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Abstract

Climate change is one of the principal challenges facing the world today. Given its harsh climate and fragile ecosystems, the MENA region is vulnerable to the physical impacts of climate change, yet, given its high dependency on hydrocarbon resources, the MENA region is also vulnerable to the impacts of climate change response measures. This paper addresses four crucial aspects in relation to climate change policy and its impacts in the MENA region. These are the rising energy/carbon intensities in the region, the impacts of climate change response measures, the mitigation potentials in the region, and the suitability of market based instrument to harness these potentials. The analysis made use of the Marginal Abatement Cost (MAC) curves and econometric techniques to assess the Green House Gas emissions (GHG) mitigation potentials in MENA and a Computable General Equilibrium (CGE) modeling to investigate the impacts of response measures and to explore the suitability of market-based instruments to harness mitigation potentials in the region. The main policy insights to be drawn from the analysis include the role of incentives to promote energy efficiency and reduce carbon emissions in the region, the potential gains from actively participating in the international carbon markets through the use of Clean Development Mechanism (CDM), the contribution of climate policy to air quality, and the role of green tax reforms and other sweeteners to improve the welfare economics of pursuing domestic carbon policies in the region.

ملخص

تغير المناخ هو أحد التحديات الرئيسية التي تواجه العالم اليوم. ونظرا إلى ظروف المناخ القاسية والنظم الإيكولوجية الهشة، تتعرض منطقة الشرق الأوسط للتأثيرات المادية لتغير المناخ، ولكن نظرا لاعتمادها الكبير على الموارد الهيدروكربونية، تكون منطقة الشرق الأوسط أيضا عرضة لآثار تدابير الاستجابة لتغير المناخ. وتتناول هذه الورقة أربعة جوانب حاسمة بالنسبة لسياسة تغير المناخ وآثاره في منطقة الشرق الأوسط. هذه هي ارتفاع كثافة الطاقة / الكربون في المنطقة ، وآثار تدابير الاستجابة لتغير المناخ، وإمكانات التخفيف في المنطقة ، ومدى ملاءمة صك السوق القائم على تسخير هذه الإمكانات. واستفاد التحليل من استخدام تحليل للتكاليف حدية منحنيات (ماك) وتقنيات الاقتصاد القياسي لتقييم انبعاثات غازات البيت الأخضر (الغازات الدفيئة) ومحسوب التوازن العام (الفريق) النمذجة للتحقيق في آثار تدابير الاستجابة لإمكانات التخفيف في منطقة الشرق الأوسط ، واستكشافا لملاءمة الأدوات القائمة على السوق لتسخير إمكانات التخفيف في المنطقة. وتشمل الأفكار الرئيسية للسياسة العامة التي يمكن استخلاصها من التحليل دور الحوافز لتعزيز كفاءة الطاقة وتقليل انبعاثات الكربون في المنطقة ، والمكاسب المحتملة من المشاركة بنشاط في أسواق الكربون العالمية من خلال استخدام آلية التنمية النظيفة (آلية التنمية النظيفة)، و مساهمة السياسات المناخية لنوعية الهواء، ودور الإصلاحات الضريبية الخضراء ومحليات أخرى لتحسين اقتصاديات رفاهية اتباع سياسات الكربون المحلية في المنطقة.

1. Introduction

Climate change is one of the principal threats facing the world today. Unchecked increases in the earth temperature are expected to have disastrous impacts on the world ecological balance. The MENA region is particularly vulnerable to these impacts given its fast low coastal lands, harsh environment and fragile ecosystems, exemplified in wide spread of desertification and water stress problems.

Climate change policies and regulations have gone through phases of negotiations, adoption and implementation. Regardless of the controversies surrounding the validity of the claims that global warming and climate change are man-made or natural phenomenon, climate change issues have now moved to the top of the list of national policy agenda in many countries of the world.

Increased global concerns about the risk of global climate change have led to the creation of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992. The objective of the convention is the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system without curtailing developing countries aspirations to economic growth and sustainable development.

The Kyoto Protocol was the first attempt towards meeting the UNFCCC objectives. The Protocol obliged industrial countries (Annex I) to reduce their greenhouse gas emissions by about 5% from their 1990 levels during the period 2008-2012. To help countries meet their emission targets, and to encourage the private sector and developing countries to contribute to emission reduction efforts, the Protocol has included three market-based mechanisms (called flexibility mechanisms) – Emissions Trading, the Clean Development Mechanism and Joint Implementation.

Though, until 2012, developing countries including the MENA region are exempted from taking GHG mitigation measures, they could experience negative impacts from climate change as well as negative spillover impacts from the implementation of mitigation policies and measures by Annex I countries. The economies of the MENA region are vulnerable to both climate change impacts and the impacts of climate change response measures. The latter form of vulnerability is revealed in the high dependence on the production and export of hydrocarbons particularly in the oil rich countries of GCC and North Africa. Hence, an adaptation approach that jointly addresses both types of vulnerabilities in the region is obviously required. Such an adaptation approach would require, in addition to the domestic effort, a parallel international effort on minimizing the impacts of response measures and strengthening the ecological resilience of these economies to cope with climate change and its related policies. Fortunately, in relation to the response measures, the literature has indicated that the magnitude of the negative spillover impacts can greatly be reduced if Annex I countries are to implement efficient market-based mitigation measures.

Looking beyond 2012, the ongoing post-Kyoto climate change negotiations have unmistakably underscored the role of developing countries and their growth trajectories in the future containment of GHG emissions. Provided this and given the established provisions of the UNFCCC and the 2007 Bali Action plan, any future major effort on emissions abatement from developing countries has to come through incentives, e.g. technology transfer, CDM, and emissions trading. Yet, it is also conceivable that developing countries, particularly large emitters, take specific future mitigation targets as a part of a post-Kyoto climate change deal. In spite of the apparent setback, the Copenhagen Accord (COP15) of December 2009 seems to have paved the road for such a deal.

In particular, COP15 provided some potential guidance of work for upcoming years, starting with COP16 in Mexico. The Accord stipulated that the rise in global temperatures should not exceed two degrees, developed countries should transfer significant funds to mitigation in developing nations, and that countries should provide unilateral GHG mitigation pledges to the UN Secretariat.[1] Furthermore, the potential of trading mechanisms to reduce the cost of GHG abatement were recognized and we expect that developed countries will use these mechanisms extensively. However, it is also clear that the pledges will not put the globe on the trajectory consistent with the two degrees scenario and that pledges from emerging and developing countries may well include mitigation projects that developed countries have funded for emissions credits. Moreover, reducing the increase of GHG gases from the large, fast growing developing countries' economies such as China are increasingly being seen as a necessary condition for any meaningful global climate policy.

Given their growing GHG footprints, a number of MENA countries may be candidates for future binding emissions targets. Hence, it is important that MENA policymakers investigate their countries GHG mitigation potentials both to decide on their future mitigation commitments and to screen out opportunities for rewarding voluntary abatement actions through CDM and similar arrangements. Such an investigation is among the themes considered in this research. In particular this chapter aims to address three themes: 1) The spillover impacts of developed countries mitigation action on MENA region and how the impacts may be ameliorated through the use of efficient policy instruments; 2) The assessment of GHG mitigation potentials in the MENA region; and 3) The use of market based policy instruments to harness these potentials.

The rest of the chapter is divided into 5 sections: section II investigates the energy and CO_2 intensity trends in the MENA region, section III discusses spillovers and the implications of Annex I policy choices, section IV assesses GHG mitigation potentials in MENA, section V reports simulation results on market instruments to harness GHG mitigation potentials of MENA, and section VI concludes.

2. Energy and CO_2 Intensity Trends in MENA: The Challenge

2.1 Energy Intensity and Trends in MENA

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 $ of real GDP, corrected for purchasing power parity (PPP) when comparing across countries.

The International Energy Agency (IEA) compiles annual energy statistics for about 140 countries. Based on these statistics for 2005, Figure 1 shows cross country comparisons of primary energy intensity in the MENA region with those in other world economies. The index of total primary energy intensity is expressed as BTU per unit of GDP measured in 2000 prices and adjusted for PPP. The main point reflected by the graph is the relatively high energy-intensiveness of the MENA economies when compared to either OECD or World averages. Different from the general pattern, the North African MENA economies of Tunisia, Morocco, and Algeria have energy intensities lower than the OECD average. In contrast, the Gulf Council Countries (GCC) and Libya have energy intensities more than twice as higher as those of the OECD with economies such as Qatar and Bahrain having intensity levels of about three times the average OECD energy intensity. The same story is also confirmed by looking at the per-person energy consumption patterns in Figure 2, where the world is again

1 Based on post COP15 official documents (http://unfccc.int/), developed countries have offered pledges to reduce emissions – 5 to 25 per cent relative to 1990 – while China and India have offered to reduce carbon intensity per unit of GDP.

led by the GCC members of the MENA. Investigating the high energy intensity from both the producer and consumer sides may point to the presence of large inefficiencies in the GCC and Mashriq economies of the MENA region, especially given the low energy prices and the absence of energy efficiency regulations.

Comparing absolute as well as relative magnitudes of energy intensities across countries is informative, yet a more complete picture requires, in addition, comparing the direction or trends in energy intensities over time. This is accomplished by looking into cross-country historical trends of energy intensities. The US Energy Information Administration (EIA) provides a comparable dataset on primary energy and PPP-corrected real GDP series for a number of countries covering the period 1980-2005 that can be used for this task. In this exercise the dataset is used to compute primary energy intensities for GCC, Middle East (GCC + Mashriq), and Egypt as representatives of MENA; China and India as typical developing-country representatives; and US, UK, Japan, and OECD as representative of the developed world. To ease comparison, the computed intensity trends are normalized around the year 1980 (i.e. 1980=100). The normalized energy intensity trends are shown in Figure 3.[2] Figure 3 provides a clear indication that, with except to MENA region, primary energy intensities are falling world-wide during the period 1980-2005, albeit at differing paces. For China the decline in primary energy intensity between 1980 and 2005 is about 60% and for OECD is about 40%. Although India witnessed a 25% increase in primary energy intensity between 1980 and 1995, its energy intensity had actually peaked in 1995 and started to decline steady to reach a level below that of 1980 by 2005. In contrast, the graph shows a rising trend for MENA with a growth in primary energy intensity in excess of 100% for GCC and Middle East regions over the period 1980-2005.

To summarize, the above analysis of energy intensities seems to suggest that, at least for some MENA countries, energy intensity may be off-track from both a cross-section and a time-wise perspectives. Yet, before characterizing that as indicative of inefficiency or not, the analysis needs to take on board all the factors that may explain cross-country variations in energy intensity. This is considered in a latter section.

2.2 Carbon Dioxide (CO_2) Intensity Trends in MENA

Figure 4 displays cross-country comparison of carbon intensities measured as CO_2 emissions per thousand dollars of GDP corrected for purchasing power parity. Consistent with the energy intensity story, the graph reveals carbon intensities for the MENA regions of Middle East, GCC, and Libya that are uniformly higher than the world average and about twice as high as those for the OECD and the EU. Nonetheless, some North African MENA countries such as Morocco and Tunisia are shown to have quite low carbon intensities even when compared to the OECD. More striking, is the observation that in almost all other countries and regions in the graph carbon intensities are falling during 1991-2008 except for the MENA regions of GCC and Middle East where carbon intensities continued to rise.

Another perspective on carbon emissions trends and responsibilities is provided by the cross-country comparison of CO_2 per-person profiles displayed on Figure 5. The graph suggests low contributions of MENA countries, except GCC, to global emissions when measured on per-capita basis with Morocco, Egypt, and Tunisia among the lowest per-capita carbon emitters in the figure. In contrast, GCC is emitting far more CO_2 per-capita than any region in the graph and with emissions per-capita exceeding the highest per-capita emitter (OECD) in the graph by more than 50% during the early 2000s and reaching more than 100% by 2008. Further, though per-capita carbon emissions seem to have peaked for OECD and Europe,

2 In absolute terms EIA statistics show that co2 emissions in the MENA region have doubled between 1990 and 2005 (emissions increased from 987 million tons in 1990 to 1822 million tons in 2005). Compared to global co2 emissions the MENA contribution increased from 4.5% in 1990 to 6.4% in 2005.

these per-capita trends are on the rise for almost all MENA region and particularly for GCC during 1991-2008. Hence both the per-GDP and per-capita measures of CO_2 emissions tend to suggest large carbon footprints for at least a number of MENA countries.

These large carbon footprints raise concerns for domestic environmental policy as well as reasons for international mitigation commitments in the region under a future climate change policy regime. Nonetheless, these carbon footprints equally represent opportunities for cheap mitigation potentials when combined with the presence of inefficient energy systems in many countries of the region. These opportunities could be harnessed through the use of Kyoto international crediting mechanisms such as Emissions Trading and Clean Development Mechanism (CDM), and/or through the National Appropriate Mitigation Action (NAMA) mechanism of the 2007 Bali Action Plan. A numerical assessment of these mitigation potentials will be provided in section IV.

3. Spillovers and the implications of Annex I policy choices

Developing countries have raised concerns about potential climate change policies taken by developed countries to mitigate greenhouse gas emissions. The implementation of certain climate change energy policies by industrialized countries will undoubtedly adversely impact economies that are heavily dependent on the production and export of oil, which is true for a number of MENA region economies. These policies include measures to reduce emissions of carbon dioxide which could translate into a reduction of fossil fuel demand, of which petroleum is the largest contributor.

There are two channels through which climate change actions by Annex I countries (mostly the advanced industrial countries) adversely affect the economies of non-Annex I countries. These channels are demand for fossil fuels (Direct) and terms of trade (Indirect). Mitigation of greenhouse emissions by Annex I parties reduces demand for fossil fuel and depresses their international prices, causing direct revenue losses for hydrocarbons exporters. Implementation of response measures by Annex I can also induce spillover effects through the international trade channel. Restrictions on the use of fossil energy in Annex I countries, whether through prices and taxes or through direct control, increase production costs and hence prices of exportable goods and services. Provided that the majority of developing countries imports are from Annex I markets, the mitigation action of Annex I will effectively translate into an adverse movements in terms of trade for energy-exporting developing countries. Being major oil exporters and highly open economies, a number of MENA economies will be significantly impacted through both channels.

On the other hand, under UNFCCC as well as Kyoto Protocol, Annex I countries have an obligation to minimize the impacts of their response measures on developing countries.[3] The first step towards meeting that obligation would be to select policy measures that have the least negative impacts on developing countries. The literature on the architecture of climate change policy design tends to suggest that such policies should be comprehensive and market-based, and should encourage maximum flexibilities across time, sources and location, including the broad use of Kyoto-type flexibility mechanisms (Emissions Trading, Joint Implementation, and CDM).

3.1 Impacts of Annex I response measures on MENA economies

3.1.1 IPCC TAR & Earlier Assessments of Kyoto Impacts:

The Intergovernmental Panel on Climate Change (IPCC) Third Assessment Report (TAR) provided a detailed evaluation of the impacts of climate change response policies on non-Annex I countries for the original version of Kyoto (with the US). The studies and model

3 Articles 4.8 and 4.10 of the UNFCCC and Articles 2.3 and 3.14 of the Kyoto Protocol.

comparisons for 13 modeling groups cited in the energy special issue, Weyant et. al. (1999), have indicated that oil exporting countries will be negatively impacted by Annex I mitigation action and that the extent of the impacts on these countries would be greater than those to be experienced by Annex I countries themselves. Babiker et. al.(2000) study has also confirmed the multi-model results from Weyant et. al., particularly estimating that the highest welfare loss from implementing Kyoto Protocol in Annex I is 1.5% whereas the welfare loss of the same policies on the North Africa MENA region is about 2.5% and on the Middle East region of MENA is more than 3.5%. The decomposition of these welfare impacts is shown to be the result of income losses of about 3% and deterioration in the terms of trade in the range 6-9% for the MENA regions compared to lower income losses and improvement in terms of trade for most Annex I countries implementing the response measure.

3.1.2 IPCC AR4 & Later Assessments of Kyoto Impacts:

In its Fourth Assessment Report (AR4), the IPCC concluded that the literature since the publication of its Third Assessment Report confirms the earlier findings with respect to the impacts of Annex I response measures on non-Annex I. In particular, the report confirmed that hydrocarbon exporters would expect lower demand and prices and lower income growth due to Annex I mitigation policies. Yet, it is understandable that, entering force without the US, the Kyoto Protocol will yield both lower costs and lower climatic impacts than the original Kyoto setup. Nonetheless, the scope of spillover effects, the distributional impacts, and the direction of the adverse effects of Annex I mitigation measures on developing countries, and hence the MENA countries, would be the same as above.

3.1.3 Assessments of Post-Kyoto Impacts:

In 2007, the Bali Action Plan set forth the negotiation stage for a post-Kyoto regime by laying out the essential concerns and aspects regarding mitigation, adaptation, technology transfer, and financing and by calling for a shared global vision. Following Bali, intense talks have taken place leading to an interim deal at COP15 in Copenhagen, Dec 2009. Though COP15 has provided some potential guidance for a future global agreement, the vast bulk of work is left for the upcoming years, with the end of 2010 summit in Mexico as the last step. Among its major provisions, the Copenhagen Accord stipulated that the rise in global temperatures not to exceed two degrees and that developed countries transfer significant funds to finance adaptation and mitigation activities in developing nations.

Aside from what actually went through Copenhagen, there are still different ambitious initiatives and proposals for post-Kyoto on the table. The G8 group has a declared goal of a 50% reduction in global emissions by 2050. The EU has a target of 20% reduction below 1990 by 2020 if no global agreement and 30% if there is a global agreement, and a global target of 50% below 1990 by 2050. Australia has declared a target of 5% below 1990 by 2020 if no global agreement and up to 15% if there is a global agreement. The US Obama administration has a target of reducing emissions to their 1990 level by 2020 and by 80% by 2050. Given the stringency of such global mitigation targets, their implications for the impacts of response measures on developing countries in general and hydrocarbons exporters in particular would be critical. Unfortunately, there are yet only a few studies that have attempted to assess these implications.

Based on the G8 reduction goal, a recent MIT study (Jacoby et. al., 2008) simulates a scenario in which global greenhouse gas emissions are reduced gradually by 10% in 2015 to 50% in 2050 from their 2000 levels. The study has considered various allocation and burden sharing schemes, including the participation of developing countries and the impacts of response measures. The study concluded that the 50% global target is unachievable without the participation of developing countries and that, unless appropriately compensated, the bulk of the mitigation costs will fall on developing countries if they participate in the mitigation regime. Among developing counties, the oil exporters will be the most burdened with welfare costs for the Middle East ranging between 18% in 2020 and 51% in 2050 for the case of no compensations and between 5% in 2020 and 9% in 2050 when compensated for mitigation costs only (i.e. no compensation for the impacts of response measures). In contrast, the welfare cost in the latter case for US ranges between 1% and 7%, for Japan between 0.6% and 4%, and for EU between 2% in 2020 and 8.5% in 2050, confirming the higher burden on hydrocarbons exporters and the legitimacy of the call for consideration of the impacts of response measures.

3.2 The Implications of the choice of Annex I response policies

Under the UNFCCC as well as Kyoto, Annex I countries have an obligation to minimize the impacts of their response policies on developing countries. The first step towards meeting that obligation would be to select policy measures with that objective in mind. In contrast to this, there is a profound concern among hydrocarbons exporting nations including those of MENA regions Annex I countries may strategically use climate change policies to target the oil sector. Historically, developed countries have shown a trend of formulating policies and regulations that tend to target oil unfairly for environmental and energy security considerations. For example, the subsidization of coal and nuclear energy production as well as the relatively high taxation on petroleum products are good examples. Reforming the existing fuel taxation system in OECD to be more geared towards the fuel content of greenhouse emissions as well as employing more broad and efficient policy instruments are necessary steps for Annex I parties to comply with the requirements of articles 4.8 and 4.10 of UNFCCC.

The literature has recognized very early the implication of the type of response measures in Annex I for the magnitude of negative spillover impacts on hydrocarbons exporters. All the models in Weyant et al. (1999) study had shown that emissions-trading in Annex I reduces these negative impacts. The more recent literature used in the IPCC Fourth assessment (http://www.ipcc.ch/publications_and_data/ar4/wg3/en/contents.html) and after has also confirmed this. Babiker et al. (2000) study has shown that both emissions trading and the removal of existing energy taxes and subsidies in Annex I reduce the impacts of the response measure on MENA compared to the case without. In particular, the study has reported that the reference welfare cost of 2.2% in the North Africa region of MENA and 3.81% in the Middle East region of MENA will be reduced, respectively, by 0.37% and 0.96% if the existing Annex I energy taxes were removed and by an additional 0.59% and 1.03%, respectively, if emissions were traded among Annex I parties. Comprehensive mitigation measures that include, in addition to CO_2, other greenhouse gases such as Methane (CH_4), Nitrous Oxide (N_2O), and the industrial CFC gases of HFC, PFC, and SF_6 were also being early confirmed to reduce greatly the policy costs for both Annex I and hydrocarbons exporters. Reilly et al (2002) has reported that the inclusion of these other gases resulted in about 50% reduction in the policy cost in Annex I and about the same level for the spillover impacts on energy exporters.[4]

A good architecture of a new policy framework should adequately accommodate the distribution, efficiency, and technology aspects of the policy design. Provided this, climate change policies and measures that would likely have the least costs on oil-exporting developing countries, such as those of the MENA region, would be:

a) Broad and comprehensive rather than sector-specific measures.
b) Use carbon-based rather than fuel-based policy instruments.

4 Future trade agreements could also affect the magnitude and/or direction of the impacts of Annex I response measures but the reviewed literature has not talked this dimension.

c) Based on climate change concerns rather than inspired by energy security or energy independence objectives.
d) Encourage maximum flexibilities across time, sources and location, including utilization of potentials from land use change, sinks, and non- CO_2 greenhouse gases and the broad use of Kyoto-type flexibility mechanisms (Trading, JI, and CDM).
e) Take into account the full environmental impacts of the response-measures policies, including their impacts on sustainable development.

Such policy measures will likely have lower costs because they tend to shift abatement to sectors, countries, and sources with cheap potentials as well as to more carbon intensive fuels.[5]

4. Assessment of GHG Mitigation Potentials in the MENA region

Two approaches are employed in this section to quantify and investigate the magnitude of mitigation potentials in the region. The first is an accounting approach that involves cross-country comparisons of energy intensities to discern whether there is an excessive use of energy in the region and hence the potential for energy saving and carbon mitigation. The second is an analytical approach that involves computing and constructing GHG abatement cost curves. The abatement costs are computed from a Computable General Equilibrium (CGE) model of the world economy.

4.1 A Top-Down Assessment of Energy Saving Potentials in MENA

There are two approaches to assess energy efficiency potentials in an economy: a Bottom-Up technology approach and a Top-Down macroeconomic approach. The Top-Down approach is usually conducted at the national or sectoral level and it 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 we extend Babiker (2010) study[6], in which a top-down approach was applied to assess aggregate energy savings or energy efficiency potentials in the GCC economies using an IEA energy dataset of 140 countries suitably augmented with international socioeconomic and climatic data for 2005, to the MENA region.

Consistent with the empirical literature (e.g., Hang and Tu (2007), and Sue Wing (2008)), the econometric component of the top-down approach in Babiker (2010) estimates the model:

$$I_i = \beta' x_i + \mu_i ; \qquad i=1,2, \ldots\ldots, N$$

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 variables:

i. The domestic price of gasoline as a proxy to energy prices
ii. Per-capita real GDP in PPP terms to capture income and population effects
iii. The total annual number of heating and cooling degree days to represent climatic conditions
iv. The value share of services in GDP to proxy economic structure (level of industrialization)

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5 The propensity of Annex I parties to apply such flexibility measures is a subject of great discussions for the UNFCCC SBSTA (Subsidiary Body for Scientific and Technological Advice), SBI (Subsidiary Body for Implementation) and AWG-KP (the Ad Hoc Working Group for further commitments of Annex I under the Kyoto Protocol) particularly in relation to compliance. The proposed policies and measures by Annex I are reported in their National Communications (see http://unfccc.int/national_reports/annex_i_natcom_/items/1095.php).

6 For a detailed explanation of the methodology and the used dataset see, Babiker (2010).

v. Life expectancy at birth to measure the stage of economic development.

The estimation makes use of the 2005 cross-country IEA data, suitably augmented with economic and climate data from various international sources (IEA, World Metrological Organization (WMO), and the World Bank).

The top-down approach uses iterative estimation and sequential sampling to specify the benchmark group and then to estimate the energy savings potentials, according to the following steps:

1. Specify the benchmarking criteria
2. Select the benchmark countries
3. Estimate the regression model for the benchmark sample
4. Apply the estimated coefficients to the MENA countries data to compute their predicted energy intensities
5. Use the actual and the predicted energy intensities to compute the potential energy savings for the MENA economies.

Starting from the full 140 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 we sample from the grand pool and sequentially check the improvement in the explanatory power of the model in step 3.[7]

The regression results from Babiker (2010) for the benchmark sample that was selected according to this procedure are reported in Table 1.

Benchmarking on the sample regression results, excess intensity and potential energy savings for the MENA countries are calculated in Table 2. The table reports the predicted primary energy intensity along with the actual intensity, the implied excess intensity, and the implied excess energy use or potential energy savings in 2005.[8] The results suggest the presence of large energy savings potentials in the MENA region, particularly in the hydrocarbon rich countries of the GCC and North Africa. These savings amount to about 20% of the total energy consumption in the GCC region and about 13% for the MENA region as a whole. Provided the direct relation between carbon emissions and hydrocarbon-based energy consumption, these large energy savings potentials represent cheap abatement opportunity for carbon emissions in the region. The main source of the potential energy savings is the existing inefficient patterns of energy consumption in the region. Country-wise, these potentials seem to vary considerably in 2005 with Tunisia, Morocco, and Egypt being the most energy efficient economies (least potentials) in the region and with Bahrain, Libya, UAE, Qatar, and Syria being the least energy efficient economies (most potentials) in the region. To harness these savings potentials, MENA countries need to adopt some explicit policies, measures, and programs to promote energy efficiency and conserve hydrocarbons, which in turn will also lead to reduction of carbon emissions and hence the risk of global warming.

4.2 GHG Mitigation Potentials in MENA based on Marginal Abatement Costs

This and the next section will make use of the MIT Emissions Prediction and Policy Analysis (EPPA) model (http://globalchange.mit.edu/) to construct Marginal Abatement Costs curves and to simulate the various proposed market-based climate change policy instruments. The analysis will be based on the most recent version 5 of the EPPA model and the MENA region will be represented by Middle East only because of difficulty to breakout the North African

7 This is consistent with the sequential sampling approach in Statistics.

8 Note that the regression results here are only suggestive and not conclusive since there may be some country specific factors responsible for discrepancies that are not accounted for in the estimation. Yet, we believe, given the very low fuel prices in the region that these discrepancies are largely apt to inefficiencies.

members of the MENA from region “Africa” in the model. Provided the analysis of sections II and subsection IV.1, the exclusion of the North African MENA countries may not affect the main insights related to mitigation policies and potentials in the region.

4.2.1 EPPA model and the Baseline Emissions trajectory for MENA

The Emissions Prediction and Policy Analysis (EPPA) model EPPA is a multi-regional, CGE model of the global economy that links GHG emissions to economic activity, and is solved through time in recursive dynamic fashion in five year increments (Paltsev et al., 2005). There is a single representative utility maximizing agent in each region that derives income from factor payments and emissions permits and allocates expenditure across goods and investment. There is also a government sector in each region that collects revenue from taxes and purchases goods and services. Government deficits and surpluses are passed to consumers as lump sum transfers. EPPA is designed to provide scenarios of anthropogenic greenhouse gas emissions and to estimate the economic impact of climate change policies either as a stand-alone model or as part of a larger Integrated Global Simulation Model (IGSM) of the climate system (Sokolov et al., 2005).

As illustrated in Table 3, EPPA recognizes Agriculture, five energy sectors (Coal, Crude oil, Refined oil, Gas and Electricity), two manufacturing sectors (Energy intensive industry and other industry), Transportation and Services. Each good is produced by perfectly competitive firms that assemble primary factors and intermediate inputs. All goods are traded internationally. Following Armington (1969), goods are differentiated by region of origin using a constant elasticity of substitution function, except for Crude oil (which is treated as a homogenous commodity). Alternative electricity generation technologies in EPPA enhance abatement options.

Electricity can be produced using conventional technologies (e.g. electricity from coal and gas) and technologies not currently in use but which may become profitable as the emissions price rises (e.g. large scale wind generation and electricity from coal or gas with carbon capture and storage).

Primary factors include three non-energy resources (capital, labor, land) and seven energy resources. Capital and labor are free to move between sectors and land is specific to agriculture. Each energy resource is sector specific. Crude and shale oil resources are perfect substitutes in the oil sector, and the hydro, nuclear, wind and solar resources are specific to electricity generation technologies.

EPPA tracks CO_2 emissions as well as the emissions of 6 non- CO_2 GHGs (methane, CH_4; nitrous oxide, N_2O; hydrofluorocarbons, HFCs; perfluorocarbons, PFCs; and sulphur hexafluoride, SF_6) measured in CO_2 equivalent (CO_2-e) units using global warming potential (GWP)[9] weights. Additionally, EPPA also tracks other air pollutants (sulphur dioxide, SO_2; nitrogen oxides, NO_x; black carbon, BC; organic carbon, OC; ammonia, NH_3; carbon monoxide, CO; and non-methane volatile organic compounds, VOC).

The model is calibrated using economic data from the Global Trade Analysis

Project (GTAP) database (Dimaranan, 2006). The GTAP database accommodates a consistent representation of regional macroeconomic consumption, production and bilateral trade flows. Energy data in physical units are based on energy balances from International Energy Agency (IEA). Non- CO_2 GHG emissions are based on inventories maintained by the United States Environmental Protection Agency (EPA). Data on air pollutants (urban gases) are based on EDGAR data (Olivier and Berdowski, 2001).

9 GWP weights measure the ability of non- CO2 gases to trap heat in the atmosphere relative to the heat-trapping capability of CO2 over a 100 year period.

The model is written in the GAMS (General Algebraic Modeling System) software and solved using the MPSGE (Mathematical Programming System for General Equilibrium) modeling language (Rutherford, 1995). The model has been used in a wide variety of policy applications (e.g. Viguier, et al., 2003; Babiker et al., 2004; Paltsev et al., 2007; Paltsev et al., 2008, and Jacoby et al., 2010).

The base year data for the current version (EPPA5) is 2005. The model baseline (reference) simulates standard economic behavior with exogenous projections on economic growth, demographic developments, natural resource availability and technological penetrations over the horizon 2005-2100. Yet, for the purpose of this research, our focus will be limited to 2020 given its relevance to the current post-Kyoto negotiations. The simulated baseline emissions from the model for Middle East are reported in Table 4, where panel 4a shows the emissions trajectories for major the greenhouse gases, panel 4b reports the emissions trajectories of the urban pollutants carbon monoxide and nitrogen oxides, and panel 4c reports the sectoral breakdown of the region CO_2 emissions trajectory.

Table 4 reveals that GHG emissions in the Middle East are expected to grow past the 40% over the period 2005-2020 with non- CO_2 emissions growing at higher rates than CO_2 emissions. Emissions affecting air quality such as NOx and CO are also expected to grow at a slower pace with NOx growing at 19% and CO (mostly from transport fuels) at 39% over the period. The sectoral breakdown shows the major sources of CO_2 emissions in the region to be Electricity generation, followed by Energy Intensive, Residential, and transport, respectively. Among the major sources, the table suggests that the power and the residential sectors have the highest emissions growth rates.

4.2.2 Middle East GHG MACs based on EPPA

Marginal Abatement Cost (MAC) is the cost of reducing emissions by one additional unit (ton) from the reference (baseline) point or path. In CGE models abatement costs are simulated by solving the model for specific incremental reductions in emissions and computing the resulting shadow prices on the emissions constraint. In this exercise Marginal Abatement costs were simulated for 2020 through uniform cutbacks of 5%, 10%, 15%, 20%, 25%, 30%, 35%, and 40% in GHG emissions from their 2020 baseline levels for all regions in the model. Two sets of marginal abatement costs were considered, national and sectoral. The national marginal abatement costs are assessed economy-wide on CO2-equivalent terms and meant to compare GHG mitigation potentials and costs across countries. The sectoral marginal abatement costs are assessed for Middle East on a CO2-only term to discern mitigation costs and potentials in the different sectors of the region's economy. The two sets of abatement costs are shown graphically on Figures 6 and 7.

Figure 6 reveals cheap GHG mitigation potentials in Middle East region of MENA when compared to the major Annex I players of US, Japan, and EU. Provided the currently discussed levels of GHG cutbacks for Annex I by 2020, the figure suggests a wide-range of beneficial abatement opportunities in Middle East that can be exploited through market-based mechanisms such as CDM and emissions trading. In contrast, figure 7 shows in which sectors of the Middle East economy do these cheap abatement opportunity lie. The figure indicates that the residential sector (FD) has the cheapest abatement opportunities or "low-hanging fruits" when only a limited scope of mitigation of less than 20% is considered, beyond which the abatement cost in the sector increases exponentially. The sector with the next cheapest and large abatement potentials is the Energy Intensive sector (EIN), where simple energy savings and demand management measures can have large effect on CO_2 emitted by the sector. Combining together the analysis from these two graphs, suggests that the residential and the energy intensive sectors of the Middle East would be the primary candidates for

CDM potentials in the region. The next section explores how these promising mitigation potentials may be harnessed.

5. The Use of Market-based Instruments to harness Mitigation Potentials in the MENA region

This section explores a range of market-based policy approaches to harness the GHG mitigation potentials in the Middle East region of MENA. The analysis will simulate a number of mitigation policy cases/scenarios using the EPPA model and will focus on emphasizing cost-effectiveness, environmental impacts, and their welfare implications of the considered policy instruments.

5.1 A Taxonomy of taxes vs. prices as regulatory instruments for GHG emissions

Cap and Trade and Carbon tax are two alternatives ways for putting a price on carbon emissions. Compared to other regulatory options, such as Cap and Trade and Carbon tax are both characterized as efficient, market-based and as cost-effective. Though, both instruments are market-based, they differ in how they use the market: in the cap and trade system the regulator determines the quantity emitted and the market determines the price whereas in the carbon tax system the regulator specifies the price and the market determines the quantity of emissions emitted.

5.1.1 The Architecture of Cap and Trade system

The key design variables in a cap and trade system include scope, point of regulation, allocation, and revenue use. The scope defines which greenhouse gases to include in the trading and what industries and sectors are covered by the scheme. Point of regulation refers to which people and companies that must hold emissions permits, e.g. upstream versus downstream point of regulation. Allocation covers decisions on how permits are distributed and whether they are auctioned or given free? How long does a permit last? Whether banking and borrowing of permits are allowed, and how many permits may a single entity hold. Revenue use defines options with regard to the use of the generated revenues from the permits sale. These options can include lump sum recycling, reduction of other taxes, or/and subsidizing renewable energy sources.

The mechanics of emissions trading can be illustrated through the use of marginal abatement cost curves (Figure 8). Differences in emissions abatement costs across sources are the main driver for trading. Abatement potentials are usually represented by Marginal Abatement Cost curves (MAC). If several sectors or regions commit to achieve given reduction targets, the aggregate cost of meeting the commitments will be reduced if sources are allowed to trade emission permits.

According to figure 8, region2 has lower abatement costs than region 1. In the case without trading region 2 abates q2 at a per-unit cost of P2 and region 1 abates q1 at a per-unit cost of P1. In the case of emissions trading between the two regions, the low-cost region 2 abates more (Q2) and high-cost region 1 abates less (Q1) than autarky. The market price of the permit after trade is P and gains from trading are shown as the dashed blue triangle for Region 1 and the dashed red triangle for region 2.

5.1.2 Cap and trade vs. carbon tax: Pros and Cons

Based on the literature, there are pros and cons when considering either carbon taxes or Cap and Trade systems that relate to efficiency, equity, uncertainty, technology, administration, and political acceptability.

a) Efficiency: Under perfect information, the two systems are equivalent in terms of their effects on the economy, e.g. employment, prices, and costs. A given emissions target can equally be achieved through cap and trade or through a direct tax. Further efficiency gains could equally arise from implementing either system through the use of the revenue recycling to reduce other more distorting taxes in the economy, such as labor or capital taxes (labeled "double dividends" in the literature).
b) Equity: The distributional implications (who gains and who loses and by how much) may differ between the two systems depending on their implementation. The tax revenues directly accrue to the government, but the proceeds from the sale of carbon permits may not depending on how the government allocates them.
c) Uncertainty: Whether the regulator is relatively more uncertain about the level of emissions or about the cost of abatement may affect the choice between a tax and a price system. The Cap and trade system assures the regulator of meeting the emissions reduction target (environmental integrity) but not the cost; while the tax system assures the regulator on the cost to the economy per ton of emitted carbon but not the emissions target.
d) Technology: Some argue that, by giving more certainty on costs, carbon taxes are better than Cap and Trade systems for development of emissions mitigation technologies. Further, when there is international emissions trading companies in developed countries can buy their way out by purchasing cheap reduction units from developing countries than investing in costly abatement technologies at home.
e) Administration: Arguments are for carbon tax as simple to initiate and easy to administer through using the existing fiscal structure whereas the implementation of a cap and trade system needs the establishment of new market (platforms, regulations, monitoring and enforcement).
f) Political appealing: Arguments are for cap and trade system as more politically acceptable than a tax.

Finally, from a practical perspective there is a possibility that hybrid or intermediate systems may actually emerge instead of a pure tax or a pure cap and trade system. An economy-wide cap and trade system or a uniform flat carbon tax across all sources is rather an ideal situation. In practice some intermediate forms of regulatory schemes are also possible, such as Partial cap and trade where some sectors are capped while other sectors are directly controlled, and the system of "cap and trade with safety valve", where the cap and trade system converges to a flat tax regime when carbon price passes a certain pre-determined threshold.

5.2 Policy Cases and Simulation Results

The global policy regime considered in our policy simulations is the recent Annex I Copenhagen's-pledges deal for 2020. In terms of EPPA baseline emissions for 2020, these pledges represent cutbacks of 19.7% for the US[10], 31.9% for EU, 27.6 for Japan, and 40.5% for Australia and New Zealand. In addition to the reference, we consider 7 policy cases, the description of which is provided in Table 5. The reference case is the EPPA reference simulation. The three policy cases CO_2-Nt, GHG-NT, and GHG-TR are meant to assess the impacts of Annex I pledges on region Middle East and to illustrate the implications of flexibility mechanisms. Cases GHG-TR-CDM (FD) and GHG-TR-CDM (ALL) are meant to assess CDM potentials in the Middle East and their welfare and revenue implications for the region. Finally, the two cases CO_2-NT-TAX and CO_2-NT-TAX (RECL) are meant to explore

10 Canada is assumed to match the US pledge.

the implications of a domestic carbon tax policy along with revenue recycling and prospects for double dividends[11] and non-climate environmental benefits.

5.2.1 the Impacts of Annex I Pledges and Flexibility Mechanisms on Middle East

The impacts of Annex I pledges under Copenhagen on Middle East along with implications of flexibility mechanisms for mitigating these impacts were simulated using the EPPA model. First, a CO_2-only pledge without trading is considered (CO_2-NT), and then the pledge cover is expanded to include all GHG gases (GHG-NT), and third experiment added trading among Annex I (GHG-TR). The results on the impacts on shadow price of carbon and the regional welfare impacts related to these simulated cases are reported on tables 6 and 7.

Table 6 shows that among Annex I countries, USA and Canada have lower abatement costs due to lower pledges and lower energy efficiency whereas Japan, Europe and Australia have higher abatement costs due to higher pledges and/or higher energy efficiency. The inclusion of GHG in the pledge coverage, however, reduces abatement costs (particularly in US) through bringing in cheaper methane (CH_4) and nitrous oxide (N_2O) abatement opportunities in agriculture and waste management. Yet, the most reduction in abatement costs are achieved when trading among Annex I is added to GHG inclusion (GHG-TR) with the uniform market price established at \$52 per ton of CO_2-equivalent. Under this latter case Table 6 indicates that US and Canada are net sellers of GHG emissions permits and Japan, Europe, and Australia are net buyers of permits.

The results on reference welfare of Table 7 suggest high rate of growth in the Middle East when compared to the mature industrialized economies in the table. This difference in economic growth is reflected in welfare improvement of more than 100% for “MES” compared to less 50% for the Annex I countries in 2020 compared to 2005 along the EPPA baseline. The implication of pledges undertaken by Annex I parties under Copenhagen are shown to reduce these reference welfare levels (the change measured in Equivalent Variation (EV) terms), yet the size of the welfare costs seems to be limited because of the modest level of the pledges given the baseline growth of emissions in these economies. Nonetheless, the results on welfare impacts of Table 7 confirm the literature predictions on the impact of Annex I response measures on MENA hydrocarbons exporters and the role of flexibility mechanisms in reducing those negative impacts. In particular, the welfare impacts of Annex I pledges on Middle East are higher than the welfare impacts experienced by any of Annex I parties in the table except Australia, which took a relatively higher pledge of 40% cutback. However these impacts are seen to be reduced when flexibility mechanism were implemented in the form of expanding abatement coverage (GHG-NT) and trading emission rights across Annex I parties (GHG-TR).

5.2.2 Harnessing the CDM Potentials and their Welfare Implications for the Middle East

Cases GHG-TR-CDM (FD) and GHG-TR-CDM (ALL) consider exploring the CDM potentials for the Middle East region provided full flexibility (All GHG plus trading) mechanisms under the Copenhagen pledges for Annex I parties. The CDM is implemented at the sectoral level where the GHG emissions of the sector are constrained to its 2020 baseline/reference level of Table 4.[12] Two polar cases are experimented with to span the range of potentials: a case to consider only the cheapest potentials (hang fruits) in the final

11 A double-dividend is the proposition that the welfare improvement from a green tax reform, where the revenue from an environmental tax is used to reduce other tax rates, must be greater than the welfare improvement from a reform where the environmental taxes are returned in a lump sum fashion (Goulder(1995), Bovenberg(1999), Babiker et a.(2003), Metcalf et al. (2004)).

12 Note CDM potentials are computed here at the sector level not at the usual project level. The sector-wide potentials are thought of as the sum of potentials from a number of projects covering the whole sector.

demand sector (FD) and a case to consider the full potentials in all sectors (ALL). The simulation results for these two cases along with the results on case GHG-TR as their reference/benchmark case are reported in Table 8.

The table reveals both good potentials and significant impacts on welfare of the CDM activity. The potentials show a total volume of credits of 380 million tons of CO_2-equivalent carrying a worth of $18.2 billion if only final demand sector of Middle East is considered and a total credit volume of 647 million tons of CO_2-equivalent with a worth of $24 billion if all economic sectors in Middle East are considered. These potentials also offer win-win deals for Annex I as indicated a fall in CO_2 price from $52 to $48 in the final demand case and to only $37 in the all-sectors case. The implication of these potentials is even more striking when welfare costs in Middle East are considered. The best deal for the Middle East is to hope for the implementation of Annex I's pledges with all GHG and trading, resulting in welfare cost of 0.96. Harnessing the CDM potentials in the final demand sector is shown to reduce the welfare cost by half to 0.49, and when fully exploiting its CDM potentials the welfare impacts for Middle East region reverse to a net gain of 0.23. This suggests that Middle East can undo the negative welfare impacts of Annex I response measures or can even benefit from those response measures if it is able to fully exploit its GHG mitigation potentials through the CDM mechanism. Yet, realistically Table 8 would rather represent upper bounds to these potentials because CDM potentials in other developing countries, which will compete with Middle East in the International market for CDM, were not considered in the simulations and because likely limitations on supplementarity in Annex I will reduce both the price and the demand for CDM credits. Yet, it remains to say that CDM as a market-based mechanism is a promising avenue for Middle-East and other MENA countries to purse.

5.2.3 Domestic Carbon Tax, Revenue Recycling, and Prospects for "Double Dividends" in Middle East

Cases CO_2-NT-TAX and CO_2-NT-TAX (RECL) explore the economics of a domestic carbon tax in the Middle East. Given that Middle East currently is under no international mitigation commitment, the rationale for a domestic carbon policy could be to prepare stage for future such obligations, to benefit from selling credits achieved in the international carbon market (CDM), to save credits achieved for meeting future commitment , or/and to achieve other environmental objectives such as air quality improvement.

The exercise considers as a benchmark the case of a CO_2-only implementation of Copenhagen pledges in Annex I without trading (CO_2-NT). The domestic carbon policy in the Middle East is represented by a uniform carbon tax of $5 per ton of CO_2. Two cases with carbon levy are examined: one (CO_2-NT-TAX) with levy on the top of the exiting tax structure and revenue returned to representative agent as lump-sum, and the other [CO_2-NT-TAX (RECL)] involves a revenue-neutral tax reform where carbon tax revenue is recycled to subsidize consumer purchases of necessary energy intensive goods such as electricity and transport services. In this later case the subsidy rate is determined endogenously by the model. Technically, the model jointly simulates two tax instruments: an exogenous carbon-tax levy on all activities emitting CO_2 and an endogenous subsidy that recycle the generated tax revenue back to the consumer. The simulation results from the exercise are reported in Table 9.

The results for case CO_2-NT-TAX show that the domestic carbon tax levy reduces welfare by 0.06% but achieves a 88 million tons of CO_2-equivalent reduction in GHG emissions and an improvement in air quality by reducing the rate of release of key criteria pollutants such carbon monoxide, particulate matters, nitrogen oxides, and sulfur. Nonetheless, unless the reduction in the global pollutants of GHG has a present/future offsetting welfare value, improvement in air quality alone in a typical developing region as the Middle East may not be a very compelling argument for enacting the carbon levy when its welfare cost is significant. Yet, the chances for the policy will be better if it is combined with a revenue-neutral tax reform that reduces the welfare loss from the carbon levy, a situation referred to in the literature as a weak "double dividends". The stronger "double dividends" holds if the accompanied tax reform more than offsets the welfare loss from the carbon levy. Case CO_2-NT-TAX (RECL) is meant to explore this avenue. In this case the proceeds from the carbon levy are endogenously used to subsidize the consumer budget for items that have high pre-existing taxes or ones that are heavily affected by the carbon tax.

The results on case CO_2-NT-TAX (RECL) in Table 9 obviously confirms the weak version of the "double dividends" hypothesis, with the tax reform yielding a welfare gain that almost totally offsets the original welfare loss from the carbon levy. In addition the environmental benefits in form of reductions in GHG emissions and air quality pollutants remain positive compared to the benchmark yet lower than in the case CO_2-NT-TAX. The endogenously decided subsidy rate is indicated to be 5% in the table. The subsidy shifts the mitigation burden away from consumer to the industry, and in turn led to a relatively higher consumption and non- CO_2 emissions from the final demand sector than in the case CO_2-NT-TAX.[13] Hence, there seems to be an almost win-win situation from enacting a carbon levy along with consumption tax reforms in the Middle East. The combined policy deal generates carbon credits that may be sold or retained for future use, yields improvement in air quality, and has virtually zero welfare cost.

6. Summary and Concluding Remarks

This chapter has addressed four issues in relation to climate change policy in the MENA region. These issues are the rising energy/carbon intensities, the impacts of climate change response measures implemented by developed countries, the mitigation potentials in the region, and the means to harness these potentials.

Rising carbon emissions trends pose a challenge to sustainable development in the region and increase the likeliness that the region be assigned future mitigation commitments. In this respect, the chapter provides cross-country and time series analysis of energy intensities and emissions trends during the last three decades and confirms the legitimacy of the worry that carbon emissions represent a true challenge for the region.

On the impacts of climate change response measures, the chapter surveys the relevant literature discussing the strength of the impacts of Annex I response measures on MENA hydrocarbon exporters and available mechanisms to mitigate those negative impacts. The important messages from the literature are that Annex I mitigation policies may yield greater welfare costs on hydrocarbon exporters than on Annex I parties themselves and that the use of broad policies that include all greenhouse gas (GHG) emissions and allow emissions trading among the constrained parties reduces these welfare impacts. In addition the chapter also provides simulation analyses of the costs and implications of the emissions cutback pledges offered by developed countries at Copenhagen, the results from which are consistent with literature predictions on the direction of welfare impacts and role of flexibility mechanisms.

On the potentials front, the chapter has demonstrated good energy savings and greenhouse gas emissions abatement in the region. The descriptive analysis of section II and the top-down decomposition analysis of section III have both revealed wastage culture and inefficient use of energy in the region and in turn identified large potentials for energy saving and cutback of the region expanding carbon footprint. The Computable General Equilibrium

13 The increase in carbon monoxide (which is less than 2% compared to the Baseline) in the case CO2-NT-TAX(RECL) is mainly from the household transport sector.

(CGE) assessment of greenhouse emissions abatement in the region, using Marginal Abatement Cost (MAC) curves, has confirmed the enormous and cheap GHG mitigation potentials in the Middle East region of MENA.

The last section of the chapter addressed in details market based options and candidate mechanisms to harness the GHG mitigations in the region. Setting the benchmark, the model simulations of the recent Copenhagen pledges have indicated that welfare impacts on the region are lowest when developed countries apply efficient market-based instruments to carry out these pledges. The principal market-based instruments and options available for the region to exploit its GHG mitigation potentials are the Clean Development Mechanism (CDM) and domestic cap & trade or carbon tax. Simulations with sectoral CDM have pointed to very lucrative potentials in the region particularly in the (residential) final demand sector. Simulations with a domestic carbon tax of $5 per ton of CO_2 tax have resulted in good abatement of criteria pollutants responsible for air quality, in addition to reductions of GHG emissions that may be sold in the international market or retained for future national use, yet these benefits may only occur at some welfare cost. The further model simulations with additional instrument to reduce the welfare cost associated with the carbon levy have indicated that a revenue-neutral tax reform involving recycling the tax revenue back to the consumer in the form of a targeted consumption subsidy achieves the goal. That result is referred to in the public finance literature as the "Double Dividends" hypothesis.

There are many lessons and policy advices to be derived from the analysis in this chapter. The principal lessons and policy advices to be learned include the importance of monitoring the region carbon footprint, the role of incentives and demand side management policies to promote energy efficiency and reduce carbon emissions in the region, the potential gains from actively participating in the international carbon markets through the use of Clean Development Mechanism (CDM) , the use of efficient and market-based policy instruments to purse climate change objectives, the contribution of climate policy to air quality, and the role of green tax reforms and other sweeteners to improve the welfare economics of a domestic carbon policy.

References

Armington, P.S. 1969. "A Theory of Demand for Products Distinguished by Place of Production", *IMF Staff Papers*, 16:159–76.

Babiker, M., 2010. "The Potentials for Energy Savings in the GCC Economies," *Journal of Development and Economic Policies,* 12(1):31-58.

Babiker, M., Metcalf, G., and J. Reilly. 2003. "Tax Distortions and Global Climate Policy," *Journal of Environmental Economics and Management*, 46:269-287.

Babiker, M., J. Reilly and H. Jacoby, 2000. "The Kyoto protocol and developing countries", *Energy Policy* 28: 525–536.

Babiker, M., Reilly, J., and L. Viguier, 2004. "Is Emissions Trading Always Beneficial?" *The Energy Journal* 25(2): 33-56.

Bovenberg, A. 1999. "Green Tax Reforms and the Double Dividend: An Updated Reader's Guide," *International Tax Public Finance*, 6:421–443.

Dimaranan, B.V. (ed.), 2006. *Global Trade, Assistance and Production: The GTAP 6 Data Base*, Center for Global Trade Analysis, Purdue University.

Hang, Leiming and Meizeng Tu. 2007. "The Impact of Energy Prices on Energy Intensity: Evidence from China," *Energy Policy*, 35(5): 2978-2988.

Goulder, L. 1995. "Effects of Carbon Taxes in An Economy with Prior Tax Distortions: An Intertemporal General Equilibrium Analysis," *Journal Environmental Economics and Management*, 29:271–297.

Intergovernmental Panel on Climate Change (IPCC), http://www.ipcc.ch/

International Energy Agency (IEA), http://www.iea.org/

Jacoby, H., M. Babiker, S. Paltsev, and J. Reilly, 2010. "Sharing the Burden of GHG Reductions," in *Post-Kyoto International Climate Policy*, J. Aldy and R. Stavins (eds.), Cambridge University Press, pp. 753-785. Also *Discussion Paper,* October 2008, Harvard Project on International Climate Agreement, http://belfercenter.ksg.harvard.edu/project/56/harvard_project_on_international_climate_agreements.

Metcalf, G., Babiker, M., and J. Reilly, 2004. "A Note on Weak Double Dividends," *Topics in Economic Analysis & Policy*, 4(1).

MIT Joint Program on the Science and Policy of Global Change, http://globalchange.mit.edu/

Olivier, J., and J. Berdowski, 2001. "Global Emissions Sources and Sinks", in *The Climate System*, J. Berdowski, R. Guicherit and B.J. Heij (eds.), Swets and Zeitlinger Publishers, Lisse, Netherlands.

Paltsev, S., Reilly, J., Jacoby, H., Gurgel, A., Metcalf, G., Sokolov, A., and J. Holak, 2008. "Assessment of US GHG Cap-and-Trade Proposals", *Climate Policy*, 8(4):395-420.

Paltsev, S., J. Reilly, H. Jacoby, R. Eckaus, J. McFarland, M. Sarofim, M. Asadoorian and M. Babiker, 2005: *The MIT Prediction and Policy Analysis (EPPA) Model: Version 4*. Report 125, MIT Joint Program on the Science and Policy of Global Change, Cambridge, MA (http://mit.edu/globalchange/www/MITJPSPGC_Rpt125.pdf).

Paltsev, S., Reilly, J., Jacoby, H., and K. Tay, 2007. "How (and why) do climate policy costs differ among countries?" in *Human-Induced Climate Change: An Interdisciplinary Assessment*, M. Schlesinger et al. (eds), Cambridge University Press: Cambridge, Chapter 23, pp. 282-293.

Reilly, J., Mayer, M., and J. Harnisch, 2002. "The Kyoto Protocol and non-CO2 Greenhouse Gases and Carbon Sinks," *Environmental Modeling and Assessment*, 7, 217-229.

Rutherford, T., 1995. "Extension of GAMS for Complementary Problems Arising in Applied Economic Analysis", *Journal of Economic Dynamics and Control* 19(8):1299-1324.

Sokolov, A., Schlosser, C., Dutkiewicz, S., Paltsev, S., Kicklighter, D., Jacoby, H., Prinn, R., Forest, C., Reilly, J., Wang, C., Felzer, B., Sarofim, M., Scott, J., Stone, P., Melillo, J., & J. Cohen, 2005. The MIT Integrated Global System Model (IGSM) Version 2: Model Description and Baseline Evaluation, MIT Joint Program on the Science and Policy of Global Change, Report 124, Cambridge, MA.

Sue Wing, Ian, 2008. "Explaining the Declining Energy Intensity of the US Economy," *Resource and Energy Economics*, 30:21-49.

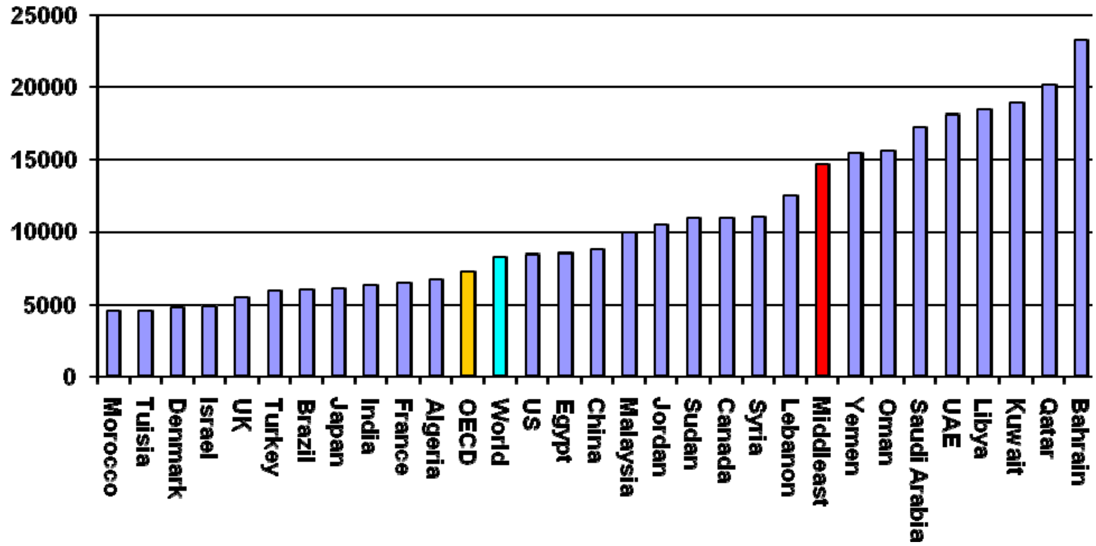
US Energy Information Administration (EIA), http://www.eia.doe.gov/

United Nations Framework Convention on Climate Change (UNFCCC), http://unfccc.int/

Viguier, L., Babiker, M., P. Criqui, J. Reilly, and D. Ellerman, 2003. "Assessing the Impact of Carbon Tax Differentiation in the European Union," *Environmental Modeling and Assessment,* 8:187-197.

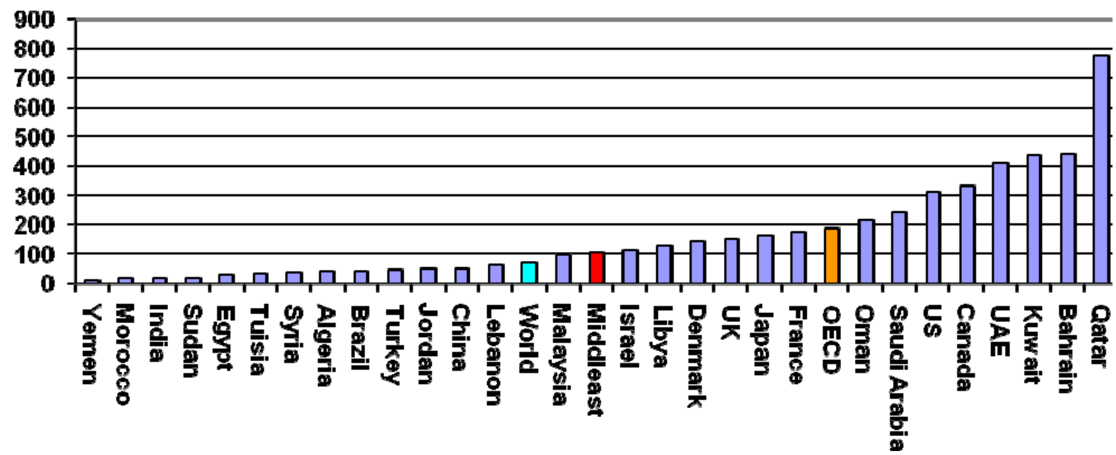
Weyant, J. P. (ed.), 1999. "The Costs of the Kyoto Protocol: A Multi-Model Evaluation", *Energy Journal*, special issue.

Figure 1: Primary Energy Intensity (BTU/$PPP), 2005



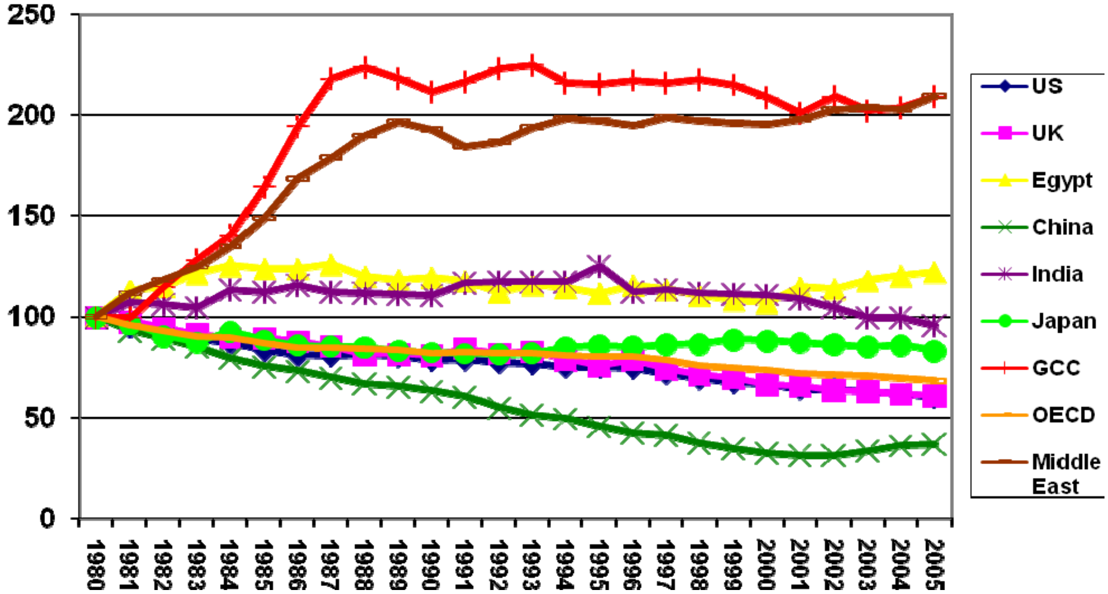
Source: IEA Data (http://www.iea.org/) and author's calculations

Figure 2: Per-capita Primary Energy Consumption (thousand BTU), 2005



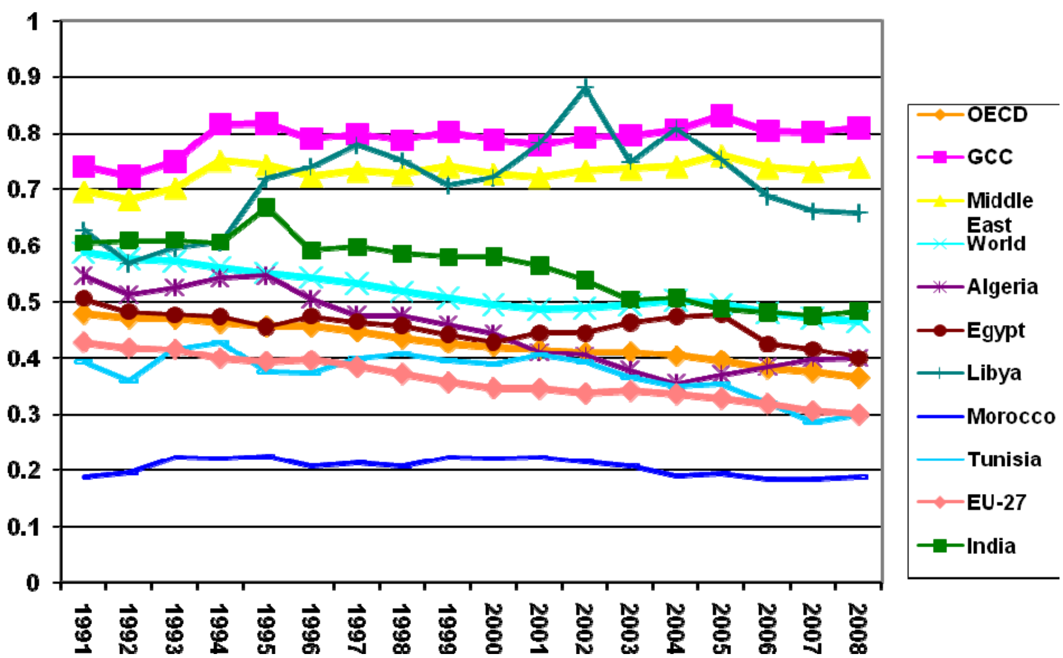
Source: IEA Data (http://www.iea.org/) and author's calculations

Figure 3: Normalized Primary Energy Intensity Trends (1980=100)



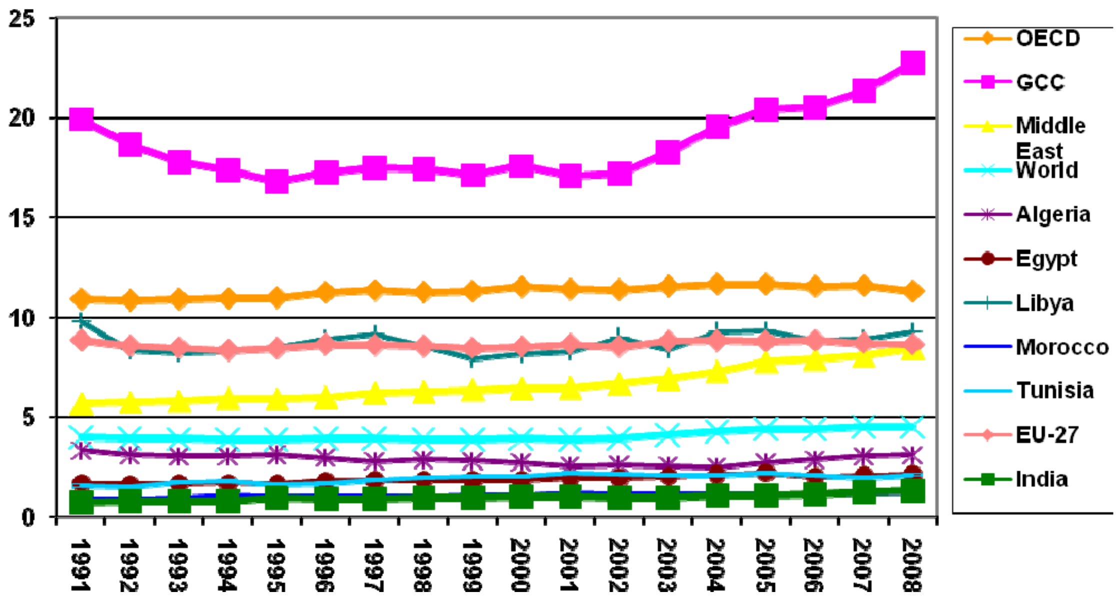
Source: EIA Data (http://eia.doe.gov/) and author's calculations

Figure 4: CO_2 Intensity (ton/$000PPP)



Source: EIA Data (http://eia.doe.gov/) and author's calculations

Figure 5: CO_2 Emissions per-person (tons)



Source: EIA Data (http://eia.doe.gov/) and author's calculations

Figure 6: Marginal GHG Abatement Cost Curves (2020)

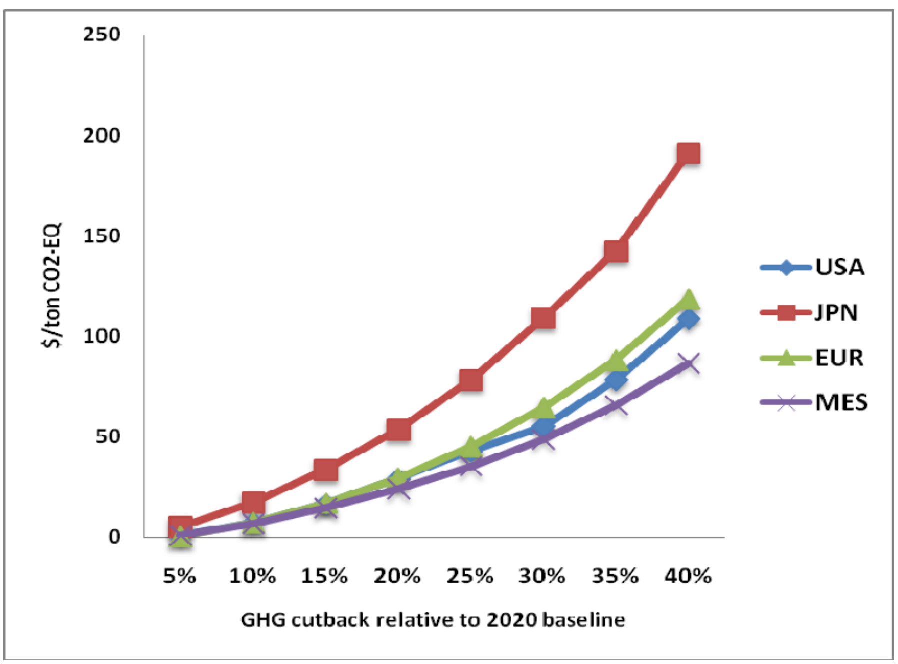


Figure 7: Marginal CO_2 Abatement Cost Curves in Middle East (2020)

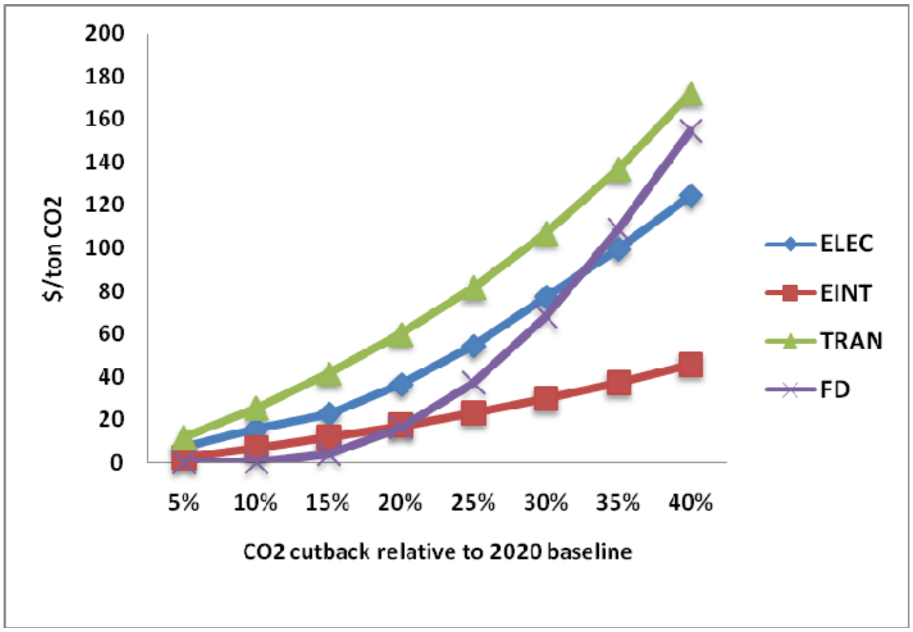


Figure 8: Marginal Abatement Curves and Cap and Trade

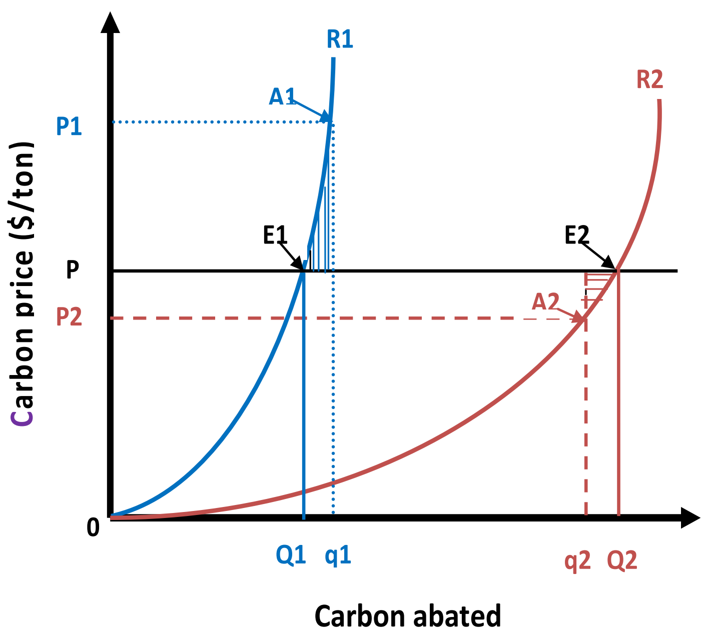


Table 1: Estimation Results on the Benchmark Sample

Variable	Coefficient	Test-Statistic	Elasticity at Mean
Constant	21931.55	8.11**	
Per-capita GDP	304.833	2.79**	0.31
Square of Per-capita GDP	-5.796	-2.54*	
Gasoline Price	-4203.51	-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**	-1.1
R-Square (R^2)	0.96	F-test 32.9**	
Diagnostic Tests:			
Ramsey RESET F-test		1.9	
Chi-Square		5.4	
Jarque-Bera	0.66	0.4	

Notes: * 5% Significance level; ** 1% significance level
Source: Babiker (2010)

Table 2: Predicted Excess Energy Use (Potential Saving) in MENA (2005)

	Actual primary energy intensity (BTU/PPP)	Model predicted energy intensity (BTU/PPP)	Excess energy intensity (BTU/PPP)	Excess use or Potential energy saving (Mtoe)	Total primary energy supply TPES (Mtoe)	Potential energy saving as % of TPES
KSA	17225	14189	3036	24.718	140.28	**17.6**
BAH	23225	13312	9913	3.47	8.13	**42.7**
KWT	18807	15488	3319	4.97	28.14	**17.6**
OMN	15591	14739	852	0.76	13.96	**5.5**
QAT	20113	15781	4332	3.41	15.83	**21.5**
UAE	18101	13307	4794	12.43	46.94	**26.5**
GCC				**49.76**	**253.28**	**19.6**
Egypt	8515	9814	-1299	-9.35	61.30	**-15.3**
Libya	18378	11739	6640	6.88	19.05	**36.1**
Morocco	4482	4836	-353	-1.09	13.81	**-7.9**
Tunisia	4489	6474	-1985	-3.74	8.45	**-44.2**
Yemen	15383	13117	2266	0.99	6.73	**14.7**
Syria	11016	8648	2368	3.85	17.91	**21.5**
MENA				**52.73**	**393.20**	**13.4**

Table 3: Regions, Sectors, and Primary Factors in the EPPA Model

Country or Region	Sectors	Factors
Developed	***Non-Energy***	Capital
United States (USA)	Agriculture (AGRI)	Labor
Canada (CAN)	Services (SERV)	Crude Oil
Japan (JPN)	Energy-Intensive (EINT)	Natural Gas
European Union+ (EUR)	Other Industries (OTHR)	Coal
Australia & New Zealand (ANZ)	Commercial Transp. (TRAN)	Oil Shale
Former Soviet Union (FSU)	Household Transp. (HTRN)	Nuclear
Eastern Europe (EET)	Other HH Consumption	Hydro
		Wind/Solar
Developing	***Fuels***	Land
India (IND)	Coal (COAL)	
China (CHN)	Crude Oil (OIL)	
Indonesia (IDZ)	Refined Oil (ROIL)	
Higher Income East Asia (ASI)	Natural Gas (GAS)	
Mexico (MEX)	Oil from Shale (SYNO)	
Central & South America (LAM)	Synthetic Gas (SYNG)	
Middle East (MES)	Liquids from Biomass (B-OIL)	
Africa (AFR)		
Rest of World (ROW)	***Electricity Generation***	
	Fossil (ELEC)	
	Hydro (HYDR)	
	Nuclear (NUCL)	
	Solar and Wind (SOLW)	
	Biomass (BIOM)	
	Natural Gas Combined Cycle (NGCC)	
	NGCC with CO2 Capture and Storage (CCS)	
	Advanced Coal with CCS	

Table 4: Baseline Emissions Trajectories for Middle East (MMT)

			Panel 4a: BaU Middle East Greenhouse Gas Emissions (MMT)		
	2005	**2010**	**2015**	**2020**	**%ch2005-2020**
CO_2	1405.28	1761.22	1823.37	1966.80	40
CH_4	13.92	18.21	19.44	21.29	53
N_2O	0.21	0.30	0.33	0.36	71

			Panel 4b: BaU Middle East Urban Emissions (MMT)		
	2005	**2010**	**2015**	**2020**	**%ch2005-2020**
NO_x	7.4	8.5	8.6	8.8	19
CO	27.1	36.5	36.8	37.6	39

			Panel 4c: BaU Middle East Sectoral CO_2 Emissions (MMT)		
	2005	**2010**	**2015**	**2020**	**%ch2005-2020**
ELEC	356.8	454.8	480.2	510.4	43
EINT	234.5	284.0	294.0	314.0	34
TRAN	200.2	227.9	237.8	249.3	24
AGR	26.0	35.9	38.0	41.0	57
Other	354.3	445.2	479.5	532.1	50
FD	233.5	313.4	293.9	320.1	37

Table 5: Description of Reference and Policy Cases used

Case	Description
REF	Simulates baseline projections on economic growth, demographic developments, natural resource availability and technological penetrations relative to 2005
CO_2-NT	Annex I pledges applied to CO_2 only and without trading among parties
GHG-NT	Annex I pledges applied to all GHG and without trading among parties
GHG-TR	Annex I pledges applied to all GHG and with trading among parties
CO_2-NT-TAX	CO_2-NT with $5/ton carbon tax applied in Middle East without recycling
CO_2-NT-TAX (RECL)	CO_2-NT with $5/ton carbon tax applied in Middle East with revenues recycled via consumer subsidies
GHG-TR-CDM (FD)	GHG-TR with CDM applied to the FD sector of Middle East
GHG-TR-CDM (ALL)	GHG-TR with CDM applied to all sectors of Middle East economy

Table 6: Annex I Pledges impacts on Carbon Price ($/ton), 2020

	CO_2-NT	GHG-NT	GHG-TR
USA	51	35	52
CAN	26	21	52
JPN	110	102	52
ANZ	156	147	52
EUR	85	72	52

Table 7: Welfare Impacts of Annex I Pledges, 2020

	REF (relative to 2005)	CO_2-NT EV%	GHG-NT EV%	GHG-TR EV%
USA	1.37	-0.29	-0.20	-0.17
CAN	1.49	-0.45	-0.36	-0.17
JPN	1.32	-0.63	-0.62	-0.41
ANZ	1.48	-2.04	-1.90	-1.18
EUR	1.31	-0.88	-0.77	-0.62
MES	2.17	-1.10	-0.97	-0.96

Table 8: CDM Potentials in the Middle East and Welfare Impacts, 2020

	EV%	CO_2-price \$/ton CO_2-eq	CDM Credits MMT CO_2-eq	CDM Revenue M\$
GHG-TR	-0.96	52	0	0
GHG-TR-CDM (FD)	-0.49	48	380	18252

Table 9: Carbon Tax Recycling and "Double Dividends" in Middle East, 2020

	EV%	CO_2 TAX $/ton	Endogenous Consumer Subsidy rate	Reduction GHG (MMT) CO_2-EQ	Reduction CO (MMT)	Reduction VOC (MMT)	Reduction NO_x (MMT)	Reduction SO_2 (MMT)
CO_2-NT-TAX	-0.06	5	0	88.1	0.54	0.45	0.23	1.07
CO_2-NT-TAX (RECL)	-0.01	5	5%	75.9	-0.75	0.18	0.13	1.02