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Discussion Paper

Opportunities for Mitigating the Environmental Impact of Energy Use in the Middle East and North Africa Region

By

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Executive Summary

Energy efficiency reduces the fiscal cost of energy subsidies and energy sector investments, improves economic competitiveness, raises household welfare, lowers local and global pollution and reduces the perception of national energy insecurity.

The Middle East and North Africa (MENA) Region has a low level of energy efficiency and energy efficiency has become a high perceived priority for most MENA governments. The World Bank is conducting a study on *Energy Efficiency in the Middle East and North Africa (MENA)* to create a platform for policy dialogue on energy efficiency based on lessons of international experience and the specific needs of MENA countries.

The main motivation for MENA governments to improve energy efficiency is to address pressing domestic concerns, such as urban air pollution, energy security, economic competitiveness, the fiscal cost of energy subsidies and the balance of payments. However, improved energy efficiency is also seen as the most promising route for reducing the region's green house gas (GHG) emissions. Therefore, as part of the study on *Energy Efficiency in MENA*, this report aims to describe and quantify the links between energy efficiency and GHG emissions as well as urban air pollution in MENA. More specifically, the objectives of the report is

- To create scenarios of emissions of GHG and selected urban air pollutants (specifically, particulate matter (PM)) under different assumptions of energy efficiency improvements;
- To identify the country/sectors where energy efficiency improvements are likely to have the greatest impact upon GHG and PM emissions;
- To benchmark MENA against other regions in terms of energy intensity and GHG emissions.

This report uses International Energy Agency (IEA) databases, the World Bank *2006 Little Green Data Book*, and the World Bank Development Data Platform (DDP) as the primary data source for the analysis. In particular, a decomposition analysis focusing on sector structure of the economy is developed to estimate CO_2 changes between 1995 and 2005 for MENA countries and to build scenarios showing how given percentage energy efficiency improvements by sector would reduce CO_2 emissions. The Global Model of Ambient Particulates (GMAPS) developed by the World Bank (Cohen et al, 2004) is adopted to estimate the changes in PM concentrations by scenario of improved energy. A cross-country regression analysis is also used to find key factors that determine energy consumption and CO_2 emissions per capita and to identify whether MENA is a relatively intensive energy user or CO_2 producer.

The primary findings of the report are:

- The MENA region contributes to 5% of the total GHG emissions in the world in 2005. Iran has the highest GHG emissions in MENA and contributes to 27% of the total GHG emissions in the region.

- The total primary energy supply in the MENA region is about 7% of the world total in 2005. In terms of fossil fuel types, compared to other regions, the MENA region has a bigger share of natural gas and smaller share of coal. Except for Israel and Morocco, few MENA countries use coal and coal products. Iran leads the region in terms of the total primary energy supply from fossil fuel.

- The energy sector is the leading sector with the highest CO_2 emissions for most MENA countries, contributing to 44% of CO_2 emissions for the MENA region. The transportation sector contributes 22% of CO_2 emissions in the MENA region, similar to the world average and higher than Asia excluding China and Latin America excluding Mexico. The industry sector contributes another 20% of CO_2 emissions in the MENA region.

- Among the five MENA countries (Egypt, Iran, Jordan, Morocco, and the United Arab Emirates) that have available data for the decomposition analysis of changes in CO_2 emissions between 1995 and 2005, Iran has the highest increase in CO_2 emissions. It also has the highest increase in CO_2 emission per capita and GDP per capita. The major factor that contributes to the increase in CO_2 emissions in Iran is scale effect of increased GDP per capita. Among the five countries, only the United Arab Emirates (UAE) has a negative pollution intensity effect, which is probably due to the fact that the country has significantly reduced gas flaring over the period.

- Using 2005 as the baseline, the decomposition analysis shows that energy efficiency improvements in energy and other sectors have the highest potential to reduce CO_2 emissions. If energy efficiency is improved by 10% in energy and other sectors, the total CO_2 emissions reduction is in the range of 4-8% and Israel has the highest reduction of 8.05%. If energy efficiency is improved by 10% in the transportation sector, MENA countries can achieve a total CO_2 emissions reduction of 1-3.5% and Iraq has the highest reduction of 3.5%. If the manufacturing sector has an energy efficiency improvement of 10%, the total CO_2 emissions reduction in MENA countries is in the range of 1-3%, with the highest reduction of 2.86% in the United Arab Emirates.

- Among its comparators-East Asia (EAP), Europe and Central Asia (ECA), Latin America and the Caribbean (LAC), upper middle income group, and lower middle income group-MENA ranks the first in terms of CO_2 emission per dollar of output in the manufacturing sector and ranks second in terms of energy consumption per dollar of output in the manufacturing sector. This shows that MENA has very high pollution intensity and energy intensity in the manufacturing sector and has great potential for energy efficiency improvement in this sector. Within the MENA region, the UAE has the highest energy consumption and CO_2 emissions per dollar of manufacturing output, which means that energy efficiency improvements in the manufacturing sector in the UAE will achieve the highest CO_2 reduction among MENA countries.

- In terms of energy consumption and CO_2 emissions per unit of GDP per capita in the residential sector, MENA has relatively low rank among its comparators. Within the MENA region, the UAE is well above other MENA countries in terms of both energy consumption and CO_2 emissions per unit of GDP per capita in the residential sector, which means that there is a great potential for energy efficiency improvements in the residential sector in the UAE.

- Among the World Bank's analytical regions (EAP, ECA, LAC, MENA, South Asia, and Sub-Saharan Africa), MENA is the second most polluting region in terms of PM concentrations, only behind South Asia. The estimated PM concentration is 90 $\mu g/m^3$, which is 50% higher than the world average. Within the MENA region, Iraq has the highest PM concentration (167 $\mu g/m^3$), followed by Egypt, Kuwait, Oman, Libya, United Arab Emirates, and Saudi Arabia, which are all above the region's average.

- In terms of magnitude of current damage costs of PM emissions, using percentage of 2004 GNI as the indicator, MENA ranks the second highest among the World Bank's analytical regions, following the EAP region. Damage cost due to PM emissions is equivalent to 0.9% of the 2004 GNI in the MENA region (about US$5.3 billion), well above the world average of 0.5%. Within the MENA region, Iraq and Kuwait have the highest damage cost of PM emissions--2.7% of GNI, more than five times the world average. Most MENA countries have higher than the world average damage costs of PM emissions, except for Yemen, Tunisia, and Morocco.

- The results from the Global Model of Ambient Particulates show that energy efficiency improvements that will lead to decreased per capita consumption in oil, diesel and coal will achieve higher PM concentration reductions. If there are 10% reduction in per capita oil, diesel and coal consumption through energy efficiency improvements, the MENA region as a whole is able to reduce PM concentrations to 83 $\mu g/m^3$, a 7.8% reduction from the baseline (90 $\mu g/m^3$). Within MENA countries, since Iraq has the highest PM concentrations in the baseline, it can achieve the highest reduction in PM concentrations in absolute terms through energy efficiency improvements.

- The cross-country regression analysis shows that GDP per capita is the most significant factor in determining energy consumption per capita and CO_2 emissions per capita. Other factors such as the sectoral composition of the economy, energy prices, and hydrocarbon production also potentially play important roles. Due to the data limitations, the cross-country regression analysis is not able to provide evidences to confirm the hypothesis that MENA is a relatively intensive energy user and CO_2 producer when controlling all the other factors.

1. Introduction

Energy efficiency reduces the fiscal cost of energy subsidies and energy sector investments, improves economic competitiveness, raises household welfare, lowers local and global pollution and reduces the perception of national energy insecurity.

The Middle East and North Africa (MENA) Region has a low level of energy efficiency and energy efficiency has become a high perceived priority for most MENA governments. The World Bank is conducting a study on *Energy Efficiency in MENA* to: (1) engage a dialogue on energy efficiency with MENA governments by bringing together the lessons of international experience on options, constraint, and opportunities for energy efficiency and their applicability in the context of MENA countries' political economy; and (2) develop the analytical foundation and the paradigm for the Bank's energy efficiency lending and advisory work in MENA.

1.1 Objectives

The main motivation for MENA governments to improve energy efficiency is to address pressing domestic concerns, such as urban air pollution, energy security, economic competitiveness, the fiscal cost of energy subsidies and the balance of payments. However, improved energy efficiency is also seen as the most promising route for reducing the region's green house gas (GHG) emissions. Therefore, as part of the study on *Energy Efficiency in MENA*, this report aims to describe and quantify the links between energy efficiency and GHG emissions as well as urban air pollution in MENA. More specifically, the objectives of the report are to:

- Create scenarios of emissions of GHG and selected urban air pollutants (specifically, particulate matter (PM)) under different assumptions of energy efficiency improvements;
- Identify the country/sectors where energy efficiency improvements are likely to have the greatest impact upon GHG and PM emissions;
- Benchmark MENA against other regions in terms of energy intensity and GHG emissions.

1.2 Methodologies

We use International Energy Agency (IEA) databases, the World Bank *2006 Little Green Data Book*, and the World Bank Development Data Platform (DDP) as the primary data source for the analysis in this report.

To estimate the changes in CO_2 emissions by scenario of improved energy efficiency, we first conduct a decomposition analysis to identify how key factors such as population growth, GDP growth, energy intensity, pollution intensity, and sector structure of the economy contribute to changes in CO_2 emissions between 1995 and 2005 for MENA countries. Since a recent World Bank report (World Bank, 2007a) uses a different decomposition method which does not consider sector structure, we also compare our results with the ones using the alternative decomposition method. Based on the decomposition analysis, we build scenarios to show how given percentage energy efficiency improvements by sector would reduce CO_2 emissions and then identify the country/sectors where energy efficiency improvements are likely to have the greatest impact upon GHG emissions.

To estimate the changes in PM concentrations by scenario of improved energy efficiency, we adopt the Global Model of Ambient Particulates (GMAPS) developed by the World Bank (Cohen et al, 2004). Then we are able to identify the country/sectors where energy efficiency improvements are likely to have the greatest impact upon PM concentration reductions.

Finally, we adopt a cross-country regression analysis to explain energy consumption and GHG emissions per capita in terms of GDP per capita, the sectoral composition of the economy, hydrocarbon production, and energy prices, and to identify whether MENA is a relatively intensive energy user or CO_2 producer.

1.3 Structure

This report is structured as follows. Chapter 2 provides an overview of GHG emissions and fossil fuel use in MENA. Chapter 3 details the decomposition analysis of changes in CO_2 emissions from fossil fuel for MENA countries and compares the results with the ones using the alternative decomposition method. Based on the decomposition analysis, changes in CO_2 emissions by scenario of improved energy efficiency are estimated in Chapter 4. In addition, Chapter 4 presents the benchmarking analysis of MENA's manufacturing and residential sectors against each other and comparators, country by county, in terms of energy consumption and CO_2 emissions per unit of GDP per capita. Chapter 5 provides an overview of PM emissions in MENA and presents the estimations of changes in PM concentrations by scenario of improved energy efficiency. The cross-country regression analysis is developed in Chapter 6.

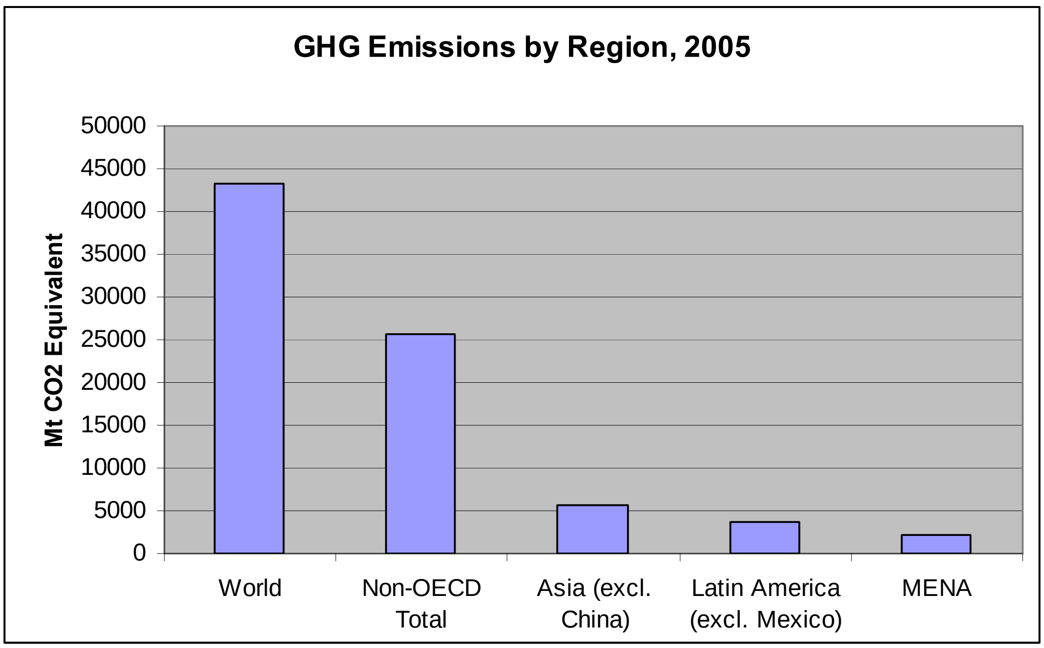
2. Overview of GHG Emissions and Fossil Fuel Use in MENA

2.1 Total GHG Emissions

According to the IEA Database, as shown in Figure 1 and Table 1, the green house gas (GHG) emissions in the MENA region in 2005 is 2207.65 Mt CO_2 equivalent, which is about 5% of the total GHG emissions in the World, and half of the GHG emissions in Asia (excluding China).

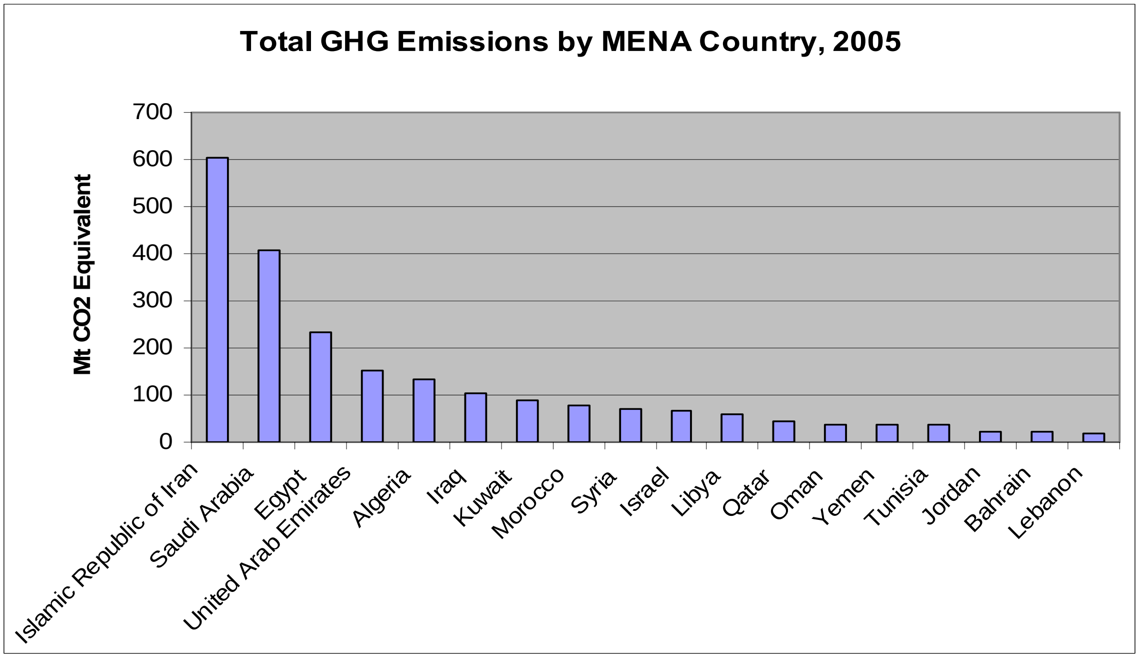
Within the MENA region, as shown in Figure 2 and Table 1, the Islamic Republic of Iran has the highest GHG emissions and contributes to 27% of the total GHG emissions in the region. Saudi Arabia and Egypt are the next two leading GHG emitters. Together with Iran, the three countries contribute to 56% of the total GHG emissions in the region.

Figure 1GHG Emissions by Region, 2005



Source: the IEA database

Figure 2 Total GHG Emissions by MENA Country, 2005



Source: the IEA database

Table 1 Total GHG Emissions by MENA Country and Region, 2005

MENA Country	***GHG Emissions (Mt CO_2 eq.)***	***% of the Region***
Islamic Republic of Iran	604.33	27%
Saudi Arabia	406.06	18%
Egypt	231.60	10%
United Arab Emirates	152.94	7%
Algeria	132.27	6%
Iraq	103.86	5%
Kuwait	90.17	4%
Morocco	75.97	3%
Syria	68.53	3%
Israel	66.44	3%
Libya	60.17	3%
Qatar	43.04	2%
Oman	36.92	2%
Yemen	36.18	2%
Tunisia	35.97	2%
Jordan	22.97	1%
Bahrain	20.65	1%
Lebanon	19.60	1%
Region	***GHG Emissions (Mt CO_2 eq.)***	***% of the World***
World	43291.91	100%
Non-OECD Total	25659.71	59%
Asia (excl. China)	5696.55	13%
Latin America (excl. Mexico)	3627.14	8%
MENA	2207.65	5%

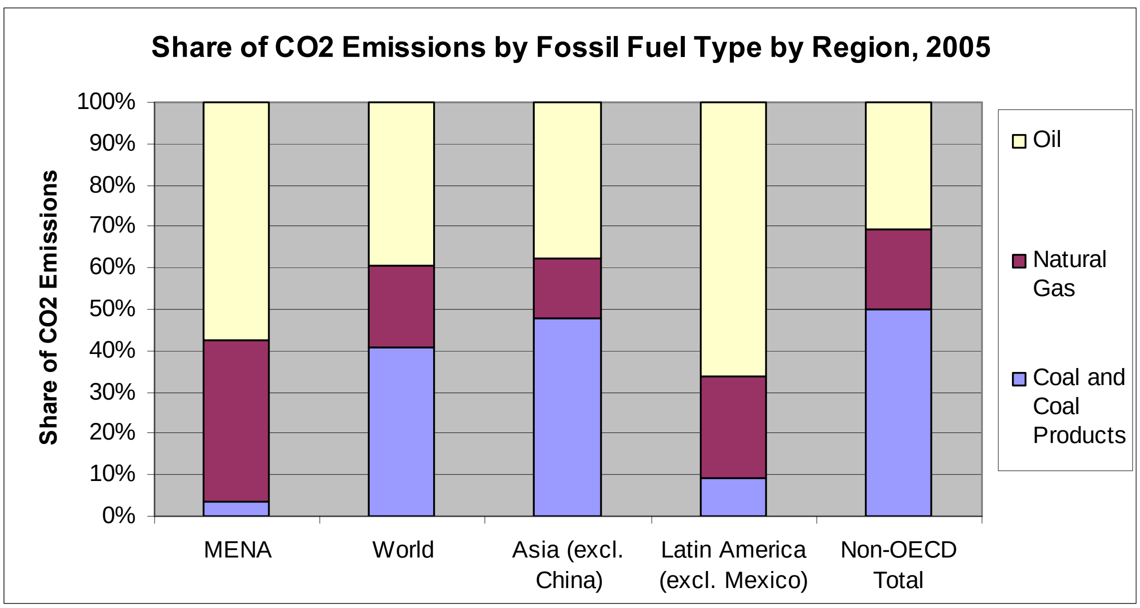
Source: the IEA database

2.2 GHG (CO_2) Emissions from Fossil Fuel Combustion by Fuel Type

Because 74% of GHG are CO_2 and the IEA only has detailed data on CO_2 emissions, we present CO_2 emissions as an indicator of GHG emissions. Fuel combustion is a major source of CO_2 emissions. The IEA published *CO_2 Emissions from Fuel Combustion 1971-2005* (2007) including global annual statistics on CO_2 emissions from fossil fuel combustion and sector-level evolution in energy use and associated CO_2 emissions. The fuel type classification is coal and coal products, natural gas, oil, and other. The following information is based on this dataset.

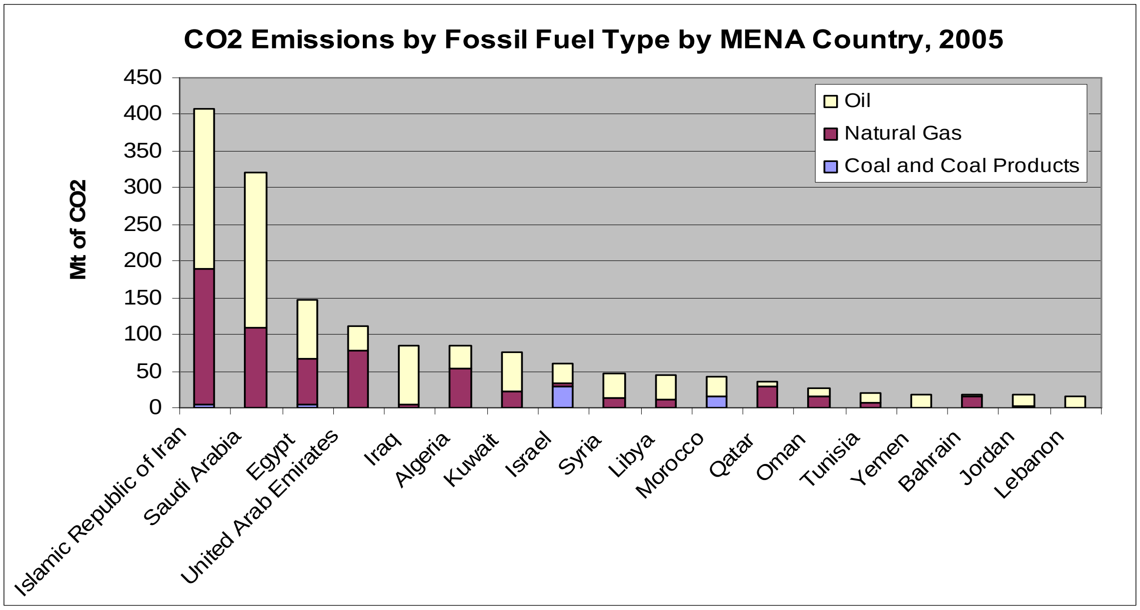
As shown in Figure 3 and Table 2, compared to other regions in terms of share of CO_2 emissions from coal and coal products, natural gas, and oil, coal and coal products contribute the least to CO_2 emissions in the MENA region. This is primarily driven by the fact that coal and coal products only represents 2% of primary fuel supplies in this region and most MENA countries are abundant in oil and natural gas resources. As shown in Figure 4 and Table 2, CO_2 emissions from oil contribute to more than 50% for most MENA countries and in the case of Yemen, all CO_2 emissions are from oil combustion.

Figure 3 Share of CO_2 Emissions by Fossil Fuel Type by Region, 2005



Source: the IEA database

Figure 4 CO_2 Emissions by Fossil Fuel Type by MENA Country, 2005



Source: the IEA database

Table 2 CO_2 Emissions from Fossil Fuel Combustion by Fuel, 2005

Country/Region	Coal and Coal Products		Natural Gas		Oil		Total
Country	Mt of CO_2	%	Mt of CO_2	%	Mt of CO_2	%	Mt of CO_2
Islamic Republic of Iran	3.9	1%	186.3	46%	216.9	53%	407.1
Saudi Arabia	0.0	0%	109.8	34%	209.9	66%	319.7
Egypt	3.5	2%	63.1	43%	81.0	55%	147.6
United Arab Emirates	0.0	0%	79.1	72%	31.3	28%	110.4
Iraq	0.0	0%	5.1	6%	79.6	94%	84.6
Algeria	1.0	1%	52.6	62%	30.7	36%	84.3
Kuwait	0.0	0%	22.0	30%	52.6	70%	74.6
Israel	29.6	50%	3.0	5%	27.3	46%	59.9
Syria	0.0	0%	12.7	27%	35.1	73%	47.8
Libya	0.0	0%	10.8	24%	34.7	76%	45.4
Morocco	15.5	37%	0.9	2%	25.0	60%	41.3
Qatar	0.0	0%	29.7	82%	6.7	18%	36.4
Oman	0.0	0%	15.0	56%	12.0	44%	27.0
Tunisia	0.0	0%	7.2	37%	12.1	63%	19.3
Yemen	0.0	0%	0.0	0%	18.7	100%	18.7
Bahrain	0.0	0%	14.6	80%	3.7	20%	18.3
Jordan	0.0	0%	3.2	18%	14.7	82%	17.9
Lebanon	0.5	3%	0.0	0%	15.3	97%	15.8
Region							
MENA	54.1	3%	614.9	39%	907.0	58%	1576.0
World	10980.1	41%	5346.8	20%	10716.7	40%	27043.6
Asia (excl. China)	1242.4	48%	366.8	14%	979.7	38%	2588.9
Latin America (excl. Mexico)	87.7	9%	230.5	25%	619.5	66%	937.7
Non-OECD Total	6644.8	50%	2544.7	19%	4059.0	31%	13248.5

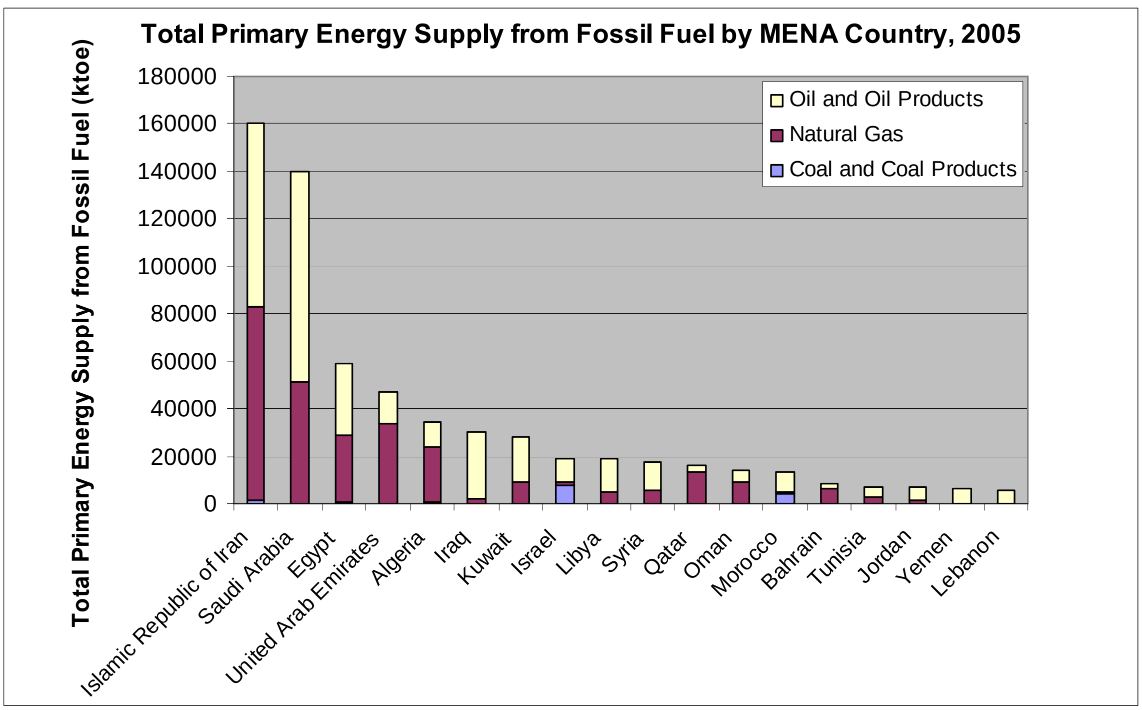
Source: the IEA database

2.3 Fossil Fuel Use by Country/Sector

As shown in Figure 5 and Table 3, nearly all primary energy supply comes from fossil fuels in the MENA region. Again, the Islamic Republic of Iran leads the region in terms of the total primary energy supply from fossil fuel. Except for Israel and Morocco, few MENA countries use coal and coal products. The total primary energy supply in the MENA region is about 7% of the world total. Compared to other regions, the MENA region has a bigger share of natural gas and smaller share of coal, as illustrated in Figure 6.

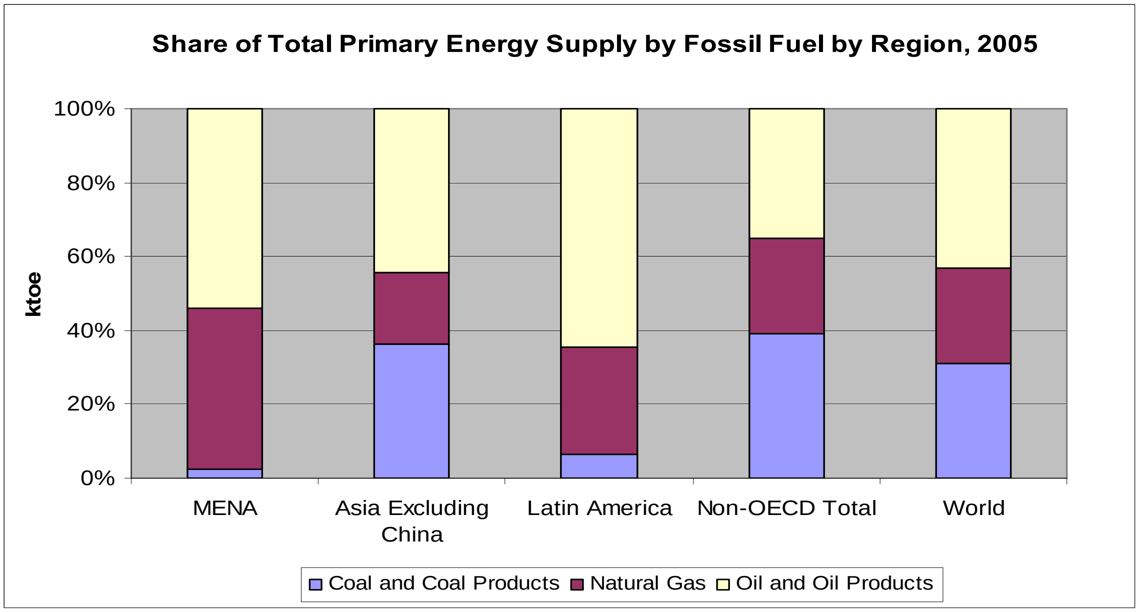
In terms of total final consumption (TFC) by sector (as shown in Table 3), the transportation sector consumes 31% of the TFC in the MENA region, above the world average 28% and well above Asia excluding China and Non-OECD total, which is 17% and 18%, respectively. The industry sector consumes 25% of the TFC in the MENA region, comparable to the world average but a bit lower than other regions.

Figure 5 Total Primary Energy Supply from Fossil Fuel by MENA Country, 2005



Source: the IEA database

Figure 6 Share of Total Primary Energy Supply by Fossil Fuel by Region, 2005



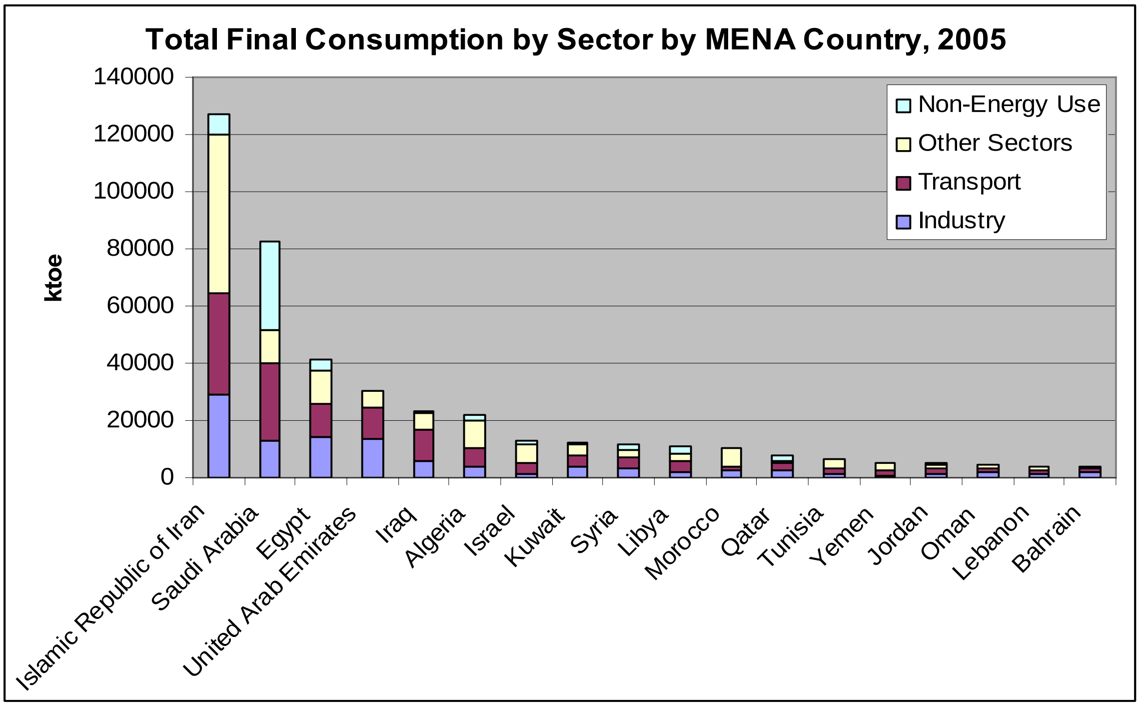
Source: the IEA database

Table 3 Total Primary Energy Supply from Fossil Fuel by Fuel, 2005

Country/Region	Coal and Coal Products		Natural Gas		Oil and Oil Products		Total
MENA Country	ktoe	%	ktoe	%	ktoe	%	ktoe
Islamic Republic of Iran	1113	1%	82055	51%	77224	48%	160392
Saudi Arabia	0	0%	51077	36%	89196	64%	140273
Egypt	895	2%	27765	47%	30136	51%	58796
United Arab Emirates	0	0%	33839	72%	13081	28%	46920
Algeria	685	2%	22931	66%	11021	32%	34637
Iraq	0	0%	2164	7%	28405	93%	30570
Kuwait	0	0%	9426	33%	18717	67%	28143
Israel	7633	40%	1289	7%	9980	53%	18902
Libya	0	0%	5145	27%	13748	73%	18892
Syria	3	0%	5914	34%	11687	66%	17603
Qatar	0	0%	13347	84%	2478	16%	15825
Oman	0	0%	9318	67%	4646	33%	13964
Morocco	4455	34%	386	3%	8313	63%	13153
Bahrain	0	0%	6245	77%	1883	23%	8128
Tunisia	0	0%	3091	42%	4223	58%	7314
Jordan	0	0%	1384	20%	5570	80%	6954
Yemen	0	0%	0	0%	6650	100%	6650
Lebanon	132	2%	0	0%	5181	98%	5313
Region							
MENA	14916	2%	275375	44%	342138	54%	632429
Asia Excluding China	329167	36%	173239	19%	401151	44%	903557
Latin America	23090	7%	100764	29%	226959	65%	350813
Non-OECD Total	1761841	39%	1150097	26%	1582319	35%	4494256
World	2892114	31%	2361537	26%	4002077	43%	9255729

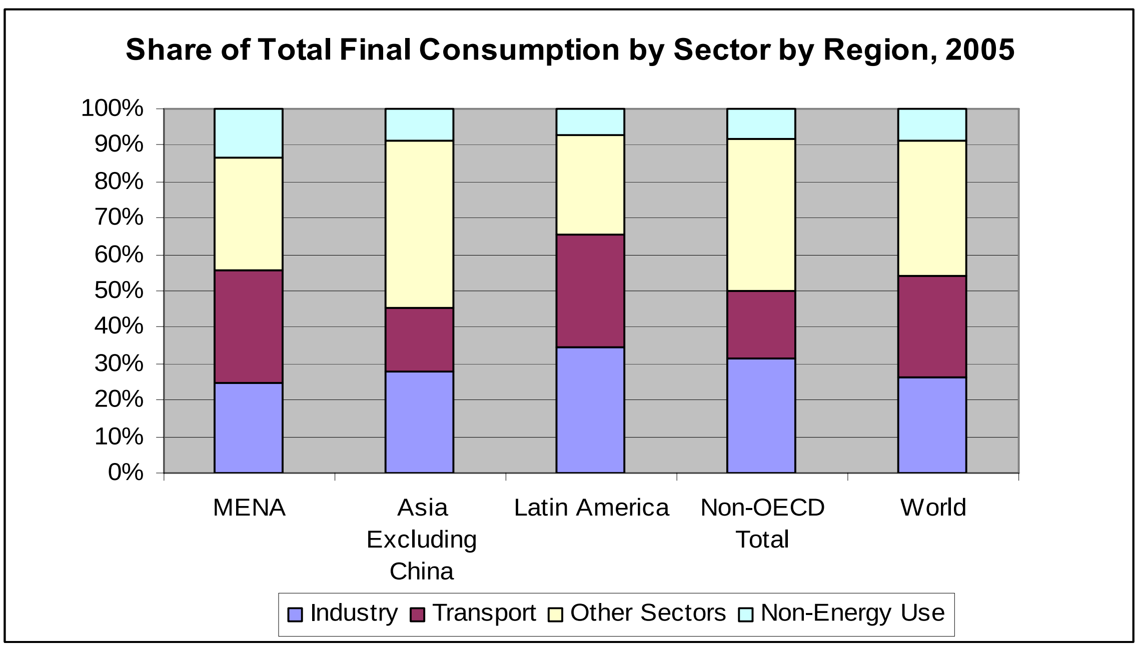
Source: the IEA database

Figure 7 Total Final Consumption by Sector by MENA Country, 2005



Source: the IEA database

Figure 8 Share of Total Final Consumption by Sector by Region, 2005



Source: the IEA database

Table 4 Total Final Consumption by Sector, 2005

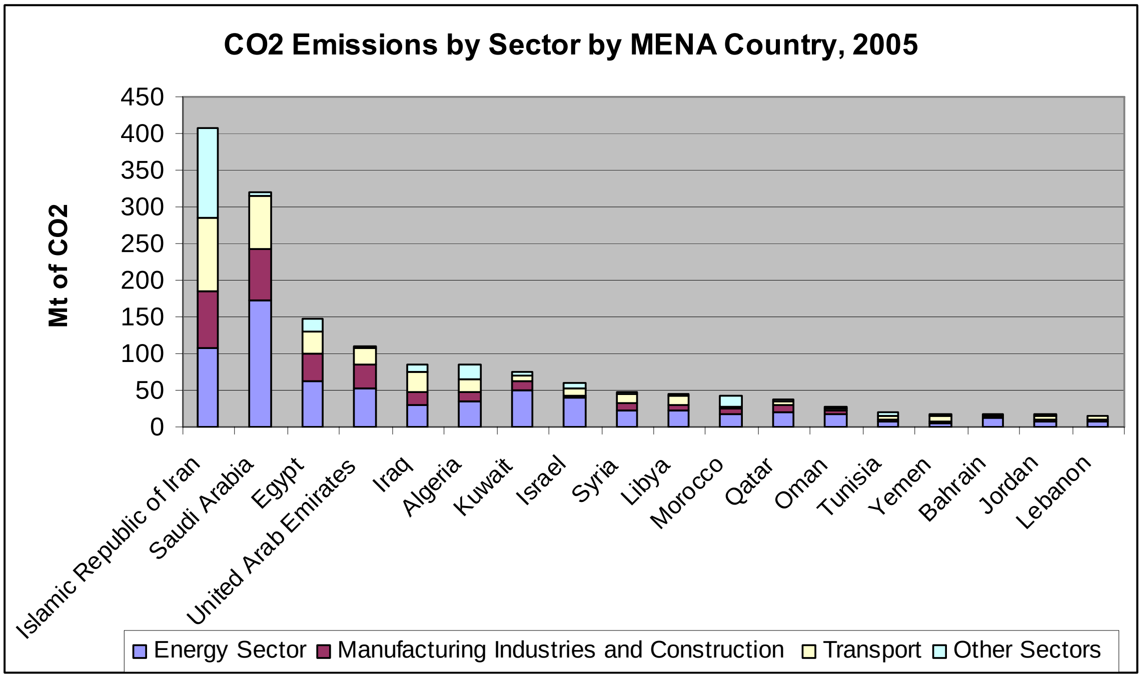
Country/Region	Industry		Transport		Other Sectors		Non-Energy Use		TFC
MENA Country	ktoe	%	ktoe	%	ktoe	%	ktoe	%	
Islamic Republic of Iran	29313	23%	34924	27%	55805	44%	7305	6%	127348
Saudi Arabia	12587	15%	27315	33%	11680	14%	31206	38%	82787
Egypt	14276	34%	11304	27%	11659	28%	4351	10%	41590
United Arab Emirates	13617	45%	11157	37%	5519	18%	30	0%	30322
Iraq	5976	25%	10841	46%	5899	25%	790	3%	23507
Algeria	3862	18%	6716	31%	9152	42%	2143	10%	21872
Israel	1383	11%	3976	31%	6012	47%	1335	11%	12707
Kuwait	4165	34%	3377	27%	3888	31%	948	8%	12378
Syria	3138	27%	4029	34%	2573	22%	1939	17%	11679
Libya	1871	17%	4174	37%	2346	21%	2844	25%	11235
Morocco	2874	28%	1057	10%	6157	59%	263	3%	10351
Qatar	2781	36%	2067	27%	855	11%	1983	26%	7686
Tunisia	1548	24%	1751	27%	2848	44%	288	4%	6434
Yemen	595	12%	2231	45%	2021	41%	109	2%	4956
Jordan	1129	23%	1934	40%	1686	35%	110	2%	4859
Oman	1726	38%	1658	37%	1098	24%	39	1%	4522
Lebanon	1135	28%	1537	38%	1327	33%	57	1%	4057
Bahrain	1854	46%	1480	37%	638	16%	43	1%	4016
Region									
MENA	103829	25%	131526	31%	131164	31%	55786	13%	422305
Asia Excluding China	249078	28%	156420	17%	412247	46%	79765	9%	897509
Latin America	135980	35%	122550	31%	105679	27%	29198	7%	393408
Non-OECD Total	1232284	32%	713348	18%	1626101	42%	316424	8%	3888156
World	2092799	26%	2182915	28%	2933084	37%	702902	9%	7911699

Source: the IEA database

2.4 GHG (CO_2) Emissions by Sector

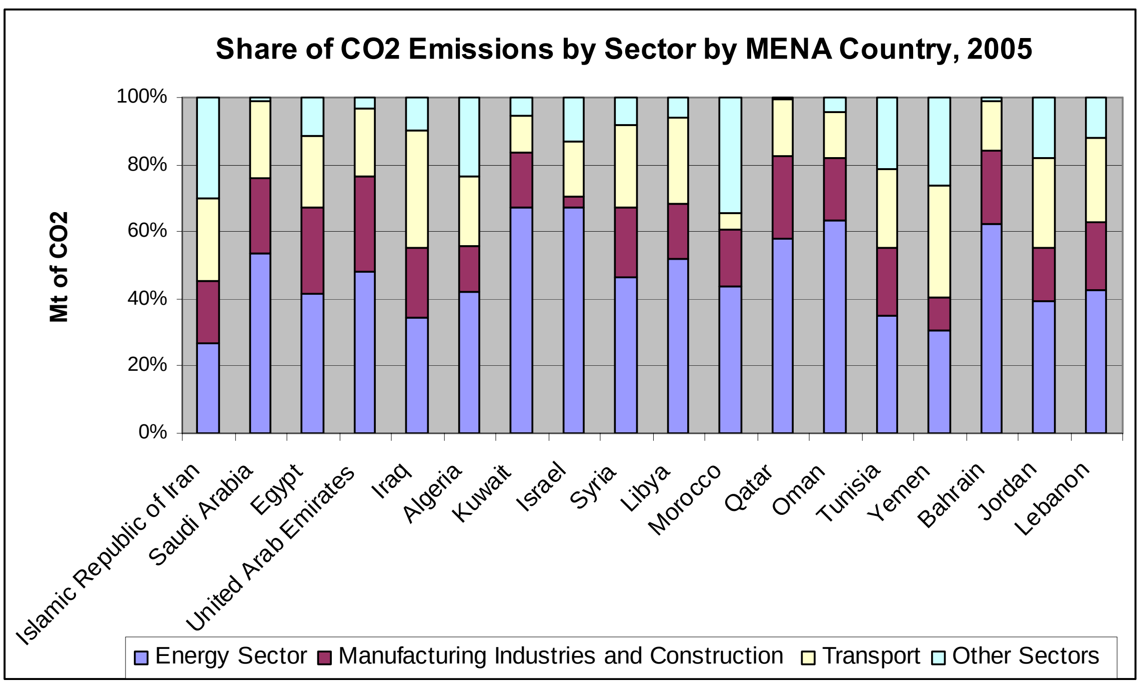
In terms of CO_2 emissions by sector, IEA's classification of sectors includes the energy sector, manufacturing industries and construction, transport, and other sectors. Manufacturing industries and construction can be treated as the industrial sector. The energy sector is the leading sector with the highest CO_2 emissions for most MENA countries, contributing to 44% of CO_2 emissions for the MENA region. The transportation sector contributes 22% of CO_2 emissions in the MENA region (as compared to 31% of TFC), similar to the world average and higher than Asia excluding China and Latin America excluding Mexico. The industry sector contributes another 20% of CO_2 emissions in the MENA region. Among MENA countries, Kuwait and Israel have the highest share of CO_2 emissions in the energy sector, Iraq has the highest share in the transportation sector, and the UAE has the highest share in the industry sector.

Figure 9 CO_2 Emissions by Sector by MENA Country, 2005



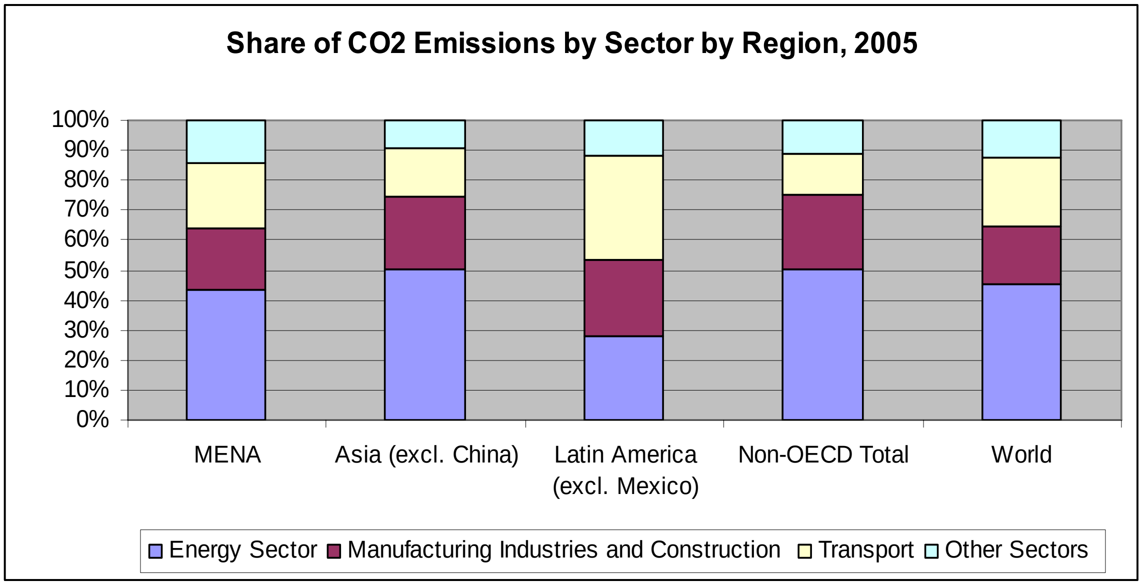
Source: the IEA database

Figure 10 Share of CO_2 Emissions by Sector by MENA Country, 2005



Source: the IEA database

Figure 11 Share of CO_2 Emissions by Sector by Region, 2005



Source: the IEA database

Table 5 CO_2 Emissions by Sector, 2005

Country/Region	Energy Sector		Manufacturing Industries and Construction		Transport		Other Sectors		Total
MENA Country	Mt of CO_2	%	Mt of CO_2	%	Mt of CO_2	%	Mt of CO_2	%	
Islamic Republic of Iran	108.14	27%	76.44	19%	100.31	25%	122.21	30%	407.10
Saudi Arabia	171.98	54%	71.44	22%	72.52	23%	3.74	1%	319.68
Egypt	61.56	42%	37.41	25%	31.59	21%	17.03	12%	147.59
United Arab Emirates	53.08	48%	31.52	29%	22.06	20%	3.72	3%	110.38
Iraq	29.08	34%	17.54	21%	29.63	35%	8.39	10%	84.64
Algeria	35.59	42%	11.18	13%	17.78	21%	19.75	23%	84.30
Kuwait	50.14	67%	12.42	17%	8.04	11%	4.02	5%	74.62
Israel	40.27	67%	1.81	3%	9.86	16%	7.91	13%	59.85
Syria	22.30	47%	9.78	20%	11.74	25%	3.94	8%	47.76
Libya	23.60	52%	7.31	16%	11.72	26%	2.77	6%	45.40
Morocco	18.03	44%	7.16	17%	1.82	4%	14.34	35%	41.35
Qatar	21.05	58%	9.04	25%	6.14	17%	0.14	0%	36.37
Oman	17.08	63%	5.10	19%	3.61	13%	1.19	4%	26.98
Tunisia	6.78	35%	3.85	20%	4.54	24%	4.11	21%	19.28
Yemen	5.76	31%	1.83	10%	6.18	33%	4.92	26%	18.69
Bahrain	11.39	62%	4.05	22%	2.65	14%	0.23	1%	18.32
Jordan	7.02	39%	2.91	16%	4.78	27%	3.20	18%	17.91
Lebanon	6.76	43%	3.19	20%	3.97	25%	1.89	12%	15.81
Region									
MENA	689.61	44%	313.98	20%	348.94	22%	223.50	14%	1576.03
Asia (excl. China)	1303.11	50%	634.89	25%	407.53	16%	245.46	9%	2590.99
Latin America (excl. Mexico)	262.94	28%	238.83	25%	324.37	35%	111.54	12%	937.68
Non-OECD Total	6636.35	50%	3294.63	25%	1856.69	14%	1479.87	11%	13267.54
World	12307.24	45%	5184.04	19%	6337.02	23%	3308.06	12%	27136.36

Source: the IEA database

3. Decomposition of Changes in CO_2 Emissions from Fossil Fuel for MENA Countries

In order to understand the factors that contribute to the changes in CO_2 emissions for MENA countries, we conduct a decomposition analysis in this chapter.

3.1 Theoretical Model

Fossil fuel related CO_2 emissions in a given year decomposed into the individual components, can be written as:

(1) $$P = \sum_j \frac{P_j}{E_j}\frac{E_j}{Y_j}\frac{Y_j}{Y}\frac{Y}{B}B = \sum_j C_j I_j S_j GB$$

P = the amount of CO_2 emissions from the consumption of fossil fuels
E = the amount of fossil fuel consumption
Y = GDP
B = population
j = sector
$C_j \equiv \frac{P_j}{E_j}$ shows pollution intensity in sector *j*.
$I_j \equiv \frac{E_j}{Y_j}$ shows energy intensity in sector *j*.
$S_j \equiv \frac{Y_j}{Y}$ shows sector structure of the economy.
$G \equiv \frac{Y}{B}$ shows GDP per capita

The change in a country's emission (ΔP) from period *0* to period *T* can be decomposed into (1) pollution intensity effect (ΔC_C), (2) energy intensity effect (ΔC_I), (3) sector structure effect (ΔC_S), (4) scale effect (ΔC_G), and (5) population effect (ΔC_B).

(2) $$\Delta P = P^T - P^0 = \Delta C_C + \Delta C_M + \Delta C_I + \Delta C_S + \Delta C_G + \Delta C_B$$

Using the logarithmic mean Divisia Index (LMDI) formulae developed by Ang (2005), these effects can be calculated as follows.

(3) $$\Delta C_C = \sum_j \frac{P_j^T - P_j^0}{\ln P_j^T - \ln P_j^0} \ln\left(\frac{C_j^T}{C_j^0}\right)$$

(4) $$\Delta C_I = \sum_j \frac{P_j^T - P_j^0}{\ln P_j^T - \ln P_j^0} \ln\left(\frac{I_j^T}{I_j^0}\right)$$

(5) $$\Delta C_S = \sum_j \frac{P_j^T - P_j^0}{\ln P_j^T - \ln P_j^0} \ln\left(\frac{S_j^T}{S_j^0}\right)$$

(6) $$\Delta C_G = \sum_j \frac{P_j^T - P_j^0}{\ln P_j^T - \ln P_j^0} \ln\left(\frac{G^T}{G^0}\right)$$

(7) $$\Delta C_B = \sum_j \frac{P_j^T - P_j^0}{\ln P_j^T - \ln P_j^0} \ln\left(\frac{B^T}{B^0}\right)$$

The change in emissions will reflect changes in the five effects because of the nature of the identity in equation (2). The pollution intensity effect reflects energy mix in terms of polluting levels. If more clean fuels are replacing dirty fuels or dirty fuels are less dirty due to strengthened environment policies, the pollution intensity will decrease and negatively contribute to the increase of CO_2 emissions from period *0* to period *T*. The energy intensity effect reflects several factors including energy efficiency of the economy. If industries adopt higher energy efficiency standards, which means that less energy is required to produce the same output, the energy intensity will fall. Therefore, with proper policies, this effect could also reduce CO_2 emissions. The sector structure effect reflects the composition of the economy. Some sectors are more energy intensive than others, e.g. manufacturing sector is more energy intensive than most service sectors. If the sector structure of GDP changes towards sectors that are less energy intensive, the average use of energy in total GDP would fall, so would the total CO_2 emissions. The scale effect and the population effect show how GDP per capita and population change over the period. We generally expect the population to grow over time and people become wealthier, so the two effects generally contribute to the increase of CO_2 emissions, unless there are price or regulatory incentives to change behaviors towards less energy intensive consumption patterns.

3.2 Data and Application

We used the data from period of 1995 to 2005 to conduct the decomposition analysis. The major challenge of the estimation is that there are no consistent data sources for the classification of economic sectors. Due to the time and data constraints, we split the economy into three sector categories: transport sector, manufacturing sector, and energy and other sectors. The data sources and data adjustment are explained as follows.

(1) The emission of CO_2 by sector P_j

IEA has CO_2 emission data measured in million tons (Mt) of CO_2 by fossil fuel type and by sector. Fossil fuel types include coal and coal products, oil, and natural gas. The sectors are classified as:

Energy Sector
--Main Activity Producer Electricity and Heat
--Unallocated Autoproducers
--Other Energy industries
Manufacturing Industries and Construction
Transport
Other Sectors

In order to match the three sectors we proposed, we aggregated the energy sector with other sectors.

(2) Fossil fuel consumption by sector E_j

IEA has energy balance data which include energy consumption measured in thousand tonnes of oil equivalent (ktoe) by fuel type and by sector. The total final consumption by sector includes industry sector, transportation sector, other sectors, and non-energy use. We aggregated other sectors and non-energy use and treated the industry sector as the manufacturing sector in our classification.

(3) The level of GDP Y

The GDP data in 1995 and 2005 are taken from the IEA database and measured in constant 2000 US$ and valued according to the purchasing power parity (PPP). We then extrapolated 2000 US$ into 2005 US$ by using the GDP deflator published by the US government. Thus, all GDP data are measured in billions of 2005 US$ PPP. We initially attempted to use the GDP data in 2005 taken from the *2005 International Comparison Program (ICP) Preliminary Results* report published in December 2007 which used an updated method to estimate PPPs. However, we found the new GDP 2005 data represent a new benchmark and are not comparable with previous results, which gave us unexpected growth rates for certain countries. Therefore, we use the GDP data from the IEA database that uses the previous version of PPP conversion factors.

(4) The level of GDP by sector Y_j

The UN national accounts database in the Development Data Platform (DDP) has categories of manufacturing (% of GDP) and transport and communications (current US$). Although the database has a separate row for transport value-added alone, unfortunately the data are missing for nearly all MENA countries. Thus, we used the transport and communications category as a proxy for the transport sector. We did notice the limitation of using such proxy because this category includes postal services and telecommunications which is a low-carbon intensity sector. Therefore, we could not estimate the effect of changes in the carbon-intensity of the transport sector over time, because the rapid growth of the low-carbon telecoms sector would have biased downwards the carbon intensity growth of transport and communications sectors. However, this proxy should not affect the validity of the decomposition analysis regarding the sector share effect because the growth decomposition is an identity. In addition, our assumption that communication is zero carbon is necessary to allow us to map IEA energy data onto DDP value-added data. Furthermore, we noticed that the GDP from the transport sector did not include private passenger transport. Thus, to ensure the consistency of the energy intensity effect, we further assumed that the private and commercial transport sub-sectors have grown at the same rates. Finally, the level of GDP by sector was adjusted to constant 2005 US$ PPP in billions.

(5) The population of the country *B*
Data on population is taken from the IEA database and measured in millions.

3.3 Results

Since complete GDP data by sector for the year 1995 and the year 2005 is only available for Egypt, Iran, Jordan, Morocco, and the United Arab Emirates, we present the decomposition results for these five countries only.

As shown in Table 6 and Figure 12, among these five MENA countries, Iran has the highest increase in CO_2 emissions between 1995 and 2005. In addition, Iran has the highest increase in CO_2 emission per capita and GDP per capita. This is why although Iran has significant energy efficiency improvements by sector, due to the big scale effect it still has the highest CO_2 emissions increase. Egypt and Morocco have positive energy intensity effect, which means that energy intensity is getting worse in the two countries and contributes to the increase of CO_2 emissions. Egypt has a negative sector structure, which means that the economy is moving towards less carbon intensive sectors. Among the five countries, only the UAE has a negative pollution intensity effect. It is probably due to the fact that the country has significantly reduced gas flaring over the period, as shown in Figure 13.

Table 6 Decomposition of the Changes in CO_2 Emissions between 1995 and 2005 (Mt of CO_2)

Country	Pollution Intensity	Energy Intensity	Sector Structure	Scale	Population	Change of CO_2 Emissions	CO_2 Emission per Capita (t/capita)		GDP per capita (2005 US$ PPP)	
	ΔC_C	ΔC_I	ΔC_S	ΔC_G	ΔC_B	ΔP	2005	2005-1995	2005	2005-1995
Iran	6.4	-9.5	10.4	103.3	47.1	157.8	6.0	1.7	7949	2184
Egypt	8.9	10.7	-5.6	28.2	21.4	63.6	2.0	0.6	4327	959
United Arab Emirates	-8.4	-15.9	11.8	0.9	54.1	42.6	24.4	-3.8	25472	272
Morocco	1.6	1.9	0.1	7.9	4.5	15.9	1.4	0.4	4544	978
Jordan	0.4	-1.7	0.3	2.9	3.9	5.8	3.3	0.4	5521	971

Figure 12 Decomposition of the Changes in CO_2 Emissions between 1995 and 2005 (Mt of CO_2)

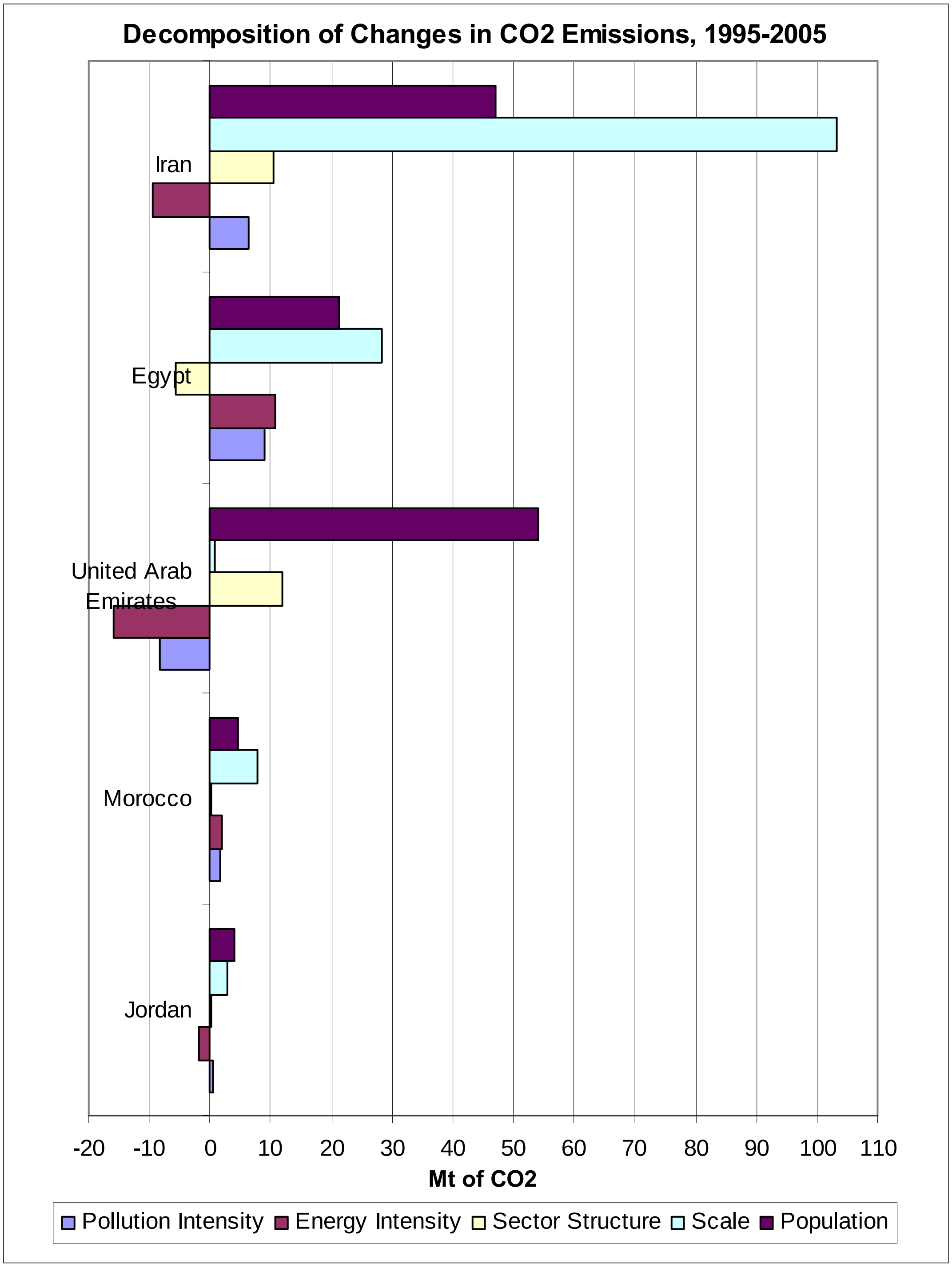
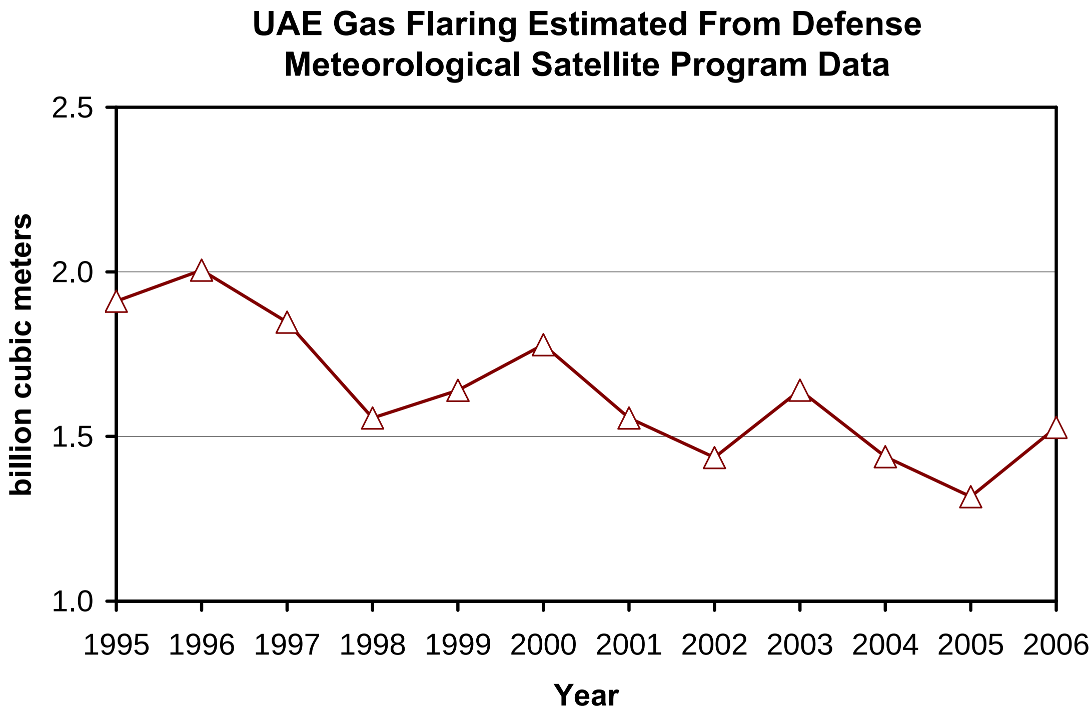


Figure 13 UAE Gas Flaring Estimated from Defense Meteorological Satellite Program Data



Source: Elvidge et al (2007)

3.4 Alternative Decomposition Method

For comparison, we applied the decomposition method used in the recent World Bank report *Growth and CO_2 Emissions: How do Different Countries Fare* (World Bank, 2007a) for MENA countries to analyze the CO_2 emissions change between 1995 and 2005. The major difference between this decomposition method and the method we used above is that this method does not consider sector structures but includes the share of fossil fuels in total energy (the substitution effect). For ease of comparison, we use the same notations here as in the report. Results are presented in Table 7 and Figure 14.

Table 8 shows comparison of the 1994-2004 CO_2 decomposition from Bacon et al (2007) and the 1995-2005 CO_2 decomposition using the same method. We see that since the two periods have significant overlaps, the results are relatively comparable, especially for GDP per capita and population effects.

Table 9 shows comparison of the decomposition results using two different methods for the five MENA countries. We denote the one includes sector structure as decomposition method 1 and the one includes the share of fossil fuels in total energy as decomposition method 2. As we expected, both methods have obtained the same scale effects and population effects. In terms of energy intensity, method 1 defines it as the fossil fuel consumption per unit of GDP while method 2 defines it as the total energy consumption per unit of GDP. Taking Iran as an example, energy intensity is negative using method 1 which means that less fossil fuel is required per unit of GDP so it negatively contributes to the CO_2 increase. However, sector structure effect is positive which means that the economy switches to more CO_2 intensive sectors and such switch contributes to the CO_2 increase. Using method 2, Iran has a positive energy intensity effect and a negative substitution effect which mean that total energy use per unit of GDP increases and such effect contributes to the CO_2 increase; but among the total energy use, the share of fossil fuel use decreases and such effect negatively contribute to the CO_2 increase. Therefore, using different decomposition methods give us different perspectives on what factors contribute to the changes of CO_2 emissions.

Table 7 Decomposition of the Change in CO_2 Emissions between 1995 and 2005 (Mt of CO_2)- Alternative Method

Country	Coefficient Effect	Substitution Effect	Energy Intensity Effect	GDP per Capita	Population	Change of CO_2 Emissions	CO_2 Emission per Capita (t of CO_2 per capita)		GDP per capita (2005 US$ PPP)	
	Ceff	Seff	Ieff	Geff	Peff	ΔE	2005	2005-1995	2005	2005-1995
Iran	3.8	-5.3	8.7	103.4	47.1	157.8	6.0	1.7	7949	2184
Saudi Arabia	-24.7	-0.2	72.7	12.4	57.1	117.2	13.8	2.9	15673	736
Egypt	9.8	-2.4	6.5	28.3	21.4	63.6	2.0	0.6	4327	959
United Arab Emirates	28.4	-7.4	-34.6	0.9	55.1	42.6	24.4	-3.8	25472	272
Kuwait	9.3	-1.6	1.8	4.2	19.4	33.2	29.4	6.4	26211	1877
Algeria	-5.2	-1.2	3.4	17.4	10.7	25.0	2.6	0.5	7046	1529
Qatar	1.1	-0.9	-5.4	11.2	11.4	17.3	44.7	8.5	43235	14756
Morocco	0.6	0.4	2.5	7.9	4.5	15.9	1.4	0.4	4544	978
Israel	9.2	-5.6	-6.7	5.1	11.7	13.5	8.7	0.3	25816	2380
Iraq	-1.7	0.1	-17.9	10.0	22.4	12.9	2.9	-0.4	1016	121
Oman	2.5	0.0	3.9	2.9	3.3	12.6	10.5	3.9	15503	2093
Libya	-0.4	-2.2	1.2	3.9	7.8	10.3	7.8	0.5	7884	736
Yemen	0.9	0.0	2.6	1.5	4.3	9.4	0.9	0.3	928	98
Syria	8.7	-4.2	-8.5	2.2	11.0	9.1	2.5	-0.1	3799	194
Bahrain	2.0	-0.6	-2.0	4.0	3.4	6.7	25.2	5.3	21337	5000
Jordan	-0.3	-0.3	-0.4	2.9	3.9	5.8	3.3	0.4	5521	971
Tunisia	0.5	-0.8	-2.9	6.3	1.9	5.0	1.9	0.3	8350	2635
Lebanon	3.4	-1.4	-3.1	2.6	1.7	3.2	4.4	0.5	5566	950

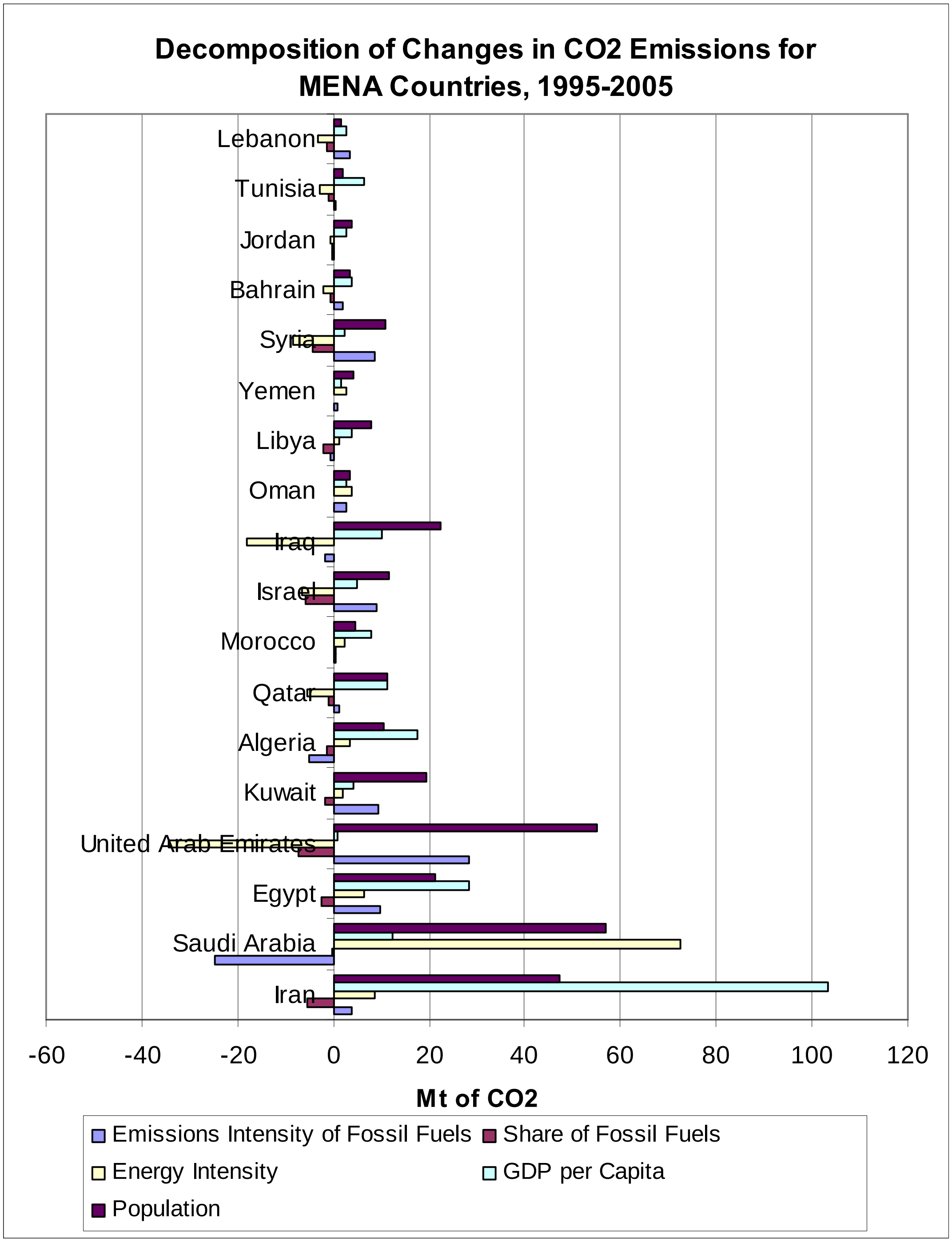
Table 8 Comparison of the 1994-2004 CO_2 Decomposition and the 1995-2005 CO_2 Decomposition

Country	Period	Coefficient Effect	Substitution Effect	Energy Intensity Effect	GDP per Capita	Population	Change of CO_2 Emissions
		Ceff	Seff	Ieff	Geff	Peff	ΔE
Algeria	1994-2004	-6.7	-0.3	-30.4	18.2	12.4	-6.9
Algeria	1995-2005	-5.2	-1.2	3.4	17.4	10.7	25.0
Bahrain	1994-2004	-0.3	0.0	-1.7	4.4	4.5	7.0
Bahrain	1995-2005	2.0	-0.6	-2.0	4.0	3.4	6.7
Egypt	1994-2004	-11.4	2.6	5.8	29.8	22.9	49.7
Egypt	1995-2005	9.8	-2.4	6.5	28.3	21.4	63.6
Iran	1994-2004	-27.3	1.3	35.2	107.5	36.6	153.1
Iran	1995-2005	3.8	-5.3	8.7	103.4	47.1	157.8
Israel	1994-2004	-1.6	0.2	0.7	5.3	13.5	18.1
Israel	1995-2005	9.2	-5.6	-6.7	5.1	11.7	13.5
Morocco	1994-2004	-0.9	-0.9	-4.6	3.9	4.4	1.9
Morocco	1995-2005	0.6	0.4	2.5	7.9	4.5	15.9
Oman	1994-2004	-0.3	0.0	2.0	3.1	3.4	8.3
Oman	1995-2005	2.5	0.0	3.9	2.9	3.3	12.6
Saudi Arabia	1994-2004	-6.6	0.0	70.9	-18.7	81.2	126.8
Saudi Arabia	1995-2005	-24.7	-0.2	72.7	12.4	57.1	117.2
Syria	1994-2004	-1.2	0.7	-2.3	2.6	12.0	11.9
Syria	1995-2005	8.7	-4.2	-8.5	2.2	11.0	9.1
Tunisia	1994-2004	-1.3	-0.1	-2.5	6.4	2.2	4.9
Tunisia	1995-2005	0.5	-0.8	-2.9	6.3	1.9	5.0
United Arab Emirates	1994-2004	-4.6	0.0	-21.6	2.0	71.7	47.4
United Arab Emirates	1995-2005	28.4	-7.4	-34.6	0.9	55.1	42.6

Table 9 Comparison of Results of Using Two Decomposition Methods

	Decomposition Method	Pollution Intensity/ Coefficient Effect	Energy Intensity	Sector Structure/ Substitution Effect	Scale	Population	Change of CO_2 Emissions
Iran	1	6.4	-9.5	10.4	103.3	47.1	157.8
Iran	2	3.8	8.7	-5.3	103.4	47.1	157.8
Egypt	1	8.9	10.7	-5.6	28.2	21.4	63.6
Egypt	2	9.8	6.5	-2.4	28.3	21.4	63.6
United Arab Emirates	1	-8.4	-15.9	11.8	0.9	54.1	42.6
United Arab Emirates	2	28.4	-34.6	-7.4	0.9	55.1	42.6
Morocco	1	1.6	1.9	0.1	7.9	4.5	15.9
Morocco	2	0.6	2.5	0.4	7.9	4.5	15.9
Jordan	1	0.4	-1.7	0.3	2.9	3.9	5.8
Jordan	2	-0.3	-0.4	-0.3	2.9	3.9	5.8

Figure 14 Decomposition of the Change in CO_2 Emissions between 1995 and 2005 (Mt of CO_2)- Alternative Method



4. GHG Emissions and Energy Efficiency Analysis by Sector

4.1 Estimating Changes in CO_2 Emissions by Scenario of Improved Energy Efficiency by Sector

As analyzed in Chapter 3, CO_2 emissions can be decomposed as the following.

(8) $$P = \sum_j \frac{P_j}{E_j} \frac{E_j}{Y_j} \frac{Y_j}{Y} \frac{Y}{B} B = \sum_j C_j I_j S_j GB$$

j=1, transportation sector
j=2, manufacturing sector
j=3, energy and other sectors.

In this chapter, we are interested in how energy intensity (energy efficiency) I_j change would affect the total CO_2 emissions P, assuming other factors do not change. Equation (8) can be rewritten as

(9) $$P = \sum_j A_j I_j ,$$

where $A_j = C_j S_j GB$, a combined factor.

We use the year 2005 as the baseline and consider three scenarios: energy efficiency improvement (i.e. energy intensity reduction) by 10% in transportation sector, manufacturing sector, and energy and other sectors. The results are presented in Table 10. In Scenario 1 if energy efficiency is improved by 10% in the transportation sector, MENA countries can achieve a total CO_2 emissions reduction of 1-3.5% and Iraq has the highest reduction of 3.5%. In Scenario 2, if the manufacturing sector has an energy efficiency improvement of 10%, the total CO_2 emissions reduction in MENA countries is in the range of 1-3%, with the highest reduction of 2.86% in the United Arab Emirates. In Scenario 3, if energy efficiency is improved by 10% in energy and other sectors, the total CO_2 emissions reduction is in the range of 4-8% and Israel has the highest reduction of 8.05%.

Table 10 CO_2 Emissions Reduction by Scenario of Energy Efficiency Improvements by Sector

Country	A1	A2	A3	Baseline: 2005				Scenario 1: 10% EE improvement in Transportation sector			Scenario 2: 10% EE improvement in Manufacturing sector			Scenario 3: 10% EE improvement in other sectors		
				P	I1	I2	I3	I1_new	P_new	% change of P	I2_new	P_new	% change of P	I3_new	P_new	% change of P
Algeria	0.02	0.04	1.00	84.29	746.35	279.11	55.10	671.72	82.51	2.11%	251.20	83.17	1.33%	49.59	78.76	6.56%
Bahrain	0.00	0.01	1.40	18.31	1553.27	428.43	8.28	1397.94	18.05	1.45%	385.58	17.91	2.21%	7.45	17.15	6.34%
Egypt	0.06	0.21	2.01	147.60	498.57	180.16	39.05	448.71	144.44	2.14%	162.14	143.86	2.53%	35.15	139.74	5.33%
Islamic Republic of Iran	0.19	0.26	2.44	407.08	521.83	290.13	94.39	469.65	397.05	2.46%	261.12	399.44	1.88%	84.96	384.05	5.66%
Iraq	0.02	0.00	0.80	84.64	1752.77	3709.65	46.68	1577.49	81.68	3.50%	3338.69	82.89	2.07%	42.01	80.89	4.43%
Israel	0.02	0.16	1.43	59.86	537.82	11.67	33.66	484.04	58.87	1.65%	10.51	59.68	0.30%	30.30	55.04	8.05%
Jordan	0.01	0.01	0.13	17.90	577.23	205.26	77.11	519.51	17.42	2.67%	184.73	17.61	1.63%	69.40	16.88	5.70%
Kuwait	0.02	0.01	2.21	74.63	531.45	1507.67	24.49	478.30	73.83	1.08%	1356.90	73.39	1.66%	22.04	69.21	7.26%
Lebanon	0.01	0.02	0.38	15.80	621.02	178.80	22.77	558.92	15.40	2.51%	160.92	15.48	2.02%	20.49	14.94	5.47%
Libya	0.01	0.06	0.32	45.40	1463.20	127.03	81.56	1316.88	44.23	2.58%	114.33	44.67	1.61%	73.40	42.76	5.81%
Morocco	0.02	0.06	0.50	41.34	110.79	124.74	64.33	99.71	41.16	0.44%	112.26	40.62	1.73%	57.90	38.10	7.83%
Oman	0.00	0.01	1.81	26.98	930.64	380.55	10.10	837.58	26.62	1.34%	342.49	26.47	1.89%	9.09	25.15	6.77%
Qatar	0.01	0.06	0.38	36.37	971.87	151.33	55.07	874.68	35.76	1.69%	136.20	35.47	2.49%	49.56	34.25	5.83%
Saudi Arabia	0.05	0.34	2.26	319.68	1554.84	208.33	77.74	1399.36	312.43	2.27%	187.50	312.54	2.23%	69.97	302.11	5.50%
Syria	0.03	0.03	0.46	47.76	436.03	379.47	57.06	392.43	46.59	2.46%	341.52	46.78	2.05%	51.36	45.14	5.49%
Tunisia	0.01	0.04	0.31	19.29	461.98	96.62	35.13	415.78	18.84	2.35%	86.96	18.90	2.00%	31.62	18.20	5.65%
United Arab Emirates	0.02	0.04	4.02	110.38	1136.47	707.10	14.14	1022.82	108.17	2.00%	636.39	107.23	2.86%	12.73	104.70	5.15%
Yemen	0.01	0.01	0.23	18.69	442.93	257.63	46.57	398.64	18.07	3.31%	231.87	18.51	0.98%	41.91	17.62	5.71%

4.2 Benchmarking Energy Consumption and CO_2 Emissions in the Manufacturing Sector

To compare energy consumption and CO_2 emissions per dollar of output in the manufacturing sector in MENA countries, we used energy consumption and CO_2 emissions data from IEA and the manufacturing output data from DDP. Since manufacturing output data are only available for eight MENA countries, we report the results for these eight countries in Figure 15 and Table 11. The UAE has the highest energy consumption and CO_2 emissions per dollar of manufacturing output among the eight countries. It means that the UAE has the worst energy intensity and pollution intensity in the manufacturing sector. This result is also consistent with the result in Chapter 3.1 that energy efficiency improvements in the manufacturing sector in the UAE will achieve the highest CO_2 reduction among MENA countries.

In terms of region/group comparison, we select EAP, ECA, LAC, upper middle income group, and lower middle income group as comparators. As shown in Table 12 and Figure 16, the MENA region ranks the first among the comparators in terms of CO_2 emissions per dollar of output in the manufacturing sector and ranks second in terms of energy consumption per dollar of output in the manufacturing sector. This result shows that the MENA region has very high pollution intensity and energy intensity in the manufacturing sector and has great potential for energy efficiency improvement in this sector.

Figure 15 Energy Consumption and CO_2 Emissions per Dollar of Output in the Manufacturing Sector by MENA Countries, 2005

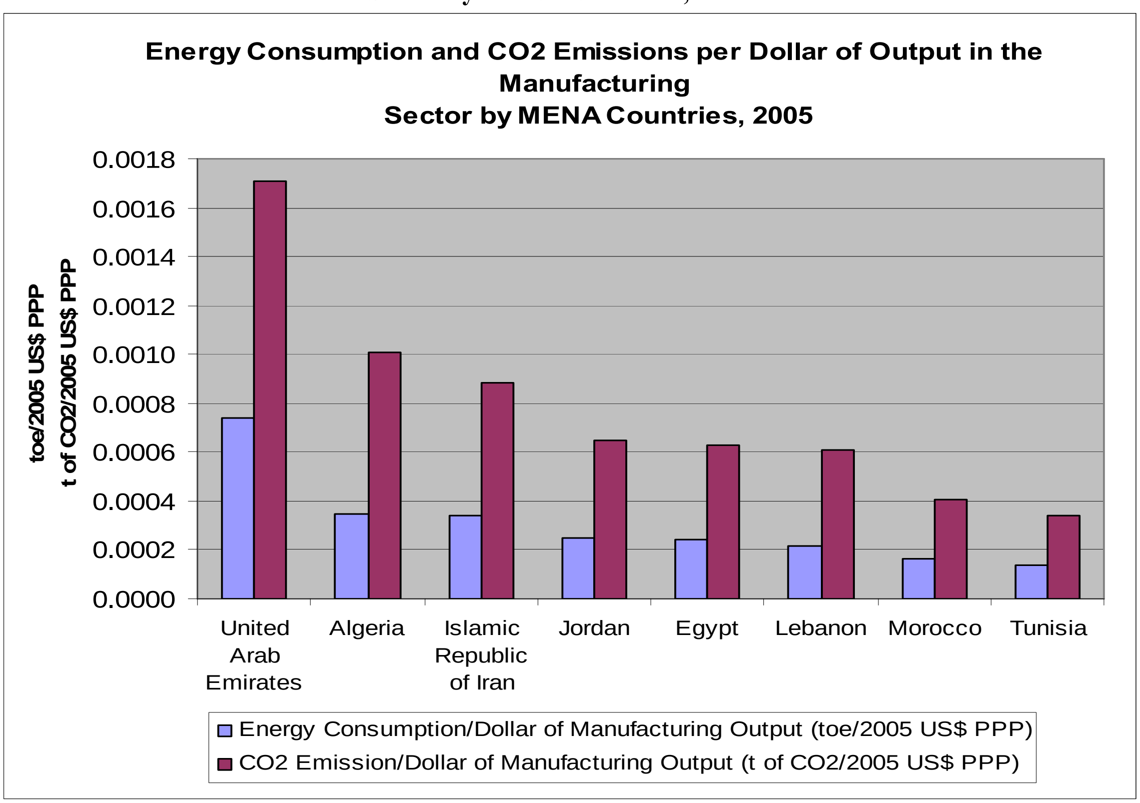


Table 11 Energy Consumption and CO_2 Emissions per Dollar of Output in the Manufacturing Sector by MENA Countries, 2005

Country	Manufacturing Output (2005 US$ PPP in billions)	CO_2 Emission in Manufacturing Sector (Mt of CO_2)	Total Energy Consumption in Manufacturing Sector (ktoe)	Energy Consumption/Dollar of Manufacturing Output (toe/2005 US$ PPP)	CO_2 Emission/Dollar of Manufacturing Output (t of CO_2/2005 US$ PPP)
United Arab Emirates	18.472468	31.52	13616.588	0.00074	0.00171
Algeria	11.106486	11.18	3861.516	0.00035	0.00101
Islamic Republic of Iran	86.400948	76.43	29313.325	0.00034	0.00088
Jordan	4.5125295	2.91	1128.67	0.00025	0.00064
Egypt	59.556768	37.41	14275.592	0.00024	0.00063
Lebanon	5.2133339	3.19	1135.166	0.00022	0.00061
Morocco	17.737661	7.16	2873.856	0.00016	0.00040
Tunisia	11.362116	3.86	1547.73	0.00014	0.00034

Table 12 Energy Consumption and CO_2 Emissions per Dollar of Output in the Manufacturing Sector by Region/Group, 2005

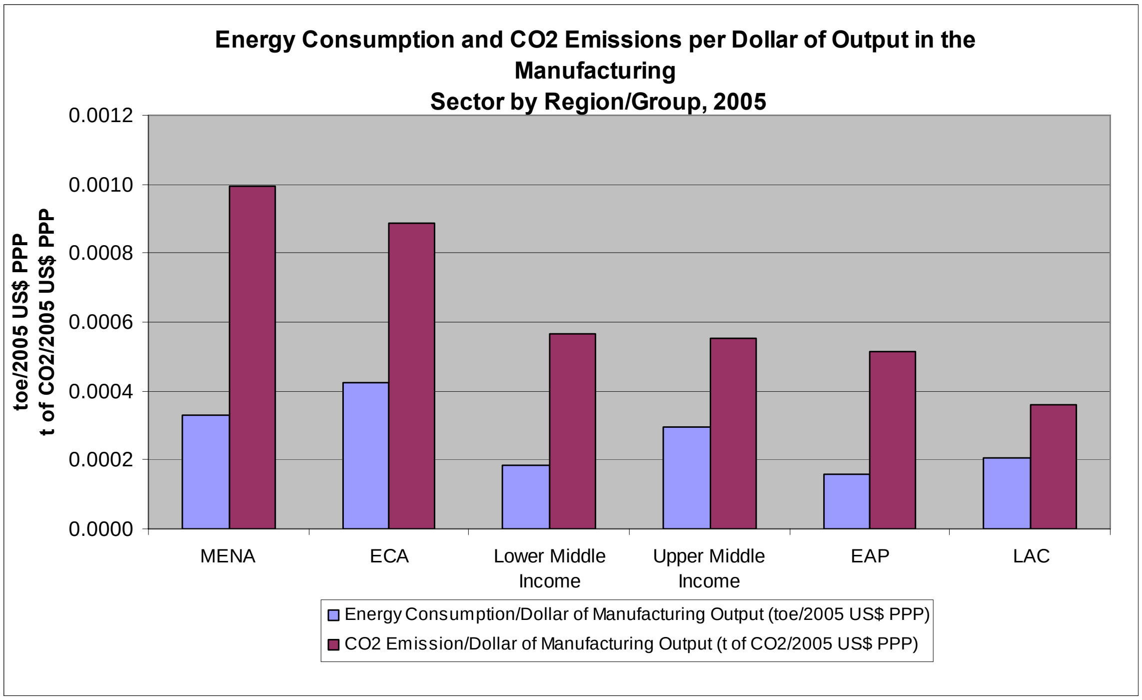
Region/Group [a]	Manufacturing Output (2005 US$ PPP in billions)	CO_2 Emission in Manufacture Sector (Mt of CO_2)	Total Energy Consumption in Manufacturing Sector (ktoe)	Energy Consumption/ Dollar of Manufacturing Output (toe/2005 US$ PPP)[b]	CO_2 Emission/Dollar of Manufacturing Output (t of CO_2/2005 US$ PPP)
MENA	315.87	313.98	103828.66	0.00033	0.00099
ECA	489.49	433.68	208514.68	0.00043	0.00089
Lower Middle Income	3666.91	2073.37	671729.83	0.00018	0.00057
Upper Middle Income	1057.97	584.84	311001.08	0.00029	0.00055
EAP	3619.26	1860.59	579775.12	0.00016	0.00051
LAC	654.93	237.07	134855.84	0.00021	0.00036

Notes:

a. Regions and income groups are based on the World Bank's classification and only cover countries that have available data for this analysis.

b. GDP data used in this table is from IEA and measured in 2000 US$ PPP and then converted to 2005 US$ PPP using the GDP deflator.

Figure 16 Energy Consumption and CO_2 Emissions per Dollar of Output in the Manufacturing Sector by Region/Group, 2005



4.3 Benchmarking Energy Consumption and CO_2 Emissions in the Residential Sector

To compare energy consumption and CO_2 emissions per unit of GDP per capita in residential sector for MENA countries, we used 2005 energy consumption and CO_2 emissions data in the residential sector from IEA. GDP data for 2005 are from the latest ICP report and the population data are from the IEA database. The results are presented in Figure 17 and Table 13, which show significant variations among MENA countries in terms of the two indicators. The UAE is well above other MENA countries in term of both energy consumption and CO_2 emissions per unit of GDP per capita in the residential sector. Libya has the lowest energy intensity and pollution intensity in terms of the two indicators.

In terms of region/group comparison, as shown in Table 14 and Figure 18, the MENA region has the relative low energy consumption and CO_2 emissions per unit of GDP per capita in the residential sector. The LAC region ranks the lowest among the comparators.

Figure 17 Energy Consumption and CO_2 Emission per unit of GDP per Capita in the Residential Sector by MENA Countries, 2005

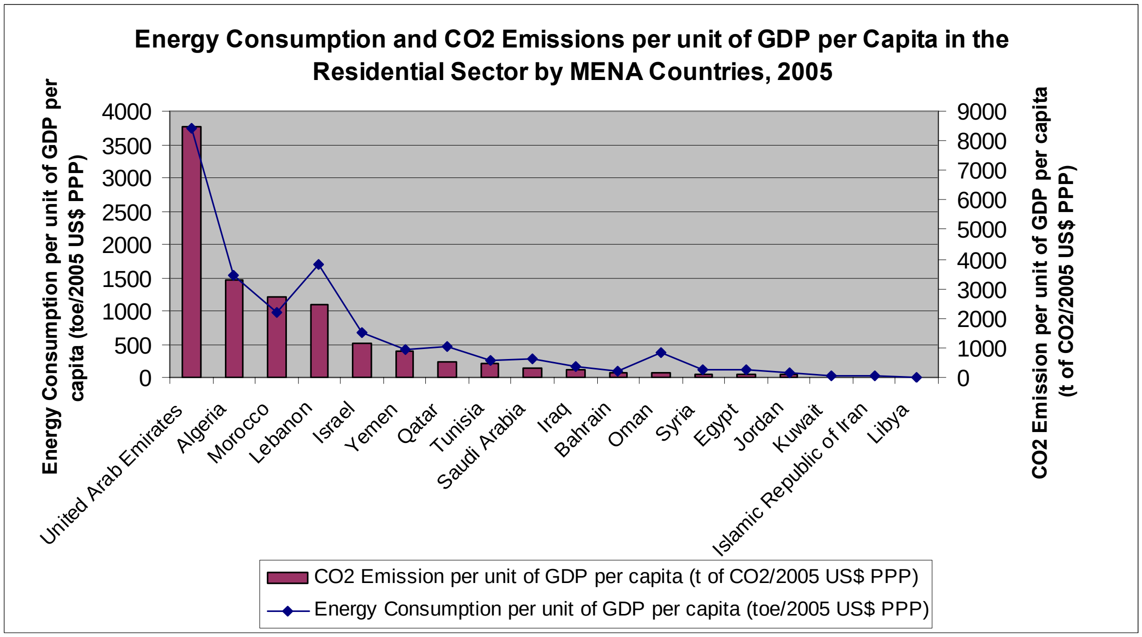


Table 13 Energy Consumption and CO_2 Emissions per unit of GDP per Capita in the Residential Sector by MENA Countries, 2005

Country	Total Energy Consumption in Residential Sector (ktoe)	Total CO_2 Emissions in Residential Sector (Mt of CO_2)	GDP per Capita (2005 US$ PPP)	Energy Consumption per unit of GDP per capita (toe/2005 US$ PPP)	CO_2 Emission per unit of GDP per capita (t of CO_2/2005 US$ PPP)
United Arab Emirates	40399.17	91.11	10762	3753.905	8465.973
Algeria	9151.90	19.75	5985	1529.139	3299.916
Morocco	3023.90	8.39	3104	974.067	2702.611
Lebanon	8154.42	11.79	4775	1707.699	2469.063
Israel	2409.72	4.05	3550	678.816	1140.882
Yemen	918.71	1.99	2202	417.195	903.684
Qatar	1877.64	2.12	3944	476.035	537.481
Tunisia	1063.44	2.13	4296	247.533	495.791
Saudi Arabia	1872.90	1.94	6461	289.894	300.281
Iraq	1750.68	2.77	10727	163.203	258.227
Bahrain	945.73	1.89	10726	88.169	176.203
Oman	8138.84	3.74	21237	383.238	176.108
Syria	3045.59	3.72	28930	105.274	128.586
Egypt	2876.51	2.61	22645	127.029	115.260
Jordan	3184.42	4.02	43504	73.198	92.405
Kuwait	515.49	0.28	19883	25.926	14.082
Islamic Republic of Iran	453.22	0.23	27671	16.379	8.312
Libya	320.10	0.14	69012	4.638	2.029

Table 14 Energy Consumption and CO_2 Emissions per unit of GDP per Capita in the Residential Sector by Region/Group, 2005

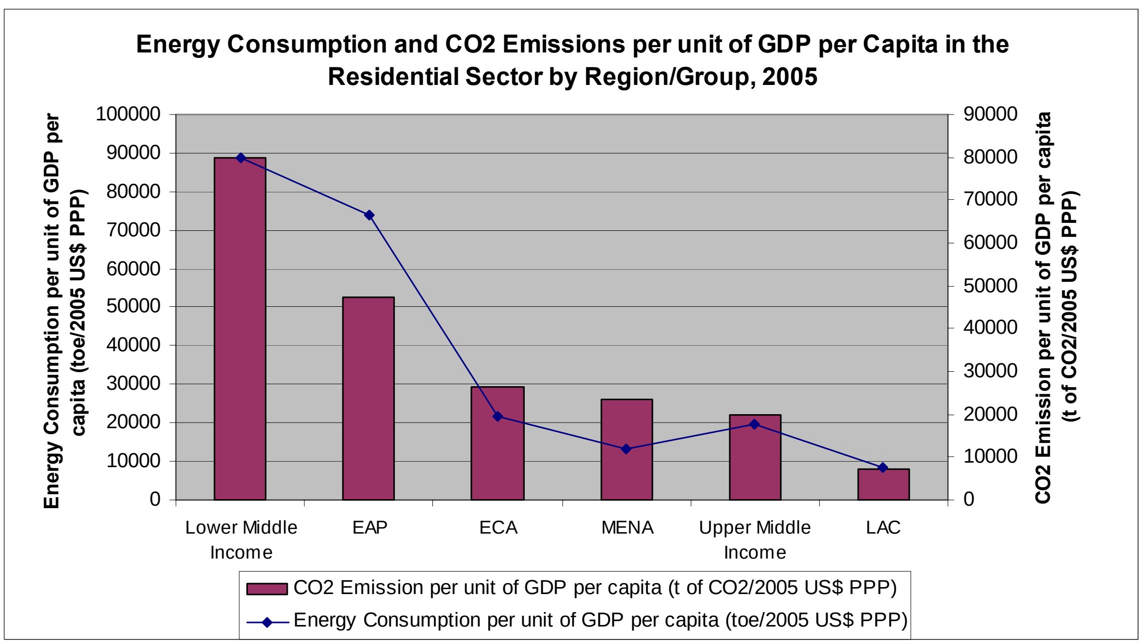
Region/Group [a]	Total Energy Consumption in Residential Sector (ktoe)	Total CO_2 Emissions in Residential Sector (Mt of CO_2)	GDP per Capita (2005 US$ PPP) [b]	Energy Consumption per unit of GDP per capita (toe/2005 US$ PPP)	CO_2 Emission per unit of GDP per capita (t of CO_2/2005 US$ PPP)
Lower Middle Income	543764.31	489.42	6120.79	88838.85	79960.22
EAP	447632.24	287.50	6052.67	73956.16	47499.70
ECA	181619.92	218.68	8326.02	21813.54	26264.66
MENA	90102.36	162.67	6893.67	13070.30	23597.00
Upper Middle Income	194814.68	196.29	9816.75	19845.12	19995.41
LAC	66714.40	57.82	7944.24	8397.83	7278.23

Notes:

a. Regions and income groups are based on the World Bank's classification and only cover countries that have available data for this analysis.

b. GDP and population data used in this table is from IEA and measured in 2000$ PPP and then converted to 2005 US$ PPP using the GDP deflator.

Figure 18 Energy Consumption and CO_2 Emissions per unit of GDP per Capita in the Residential Sector by Region/Group, 2005



5. PM Concentrations in MENA

Combustion of fossil fuels for power generation, transportation, industry, and other human activities produce a complex mixture of particular matter (PM) and gaseous pollutants, with serous health consequences for the exposed population. Fine particles less than 10 microns (μm) (PM10) and especially less than 2.5 μm (PM2.5) in diameter are considered the most harmful to health because they are small enough to be inhaled and transported deep into the lungs. The concentration of PM10 (in micrograms per cubic meter, or μg/m3) is used in this study as the indicator of air pollution.

5.1 Cost of Environmental Degradation Studies in MENA

During the period 2001-2005, Cost of Environmental Degradation Studies were prepared for eight MENA countries by the World Bank to provide a first order of magnitude of the cost of environmental degradation as a percentage of GDP as regards to the health impacts of air pollution and waterborne illnesses, the economic cost of water resources and soil/land degradation, impacts related to waste management, and the cost of coastal zone degradation (Sarraf et al, 2004). The studies rely on existing data and analysis of environmental issues, and apply commonly used methodologies of valuation and quantitative impact assessments to country specific issues in order to arrive at estimates of the cost of degradation. Urban air pollution dose response coefficients from international studies reflecting acute mortality of particulates (PM) have been applied in all the eight country reports. The summary of damage costs of air pollution by the eight MENA countries is presented in Table 15. Among the eight studied countries, Egypt has the highest damage cost of air pollution as the percentage of GDP and air pollution is the leading category that has the most significant impacts on health and quality of life in Egypt.

Table 15 Cost of Environmental Degradation Studies: Damage Costs of Air Pollution by MENA Country

Country	Reference Year	US$/Year (millions)	% of GDP	Number of estimated annual premature death due to urban air pollution	Total Disability Adjusted Life Years (DALYs)	% of overall estimated cost of environmental degradation to the country
Algeria	1999	446	0.9%	N/A	157,000	26%
Egypt	2001	1,890	2.1%	20,000	450,000	44%
Iran	2002	1,810	1.6%	13,200	191,000	21%
Jordan	2000	64	0.8%	600	15,300	28%
Lebanon	2000	170	1.0%	350	9,000	30%
Morocco	2000	340	1.0%	2,300	73,000	28%
Syria	2001	218	1.2%	3,400	95,000	35%
Tunisia	1999	121	0.6%	590	15,000	28%

Note: damage cost due to air pollution includes both urban air pollution and indoor air pollution (IAP). However, IAP is minimal in Syria and Jordan since there is nearly universal access to commercial fuels.
Source: compiled by the author from Cost of Environmental Degradation Studies in MENA.

5.2 The 2006 Little Green Data Book and the GMAPS

Because Cost of Environmental Degradation Studies are not available for all MENA countries and their reference years are not all the same, we use the *2006 Little Green Data Book* by the World Bank as the primary source for the following analysis of urban air pollution. The PM data in the *Little Green Data Book* were estimated using the Global Model of Ambient Particulates (GMAPS) (Cohen et al, 2004) developed at the World Bank. The GMAPS model is used to generate estimates of concentrations of PM10 in all world cities with a population of >100,000. The GMAPS model econometrically estimates a fixed-effect model of the concentrations of urban ambient PM using the latest available data from a sample of cities from the World Health Organization (WHO) and other sources and then uses regression estimates to predict PM concentrations worldwide.

The primary determinants of the GMAPS include the scale and composition of economic activity, the energy mix, the strength of local regulation of pollution, and geographic and atmospheric conditions that affect the transport of pollutants. The GMAPS is a log-log linear model. The dependent variable is log [PM10] and the independent variables are the log form of the following variables plus time-tend variables:

- -Energy consumption,
- -Meteorological and geographic factors,
- -City and national population and national population density,
- -Local population density,
- -Local intensity of economic activity, and
- -National income per capita.

The GMAPS model is designed to obtain the best city-level prediction of concentrations of PM for a wide range of cities on the basis of the limited amount of data. Subregion PM concentrations are computed from estimates of concentrations of PM10 in the cities, using the populations of each city as weights.

In terms of the cost of PM emissions, the *2006 Little Green Data Book* uses a percentage of 2004 gross national income (GNI) to provide an order of magnitude. It is also useful to compare the cost of air pollution to GNI to assess the relative magnitude over time.

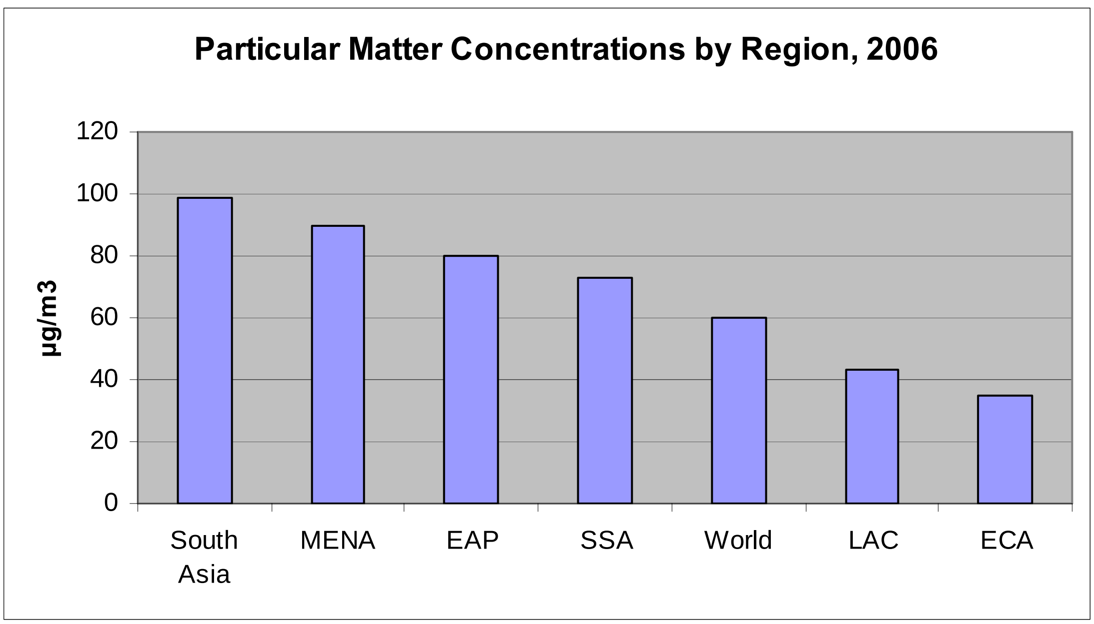
The process of estimating the cost of air pollution involves placing a monetary value on the consequences of air pollution. A three-step process is usually used. Step (1) is to translate PM levels to health effects -- mortality and morbidity by age/sex for each country. The concentration response relationships are the same for all countries. These define the percentage increase in health effects for each unit increase in PM levels. The concentration-response functions vary by the age of a person. As a result, the health effects for a country depend on population characteristics (age structure) and baseline health characteristics. This step is outlined in Cohen et al (2004). Step (2) is to translate health effects to economic costs. The lost lives and morbidity effects are translated to Disability Adjusted Life Years (DALYs). Since DALYS are age/sex dependent, demographic characteristics are also important in this step. Finally, Step (3) is to translate DALYS to monetary costs. This requires valuation of a statistical life. This is assumed to vary in proportion to GNI.

5.3 Magnitude of PM Concentrations in MENA

According to the *2006 Little Green Data Book*, as shown in Figure 19, the MENA region is the second most polluting region in terms of PM concentrations, only behind South Asia. The estimated PM concentration weighted by the share of the urban population [weighted average concentration] is 90 µg/m^3, which is 50% higher than the world average.

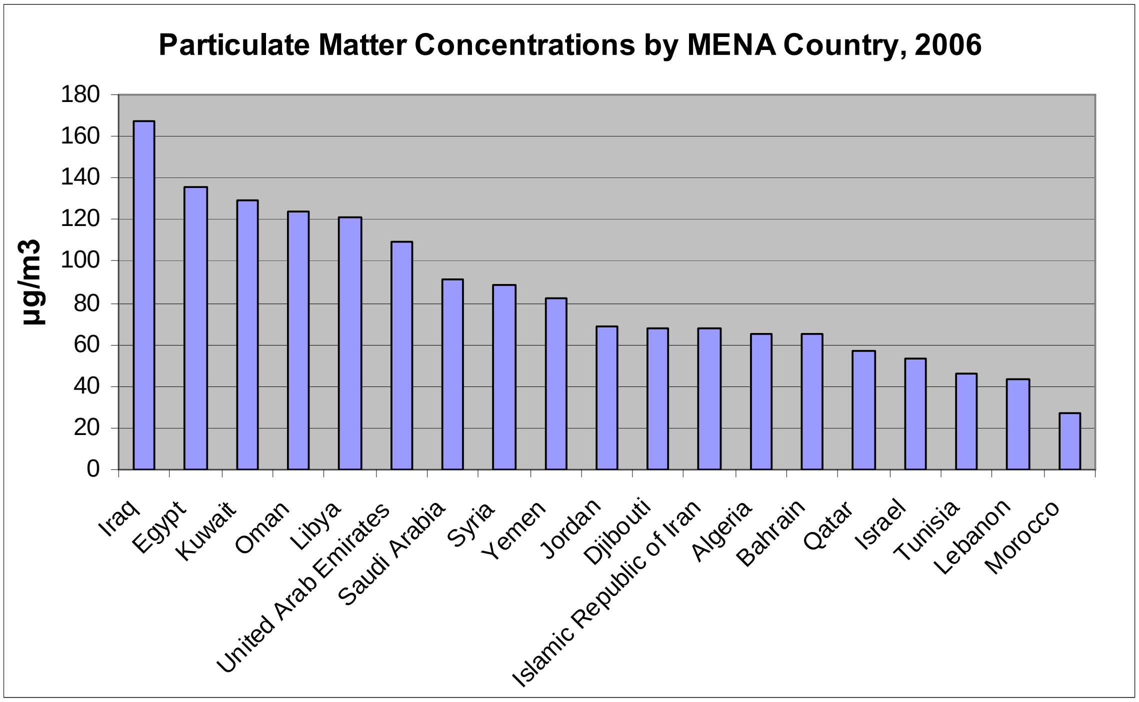
Within the MENA region, as shown in Figure 20, Iraq has the highest PM concentration (167 µg/m^3), followed by Egypt, Kuwait, Oman, Libya, United Arab Emirates, and Saudi Arabia, which are all above the region's average.

Figure 19 Particular Matter Concentrations by Region, 2006



Source: World Bank, *2006 Little Green Data Book*

Figure 20 Particular Matter Concentrations by MENA Country, 2006



Source: World Bank, *2006 Little Green Data Book*

5.4 Damage Costs of PM Emissions in MENA

In terms of magnitude of current damage costs of PM emissions, as we mentioned earlier, the *2006 Little Green Data Book* provides particulate emission damage as a percentage of 2004 GNI as the indicator. As shown in Table 16 and Figure 21, the MENA region ranks the second highest, following the EAP region. Damage cost due to PM emissions is equivalent to 0.9% of the 2004 GNI in the MENA region (about $5.3 billion), well above the world average of 0.5%.

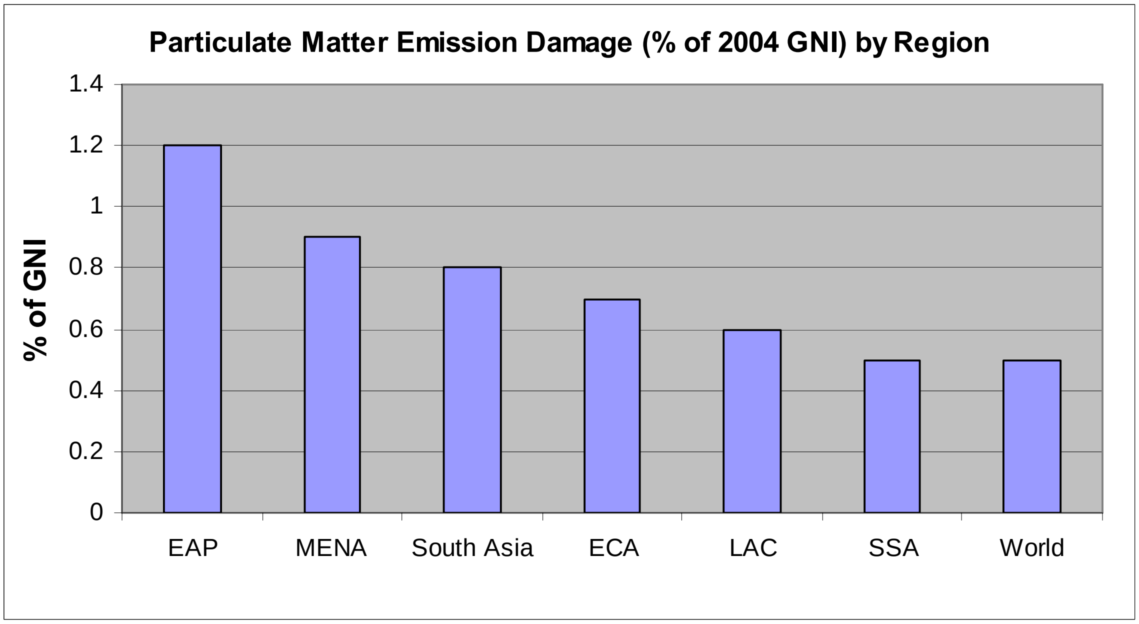
Within the MENA region, as shown in Table 16 and Figure 22, Iraq and Kuwait have the highest damage cost of PM emission--2.7% of GNI, more than five times the world average. Most MENA countries have higher than the world average damage costs of PM emissions, except for Yemen, Tunisia, and Morocco.

Table 16 PM Concentrations and Damages by MENA Country and by Region

Country/Region	Particulate matter (urban-pop.-weighted avg., µg/m3)	Particulate emission damage (% of GNI)
MENA Country		
Iraq	167	2.7
Egypt	136	1.7
Kuwait	129	2.7
Oman	124	1.1
Libya	121	..
United Arab Emirates	109	2.5
Saudi Arabia	91	1
Syria	89	1
Yemen	82	0.5
Jordan	69	0.9
Djibouti	68	..
Islamic Republic of Iran	68	0.9
Algeria	65	0.7
Bahrain	65	0.6
Qatar	57	1.3
Israel	53	1.2
Tunisia	46	0.4
Lebanon	43	0.9
Morocco	27	0.3
Region		
EAP	80	1.2
MENA	90	0.9
South Asia	99	0.8
ECA	35	0.7
LAC	43	0.6
SSA	73	0.5
World	60	0.5

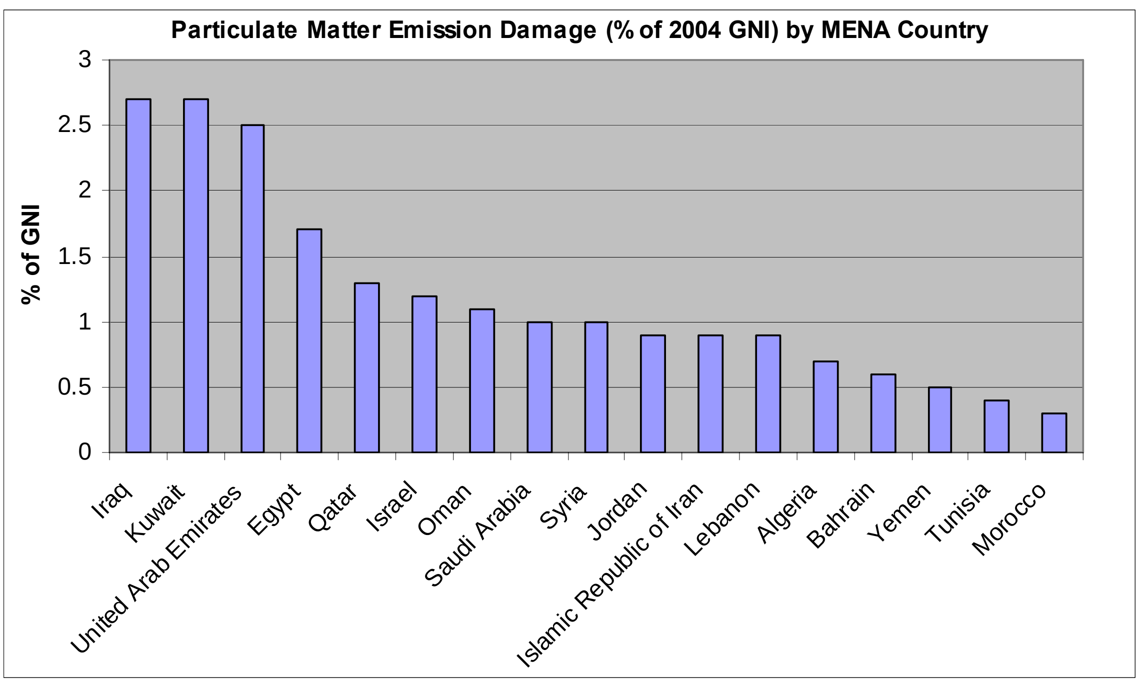
Source: World Bank, *2006 Little Green Data Book*

Figure 21 Particulate Matter Emission Damage (% of GNI in 2004) by Region



Source: World Bank, *2006 Little Green Data Book*

Figure 22 Particulate Matter Emission Damage (% of GNI in 2004) by MENA Country



Source: 2006 Little Green Data Book

5.5 Estimating Changes in PM Concentrations by Scenario of Improved Energy Efficiency

We used results from the GMAPS to estimate change in PM concentrations by scenario of improved energy efficiency. Among the GMAPS independent variables, energy consumption variables are of our primary interest. The model includes six separate per capita energy consumption categories-coal, oil, natural gas, nuclear, hydro-electric, and combustible renewables and wastes. In addition, it includes per capita consumption of petrol and diesel used in the transportation sector. All the energy consumption data are from IEA.

The method for estimating change in PM concentrations by scenario of improved energy efficiency can be illustrated in Figure 23. We assume energy consumption is inversely proportional to energy efficiency, given all other factors do not change. The GMAPS estimated coefficients for energy consumption variables are summarized in Table 1. Note that the model is designed to provide stable predictions under a wide domain space and may not be able to provide all cause-effect relationships of individual factors. Although the model specification assumes independent relationships among fuel types, some fuel types are substitutable (e.g. gasoline and diesel in the transportation sector). Thus, the coefficients which can be interpreted as elasticities capture both a scale effect and a substitution effect. This is why we see a negative sign for the gasoline variable coefficient. Therefore, the following results should be interpreted based on this limitation of the model.

As shown in Table 17, per capita oil consumption has the highest coefficient, followed by per capita diesel and coal consumption. This implies that energy efficiency improvements that will lead to decreased per capita consumption in oil, diesel and coal will achieve higher PM concentration reductions. For example, if a country is able to reduce per capita oil consumption by 10% through an energy efficiency program, such program will result in 5.9% of reduction in PM concentrations. Similarly, if an energy efficiency program is targeted to reduce per capita diesel consumption in the transportation sector by 10%, PM concentrations are expected to be reduced by 1.1%.

We assume three scenarios of reduced energy consumption from improved energy efficiency: per capita coal, oil, and diesel consumption are reduced by 10%, 20%, and 30%. Table 18 and Figure 24 present the results for each MENA country under the three scenarios. Since Iraq has the highest PM concentrations in the baseline, it achieves the highest reduction in PM concentrations in absolute terms, from 167 $\mu g/m^3$ to 129 $\mu g/m^3$ in Scenario 3. Also under Scenario3, the MENA region as a whole is able to reduce PM concentrations to 70 $\mu g/m^3$, a 22% reduction from the baseline.

Table 17 The GMAPS Estimated PM Emission Coefficients for Variables on Energy Consumption

Variable on Energy Consumption	Description	Estimated PM Emission Coefficients
lnymotorgaspc	ln country per capita motor gasoline consumption	-0.1408
lnygasdiespc	ln country per capita diesel consumption	0.1123
lnycoalpc	ln country per capita coal consumption	0.0557
lnyhydpc	ln country per capita hydro consumption	-0.0850
lnynatgaspc	ln country per capita natural gas consumption	-0.0489
lnynucpc	ln country per capita nuclear consumption	-0.0036
lnycmrepc	ln country per capita combustible and renewable consumption	-0.0654
lnyoilallpc	ln country per capita oil consumption	0.5867

Source: the GMAPS model result.

Figure 23 The Approach Used to Estimate Change in PM Concentrations by Scenario of Improved Energy Efficiency

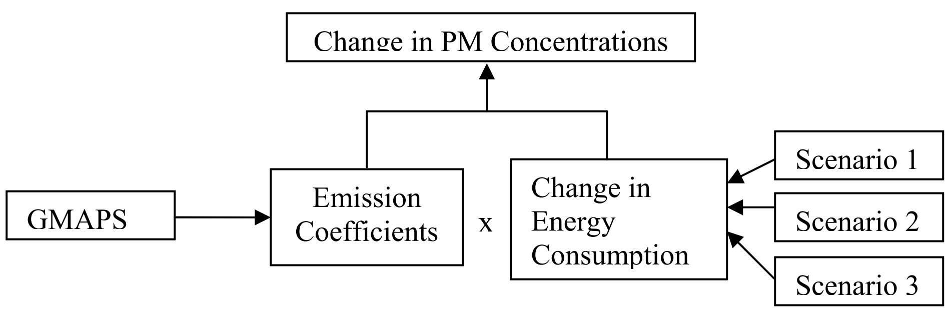
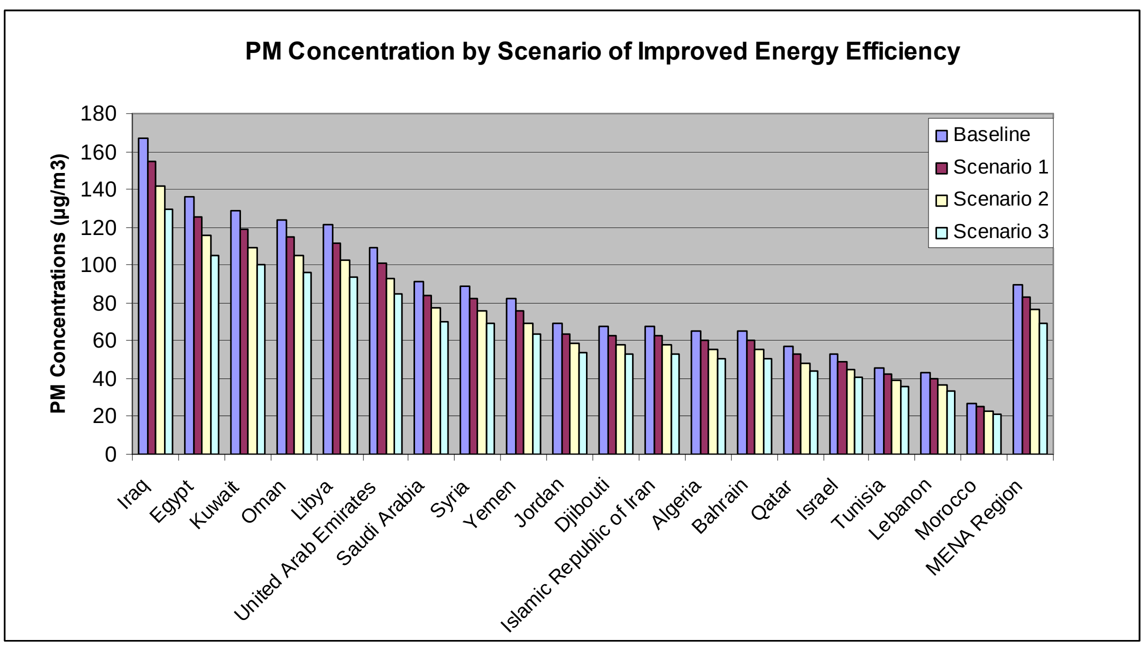


Table 18 PM Concentrations (µg/m3) by Scenario of Improved Energy Efficiency

MENA Country	Baseline	Scenario 1 10% reduction in per capita coal, oil, and diesel consumption	Scenario 2 20% reduction in per capita coal, oil, and diesel consumption	Scenario 3 30% reduction in per capita coal, oil, and diesel consumption
Iraq	167	154	142	129
Egypt	136	126	115	105
Kuwait	129	119	110	100
Oman	124	115	105	96
Libya	121	112	103	94
United Arab Emirates	109	101	93	84
Saudi Arabia	91	84	77	70
Syria	89	82	76	69
Yemen	82	76	70	63
Jordan	69	64	59	53
Djibouti	68	63	58	53
Islamic Republic of Iran	68	63	58	53
Algeria	65	60	55	50
Bahrain	65	60	55	50
Qatar	57	53	48	44
Israel	53	49	45	41
Tunisia	46	43	39	36
Lebanon	43	40	37	33
Morocco	27	25	23	21
MENA Region	***90***	***83***	***76***	***70***

Figure 24 PM Concentrations by Scenario of Improved Energy Efficiency



6. Cross-Country Regression Analysis

In order to determine whether MENA is a relatively intensive user of energy and CO_2 producer, we conducted a cross-country regression analysis to explain energy consumption and CO_2 emissions per capita. The factors we considered included GDP per capita, the sectoral composition of the economy, hydrocarbon production, and energy prices. Again, the main challenge is to find comparable data for this analysis and we detail the data source for each variable as follows. All data are in year 2005.

- The two dependent variables energy consumption per capita measured in toe/capita and CO_2 emissions per capita measured in ton of CO_2 per capita are calculated using the data from IEA.

- GDP per capita measured in 2005 US$ PPP is from the latest ICP report (World Bank, 2007b).

- In term of sectoral composition of the economy, we use two sets of sectoral compositions. The first set is what we used for the decomposition analysis, by manufacturing sector, transportation sector, and energy and other sectors. The second set is the standard classification of GDP by sector: industry, agriculture, and service. We are more interested in the first set of sectoral composition; however, due to missing data, analysis using such sectoral composition yields a very small sample size and significantly limits the interpretation of the results. Nevertheless, we report both results. Data for the first set of sectoral composition are from the DDP database and for the second set of sectoral composition from the 2005 CIA World Factbook.

- In terms of hydrocarbon production, we use two indicators. One is fuel exports as a percentage of GDP in order to capture the importance of fuel exports in the economy. The hypothesis that we are trying to test is that a high ratio of fuel exports to GDP encourages investment in energy intensive activities. The advantage of using fuel exports data is that the cost of energy for a net exporting country would be the export parity price. So it is exports that would explain substitution towards energy-intensive activities on the basis of economic cost. The other indicator we use is energy production measured in ktoe. The advantage of using energy production data is that it would capture non-tradable energy production such as natural gas. Both data sets are from the DDP database.

- In terms of energy prices, there is no consistent energy price index available for all countries. We used the diesel price measured in egg index from the GTZ report *International Fuel Prices 2005* (GTZ, 2005) as an indicator for energy prices. However, we notice that although the price of diesel price is well correlated with gasoline prices, it is not well correlated with electricity prices. Thus diesel price is unable to capture variations of electricity price across countries. IEA has electricity prices for both industry and household uses measured in current US$ (*IEA, 2007*) and we converted the data into 2005 US$ PPP using the PPP ratios in the latest CIP report. However, electricity price data are not available for MENA countries. Therefore, we run separate regressions for countries with available data to see how important the electricity price is in determining energy consumption and CO_2 emissions. Since electricity prices for industry and household uses are highly correlated, we only included electricity price for industry.

We used a log-log linear model to estimate elastisities of different factors on energy consumption per capita and CO_2 emissions per capita. The Ordinary Least Square (OLS) regression results on energy consumption per capita are presented in Table 19. We used different specifications to show how inclusion of different factors would change the results. Since Columns (1) and (2) use the first set of sectoral composition and yield very small sample sizes, we focus on our discussion on Column (3)-(5) which use the second set of sectoral composition (industrial, agriculture, and service). Column (3) include share of fuel exports, Column (4) include energy production, and Column (5) include both of indicators. GDP per capita has the positive effect on energy consumption per capita and it is statistically significant at 1% level for all three specifications. It also has the highest coefficient, which means that GDP per capita is the most significant factor on energy consumption per capita. Share of fuel exports has a negative effect on energy consumption per capita although it is not significant. So our results do not support the hypothesis that a high ratio of fuel exports to GDP encourages investment in energy intensive activities. Energy production shows a positive effect on energy consumption per capita, but again it is not statistically significant. So we do not find evidences that being a hydrocarbon producer will increase energy consumption per capita. Diesel price has negative effect on energy consumption per capita as expected and it is statistically significant at 5% level in specification (4). In addition, increase in the share of industry sector production has a positive sign and being a MENA country has an ambiguous sign, but since both of them are not statistically significant, we cannot give definitive conclusions on their effects. The reason that few variables show significant effects may be that in addition to the small sample size, some key independent variables have relatively high correlations as shown in Table 20, which can cause high multicollinearity and lead to high standard errors.

The regression results on CO_2 emissions per capita are presented in Table 21. Again, we focus on the results in Columns (3)-(5). GDP per capita has a positive effect on CO_2 emissions per capita and it is statistically significant at 1% level. Increase in the share of industry sector production has a positive effect and it is statistically significant in Columns (3) and (4) but not in Column (5). All other factors are not statistically significant.

Since the specification in Column (4) yields the highest sample size and gives more statistical power, it is our preferred specification. Summary statistics of variables in Column (4) are presented in Table 22.

For reference, the regression results including electricity price are presented in Table 23. Only around 20 countries have all the available data. Electricity prices shows a negative effect on both energy consumption and CO_2 emissions per capita and it is statistically significant in Columns (1)-(3). The results show that omitting electricity price in our earlier regression analysis may result in biased estimates. Therefore, our cross-country regression analysis above needs to be interpreted with caution.

Table 19 OLS Regression on Natural Log of Energy Consumption per Capita

	(1)	(2)	(3)	(4)	(5)
Ln GDP per capita	0.610**	0.492**	0.636**	0.560**	0.635**
	[3.97]	[5.06]	[5.20]	[6.64]	[5.14]
Ln Share of manufacturing output	0.372	0.207			
	[0.95]	[1.10]			
Ln Share of transportation sector	0.209	-0.066			
	[0.39]	[0.24]			
Ln Fuel exports as % of GDP	-0.073		-0.017		-0.025
	[0.58]		[0.27]		[0.37]
MENA region	-0.241	-0.082	0.064	-0.13	0.09
	[0.18]	[0.20]	[0.20]	[0.80]	[0.28]
Ln Diesel price (egg index)	-0.411	-0.22	-0.04	-0.147*	-0.045
	[1.07]	[1.17]	[0.29]	[2.11]	[0.32]
Ln Energy production		0.027		0.049	0.034
		[0.66]		[1.65]	[0.73]
Ln Share of industry			0.506	0.102	0.363
			[1.66]	[0.46]	[1.00]
Ln Share of agriculture			-0.054	-0.045	-0.054
			[0.53]	[0.61]	[0.53]
Constant	-6.367*	-4.902**	-7.239**	-5.545**	-7.058**
	[2.97]	[4.45]	[5.40]	[5.78]	[5.14]
Observations	17	26	36	65	36
R-squared	0.807	0.753	0.777	0.719	0.781

Absolute value of t statistics in brackets
+ significant at 10%; * significant at 5%; ** significant at 1%

Table 20 Correlations of Key Variables

	Energy Consumption per Capita	GDP per capita (2005 US$ PPP)	Share of industry sector (%)	Share of agriculture (%)	Share of fuel exports (%)	Energy Production (ktoe)	MENA region	Diesel price (egg index)
Energy Consumption per Capita	1							
GDP per capita (2005 US$ PPP)	0.90	1						
Share of industry sector (%)	0.50	0.43	1					
Share of agriculture (%)	-0.54	-0.64	-0.51	1				
Share of fuel exports (%)	0.69	0.55	0.58	-0.35	1			
Energy Production (ktoe)	0.24	0.11	0.45	-0.17	0.12	1		
MENA region	0.49	0.39	0.39	-0.30	0.67	0.04	1	
Diesel price (egg index)	-0.36	-0.27	-0.39	0.23	-0.55	0.06	-0.49	1

Note: Number of Observations=36

Table 21 OLS Regression on Natural Log of CO_2 Emissions per Capita

	(1)	(2)	(3)	(4)	(5)
Ln GDP per capita	1.071**	1.028**	1.222**	0.971**	1.214**
	[6.44]	[6.00]	[8.17]	[7.53]	[8.08]
Ln Share of manufacturing output	0.388	0.908*			
	[0.88]	[2.69]			
Ln Share of transportation sector	-0.627	0.062			
	[1.02]	[0.13]			
Ln Fuel exports as % of GDP	0.057		0.04		0.03
	[0.40]		[0.50]		[0.38]
MENA region	-1.058	0.129	-0.161	0.041	-0.128
	[0.73]	[0.17]	[0.42]	[0.16]	[0.33]
Ln Diesel price (egg index)	-0.494	-0.363	-0.081	-0.168	-0.095
	[1.14]	[1.06]	[0.49]	[1.57]	[0.57]
Ln Energy production		-0.018		0.017	0.047
		[0.25]		[0.39]	[0.88]
Ln Share of industry			0.796*	1.099**	0.614
			[2.15]	[3.26]	[1.44]
Ln Share of agriculture			0.075	-0.022	0.081
			[0.63]	[0.20]	[0.68]
Constant	-7.678**	-10.304**	-12.645**	-11.403**	-12.416**
	[3.13]	[5.40]	[7.66]	[7.63]	[7.40]
Observations	18	27	39	69	39
R-squared	0.91	0.813	0.866	0.800	0.869

Absolute value of t statistics in brackets
+ significant at 10%; * significant at 5%; ** significant at 1%

Table 22 Summary Statistics of Key Variables

Variable	Obs	Mean	Std. Dev.	Min	Max
Energy Consumption per Capita	65	0.93	0.90	0.14	5.50
CO_2 Emissions per Capita	69	3.30	4.28	0.04	25.19
GDP per capita (2005 US$ PPP)	69	7,238	8,535	591	47,465
Share of industry sector (%)	69	32.09	10.79	11.00	67.20
Share of agriculture (%)	69	17.17	12.26	0.10	55.00
Energy Production (ktoe)	69	98,745	243,486	230	1,536,782
Share of fuel exports (%)	42	8.28	13.82	0.00	59.85
MENA region	69	0.16	0.37	0	1.00
Diesel price (egg index)	69	5.11	3.07	0.10	15.50

Table 23 OLS Regression including Electricity Price

	(1)	(2)	(3)	(4)
	Energy Consumption per Capita		CO_2 Emissions per Capita	
Ln GDP per capita	1.201**	0.751**	1.287**	0.917**
	[7.75]	[4.52]	[4.28]	[4.33]
Ln Share of industry	1.511*	-0.008	0.998	0.456
	[3.35]	[0.02]	[1.23]	[0.82]
Ln Share of agriculture	0.191	0.144	0.167	0.076
	[1.65]	[0.94]	[0.92]	[0.47]
Ln Fuel exports as % of GDP	0.232*		0.26	
	[2.85]		[1.70]	
Ln Diesel price (egg index)	0.079	-0.243	0.063	-0.13
	[0.39]	[1.17]	[0.20]	[0.62]
Ln Electricity price for industry	-0.530**	-0.338+	-0.635*	-0.348
	[3.48]	[1.90]	[2.23]	[1.58]
Ln Energy production		0.038		0.132+
		[0.64]		[2.09]
Constant	-18.112**	-7.748**	-16.114**	-10.895**
	[7.47]	[4.25]	[3.63]	[4.67]
Observations	15	22	18	26
R-squared	0.936	0.835	0.809	0.859

Absolute value of t statistics in brackets
+ significant at 10%; * significant at 5%; ** significant at 1%

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Appendix

Data for Table 21 Column (4)

Country	CO_2 Emissions per Capita	GDP per capita (2005 US$ PPP)	Share of industry sector (%)	Share of agriculture (%)	Energy Production (ktoe)	MENA region	Diesel price (egg index)
Algeria	2.57	5985	57.4	10.3	165728	1	1.5
Argentina	3.64	11076	35.9	10.6	85446	0	6.1
Armenia	1.37	3903	36.1	22.9	746	0	4.7
Azerbaijan	3.73	4648	45.7	14.1	20053	0	1.8
Bahrain	25.19	27257	41	0.7	15842	1	1.7
Bangladesh	0.26	1268	27.1	21.2	18390	0	4.9
Benin	0.3	1390	14.3	36.3	1623	0	6
Bolivia	1.29	3623	28	13	11818	0	6.7
Botswana	2.44	12057	44	4	1008	0	5.1
Brazil	1.77	8606	38.6	10.1	176312	0	9.8
Brunei Darussalam	13.62	47465	45	5	20768	0	1.4
Bulgaria	5.96	9353	30.1	11.5	10270	0	8.9
Cameroon	0.18	1995	20.1	43.7	12476	0	5.5
Chile	3.6	12277	38.2	6.3	8390	0	5.3
China	3.88	4091	52.9	13.8	1536782	0	7.2
Taiwan	11.41	26068	30.9	1.7	12760	0	4.6
Colombia	1.31	6314	32.1	13.4	76233	0	2.8
Congo, Dem. Rep	0.04	3621	11	55	17002	0	6.2
Ecuador	1.77	6541	30.5	8.7	29295	0	3.4
Egypt	1.99	5051	33	17.2	64662	1	2
El Salvador	0.86	5212	31.1	9.2	2441	0	5.8
Ethiopia	0.07	591	12.4	47	19370	0	8.4
FYR of Macedonia	4.07	7393	26	11.2	1536	0	7.7
Georgia	0.84	3505	22.6	20.5	1287	0	5.2
Germany	9.86	30496	31	1	136009	0	12.9
Ghana	0.32	1225	24.2	34.3	6230	0	2.7
Guatemala	0.83	4902	19.5	22.7	5331	0	4.9
Haiti	0.2	1242	20	30	1654	0	4.3
Honduras	0.89	3048	32.1	12.7	1747	0	9.4
India	1.05	2126	28.4	23.6	466873	0	15.5
Indonesia	1.55	3234	45	14.6	258009	0	3
Iraq	2.94	3202	58.6	13.6	103419	1	0.1
Iran, Islamic Rep.	5.96	10692	40.9	11.2	277992	1	0.3
Jordan	3.27	4297	26	2.4	292	1	2.1
Kazakhstan	10.22	8699	37.8	7.4	118597	0	3.8

Country	CO_2 Emissions per Capita	GDP per capita (2005 US$ PPP)	Share of industry sector (%)	Share of agriculture (%)	Energy Production (ktoe)	MENA region	Diesel price (egg index)
Kenya	0.29	1359	18.5	19.3	13675	0	10.9
Kyrgyzstan	1.06	1728	22.8	38.5	1482	0	3.9
Lebanon	4.42	10220	21	12	230	1	3.9
Mexico	3.7	11317	27.2	4	253859	0	5
Mozambique	0.08	743	32.1	21.1	8236	0	5.3
Namibia	1.36	4547	30.8	11.3	321	0	5
Nepal	0.11	1081	20	40	8066	0	8.2
Nicaragua	0.8	2725	24.7	20.7	1930	0	6.4
Nigeria	0.42	1892	30.5	36.3	229440	0	3
Pakistan	0.76	2396	24.1	22.6	58993	0	6.8
Paraguay	0.58	3905	24.9	25.3	6628	0	8.5
Peru	1.02	6474	27	8	9474	0	10.9
Philippines	0.92	2932	31.9	14.8	23391	0	3.8
Romania	4.2	9374	33.7	13.1	28110	0	4.8
Russia	10.79	11861	33.9	4.9	1158465	0	3.8
Saudi Arabia	13.83	21236	67.2	4.2	556212	1	1.7
Senegal	0.4	1676	21.4	15.9	1106	0	5.6
South Africa	7.05	8477	31.2	3.6	155998	0	4.4
Sri Lanka	0.63	3481	26.2	19.1	5161	0	5.9
Switzerland	6	35520	34	1.5	11822	0	4.9
Syria	2.51	4062	31	25	29516	1	1.6
Tajikistan	0.87	1413	24.3	23.7	1517	0	4.5
Thailand	3.34	6869	44.3	9	50103	0	4.1
Togo	0.16	888	20.4	39.5	1910	0	5.5
Tunisia	1.92	6461	31.8	13.8	6805	1	4.9
Turkey	3.04	7786	29.8	11.7	24111	0	11.2
Turkmenistan	8.59	4211	42.7	28.5	58151	0	0.1
Ukraine	6.31	5583	45.1	18	76287	0	4.9
Uruguay	1.52	9277	27.4	7.9	850	0	7.1
Uzbekistan	4.21	1970	26.3	38	56867	0	2.3
Venezuela	5.35	9888	46.5	0.1	196064	0	0.3
Vietnam	0.97	2142	40.1	21.8	65271	0	3.2
Yemen	0.89	2278	44.7	15.5	20609	1	1.3
Zambia	0.18	1175	28.9	14.9	6360	0	7.5