number of heat/cooling degree days will increase energy intensity by about 0.6%; 1% increase in the services sector share in GDP (or an equivalent reduction in the share of industry) will reduce energy intensity by about 0.6%; and a 1% increase in life expectancy will also reduce energy intensity by about 1%.

Contrasting the regression results with the descriptive statistics of Table 1, the main drivers of the observed high energy intensity of the GCC economies may be linked to the very low energy prices, the harsh climatic conditions, and to a lesser extent, to energy-intensive industrialization.

A Top-Down Assessment of Energy Saving Potentials in the GCC

There are two approaches to assessment of energy efficiency potentials in an economy: (a) Bottom-up technology approach; and (b) Top-down macroeconomic approach. The bottom-up approach essentially involves comparing existing economic processes and production technologies at the micro level with their counterparts of peer technologies and best practices. In contrast, the top-down approach is usually conducted at the national or sectoral level and involves comparing performance indices such as energy intensity for the given economy or sector to those of a benchmark country or a group of countries after controlling for the various factors that may explain variations in the performance index within the benchmark group.

In this exercise, a top-down approach is applied to assess aggregate energy savings or energy efficiency potentials in the GCC economies using the assembled dataset of Table 1. The choice of the top-down approach is necessitated by the availability of data and by the objective of the paper to provide an overall assessment of energy saving potentials in the region. The approach involves using an econometric technique to specify the benchmark group and then to estimate the energy savings potentials, following the algorithm:

1. Specify the benchmarking criteria;
2. Select the benchmark countries;
3. Estimate the regression model using the benchmark sample;

4. Apply the estimated coefficients to the GCC countries data to compute their predicted energy intensities; and
5. Use the actual and the predicted energy intensities to compute the potential energy savings for GCC economies.

Starting from the full 137 countries sample, the benchmark group is specified as the largest sub-sample that maximizes the model explanatory power in Step 3, which implies that Steps 2 and 3 are performed iteratively in the sense that the grand pool is sampled and sequentially checked on the improvement in the explanatory power of the model in Step 3.(5) Following this procedure, a sample of 25 countries is identified. The data for this sample are shown in Table A2.

Following on the algorithm steps, the regression estimation results based on the benchmark sample are reported in Table 3.

Table 3. Estimation Results on the Benchmark Sample

Variable	Coefficient	Test-Statistic	Elasticity at Mean
Constant	21931.550	8.11**	
Per capita GDP	304.833	2.79**	0.31
Square of Per capita GDP	-5.796	-2.54*	
Gasoline Price	-4203.510	-8.98**	-0.45
Heat/Cool Degree Days	1.039	5.14**	0.35
Service GDP Share	-69.708	-2.95**	-0.43
Life Expectancy	-145.219	-4.31**	-1.10
R-Square (R^2)	0.960	F-test 32.9**	
Diagnostic Tests: Ramsey RESET[6] F-test Chi-Square Jarque-Bera[7]	 0.660	 1.90 5.40 0.40	

* 5% Significance level
** 1% significance level

The estimation results on the benchmark sample reported in Table 3 are clearly very satisfactory. The regression model explains about 96% of the cross-country variations in energy intensities within the sample, which is an exceptionally large explanatory power in a cross-sectional context. Further, the diagnostic tests, summarized by the Ramsey RESET test and Jarque-Bera statistic, assure the statistical soundness of the estimated model. In addition, all the explanatory variables in the model have the right expected sign and all are statistically significant.

In terms of ranking, energy price has the largest impact on primary energy intensity, followed by climatic conditions, the stage of economic development, economic structure, and per capita income in the respective order. Measured in elasticity terms, these impacts are shown on the last column.(8) More interestingly, the benchmark sample strongly supports the Kuznets hypothesis as indicated by the negative coefficient of the second order income term (the squares of per capita income), implying that energy intensity increases with income at the early development stages but declines with income growth at the later stages of economic development.

Based on the satisfactory estimation results from the benchmark sample, the final two steps of the algorithm are applying the estimated coefficients to the GCC data and then computing the implied excess energy consumption (potential energy savings). The results from these two steps are reported in Table 4, where the predicted primary energy intensity is shown along with the actual intensity, the implied excess intensity and the implied excess energy use or potential energy savings for the GCC countries.

The results suggest the presence of huge energy savings potentials in the GCC countries. For 2005, these savings amount to about 20% of the total energy consumption in the GCC region. Country-wise, these potentials seem to vary considerably among GCC states with minimum potentials for Oman but large ones for Bahrain and the UAE.

Looking at it from the efficiency side, the results suggest the presence of large energy inefficiencies and waste in all GCC countries, with the exception of Oman. To discourage energy waste and harness these savings potentials, the

GCC countries need to adopt some explicit policies, measures, and programs to promote energy efficiency and conserve their hydrocarbon resources.

Table 4. Predicted Excess Energy Use or Potential Energy Saving in GCC (2005)

	KSA	BAH	KWT	OMN	QAT	UAE	GCC
Actual primary energy intensity (BTU/PPP)	17225	23225	18807	15591	20113	18101	
Model predicted energy intensity (BTU/PPP)	14189	13312	15488	14739	15781	13307	
Excess energy intensity (BTU/PPP)	3036	9913	3319	852	4332	4794	
Excess energy use or potential energy saving in billions BTU	980867	137688	197036	30256	135280	493286	1974415
Excess energy use or Potential energy saving (Mtoe)	24.718	3.47	4.97	0.76	3.41	12.43	49.76
Total primary energy supply (TPES) in Mtoe	140.28	8.13	28.14	13.96	15.83	46.94	253.28
Potential energy saving as % of TPES	17.60	42.70	17.60	5.50	21.50	26.50	19.60

Source: Author's calculations

Policies and Measures to Promote Energy Efficiency

The International Experience

A good documentation of the international experience on energy efficiency policies and measures is provided in the report of the Expert Group of the United Nations Foundation (2007) to the G8 Countries. The report identifies both price and non-price options as well as incorporating both economy-wide and sector-specific policy levels.

Economy-wide Policies and Measures. These include crosscutting policies and measures to improve overall energy efficiency such as: (a) Incentives for private sector investment in energy efficiency including the creation of funding arrangements to support energy efficiency investments by small and medium size enterprises and their customers; (b) Promotion of Energy Services Companies (ESCOs) and provision of fiscal incentives; (c) Government procurement of energy efficient products; and (d) Promotion of effective use of energy-efficient technologies through public information and education.

Sector-Specific Demand Side Management (DSM) Measures

The Buildings and Equipment Sector. The Buildings and Equipment sector possesses large potentials of untapped energy efficiency improvements worldwide. Urge-Vorsatz et al. (2006) put the potential energy saving at 34% of total projected energy consumption by the world's building sector by 2020. These efficiency potentials include both energy savings from changing buildings design and from upgrading appliances and equipment used.

Policies and measures to improve energy efficiency in Buildings include: (a) Adoption of Minimum Energy Performance Standards (MEPS) for new buildings; (b) Encouragement for renovation of existing buildings through Energy Performance Contracting (EPC) and the use of fiscal incentive; (c) Establishing guidelines and procedures for inspection and audits to verify compliance with standards; and (d) Establishing building energy efficiency certificate programs to inform owners and occupants about the energy efficiency of their buildings.

Key successful stories on measures related to Appliances and Equipment include the Chinese and Malaysian experiences (Mahlia, Masjuki and Choudhury, 2002). Policies and measures on this category include: (a) Updated MEPS to ensure the phase-out of inefficient equipments; (b) Labels to inform consumers of energy-efficiency characteristics of appliances in the market; and (c) Financial incentives to stimulate market penetration of efficient equipments. A successful experience is the case of creating markets for efficient lighting through fiscal and DSM measures in Australia and some other countries.

The Industry Sector. The necessary conditions for achieving substantial improvements in industrial energy efficiency include, to name a few: access to information, improved decision-making processes, access to financing, access to technology, and the ability to measure and verify the achieved energy savings. Policies and measures to help create these necessary conditions and reduce barriers to improvement in industrial energy efficiency include: (a) Energy management standard for large industrial energy users; (b) Binding targets to reduce industrial energy consumption over a specific time frame accomplished through negotiated long term agreements between government and industry ─ examples are Netherlands, Italy, Norway, and Austria; and (c) Minimum energy efficiency standards for crosscutting technologies such as motors, boilers, pumps, compressors and other large energy-using systems.

The Transport Sector. Policies and measures to improve the overall fuel efficiency in the transport sector include: (a) Fleet efficiency standards, e.g. the US Corporate Average Fuel Economy (CAFÉ) regulations; (b) Consumer incentives for the purchase of fuel efficient vehicles; (c) Accelerated vehicle retirement programs such as those in US and EU that aim at scrapping/recycling older inefficient vehicles and their replacement with new and more efficient ones (Alberini, Harrington and McConnell, 1996); (d) Public procurement at highest efficiency standards for government transport fleets; (e) Creation of a funding mechanism to build and operate efficient public transit systems; (f) Incentives to increase vehicle occupancy and encourage the use of public transit; and (g) Technical support and incentives to improve both technology and logistics of freight movement in ways that optimize fuel economy.

The Utility Sector. Some policy options for improving energy efficiency in the power supply sector include: (a) Restructuring of rates to provide attractive incentives to utilities to invest in end-use energy efficiency ─ as in the example of California where savings from energy efficiency are shared with the power generation companies; (b) Mandatory energy-efficiency targets/obligations for power supply companies along with an effective system of auditing, monitoring, and reporting ─ examples of successful cases are UK, Italy and France; (c) Minimum generation efficiency standards for new power plants; (d) Policies and institutional capacity to reduce losses in transmission and distribution lines; and (e) Promotion of combined heating, cooling, and power (Combined Heat and Power (CHP) or Cogeneration) technologies through regulatory standards and government support.

Recommendations on Policies and Measures for GCC

The analysis of energy intensity trends and energy-saving potentials provide strong support to concerns of excessive energy consumption in the GCC. The international experience seems to suggest both pricing and non-pricing policies to deal with wasteful consumption patterns and promote energy conservation and efficiency.

Although the very low energy prices are certainly a major driver of excessive energy use in GCC, pricing measures alone may not provide an effective cure for at least two reasons. Firstly, the successful experience of some developed countries in pricing measures may not be replicable in developing economies given the large differences with respect to market structure, market institutions, and market incentives. Secondly, given the very low GCC price elasticities as suggested by Tables 2 and 3, large increases in end-use prices will be needed to discourage excessive energy use. Such large increases in energy prices in the GCC may not be politically feasible.

Non-pricing policy options include awareness, capacity building and DSM measures. The promotion of awareness on energy conservation and efficiency in GCC requires scaling up efforts through engaging various government departments, large corporations, and religious and other civic society organizations. Capacity-building measures should target the creation of an enabling institutional setup for improving energy efficiency, including energy conservation law and regulations, testing labs and research institutions, and ESCOs.

Alternative and renewable energy sources may also be tapped in remote areas to reduce large transportation and distribution losses in the GCC power grids. There is a range of technologies that may be introduced into the household sector that would reduce the demand for electricity from the power grid. The key technologies with promising potentials in the GCC include solar water heating, solar power, solar air conditioning and wind turbines, to name but a few.

DSM measures are widely used worldwide and have produced very successful results in a number of countries. Among developing countries, China and India are two examples where DSM measures have noticeable contribution to energy efficiency. Both of these countries share similar characteristics to those of the GCC economies, in terms of demographics (India), subsidized energy prices (China), energy intensive industrialization (China), and recent patterns of rapid transformation and economic growth.

In China, DSM measures have contributed to reduction in economy-wide energy intensity of more than 30% between 1980 and 2000. India has one of the fastest growing economies in the world, yet the country's energy intensity is decreasing at about 1.5% per year since the mid 1990s. DSM has been one of the most important policy tools contributing to this intensity decline. The Energy and Resources Institute (TERI) of India (2003) has assessed the potentials of end-use energy efficiency through DSM to be 10-25% for industry, 30-35% for lighting, and 50% for commercial buildings.

Based on their potential energy savings and applicability in the GCC, the following specific DSM measures are recommended as primary candidates for promoting energy efficiency in the following sectors:

- The Buildings and Equipment Sector. The recommended DSM measures for this sector are: (a) Develop building codes and implement MEPS for new buildings; (b) Establish and enforce guidelines and procedures for inspection and audits to verify compliance with standards; (c) Encourage renovation of old public and commercial buildings through Energy Performance Contracting (EPC) and the use of ESCOs; (d) Establish regularly updated MEPS along with labeling schemes for major appliances and equipment. These standards could be established through negotiated agreements with manufacturers and importers or modeled after existing examples of China, Japan, the EU (EU Directive 2006/32/EC) and the US; and (e) Use government procurement to stimulate market penetration of efficient appliances and equipment. This could also include encouraging major corporations to follow similar practices.
- The Industry Sector. The three DSM measures recommended for this sector are: (a) Energy management standards for large industrial energy users, including the setup for energy auditing, monitoring, rating and

benchmarking processes; (b) Negotiated long-term agreements with industry to set binding targets for industrial energy efficiency/conservation over specific time frames; and (c) Minimum energy efficiency standards for crosscutting technologies and large energy-using systems.

- The Transport Sector. Two DSM measures to be recommended for the GCC's transport sector are: (a) Fleet efficiency standards and/or specific fuel economy standards on newly imported cars; and (b) Procurement at the highest efficiency standards for government and large corporation transport fleets.

Conclusion

Energy intensities are alarmingly high in the GCC region. Even more challenging, these intensities are expected to accelerate given the growing demographic pressures and the move towards energy-intensive industrialization. Aside from its environmental repercussions, the increased use of hydrocarbon to meet domestic needs in the GCC entails the need for costly capital investments and may eventually compromise the ability of the GCC to meet their future hydrocarbon export targets. Hence, a quest for efficiency and energy savings in the GCC countries will certainly prove to be a win-win endeavor.

This paper has investigated energy intensity trends and the scope of potential energy savings in the GCC economies. Unsurprisingly, the analysis reveals the presence of large energy savings potentials in the region. Harnessing these potentials undoubtedly requires some programs and active policy efforts. Towards this, the paper has surveyed the international experience on policies and measures to promote energy efficiency and offered some specific recommendations. These recommendations include awareness and educational programs, the tapping of renewable energy sources in remote areas, and the active use of DSM measures in end-use energy demand sectors.

Given the potential for energy savings and the high urgency for the GCC states to act now, these recommendations provide some of the essential ingredients for the design of national and region-wide energy efficiency programs.

Footnotes

(1) Although BTU per unit of GDP is the standard yardstick used in the literature, it may be argued that non-oil GDP intensity is a more relevant measure for characterizing energy consumption intensity of the GCC economies. Unfortunately, data on non-oil income are not available for all countries in the sample, thus distorting the comparability of the measure across the sample. Nonetheless, contrary to what might be suspected, for the GCC countries non-oil, GDP intensity is actually higher than the all-GDP intensity because oil and gas activity contribute very little to energy consumption but contribute significantly to GDP.

(2) Shephard>s lemma is a major result in microeconomics having applications in the theory of consumer and producer. The lemma states that if indifference curves of the expenditure or cost function are convex, then the cost minimizing point of a given good (i) with price p_i is unique.

(3)The Kuznets hypothesis predicts that energy intensity increases with per capita income at early development stages, reaches a maximum, and later declines with income growth at the advanced development stage. An intuitive explanation of such a relationship is that energy intensity increases to meet modernization and industrialization needs at the early stages of development but later declines as economic activity moves increasingly into the services sector.

(4)When replacing the sample means with the actual GCC values, the point price elasticity will fall to the range of -0.04 to -0.09, which suggests greater price inelasticity for the GCC countries

(5) This is consistent with the sequential sampling approach in the statistical sampling theory.

(6) RESET, stands for REgression Specification Error Test, is a general test of misspecification that accommodates all violations of the classical regression model as well as estimation problems such as omitted variable, incorrect functional form, measurement errors and simultaneity problems. The simultaneity (or endogeniety) bias is the most serious among these since it renders OLS estimates biased and inconsistent, in which case the Generalized Method of Moments (GMM) rather than the OLS approach, should be used. The RESET test may be implemented via the F-statistic or the Chi-Square statistic. Failure to reject the test statistic implies that the model meets the classical regression assumptions. For test results in Table 3, the levels of significance to reject the null hypothesis are 18% for the F-test and 7% for the Chi-Square test (i.e., the p-values are 0.18 and 0.07, respectively).

(7) Jarque-Bera is a statistic to test the white noise and the normality assumption of the estimation residuals, i.e., it jointly tests for a Skewness coefficient of 0 and a Kurtosis coefficient of 3.

(8) When measured at the observed values instead of at the means, the price elasticities for the GCC are reduced from the value of -0.45 to the range of -0.04 to -0.085. Again, this suggests that price elasticity in the GCC is very low

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Appendices

Table A1. Energy Efficiency Targets for Some World Economies

Indicator	Country/ Region	Target
Energy Intensity (Energy/GDP)	Japan China Indonesia Vietnam	30% reduction by 2030 compared to 2003 20% reduction by 2010 compared to 2005 1% annual reduction starting 2000 32% reduction of elasticity by 2015 compared to 2005
Energy Efficiency	Australia South Korea US South Africa	Increase fuel efficiency of new vehicles by 20% in 2010 compared to 2006 Increase fuel efficiency of vehicles by 20% in 2009 compared to 1999 Increase vehicle fuel efficiency from 25 to 35 miles/gallon by 2020 12% improvement in overall energy efficiency by 2015 compared to the Business as Usual (BaU) case
Energy Consumption	EU US	20% reduction by 2020 compared to 2005 20% reduction in gasoline consumption by 2017 compared to 2007

Source: Country national communications and submissions to the United Nations Framework Convention on Climate Change, UNFCCC (http://unfccc.int/national_reports/items/1408.php, http://unfccc.int/meetings/ad_hoc_working_groups/lca/items/4578.php, http://unfccc.int/kyoto_protocol/items/4752.php)

Table A2. The Benchmark Sample Data

Country	Energy Intensity (BTU/ PPP)	Per Cap GDP (000PPP)	Gasoline Price ($/ litre)	Heat/Cool Degree Days	Services GDP-Share	Life Expectancy (years)
Australia	7847	30.1	0.93	1667	68.4	80.6
Brazil	5967	7.5	1.26	2133	64.0	71.2
Brunei	12869	22.0	0.34	3516	50.0	77.0
Canada	10895	30.7	0.84	4664	71.3	80.0
Chile	6730	10.7	1.09	1838	47.7	78.2
Czech Rep	9846	17.8	1.30	3677	58.8	75.9
Denmark	4732	30.3	1.58	3661	73.5	77.8
Finland	9079	29.1	1.55	5260	67.5	78.8
France	6457	27.0	1.48	2719	76.9	80.2
Germany	6306	26.3	1.55	3374	69.4	78.9
Hong Kong	3334	31.0	1.69	2363	90.7	81.6
Hungary	7069	15.4	1.30	3313	65.6	72.6
Iran	13328	7.1	0.09	2850	45.0	71.1
Italy	4829	26.0	1.56	2438	70.9	80.3
Mexico	7128	9.3	0.74	1924	70.2	75.4
NewZealand	7030	23.3	0.98	1774	68.0	79.6
Norway	7063	39.1	1.80	4578	55.1	80.0
Poland	7793	12.4	1.30	3819	64.6	75.0
Portugal	5555	18.4	1.56	1712	72.5	78.1
Singapore	10424	26.4	0.92	3261	66.1	79.7
South Africa	10928	9.9	0.85	1454	67.1	47.7
Spain	5788	22.9	1.15	2133	67.2	80.6
Sweden	7641	30.0	1.46	4420	70.7	80.5
UK	5462	28.2	1.63	2876	72.8	78.9
US	8445	37.1	0.63	3041	79.4	77.7

Source: World Bank World Development Indicators (WDI), WMO, and Author’s calculations.