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Prospects for Energy Supply and Demand in the Southern Mediterranean: Scenarios for 2010–30

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Abstract

The aim of this technical report is to quantify alternative energy demand and supply scenarios for ten southern and eastern Mediterranean countries up to 2030.

The report presents the model-based results of four alternative scenarios that are broadly in line with the MEDPRO scenario specifications on regional integration and cooperation with the EU. The report analyses the main implications of the scenarios in the following areas:

- final energy demand by sector (industry, households, services, agriculture and transport);
- the evolution of the power generation mix, the development of renewable energy sources and electricity exports to the EU;
- primary energy production and the balance of trade for hydrocarbons;
- energy-related CO_2 emissions; and
- power generation costs.

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Prospects for Energy Supply and Demand in the Southern Mediterranean: Scenarios for 2010–30

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1. Introduction

The aim of this technical report is to present the work completed for Task F of Work Package 4b "Energy and mitigation of climate warming" of the MEDPRO project. The goal of Task F is to quantify alternative energy scenarios for ten southern and eastern Mediterranean countries (MED-10)[1] and in particular to project into the future the fuel mix, investment and energy demand under alternative assumptions about policy goals and relations with the EU in the energy field.

The MED-10 region consists of a group of diverse countries that in the past few decades have undergone radical changes in their energy systems. These changes have involved the rapid growth of energy demand, with energy supply playing an important role in economic development. The region has also been characterised by persistent political instability, complicating relations among countries within the region as well as the region's position *vis-à-vis* the rest of the world. There is growing awareness that the MED-10 as well as the neighbouring EU could derive considerable benefits from closer cooperation in the fields of energy and the environment, and in recent years many initiatives have been proposed in this direction. Recent developments in the political arena may facilitate this process.

To examine the prospects for the energy economy of the region and to evaluate the risks and opportunities in alternative scenarios, the E^3M-Lab of the Institute of Communication and Computer Systems at the National Technical University of Athens has constructed a detailed energy demand and supply model for the countries in the region.

Section 2 of this report gives a short non-technical description of this model to facilitate interpretation of the scenario results.

Section 3 elaborates the reference-quadrant I (QI) scenario used as a benchmark for alternative scenario comparisons. It represents a quantified view of the development of the energy system of the region under relatively cautious assumptions about the main drivers of change.

The alternative scenarios reflect the framework developed in the MEDPRO Policy Paper by Ayadi and Sessa (2011), *What scenarios for the Euro-Mediterranean in 2030 in the wake of the post-Arab spring?*, and they attempt to formulate assumptions regarding the energy system consistent with the "green transition", "blue transition" and "red transition" paradigms.

Section 4 analyses a scenario of close cooperation with the EU in the context of a vigorous climate policy.

Section 5 looks at the possibility of countries in the region undertaking accelerated modernisation of their energy systems without common institutional mechanisms integrating them with the EU and in the context of opening up to cooperation with non-EU countries.

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[1] The MED-10 region comprises Algeria, Morocco, Tunisia, Egypt, Libya, Israel, Syria, Lebanon, Jordan and Turkey.

Section 6 analyses a possibility that normalisation of the region fails and its energy system follows what is effectively an unsustainable course.

Section 7 provides a comparison of the alternative scenarios examined. Section 8 concludes the report.

2. Brief description of the model

For the MEDPRO project purposes, E^{3}M-Lab has constructed and operated the MENA-EDS[2] model, which is a large-scale energy–economic model that simulates the formation of prices for end-users of energy, estimates the energy quantities demanded and supplied by the main energy-system actors in an exhaustive manner and incorporates energy-related CO_2 emissions, environmentally-oriented policy instruments and emission abatement technologies. Historical energy demand and supply data for the years up to 2010 are derived from the IEA and Enerdata databases, while transport data from the International Road Federation's *World Road Statistics 2011* are used. The model is designed for medium and long-term projections and produces analytical quantitative results up to 2030. In the framework of the MEDPRO project, the model has been applied to the MED-10.

MENA-EDS is a recursive dynamic model with annual resolution and has a predominantly triangular structure in order to limit contemporaneous simultaneity. On the other hand, simultaneity is modelled through lagged instances of endogenous variables. The MENA-EDS model takes as exogenous inputs macroeconomic, demographic and sectoral activity projections, covering the major energy-consuming sectors in industry, households, agriculture, the tertiary sector and transportation up to the year 2030. These activity forecasts, together with consumer prices for fossil fuels – which are themselves derived from international primary fuel prices (coming from the latest PROMETHEUS[3] projections), taking into account country-specific characteristics, such as removal of subsidies, market liberalisation and gradual price reform – are used to determine sectoral energy consumption. Long-term and short-term price effects are accounted for separately by using different elasticities.

Final energy demand is simulated for three main sectors:

- the industrial sector (where ten subsectors are included in the analysis depending on data availability);
- the residential/commercial sector (where three main subsectors are included – households, services and agriculture); and
- the transportation sector (which includes private passenger cars, road freight transport, passenger aviation, and rail passenger and freight transport).

Energy demand arises from net increases in consumers' energy needs, the replacement of scrapped capacity and the existing surviving equipment. Regarding new energy demand, a compact but analytically rich specification encapsulates the dynamic process of technological substitution in all sectors (and subsectors) taking into account the technical and economic characteristics (investment costs, energy efficiency, availability, fixed and variable operating costs) of the major available fuel/technology combinations. Existing and potential policy instruments are also taken into account, such as taxes or subsidies, environmental legislation and efficiency standards and regulations.

Regarding transportation, the share of which in total, final energy demand is expected to increase considerably in the future, a more detailed approach is followed. The evolution of the passenger car stocks in different countries is simulated by considering the effect of economic development and behavioural changes on both the number and use of vehicles, also allowing for potential saturation effects to appear in the car market. In the demand forecasts of all transport modes potential changes in

[2] MENA-EDS stands for Middle East and North Africa Energy Demand and Supply.

[3] PROMETHEUS is a stochastic world energy demand and supply model used by E^{3}M-Lab at the National Technical University of Athens to examine uncertainties regarding the evolution of the energy system and especially world price trajectories.

utilisation rates are modelled, i.e. the development of average capacities or load factors (or both) of each mode.

An innovative aspect considered for determining the technology shares in sectoral final energy demand is consumer size (expressed for example as annual energy consumption of a type of utility in industry, as annual utilisation rates of space-heating boilers in households or as vehicle kilometres in road transport). Consumer size is important in the substitution process, as it provides the possibility for a more accurate coverage of technologies with different technical and cost data, and also allows consideration of potential economies of scale that can be achieved by various technologies. Thereby it can lead to a more appropriate economic representation of the energy structure. Furthermore, for this purpose, existing and potential policy instruments – such as taxes or subsidies, environmental legislation and any other national or international regulations – are taken into account.

A detailed representation of the power supply sector has been implemented in the MENA-EDS model, as power generation is projected to play an increasingly important role in environmental and climate mitigation policies.

Total electricity generation is determined by electricity demand for the industrial, residential and transport sectors, own-consumption of power plants, electricity trade among countries and the transmission and distribution losses in each country. The sectoral origin of electricity demand is used to construct an annual load duration curve, by taking into account that demand by energy-intensive sectors is mainly base-load, while pronounced peaks characterise demand by services and households.

A wide variety of technological options compete to satisfy the electricity demand. The main categories of power generation options are as follows:

- gas-fired technologies, using steam turbine, gas turbine or combined cycle technology;
- coal-fired technologies, which include thermal, fluidized bed, supercritical and integrated gasification technologies using coal or lignite as a fuel;
- oil-fired technologies, including thermal fuel oil and peak devices fuelled by diesel;
- nuclear technologies, third and fourth generation;
- biomass-fired technologies, including thermal and integrated gasification technologies; and
- a wide variety of renewable technologies, including hydroelectricity (large or small scale), wind (onshore and offshore), solar (CSP and photovoltaic) and geothermal.

Capacity installation decisions are based on long-term marginal costs in combination with expectations for the load duration curve. Scrapping rates of power plants include normal scrapping, due to plants reaching the end of their lifetimes, and premature scrapping, due to changes in variable and fuel costs, which render the continuation of a plant's operation economically unsustainable. To determine the utilisation rates of each power-generating technology, the year is divided into nine-hour segments. The annual load duration curve, together with the operating costs and installed capacities of the different technologies, are used in determining capacity utilisation for each time segment (dispatching of power plants) and hence electricity production and associated fuel inputs for each technology. The price of electricity is determined as a function of long-term average marginal costs and is differentiated by sector (industry, services, households and agriculture), reflecting the varying costs of supplying each sector (which mostly arise from the fact that different technologies supply different segments of the load duration curve, but also from economies of scale in distribution to the different types of consumers).

Primary production of fuels is a function of reserves, investments in productive capacity and, in the case of gas and coal, demand (both internal and export). For crude oil it is assumed that the world market can absorb whatever quantities can be produced. Reserves are determined by a motion equation that gives net additions in terms of discoveries minus production. The rate of discovery depends on fuel prices and the undiscovered resources of the fuel as estimated by geological experts

(BGR, 2010;[4] USGS, 2003[5]). The difference between primary consumption and primary production gives net trade through an identity. Natural gas trade among countries and regions takes into account existing pipeline and LNG infrastructure along with projects for their future evolution.

The model calculates emissions and costs in the energy system, as well as the standard energy balances in the context of a projection for the future. The model represents policy instruments, for instance taxes and subsidies, and other mechanisms, such as carbon pricing and incentives promoting energy efficiency and renewables.

3. The reference-QI scenario

3.1 Summary of the present situation

The MED-10 region consists mostly of emerging economies that are characterised by different stages of development as measured by GDP per capita. These differences are to a certain extent reflected in indicators for primary energy demand per capita and for electricity production per capita (Table 1). Morocco registers very low values for both indicators, as it has not followed an energy-intensive mode of development and is characterised by high consumer prices for hydrocarbons and electricity. Syria, Jordan and Egypt register values that stand approximately three or four times lower than EU-27 indicators. Algeria and Tunisia, despite having somewhat higher GDP per capita, are nonetheless characterised by low values, especially where electricity consumption is concerned. For Turkey and Lebanon, the indicators stand higher because these countries have achieved higher levels of economic development. Israel is directly comparable to the EU-27 in terms of both GDP per capita and the consumption indicators. Libya is a case apart, being characterised by a very energy-intensive mode of development. In most cases there is clearly broad scope for MED-10 countries to increase their consumption per capita in line with economic development and standards of living and comfort. On the other hand, the region is characterised by a different climate than that of the EU-27 and may not necessarily converge on saturation levels comparable to Europe.

Looking at dynamic trends as they are reflected by crude elasticity measures of energy demand with respect to GDP, it is worth noting that over the period 1990–2010 the region as a whole registered a value that is very close to unity compared with a mere 0.12 for the EU-27. High empirical elasticities characterise even the more developed countries in the region like Israel and Turkey. Over the period 1990–2010, the empirical elasticity of power generation with respect to GDP for the region taken as a whole was more than two times higher than the equivalent EU-27 elasticity (1.64 compared with 0.71). This overall figure, however, masks very wide differences among the countries (from around 1.2 for Tunisia, Israel, Morocco and Jordan to values of around 2 for Algeria and Lebanon and a value of 3.05 for Libya). At any rate, electricity demand in the MED-10 countries shows little sign of reaching saturation levels in the medium term.

The carbon intensity of energy in the region as a whole in 2010 was just over 2.5 tCO_2/toe, which was higher than that of the EU but not overwhelmingly so. Differences among the countries mostly reflect the balance between oil and gas, the fact that some countries use coal for power generation (Israel and Morocco) and the extent to which renewable energy sources are tapped (Turkey and Egypt). On the other hand, most countries in the region (with the exception of Israel and Libya) were characterised by much lower emissions per capita than those that prevailed in the EU, and differences in climate notwithstanding there is a clear risk that as economic development and living standards rise in the region CO_2 emissions will also rise if no explicit effort is made to counter them. In fact, over the time horizon used by the Kyoto Protocol (1990–2010), all the countries of the region nearly doubled or more than doubled energy-related CO_2 emissions at a time when the EU managed to reduce them more

[4] See Federal Institute for Geosciences and Natural Resources (BGR), *Annual Report: Reserves, Resources and Availability of Energy Resources 2010*, BGR, Hanover (2010).

[5] See US Geological Survey (USGS), "USGS World Petroleum Assessment 2000", Fact Sheet FS–062–03, USGS, Reston, VA, June (2003).

or less in line with the Kyoto commitments. In terms of the availability of fossil fuel resources, the region can be subdivided into the following groups: major energy exporters (Algeria and Libya), modest exporters (Egypt and Syria), a minor net importer (Tunisia) and predominantly net importers (Jordan, Lebanon, Morocco, Israel and Turkey).

Table 1. Summary of energy indicators for the MED-10 countries in 2010

	ALG	EGY	ISR	JOR	LEB	LIB	MOR	SYR	TUN	TUR	MED-10	EU-27
GDP (000 US$ at constant purchasing power parity of 2005/person)	7.61	5.32	26.07	5.14	12.47	14.63	4.25	4.41	7.66	12.06	8.16	27.58
Primary energy demand per capita in 2010 (toe/person)	1.14	0.89	2.90	1.15	1.43	3.48	0.50	1.15	0.92	1.38	1.16	3.42
Electricity per capita in 2010 (kWh/person)	1362	1768	7695	2356	3482	4968	724	2147	1506	2786	2159	6651
GDP elasticity of primary energy demand (1990–2010)	1.07	0.96	0.74	0.70	1.00	1.78	1.17	0.90	0.74	0.95	0.98	0.12
GDP elasticity of electricity generation (1990–2010)	1.93	1.43	1.19	1.26	2.06	3.05	1.25	1.50	1.12	1.79	1.64	0.71
Energy intensity of GDP in 2010 (toe/k$)	0.15	0.17	0.11	0.22	0.12	0.24	0.12	0.26	0.12	0.11	0.14	0.12
Carbon intensity of energy in 2010 (tCO_2/toe)	2.53	2.42	2.96	2.65	2.89	2.64	2.83	2.66	2.22	2.48	2.55	2.10
Carbon intensity of GDP in 2010 (tCO_2/k$)	0.38	0.41	0.33	0.59	0.33	0.63	0.33	0.69	0.27	0.28	0.36	0.26
Carbon per capita in 2010 (tCO_2/person)	2.88	2.16	8.57	3.04	4.14	9.20	1.40	3.06	2.03	3.43	2.95	7.17
Index of CO_2 emissions in 2010 (1990=100)	176.8	226.7	188.4	204.6	324.9	207.9	226.1	222.7	171.0	207.9	207.9	89.4
Net exports as a % of primary production if an exporter (2010)	72.6	12.0	–	–	–	74.0	–	11.7	–	–	16.0	–
Net imports as a % of demand if an importer (2010)	–	–	88.1	97.8	97.4	–	91.7	–	20.5	72.5	–	55.4

Sources: Authors' own calculations using historical data from the IEA and Enerdata databases for the MED-10 and the EU-27 regions.

Assumptions for the reference-QI scenario

The MED-10 region as a whole has been characterised by relatively high rates of population growth in the recent past. The reference-QI scenario is derived from the medium fertility variant of the *World Population Prospects, the 2010 revision* of the United Nations.[6] This projection takes into account the present situation concerning age cohorts, and by assuming median trends in fertility rates and life expectancy it produces forecasts for population and age structure. It implies a marked deceleration in population growth for all countries in the region. This trend is particularly pronounced in Jordan, Lebanon, Israel, Syria and Libya. By contrast, the deceleration is only slight in the case of Egypt. As a consequence, by 2030 Egypt becomes by far the most populous country in the region, with 106.5 million inhabitants. The reference-QI scenario also assumes a continuation of the trends in terms of urbanisation with notable consequences for changes in lifestyles and energy consumption patterns.

Growth of economic activity in MED-10 countries over many years has been strongly influenced by political instability and conflicts, which have characterised almost the entire region. Nonetheless, over the period from 1990 to 2010, growth (Table 2) on average occurred at relatively high rates. For the reference-QI scenario a certain amount of political normalisation is assumed, leading to increased trade and cooperation as well as lower risks and resulting in an increase in foreign direct investment (FDI). Tunisia, Egypt and Jordan are projected to continue their relatively satisfactory growth in per capita incomes. Algeria and Morocco are projected to accelerate their overall economic performance. Libya, which experienced a long stagnation period in the 1990s, according to the forecast, sees a marked acceleration fuelled mostly by rising exports and the international prices of hydrocarbons. With its relatively small population sharing this wealth Libya achieves by 2030 standards of living comparable to those presently enjoyed by oil-rich Middle Eastern states. In recent years the Turkish economy has been growing at a very fast rate (3.5% p.a. in per capita incomes between 2002 and 2010). The reference-QI scenario assumes only a very slight deceleration in this growth. As a consequence, by 2030 Turkish GDP per capita is expected to reach nearly $24,000 (2005, PPP), which is not far removed from the present average in the EU-27. Lebanon is projected to experience a marked deceleration from the very high growth rates that it experienced in the past two decades. Still, by 2030 per capita incomes are set to reach over $20,000 (2005, PPP).

Overall economic activity is a key driver of energy demand. Another general driver is the evolution of consumer prices for energy. To a greater or lesser extent these reflect movements in the prices of internationally traded fuels (Table 3). World oil prices in the reference-QI scenario are assumed to remain high in the medium term due to political uncertainties and the failure of global productive capacity to keep pace with the increase in demand emanating particularly from the rapidly growing economies of Asia. In the longer term, gradually declining reserves to production ratios will mean a continued upward pressure on world oil prices. In the short to medium term, gas prices stand at high levels owing to the continued linkage of contracted gas prices to oil spot prices on the one hand and expanding demand in Asia (Japan and especially China) on the other hand, which will produce a diversion of supplies from Europe to the Pacific. In the longer term, the increased discovery and exploitation of unconventional gas resources in areas beyond North America will result in a relative moderation of gas price increases worldwide and eventually in decoupling from oil prices. International coal prices have recently increased sharply to around $28 (2010/boe), reflecting demand pressure as China increases its imports. The reference-QI scenario assumes little climate policy effort outside the EU and consequently coal demand remains buoyant with coal prices standing at historically high levels.

[6] See UN Department of Economic and Social Affairs, *World Population Prospects, the 2010 Revision*, UN, New York, NY (2010).

Table 2. GDP and population assumptions for the MED-10 countries (annual growth rates in %)

		ALG	MOR	TUN	EGY	LIB	ISR	LEB	SYR	JOR	TUR	MED-10
Population	**1990–2010**	1.70	1.28	1.23	1.79	1.93	2.53	1.82	2.55	3.02	1.49	1.71
	2010–30	1.02	0.80	0.77	1.37	1.02	1.41	0.53	1.57	1.55	0.88	1.11
GDP (at constant PPP)	**1990–2010**	2.65	3.65	4.61	4.57	1.97	4.41	5.90	4.78	5.78	3.75	3.84
	2010–30	3.12	3.92	4.10	4.18	4.41	4.08	2.98	3.49	4.39	4.11	3.97
GDP per capita	**1990–2010**	0.93	2.34	3.34	2.73	0.03	1.83	4.01	2.17	2.68	2.23	2.09
	2010–30	2.08	3.09	3.30	2.78	3.35	2.63	2.43	1.89	2.80	3.21	2.83

Sources: Population projections are derived from the medium fertility variant of the UN's *World Population Prospects*, *the 2010 revision*, while GDP projections come from the GEM-E3 MEDPRO model.

Table 3. International fossil fuel prices (in $2010/boe)

$2010/boe	**2000**	**2010**	**2015**	**2020**	**2025**	**2030**
Oil price	36.2	79.5	111.5	114.9	115.7	120.8
Gas price	25.3	50.2	69.8	79.8	76.4	83.7
Coal price	10.0	21.2	28.5	29.3	30.7	31.1

In principle, movements in international prices should be reflected in domestic consumer prices. Yet, the MED-10 region is characterised by a great variety of pricing regimes. Looking at transportation fuels, Turkey, Israel and Morocco have prices and taxation comparable to the prices that prevail in the EU. In Tunisia and Lebanon, transport fuel taxation is very low. The other countries in the region effectively subsidise transport fuels, as prices for the consumer are lower than tax-free spot prices for exports. This is particularly pronounced in Libya, Egypt and Algeria. Clearly this situation makes little economic sense, given that such spot prices constitute an opportunity cost. Most governments in the region are aware of the need for price reform, but it tends to be unpopular with consumers who have on occasion vigorously agitated against attempts to introduce it. The reference-QI scenario assumes a very gradual movement towards rational prices for transport fuel in these countries. The pace of reform is assumed to be faster in Egypt than in Syria, while Libya and Algeria are assumed to achieve merely the equality of pump prices with spot prices, and only at the end of the forecast horizon (2030).

Concerning electricity prices, it is generally agreed that in order to have a sustainable generation and distribution system the prices to the consumer must cover long-term marginal costs (i.e. apart from operating costs they should also include appropriate capital annuities to ensure that investments are profitable). Generation and distribution costs vary depending on the load profile of different consumers and are generally considerably lower for industrial users than for residential/commercial ones. Concerning industrial users, Jordanian, Syrian and Egyptian industrial consumer prices do not cover long-term marginal costs, calculated using an 8% discount rate. The situation is particularly pronounced in Egypt, where the costs are approximately three times higher than consumer prices. In the case of Algeria and Libya, industrial prices are particularly low but they cover long-term marginal costs because of the extremely low prices of natural gas inputs. Residential/commercial prices in the region cover long-term marginal costs only in Tunisia and Israel. In Syria, the costs are approximately ten times higher than the prices charged to consumers. There are also wide discrepancies in Egypt, but even countries like Morocco and Turkey, where energy price reform has progressed significantly, residential/commercial electricity prices are still subsidised albeit to a lesser extent. The usual justification for such subsidies is that electricity use in households effectively performs a social service in facilitating the enjoyment of material civilisation for every citizen. With growing prosperity in the countries of the region, it can be expected that such arguments will become weaker and gradual price reform will take place in order to ensure the sustainability of the overall power generation and distribution system. In the reference-QI scenario, such price reform is assumed to take place gradually and at a different pace depending on the country (more slowly for Algeria, Libya, Egypt and Syria).

3.2 Industrial energy demand

In the recent past, many MED-10 countries adopted government-assisted industrialisation programmes as vehicles for rapid economic development. This tendency led to an increase of value added in industry as a percentage of total GDP. In recent years, this ratio has tended to stabilise. For the projection period, owing to the gradual opening of the economies and a shift in domestic demand towards services, the share of industrial value added in GDP is forecast to follow a declining trend (between 2010 and 2030, average industrial growth is expected to be 2.74% compared with almost 4% for GDP). On the other hand, the persistence of low energy prices in most MED-10 countries means that international specialisation will favour more energy-intensive subsectors and as a consequence the specific energy consumption (excluding electricity) of industry is expected to decline rather slowly. The projection implies a big increase in the share of electricity in the total, final energy demand by industry as a result of the penetration of electrical industrial processes and increased demand for specific electricity needs, such as electric motors. Another striking feature of the projection is the increased penetration of natural gas for heat and steam-raising purposes, mostly at the expense of oil. This substitution occurs primarily for purely economic reasons: with the expansion of the natural gas grid there is greater potential for more attractively priced gas to substitute residual fuel oil. Libya, Algeria and Egypt, which are the main exporters of natural gas, naturally register the highest shares. Meanwhile, natural gas deeply penetrates the industrial energy market, even in such countries as Tunisia, Syria and Jordan. Solid fuels are overwhelmingly used in the iron and steel and construction materials sector of Turkey and their importance is projected to decline on the horizon towards 2030. Tables 4 and 5 summarise the evolution of the shares of different fuels in industrial demand for the entire MED-10 region according to the MENA-EDS model results for the reference-QI scenario.

Table 4. Shares of fuels in final industrial demand for energy in the MED-10 region, (reference-QI scenario) (in %)

	2005	2010	2015	2020	2025	2030
Solids	19.1	13.8	9.9	9.4	8.8	8.2
Oil	35.0	21.9	17.8	14.8	12.5	10.8
Gas	22.2	35.6	38.9	40.3	41.2	41.7
Electricity	23.7	28.7	33.4	35.5	37.4	39.3

Table 5. Share of natural gas in final industrial demand for energy in MED-10 countries in 2030 (reference-QI scenario) (in %)

	ALG	MOR	TUN	EGY	LIB	ISR	LEB	SYR	JOR	TUR	MED-10
2030	57.1	25.0	48.6	55.7	68.5	29.6	22.4	35.9	31.1	25.7	41.7

3.3 Energy demand in other sectors

In 2010, agriculture in the MED-10 region accounted for 5.5% of the total, final energy demand (in Morocco it stood at 15.3%) compared with around 2.5% for the EU-27. As many countries in the region are far from having experienced full mechanisation of agriculture, this share is projected to increase to 5.9% in 2020 before declining slightly to 5.63% in 2030. Gas/oil will remain the dominant fuel in the sector, growing by 60% from 2010 to 2030. Over the same period electricity demand is projected to more than double.

The services sector is projected to increase its importance in total economic activity in the MED-10 region, rising from 38% of total value added in 2010 to 43% in 2030. It is also a sector with considerable energy-saving potential, which will in part materialise (an average 1.6% per annum between 2010 and 2030) primarily as result of the higher prices implied by price reform with regard to natural gas and especially electricity. Electricity is the dominant fuel in the sector and is projected to grow 2.6 times from its 2010 level. In Algeria, Morocco, Tunisia, Syria and Jordan, the increase will be more than 3 times. A major component of the growth comes from the increased penetration of air-conditioning.

The residential sector currently accounts for around 26% of the MED-10 region's total, final energy demand. With the exception of Turkey, energy demand for heating is not particularly important. On the other hand, for cooking and water-heating purposes, a wide variety of fuels are used, including LPG, natural gas, traditional biomass and electricity. The use of traditional biomass is projected to decline continually throughout the period because of increased urbanisation and rising living standards. The share of LPG use is projected to decline to the extent that households are connected to the natural gas grid. The share of natural gas in total final demand by households is forecast to increase from 22% at present to almost 35% by 2030 (Table 6). Electricity is by far the fastest growing form of energy in this sector. Apart from cooking and water heating, electricity demand is pushed forward by the rapid spread of electrical appliances, such as refrigerators and deep freezers, washing machines, dishwashers, television sets and an array of other appliances that in many countries of the region are far from having reached saturation levels. Noteworthy in this context is air-conditioners, which are mostly used for cooling purposes. They already tend to modify the load curve in many countries, where overall peaks start occurring in the afternoon hours of the summer instead of winter evenings. The high growth of electricity demand is a prominent characteristic of the outlook for all countries (Table 7) in the region except Israel, where some saturation signs are evident. Even relatively prosperous countries like Tunisia and Turkey register very high rates of growth in residential electricity demand despite a marked deceleration towards the end of the forecast period.

Table 6. Final household demand for energy in the MED-10 region, by type of energy (reference-QI scenario) (in %)

	2005	2010	2015	2020	2025	2030
Solids	3.4	8.1	4.8	3.4	2.7	2.2
Oil	32.5	26.3	21.8	17.6	14.7	12.6
Gas	21.2	22.0	27.6	31.9	34.2	34.8
Traditional biomass	18.1	14.0	10.7	8.2	6.1	4.7
Electricity	24.7	29.6	35.2	38.9	42.3	45.8

Table 7. Average annual growth of residential electricity demand in the period 2010–30 (reference-QI scenario) (in %)

	ALG	MOR	TUN	EGY	LIB	ISR	LEB	SYR	JOR	TUR	MED-10
2010–30	6.2	6.2	7.3	5.8	5.9	2.2	5.9	6.5	5.8	6.3	5.9

3.4 Energy demand in the transport sector

The major uncertainty with regard to energy consumption for transport in the region arises from the possible evolution of car ownership in the different countries. At present most countries have very low car ownership rates. Lebanon is an exception, with a rate approaching 400 vehicles/000 inhabitants. Israel, with a GDP per capita close to the EU average, has a car ownership rate that is well below the rate registered in European countries enjoying similar living standards. The model-based projections resemble S-shaped penetration curves simulating take-off and saturation effects. According to the analysis, by 2030 Israel, Libya, Lebanon and Turkey will be experiencing saturation effects at levels that are comparable to current European rates (Table 8). Algeria, Tunisia and Jordan will be experiencing car ownership expansions characteristic of the steep segment of the penetration curve. Morocco, Egypt and Syria will still be at relatively early stages of private motorisation.

Table 8. Evolution of private cars per thousand inhabitants in the MED-10 countries (reference-QI scenario)

	ALG	MOR	TUN	EGY	LIB	ISR	LEB	SYR	JOR	TUR	MED-10
2010	82	61	82	33	235	273	395	31	115	116	85
2020	122	89	135	50	397	382	440	46	148	235	139
2030	176	126	213	75	495	508	495	71	223	424	217

Average consumption per vehicle is influenced by a variety of factors, such as vehicle utilisation rates (km/year), driving conditions (urban versus country driving), the average size of vehicles and technological improvements leading to higher fuel efficiency. There is an overall tendency for a reduction in the utilisation rates as motorisation increases. On the other hand, in almost all countries in the region, the share of urban driving in conditions of congestion increases significantly over the forecast horizon. The average size of vehicles will have a slight tendency to increase as incomes rise. Enhanced vehicle efficiency will occur through international trade (the overwhelming majority of vehicle registrations concern imported vehicles). The modest reform of pump prices assumed for some of the countries will have a relatively small effect on vehicle choices. The net result of all the above is that fuel consumption per vehicle displays a modest improvement, ranging from 1% per annum for Morocco, Tunisia, Jordan and Egypt to around 1.4% p.a. for Algeria, Syria, Israel and Turkey. Among the new vehicle technologies only conventional hybrid vehicles slowly gain a share. By 2030, they account for approximately 9% of the vehicle stock in most countries of the region yet reach 13% in Israel, where pump prices are considerably higher.

Commercial road transport in 2010 accounted for approximately 36% of total energy consumption in the road transport sector. Energy consumption for trucks is closely linked to economic activity and is projected to increase vigorously in the region (2.8% p.a.), surpassing 3% p.a. in Morocco, Egypt and Jordan. Meanwhile, the expansion in private motorisation is expected to be such that the share of trucks in energy demand for road transport in the region as a whole is projected to decline to 26% by 2030.

Air transport activity in the region is expected to show particular dynamism in the period. Measured in terms of the number of passengers carried, it is projected to grow by 5.2% p.a. over the 2010 to 2030 period, compared with growth of 4% p.a. for GDP. Aircraft occupancy rates will slightly decline but improvements in the energy efficiency of aircraft will mean that fuel consumption by the air transport sector as a whole will grow at an average rate of 4% p.a.

The buoyant demand for oil for transportation purposes combined with its diminishing role in the industrial, residential/commercial and especially the power generation sectors mean that in all countries of the region transport is expected to become the dominant market for oil products. This dominance is overwhelming in the cases of Israel, Algeria and Tunisia, but it is also very significant in Turkey and Syria (Table 9).

Table 9. Share of oil demand for transport in primary oil consumption (reference-QI scenario) (in %)

	ALG	MOR	TUN	EGY	LIB	ISR	LEB	SYR	JOR	TUR	MED-10
2010	73	39	64	46	50	82	36	45	47	66	56
2020	83	45	76	59	55	89	47	63	56	71	66
2030	90	50	83	69	66	93	51	74	63	77	74

3.5 Electricity sector

The sustained electrification of industry and the rapid penetration of electrical appliances in the residential/commercial sectors translate into vigorous growth in final demand for electricity for most countries in the region (the main exception is Israel, where saturation effects become apparent).

Growth of demand for electricity is projected on average to be faster than the growth of GDP (Table 10) and means that by 2030 the region is projected to become a major electricity market (1,564 TWh), requiring large-scale expansion of productive capacity. In some countries, notably Syria and Algeria, this growth will be somewhat moderated by a reduction in transmission and distribution losses, which are currently recorded at very high levels. Indeed, for all countries in the region (with the exception of Israel), there is considerable scope for the reduction of losses. These considerations notwithstanding, power generation growth in the current decade is projected to be equivalent to the growth experienced in the decade from 2000 to 2010. In some cases, such as Algeria and Tunisia, a slight acceleration is forecast. Towards the end of the projection horizon, the saturation effects result in a certain deceleration in the growth of power needs. This is particularly noticeable in the cases of Turkey and Libya, where per capita incomes reach levels comparable to current European standards. Tables 11-13 summarise the evolution of power generation in the MED-10 countries projected in the reference-QI scenario.

At present, the size of the MED-10 electricity market is 15% of the EU electricity market size. The fast pace of the growth in demand in the MED-10, contrasting with the slower pace in the EU, will lead the MED-10 electricity market size to exceed 35% of the EU size in the future (Figure 1).

Table 10. Average annual growth of total, final electricity demand (reference-QI scenario) (in %)

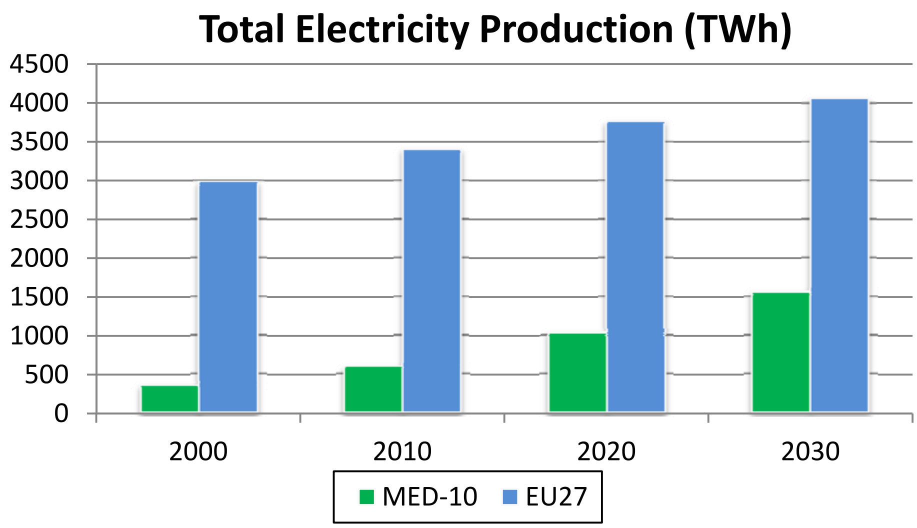
	ALG	MOR	TUN	EGY	LIB	ISR	LEB	SYR	JOR	TUR	MED-10
2010–30	6.3	6.4	6.5	5.2	4.2	1.9	3.8	6.2	5.7	5.0	5.1

Table 11. Evolution of power generation in MED-10 countries (reference-QI scenario)

	Power generation in TWh				Average annual growth (in %)		
	2000	**2010**	**2020**	**2030**	**2000–10**	**2010–20**	**2020–30**
ALG	28	46	84	147	5.9	6.2	5.7
MOR	13	23	48	94	7.7	7.4	7.0
TUN	9	16	30	53	5.9	6.6	6.0
EGY	78	150	258	405	6.7	5.6	4.6
LIB	15	29	47	65	6.5	4.9	3.2
ISR	43	55	68	80	2.5	2.2	1.6
LEB	10	15	23	32	5.2	4.0	3.5
SYR	25	44	80	128	6.3	6.2	4.8
JOR	7	14	25	43	7.7	5.7	5.5
TUR	125	205	375	518	5.6	6.3	3.3
MED-10	353	597	1037	1564	6.0	5.7	4.2
EU-27*	2992	3410	3767	4067	2.7	2.0	1.5

* Based on the PRIMES model reference scenario.

Figure 1. Electricity market size: Comparison between the MED-10 and the EU



Sources: Results from the reference projections of the MENA-EDS and PRIMES models.

According to the reference-QI scenario, the MED-10 region will produce 1,564 TWh in 2030 through the operation of 367 GW of power (in 2010 the installed capacity in the region was 141 GW).

The nuclear option has at various times been considered by a number of countries, including Turkey, Algeria, Morocco, Egypt, Israel and Jordan. The Fukushima accident of 2011 has brought to the fore a considerable amount of scepticism concerning most of these projects. Even if some of them finally go ahead, experience from the past shows that given present concerns the entire process of planning, tendering, licensing and construction may take even longer than the two decades that separate us from the projection horizon (2030). This is particularly the case in countries like those in the MED-10, which have little or no experience with this type of project. The only nuclear project retained in the reference-QI case is the Akkuyu project in southern Turkey. Indicatively, this project was first discussed in the 1970s when the first round of bids took place. It was on and off the agenda throughout the 1980s and 1990s, but is finally under construction. The nuclear plant will be built, owned and operated by a Russian subsidiary of Rosatom, a state-owned nuclear company, and the first unit of 1.2 GW is expected to come on-stream in 2019, with three more similar units starting production by 2023.

The hydroelectric potential of the region has already been tapped to a large extent. A major exception to this generalisation is the case of Turkey. In this country, the reference-QI scenario projects a near doubling of capacity from 15.3 GW in 2010 to 27.8 GW in 2030. A minor expansion of hydropower is also projected for Morocco (concerning 560 MW of additional capacity).

Wind power is already being exploited in the region, notably in Turkey, Egypt, Morocco and Tunisia. In 2010, total installed capacity in the region amounted to 2.6 GW, which of course represents a tiny fraction of the region's potential. Most countries in the region have ambitious plans for increasing the contribution of wind power. The main instruments used for promotion are direct investment by state-owned enterprises, investment subsidies, feed-in tariffs and quotas accompanied by economic instruments. The reduction in capital costs of recent years together with the availability of many suitable sites (enabling high utilisation rates) in combination with the various promotion policies are likely to produce a large expansion of wind capacity in the coming two decades. The bulk of the capacity expansion is projected to occur in Egypt and Turkey. Yet, the contribution of wind power to total electricity requirements in 2030 is higher (6.5% to 8%) in Tunisia, Morocco, Libya and Jordan. Even in these countries, however, this represents a small fraction of the potential. A larger share is clearly possible but would probably require a more sustained and coordinated effort of the type examined in the various alternative scenarios below.

Table 12. Evolution of power plant capacity in the MED-10 region in the reference-QI scenario in 2030 (in GW)

		ALG	MOR	TUN	EGY	LIB	ISR	LEB	SYR	JOR	TUR	MED-10
Total electricity capacity	**2010**	12.5	7.3	3.9	30.0	7.7	13.7	3.1	9.8	3.6	49.3	140.9
	2020	24.4	15.7	8.1	52.8	13.1	15.3	4.7	17.2	6.8	91.5	249.5
	2030	37.5	26.9	14.5	82.2	18.2	18.0	7.0	27.5	10.7	124.9	367.2
Nuclear power plants	**2010**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2020	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	1.2
	2030	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.8	4.8
Renewables	**2010**	0.3	2.2	0.2	3.4	0.0	0.0	0.3	1.4	0.1	16.7	24.7
	2020	2.0	4.6	1.1	6.5	1.0	1.2	0.4	2.0	1.2	25.9	45.9
	2030	5.8	7.0	3.2	10.4	3.5	2.9	1.1	3.2	2.1	36.5	75.6
Hydro	**2010**	0.3	1.7	0.1	2.8	0.0	0.0	0.3	1.4	0.0	15.3	21.9
	2020	0.3	2.1	0.1	2.9	0.0	0.0	0.3	1.5	0.0	21.5	28.5
	2030	0.3	2.3	0.1	3.0	0.0	0.0	0.3	1.5	0.0	27.8	35.3
Wind	**2010**	0.0	0.5	0.1	0.6	0.0	0.0	0.0	0.0	0.1	1.3	2.6
	2020	0.3	1.4	0.7	3.4	0.8	0.6	0.1	0.4	0.7	3.9	12.3
	2030	1.0	2.4	1.8	6.6	2.1	1.3	0.3	1.2	1.3	7.6	25.7
Biomass & waste	**2010**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
	2020	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3
	2030	0.0	0.1	0.1	0.1	0.0	0.3	0.0	0.1	0.1	0.1	0.9
Concentrating solar power (CSP)	**2010**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2020	1.2	1.1	0.3	0.2	0.1	0.3	0.0	0.0	0.4	0.1	3.7
	2030	3.0	2.1	1.0	0.6	1.1	0.6	0.4	0.2	0.6	0.1	9.7
Photovoltaics	2010	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2020	0.2	0.1	0.0	0.1	0.0	0.3	0.0	0.0	0.1	0.0	0.8
	2030	1.5	0.1	0.3	0.1	0.3	0.7	0.1	0.2	0.1	0.4	3.7
Fossil fuel-based plants	**2010**	12.3	5.1	3.7	26.6	7.7	13.6	2.8	8.4	3.4	32.5	116.2
	2020	22.4	11.1	7.0	46.3	12.1	14.1	4.3	15.2	5.6	64.4	202.4
	2030	31.6	19.9	11.3	71.8	14.7	15.1	5.9	24.3	8.6	83.6	286.8
Solids	**2010**	0.0	3.5	0.0	0.0	0.0	6.2	0.0	0.0	0.0	12.2	21.9
	2020	0.0	5.6	0.0	0.0	0.0	5.3	0.0	0.0	0.0	20.5	31.5
	2030	0.0	6.4	0.0	0.0	0.0	4.6	0.0	0.0	0.0	29.0	40.1
Oil	**2010**	0.7	1.0	0.5	5.2	3.3	1.9	2.2	1.9	1.7	5.5	23.8
	2020	0.6	1.9	0.4	5.3	3.1	1.4	1.8	1.9	1.7	3.4	21.6
	2030	0.5	2.5	0.4	5.3	2.7	0.8	1.9	1.5	1.8	2.1	19.5
Gas	**2010**	11.6	0.6	3.2	21.4	4.4	5.6	0.6	6.5	1.8	14.8	70.4
	2020	21.8	3.5	6.5	40.9	9.0	7.4	2.5	13.4	3.9	40.5	149.3
	2030	31.1	11.0	10.9	66.5	12.0	9.7	4.0	22.8	6.7	52.5	227.3

Table 13. Evolution of electricity production in the MED-10 region in the reference-QI scenario in 2030 (in TWh)

		ALG	MOR	TUN	EGY	LIB	ISR	LEB	SYR	JOR	TUR	MED-10
Electricity generation	**2010**	46.1	23.3	15.7	149.9	29.2	54.7	15.3	43.7	14.4	204.5	596.9
	2020	84.1	47.7	29.7	257.9	47.1	68.1	22.7	79.7	25.2	375.3	1037.4
	2030	146.7	93.6	53.2	405.0	64.6	80.1	32.0	127.7	43.0	517.6	1563.6
Nuclear power plants	**2010**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2020	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.7	8.7
	2030	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	34.6	34.6
Renewables	**2010**	0.2	3.9	0.4	13.6	0.0	0.1	0.6	1.8	0.3	40.1	61.0
	2020	4.9	9.0	2.3	22.2	2.0	3.0	1.0	3.1	2.9	61.4	111.8
	2030	16.7	16.2	7.5	34.6	8.1	8.0	2.9	6.6	5.7	87.4	193.8
Hydro	**2010**	0.2	3.0	0.1	12.2	0.0	0.0	0.6	1.8	0.1	37.1	55.1
	2020	0.3	3.6	0.1	12.6	0.0	0.0	0.7	1.8	0.1	52.2	71.3
	2030	0.3	3.9	0.1	13.0	0.0	0.0	0.7	1.9	0.1	67.4	87.4
Wind	**2010**	0.0	1.0	0.3	1.4	0.0	0.0	0.0	0.0	0.2	2.8	5.6
	2020	0.6	3.1	1.6	9.0	1.7	1.3	0.2	1.0	1.6	8.7	28.9
	2030	2.2	6.0	4.3	19.2	4.7	3.2	0.8	2.9	3.2	18.5	65.0
Biomass & waste	**2010**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.3
	2020	0.0	0.0	0.0	0.1	0.0	0.3	0.0	0.1	0.1	0.3	0.9
	2030	0.0	0.2	0.1	0.4	0.0	1.5	0.2	0.5	0.3	0.3	3.6
Solar	**2010**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2020	4.0	2.3	0.6	0.6	0.3	1.3	0.0	0.2	1.1	0.2	10.7
	2030	14.2	6.0	3.0	2.1	3.4	3.2	1.2	1.2	2.1	1.2	37.8
Fossil fuel plants	**2010**	45.9	19.3	15.3	136.3	29.2	54.6	14.7	42.0	14.1	164.4	535.9
	2020	79.2	38.7	27.4	235.7	45.1	65.1	21.7	76.6	22.3	305.2	916.9
	2030	129.9	77.4	45.7	370.4	56.5	72.1	29.1	121.1	37.3	395.6	1335.1
Solids	**2010**	0.0	12.3	0.0	0.0	0.0	29.4	0.0	0.0	0.0	62.7	104.4
	2020	0.0	19.2	0.0	0.0	0.0	26.4	0.0	0.0	0.0	89.3	135.0
	2030	0.0	24.9	0.0	0.0	0.0	22.2	0.0	0.0	0.0	125.7	172.9
Oil	**2010**	0.9	4.8	1.7	31.2	14.1	2.1	11.1	11.9	4.2	6.2	88.4
	2020	0.8	7.2	1.0	23.1	13.8	1.5	7.4	9.1	4.6	3.3	71.8
	2030	0.6	10.1	0.8	20.2	9.5	0.9	7.0	7.4	6.2	1.7	64.4
Gas	**2010**	45.0	2.2	13.6	105.1	15.0	23.1	3.6	30.0	9.9	95.5	343.1
	2020	78.4	12.3	26.4	212.6	31.3	37.2	14.3	67.4	17.7	212.5	710.1
	2030	129.3	42.4	44.9	350.2	47.0	49.0	22.1	113.7	31.1	268.1	1097.8

According to the reference-QI scenario, biomass and waste-based power generation will make a minor contribution even by 2030. In that year only 3.6 TWh will be produced in this way, about half of which is expected in Israel, which has a promotion programme aimed at the construction of biogas, biomass and waste electricity production.

With regard to the production of solar thermal power, the main technology considered in the model is concentrating solar rower (CSP) with varying storage capacities. The region as a whole but especially its Saharan parts is considered to contain among the most suitable sites for this type of technology in the world. Up until now, however, this technology contributes virtually nothing to the electricity production needs of the countries concerned. The main reason for this is the relatively high cost of CSP, especially when compared with its most obvious competitor in the region, which is the combined cycle gas turbine technology. Under these conditions, CSP deployment necessitates a special support system that goes even beyond the one created to encourage wind power. In very recent years, such support systems have begun to be put in place and there is considerable interest in the promotion of many CSP projects in a number of countries in the region, such as Algeria, Morocco, Tunisia, Egypt, Israel and Jordan. A major impetus in this direction has been given by several initiatives emanating from the EU (e.g. DESERTEC), which are ultimately aimed at facilitating trade in renewable energy across the Mediterranean Sea. The reference-QI scenario presented here does not incorporate large-scale exports of renewable electricity from MED-10 countries to the EU, as for analysis purposes such a possibility is included in some of the alternative scenarios. Nevertheless, it assumes that the present effervescence concerning the possibility of such exports leads to the undertaking of a number of projects and the creation of a suitable framework in which CSP is initially deployed. With increased deployment comes learning by doing, which enhances the economic attractiveness of the option. By 2030, CSP is expected to produce around 2% of the MED-10 region's generation requirements overall. By country, in Algeria it is forecast to contribute 7.5% and in Morocco 6.2%, while in Tunisia, Libya and Jordan between 4% and 5%.

Photovoltaic (PV) generation is less systematically pursued than CSP. It mainly involves relatively small units and also requires considerable support to become competitive under the conditions prevailing in the energy markets of the MED-10 countries; another factor limiting wide development of PV is the lack of adequately meshed low/medium voltage grids and the relatively high investment that would be needed. The modelling takes into account learning by doing in PV technology, which implies that investment costs decrease over time. The decrease is such that PV gets close to grid parity in regions with high solar radiation, such as the MED-10 region, provided that low voltage tariffs are fully cost reflective. Still, in many of the MED-10 countries, electricity tariffs are not cost-reflective (they are indirectly subsidised) and so PVs are not competitive at such low electricity tariffs unless supported by subsidisation policies. The modelling assumes a gradual increase of electricity tariffs to approach alignment with true costs, which favours PVs in the long term. At present, Algeria has already set targets concerning PV power (2.8 GW in 2030) and is setting up domestic manufacturing facilities capable of producing 50 MW/year. According to the reference-QI scenario, Algeria only reaches 1.5 GW in 2030, but this still constitutes about 40% of installed PV capacity in the MED-10 region. The only other country for which projected PV contribution exceeds 1% is Israel (1.5% of total generation).

Only three countries in the region (Turkey, Morocco and Israel) currently use coal for power generation and the reference-QI scenario projects that no other country will use such options. Turkey currently produces around 30% of its electricity needs from solid fuels, a percentage that is projected to fall to 24% by 2030. This drop in share notwithstanding, Turkey is forecast to increase its coal-fired capacity from 12 GW in 2010 to 29 GW in 2030. Currently, domestically produced lignite is by far the dominant solid fuel. By 2030, imported hard coal and lignite are expected to make an almost equal contribution. Most of the new plants use fluidized bed and supercritical technologies. By the end of the period, Turkey is forecast to introduce 5 GW of integrated coal gasification plants. Morocco currently provides 52% of its electricity needs through solid fuel plants. This figure is projected to decline to 26% by 2030. New coal-fired plants are mostly expected to be introduced in the relatively short term to 2020, dominated by 1.3 GW from an ultra-supercritical pulverised coal-fired power plant. For Israel, which in 2010 met 58% of its needs from imported hard coal, no new investments in coal-fired power plants are projected for the entire forecast period, since domestically produced gas mostly fuels the majority of additional capacity.

Oil as a fuel for power generation has seen its shares drop sharply in recent years. This process is forecast to continue in all countries of the region until 2030, by which time many of them (Algeria, Tunisia, Israel and Turkey) will generate virtually no oil-fired electricity. This rapid transition takes place in the light of competition from gas facilitated by higher production and increased intra-regional trade for the latter.

Natural gas already dominates the power generation sector of the region and its position overall is projected to strengthen in the coming two decades (Table 14).

Table 14. Share of natural gas in the power generation mix in the reference-QI scenario (in %)

	ALG	MOR	TUN	EGY	LIB	ISR	LEB	SYR	JOR	TUR	MED-10
2000	96.8	0.0	87.6	67.7	21.9	0.0	0.0	37.1	10.1	37	**41.9**
2010	97.7	9.6	86.5	70.1	51.5	42.3	23.5	68.7	68.8	46.7	**57.5**
2020	93.3	26	88.7	82.4	66.4	54.7	63	84.6	70.2	56.6	**68.5**
2030	88.2	45.5	84.4	86.5	72.7	61.1	69.1	89	72.3	51.8	**70.2**

Only Algeria and Tunisia experience relatively minor reductions in their already very large shares owing to competition from renewable energy sources. In Turkey, there is a slight reduction in the share of gas between 2020 and 2030 as a result of the commissioning of major nuclear power plants and the rapid expansion of wind power. Even countries like Morocco and Lebanon, which have no domestic production, experience a major transformation based on natural gas imports as the gas trade infrastructure expands. The dominant option for new gas-fired capacity is the combined cycle gas turbine technology. It combines relatively low capital costs with very high efficiency rates, thus making it attractive even in natural gas-importing countries where the prices of fuel approach international levels. Gas-fired power generation is also convenient in complementing the intermittent production of renewable power and facilitates load management, especially when renewable shares are relatively high.

3.6 Primary energy supply

In 2010, Algeria was marginally the biggest oil producer in the region. The reference-QI scenario projects a slight increase between 2010 and 2020. On the other hand, Algeria has become a relatively mature oil province with few and smaller new fields being discovered and old ones being gradually exhausted. As a consequence, oil production is projected to decline after 2020 and reach levels below current production by 2030. With domestic demand growth of 40% between 2010 and 2030, exports are projected to drop by 16.5% in the same period (Table 15).

Libya is the other major producer in the region with good prospects for the expansion of production in the coming decades. In the short term, most of the increase will come as a result of enhanced recovery, while in the longer term the expansion of pipeline infrastructure will play a major role. Production is projected to more than double between 2010 and 2030. During this period, domestic demand growth is expected to be very modest as a result of a massive switch from oil to gas in power generation. Consequently, oil exports are forecast to increase 2.37 times.

Egyptian production is projected to remain virtually flat between 2010 and 2020 thanks to the coming on-stream of some small oil fields and the increased use of enhanced recovery. Production is nonetheless projected to decline gradually during the 2020s, reflecting the relative maturity of Egypt as an oil province. The country became a net importer in 2010 and net imports are projected to increase rapidly, covering 15% of domestic needs in 2020 and 41% in 2030.

Syrian oil production peaked at 31.9 Mtoe in 2002 and has declined considerably since then, and in recent years it has averaged around 19 Mtoe. The reference-QI scenario projects a further decline, reaching 17.5 Mtoe by 2030. By that time Syria, which in 2010 exported 24% of its production, will have become a slight net importer of oil.

Tunisia, which in 2010 was a very marginal net oil importer, is projected to import 56% of its needs by 2030. Jordan, which currently has no oil production, is projected to become a shale oil producer after 2025. By 2030, such production is forecast to supply 23% of domestic needs. With an average growth in oil demand of 4.2% p.a., a small and secular decline in production is expected as a consequence of a very low reserve base.

Turkey is set to become the major oil importer of the region (75.2 Mtoe in 2030). Lebanon, which imports all of its oil, is projected to register a reduction in the order of 13% between 2010 and 2030, mostly owing to fuel switching in the power generation sector.

Gas production in the MED-10 region is set for a major expansion (more than doubling between 2010 and 2030). The main producer is Algeria, which currently possesses around 4,500 billion cubic meters[7] and has ample scope for meeting expanding domestic demand and additional exports. According to the reference-QI scenario, the latter increase from nearly 50 Mtoe in 2010 to just less than 95 Mtoe in 2030 (Table 16). Exports to neighbouring countries (Morocco and Tunisia), which in 2010 accounted for only 1.5 Mtoe, are projected to increase to 15.5 Mtoe by 2030. Egypt is also a major producer with reserves equivalent to about half those of Algeria. Unlike Algeria, where the export market absorbs around two-thirds of production, Egypt's output is mostly directed towards domestic needs. This predominance of the domestic market is projected to increase from around 65% in 2010 to 75% in 2030.

Table 15. Primary production and net imports of oil in the reference-QI scenario (in Mtoe)

		ALG	MOR	TUN	EGY	LIB	ISR	LEB	SYR	JOR	TUR	MED-10
Primary production	**2010**	78.7	0.0	3.9	34.7	74.6	0.0	0.0	19.1	0.0	2.5	213.5
	2020	86.5	0.0	3.3	35.4	116.9	0.0	0.0	18.8	0.0	1.4	262.3
	2030	74.4	0.0	2.7	32.0	165.3	0.0	0.0	17.5	1.8	0.4	294.2
Net imports	**2010**	-62.3	10.7	0.0	0.7	-62.7	10.7	4.9	-4.5	5.1	31.1	-66.5
	2020	-67.2	13.0	1.5	6.3	-101.5	13.7	4.2	-3.0	6.2	49.6	-77.3
	2030	-51.8	16.0	3.5	22.5	-148.4	17.3	4.3	0.5	6.1	75.2	-54.8

Table 16. Primary production and net imports of natural gas in MED-10 countries in the reference-QI scenario (in Mtoe)

		ALG	MOR	TUN	EGY	LIB	ISR	LEB	SYR	JOR	TUR	MED-10
Primary production	**2010**	71.2	0.0	2.7	53.0	13.7	2.5	0.0	6.4	0.2	0.6	150.2
	2020	110.6	0.0	3.3	83.7	25.4	15.8	0.0	9.3	0.2	0.3	248.7
	2030	144.2	0.0	3.4	119.5	34.9	20.0	0.0	10.4	0.2	0.1	332.8
Net imports	**2010**	-49.7	0.4	1.1	-18.6	-8.2	1.7	0.6	0.1	1.6	29.0	-41.9
	2020	-76.1	3.9	2.8	-24.6	-16.0	-8.3	2.5	4.2	3.0	55.6	-53.0
	2030	-94.5	9.9	6.1	-30.4	-22.2	-10.0	3.8	10.5	5.6	71.7	-49.5

Furthermore, exports to countries within the region (Jordan, Syria, Lebanon and Israel until 2025) are projected to gain an increasing share (from 29% in 2010 to 52% in 2030). The remainder of Egypt's exports are set to take the form of LNG (including spot sales), a situation that is expected to continue throughout the forecast period. Production in Libya is projected to increase by 155% between 2010 and 2030, while exports grow even faster. Unlike Egypt, Libyan exports are directed outside the region (to Europe, mainly Italy). This situation is forecast to continue overwhelmingly throughout the projection period. In 2010, less than 6% of exports took the form of LNG, while the remainder was carried through underwater pipelines. The share of LNG exports is projected to increase somewhat with the expansion of capacity in the existing terminal and the establishment of a new one. Beyond 2025, small amounts of Libyan gas exports would be directed towards Tunisia. In 2010, Syria was almost self-sufficient in natural gas. This situation is expected to change rapidly, with net imports accounting for 31% of primary consumption in 2020 and 50% in 2030. From being a small producer and net importer of natural gas, Israel is forecast to become an important producer within the current

[7] See Cedigaz, *Natural gas in the World*, 2011 Edition, Cedigaz, Rueil Malmaison, December (2011).

decade. In 2012–13, production from the Tamar offshore field is expected to begin followed by production from Dalit and in 2016–18 the large Leviathan field. A floating LNG terminal and a pipeline will supply the domestic market (mostly for power generation). A larger LNG terminal is expected for Leviathan production, which will be directed towards export markets. According to the reference-QI case, by 2030 50% of Israeli output will be exported to destinations outside the region. Tunisian natural gas production is projected to increase but at a rate that is slower than demand growth. Consequently, the share of imports in primary consumption is expected to increase from 29% in 2010 to 64% in 2030. The remaining countries in the region either have no production (Morocco and Lebanon) or have insignificant production with poor prospects (Turkey and Jordan). Their net imports would depend entirely on the evolution of the domestic market. In the case of Turkey, this would be very large – rising from 29 Mtoe in 2010 to 72 Mtoe in 2030. All gas imports to Turkey are expected to originate outside the MED-10 region.

3.7 Primary energy requirements and CO_2 emissions

The MED-10 region in the recent past has registered generally very high growth rates in primary consumption (Table 17). This has been the case for Egypt, Morocco, Syria and Jordan in particular. In the current decade, most countries are characterised by a clear deceleration (notable exceptions are Israel and Turkey). For the decade from 2020 to 2030, the reference-QI scenario projects acceleration, especially in Tunisia, Jordan and Syria. On the other hand, Israel and Turkey will start experiencing saturation effects and a marked deceleration.

Table 17. Evolution of primary energy consumption and carbon intensity in the reference-QI scenario

	Primary consumption			**Energy-related CO_2 emissions**			**CO_2 emissions per TWh produced**	
	Average annual growth rate (in %)							
	2000–09	**2009–20**	**2020–30**	**2000–09**	**2009–20**	**2020–30**	**2009–20**	**2020–30**
ALG	4.20	2.92	3.13	4.52	3.04	2.83	-3.36	-1.07
MOR	5.14	3.76	3.83	4.63	3.40	3.59	-1.96	-1.84
TUN	2.02	2.10	3.28	2.13	1.95	3.05	-3.60	-1.34
EGY	5.83	3.30	3.62	5.74	3.08	3.30	-2.13	-0.87
LIB	3.54	1.72	1.98	2.51	0.98	1.62	-5.42	-2.34
ISR	2.06	2.54	1.90	2.34	1.81	1.39	-1.98	-1.88
LEB	2.76	1.69	1.94	2.17	1.02	1.53	-3.53	-1.41
SYR	4.88	2.62	3.02	5.49	1.58	2.84	-4.12	-1.05
JOR	4.49	2.07	3.33	3.91	1.76	2.84	-3.43	-0.83
TUR	3.52	3.75	3.20	3.55	3.54	3.08	-1.12	-1.05
MED-10	4.16	3.06	3.18	4.04	2.84	3.05	-2.44	-1.26

In the period 2009 to 2020, the carbon intensity of primary consumption is expected to be stagnant or slowly declining in some countries, such as Algeria, Tunisia, Egypt and Turkey. Meanwhile, Libya, Lebanon and Syria are expected to experience sharp reductions in CO_2 intensity, mostly owing to emission reductions in power generation. Decarbonisation of primary consumption will continue at generally lower rates during the period 2020–30. CO_2 emissions per TWh produced are forecast to decline in all countries, at varying rates depending on the penetration of renewables, substitution of oil for gas (where this has not already taken place) and the introduction of more efficient thermal technologies, such as combined cycle gas turbines. Yet overall CO_2 emissions are projected to increase at rates that are not compatible with climate policy goals: having increased by 110% between 1990 and 2009 they are projected to increase by 91% in the next 20 years. Given the climate policy concerns in the EU there is obviously plenty of scope for EU collaboration with MED-10 countries in order to pursue global CO_2 emission reductions.

4. The MED–EU cooperation scenario

For the last 25 years the energy policy agenda has been increasingly focused on the question of climate change and the need to mitigate it by reducing greenhouse gas emissions. This has been particularly the case in the EU, where ambitious plans are increasingly adopted, ultimately aiming at a carbon-free energy system.

Fossil fuel-producing countries are concerned with an optimal inter-temporal management of their ultimately finite resources, while net importers of fossil fuels are seeking to reduce their dependence in order to decrease their vulnerability and improve their economic development prospects. The MED-10 region contains countries that fall into both categories. At the same time, most of them are characterised by considerable potential for expanding the use of renewable energy sources.

In view of these policy goals, there has been growing interest in the development of the Mediterranean energy system, with a view to determining the optimal future mix of electricity generation and specifically addressing the central question of deploying renewable or nuclear energy in the region, e.g. Marktanner and Salman (2010) and Brand and Zingerle (2010). Other studies reflect the growing interest in the potential cooperation of Mediterranean countries in the fields of energy and climate action, e.g. Trieb and Müller-Steinhagen (2007), Folkmanis (2011) and Viebahn et al. (2011).

Following the scenario definitions of "Euro-Mediterranean policy to 2030", as presented in Ayadi and Sessa (2011), and in line with the "green transition" scenario, E^3M-Lab has specified and simulated a MED–EU[8] energy cooperation scenario.

To quantify scenarios involving successful MED–EU integration, it is assumed that the energy system evolves in the context of a cooperative MED–EU frame of action, aimed at both mitigating climate change and establishing a well-interconnected Mediterranean electricity grid. In this context, the MED–EU energy cooperation scenario assumes that such projects as the Mediterranean Solar Plan, DESERTEC and MEDRING will to a large extent materialise and that the EU Emissions Trading Scheme (EU ETS) will expand to the MED-10 with special provisions for these countries. The scenario assumes that the MED–EU countries form a common emissions trading scheme (ETS) similar to the currently operating EU ETS, constrained by a cap with a total number of emission allowances decreasing over time. It is assumed that only CO_2 emissions are concerned and that only the energy-intensive industries and power generation are subject to allowance obligations. Emission allowances are assumed to be issued so as to achieve predefined emission-reduction targets, which are shown in Table 18.

The model considers the emission reduction targets to be constraints for the ETS sectors and for the entire MED–EU region. The EU countries need to purchase the allowances in public region-wide auctions. This obligation does not apply to the MED-10 countries, which receive allowances for free, equal to their emissions under the reference-QI scenario projections (grandfathering principle). In that way, the MED-10 countries do not face an additional cost associated with emissions, but may benefit from an opportunity to generate revenues by reducing their emissions and by selling their allowances to the EU countries. The EU countries may benefit from the participation of the MED-10 countries in the ETS, arising from wider options for cost-effective emission reductions that lead to a reduction in marginal mitigation costs and hence lower average costs for achieving an equivalent emission result. Apart from direct sales of emission permits, the exploitation of emission reduction opportunities may result in benefits for MED-10 countries stemming from an increase in FDI and the creation of additional employment.

The scenario implies that policies facilitating renewables (licensing and others) accompany the ETS enlargement. Renewable electricity exports to the EU will require investment in new electricity high-

[8] The MED–EU group consists of the MED-10 region and the EU-27.

voltage DC interconnectors linking the MED-10 countries with the southern countries of Europe, mainly France, Spain, Italy and Greece (Table 19). The exported renewable electricity would be charged at pre-defined fixed tariffs, which would be set at a sufficient level to allow recovery of the total capital and operating costs, and to allow for a reasonable rate of return on capital (at an 8% discount rate). It is assumed that adequate terms for power purchase agreements (PPAs) are determined to ensure long-term viability, and hence materialisation, of the projects exploiting the renewable energy and transporting electricity to the EU. The data and calculations for the stylised PPA terms used for this scenario are based on a variety of sources, including the DLR (2005) report on the DESERTEC project.

It is also assumed that significant grid enhancement takes place within the EU to allow for the transportation of electricity within the EU's internal market towards countries with low renewable or generally carbon-free potential. The projections about such enhancements influencing absorption of renewable electricity in the EU are based on E^3M-Lab's PRIMES model simulations performed for the European Commission's DG ENER "Energy Roadmap 2050" (published in 2011).

The MED-10 region accounts for a relatively small part of the total MED–EU club emissions,[9] especially at the beginning of the forecast period. The impact of including the MED-10 in the overall effort is small until 2020. Beyond that date, as the MED-10 region accounts for more emissions, the projects for transporting renewable electricity to Europe start bearing fruit and abatement in the MED-10 accelerates. Subsequently, the impact of establishing the club becomes more pronounced, with marginal abatement costs significantly lower than those in the 'EU alone' case (quantified using the PRIMES model, referring to the case where the EU performs equivalent emission reductions without embarking on an ETS with the MED-10).

The impact of the carbon prices on final demand in industry is very pronounced in countries like Algeria, where fuel prices in the reference-QI case are very low and the scenario implies a very large increase in fuel costs (Table 20). In countries like Tunisia, Israel and Morocco, where fuel prices are high even in the reference-QI case, the impact of the scenario is relatively small. Regarding emission reductions, however, the most important issue appears to be the carbon intensity of industrial energy demand. In this way, Turkey – where coal covers a relatively large proportion of industrial energy needs (32% in 2010 and 19% in 2030 according to the reference-QI scenario) – there is significant potential for CO_2 abatement through fuel substitution. Emission reductions are more modest in countries where natural gas in the reference-QI scenario is overwhelmingly dominant in industrial energy demand (Algeria, Tunisia, Egypt, Libya and Israel), because substitution possibilities are limited.

Looking at the region as a whole, the scenario implies a deep reduction in the share of solid fuels and acceleration in the process of substitution away from oil (Table 21). The main beneficiary in this situation is natural gas, which in the scenario ends up covering half of the industrial needs for energy. There is also a small but consistent tendency towards more electrification.

Table 18. Emission reduction targets and the corresponding carbon values in the MED–EU cooperation scenario

	2015	2020	2025	2030
MED–EU club CO_2 emission reductions, ETS sectors relative to 2005 (in %)	-24.1	-28.4	-31.4	-43.1
MED–EU club CO_2 emission reductions, ETS sectors relative to the reference-QI scenario (in %)	-16.7	-21.3	-29.0	-37.5
Carbon prices for ETS sectors in the MED–EU cooperation scenario (€'08/tCO_2)	13	25	35	60
Carbon prices for ETS sectors in the EU alone scenario (€'08/tCO_2)	14	29	52	78

[9] Club emissions refer to emissions for the entire region including the EU and MED-10.

Table 19. New electricity interconnections from North Africa to the EU simulated in the MED–EU cooperation scenario

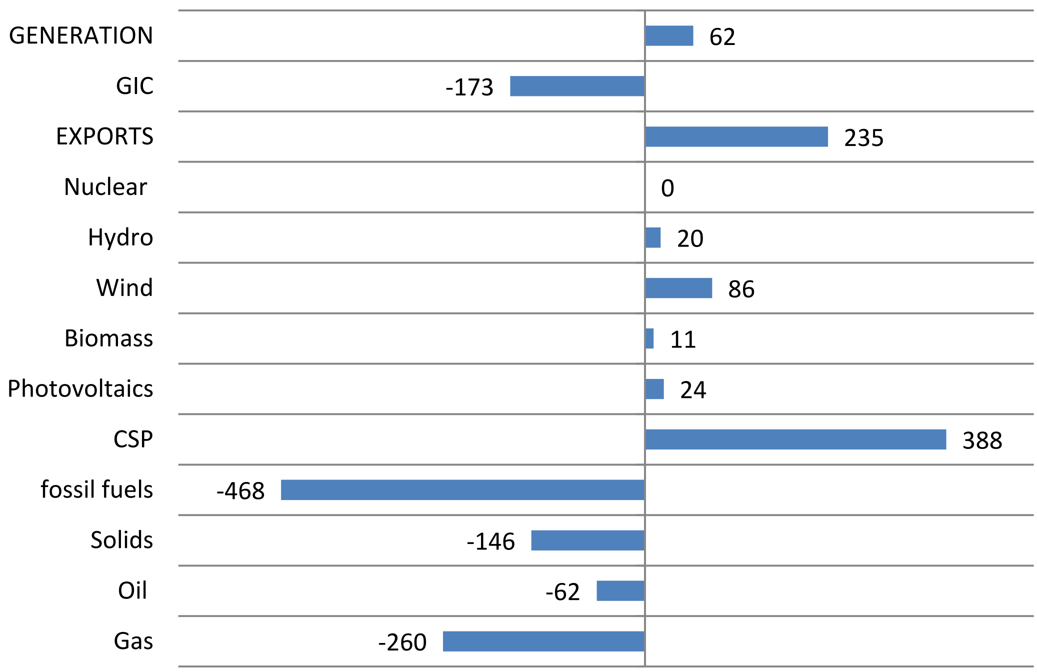
New HVDC interconnections			
Algeria–Italy	Libya–Italy	Algeria–Spain	Tunisia–Italy
Algeria–France	Morocco–Spain	Reinforcement of Morocco–Spain AC line	

Table 20. Change in CO_2 emissions and final industrial demand for energy in the MED–EU cooperation scenario compared with the reference-QI case in 2030 (in %)

	ALG	MOR	TUN	EGY	LIB	ISR	LEB	SYR	JOR	TUR	MED-10
CO_2 emissions	-10	-18	-10	-12	-12	-13	-16	-17	-19	-27	-17
Final energy demand	-18	-10	-7	-12	-13	-8	-12	-13	-11	-15	-14

The reductions of CO_2 emissions in industry represent approximately 10% of the total reductions that occur as a consequence of the MED–EU cooperation scenario. The remaining 90% occurs in the power generation sector, which according to the scenario undergoes a major transformation (Figure 2).

Figure 2. Changes in power generation between the MED–EU cooperation and the reference-QI scenarios in 2030 (in TWh)



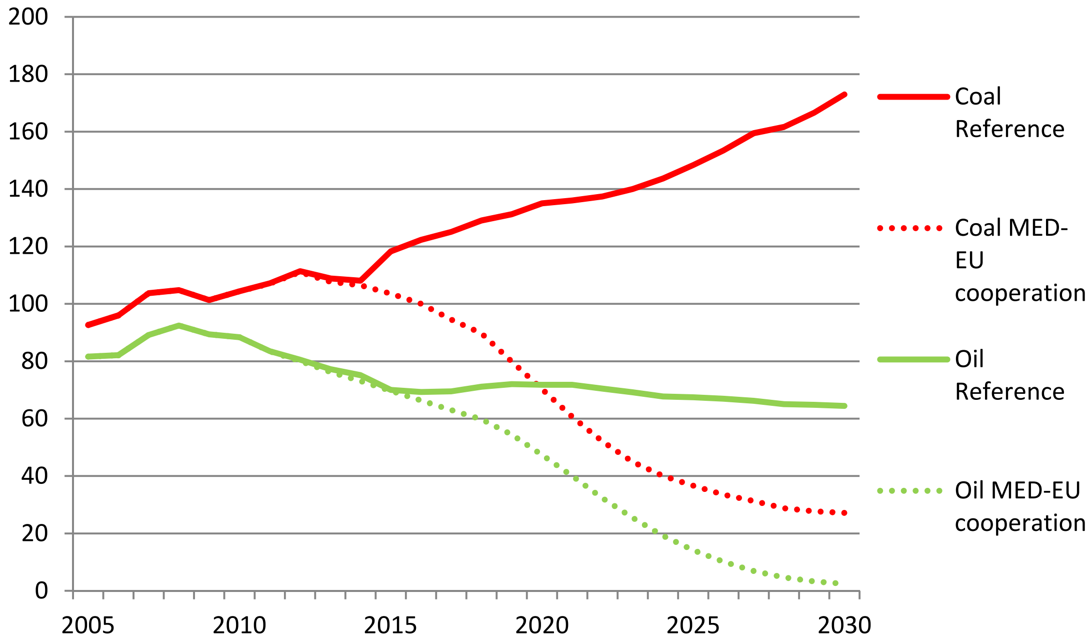
The imposition of the carbon value on fossil fuels and the additional investments and other generation costs incurred through decarbonisation efforts would be incorporated into electricity prices. The price increases would result in some electricity-saving measures on the part of consumers and consequently demand for electricity in the whole region would drop by 173 TWh compared with the reference-QI case in 2030. This figure represents 11% of gross inland consumption (GIC) of electricity. On the other hand, exports of electricity to the EU would build up rapidly in the period after 2025 (7.7 TWh in 2024, 116 TWh in 2027 and 235 in 2030). The net result of the reduction in demand and the increase in exports is that generation requirements in 2030 would be 62 TWh or 4% higher than in the reference-QI case.

In 2030, fossil fuel-based generation is expected to be 468 TWh lower in the scenario compared with the reference-QI case. This represents a 35% drop. With regard to coal, according to the scenario, investment in new coal-fired plants would virtually stop early in the projection period. Older plants would be retired early and the remainder would be underutilised. By 2030, coal would account for only 27 TWh, of which 25.5 TWh would be in Turkey, where capacity is relatively more modern and efficient. The trend of backing away from oil in the region is forecast to accelerate, with plants increasingly used as a reserve for peaks until natural gas substitutes oil even for this purpose, a process that is forecast to be virtually complete by 2025 (Figure 3). By 2030, natural gas-fired capacity is expected to be 19.2 GW lower in the cooperation scenario than in the reference-QI case. This represents a drop of 8%, while at the same time gas-based generation drops by 24%. Gas in the scenario increasingly assumes the role of following the load, especially in the context of an increase in the share of intermittent renewable energy in the generation mix.

Table 21. Shares of energy types in final industrial demand for energy in the reference-QI and cooperation scenarios(in %)

		2015	2020	2025	2030
Solids	**Reference-QI**	9.9	9.4	8.8	8.2
	Cooperation	9.8	7.1	4.8	3.3
Oil	**Reference-QI**	17.8	14.8	12.5	10.8
	Cooperation	17.7	13.1	8.7	6.1
Natural gas	**Reference-QI**	38.9	40.3	41.2	41.7
	Cooperation	38.9	44.0	48.4	49.7
Electricity	**Reference-QI**	33.4	35.5	37.4	39.3
	Cooperation	33.6	35.8	38.2	40.9

Figure 3. Oil and coal-based generation in the MED-10 region: Comparison of the MED–EU cooperation scenario with the reference-QI case (in TWh)



In 2030, the share of renewable energy sources in total generation according to the MED–EU cooperation scenario is 44.5% compared with 12.4% in the reference-QI case. About a third of this additional generation would be destined for direct exports to the EU.

In 2030, hydroelectric production in the scenario is 20 TWh higher than in the reference-QI case. Of these, 18 TWh are attributed to Turkey, which still has significant and underutilised hydroelectric potential even after the expansion projected in the reference-QI case. The remaining additional 2 TWh materialise in Morocco. The other countries in the region have very little additional potential even at the beginning of the forecast period.

Biomass plays a relatively small role even under the conditions of the cooperation scenario, which implies an additional 11 TWh of biomass-based generation in the region in 2030. Nearly 7.5 TWh of these occur in two countries: Israel and Turkey.

Wind power plays an important role in reducing the carbon intensity of the power generation sector in the MED-10 region. In 2030, the scenario registers a contribution that is 86 TWh higher than the reference-QI case (33 GW of additional capacity). By that date, according to the scenario, wind power generation would exceed hydro output in the region. Turkey and Egypt together would account for 63% of MED-10 wind power production. High shares of wind power would also materialise in Morocco (16.8%) and Tunisia (15.3%).

The reference-QI scenario is characterised by a rather small penetration of generation by photovoltaics. The extent of such penetration is primarily dependent on appropriate supports to ensure its competitiveness relative to electricity prices, which are generally below true costs. For the MED–EU cooperation scenario, such supports are assumed to extend to all the countries in the region, which in 2030 would see the share of PVs in power generation rising to 3% in Morocco, 2.8% in Jordan and 2.8% in Israel. In Libya and Lebanon, these shares would be around 1%. Most of the additional PV development is assumed to take place on a small scale (many units primarily on private initiative) and would not be destined for exports owing to the low availability factors when compared with CSP technologies.

CSP occupies a central position in the MED–EU cooperation scenario. As mentioned in the discussion on the reference-QI scenario, the region offers some of the best sites in the world for the deployment of this technology.[10] It is already present in the reference-QI case and is expected to reach 32.7 TWh in 2030, all destined for the domestic market. In the cooperation scenario, production from CSP would reach 420 TWh, of which 247 TWh would be for export. According to the cooperation scenario, at the initial stages of its development CSP would primarily contribute to domestic needs, while awaiting the construction of the appropriate high-voltage DC interconnections that would bring the electricity deep into the EU (Table 22). Morocco is the first country to engage in this kind of trade because of its proximity to Spain, which is expected to become the first EU country to import under the scheme. By 2025, green electricity exports to Europe are expected to have taken off, reaching over 60 TWh/year. Algeria and Libya are forecast to become major players, exporting mainly via Italy. The years between 2025 and 2030 would see massive additions to export capacities, with the region's exports nearly quadrupling to reach 247 TWh. In 2030, they are expected to represent 14.5% of total power generation in the region and cover 6.4% of the EU's electricity needs. Export capacity is assumed to develop unevenly among the countries of the region. Algeria would dominate volumes and export around 50% of its total generation. Libya would export about half that amount but still devote 52% of its generation to exports. Morocco and Tunisia would also be important players, exporting 28% and 36% of their generation respectively. Syria and Jordan are assumed to export exclusively to Turkey. Egypt would take no part in this trade, as the scenario assumes that the connections to Greece and through the Balkans will not materialise before 2030; such developments may take place after 2030. Apart from exports, production would take place on a large scale for the satisfaction of domestic needs. By 2030, in most countries of the region CSP would significantly penetrate the local market. This penetration would be highest in the main exporting countries: Algeria (35%), Libya (35%),

[10] Molten salt technology with at least eight hours of storage.

Morocco (24%) and Tunisia (21%). This is because in these countries there is earlier technology transfer and learning by doing in anticipation of the large export volumes. Turkey would be the sole country in the region that would adopt CSP at only an insignificant level. This is due to the relative unsuitability of most of Turkish territory for CSP development (the most suitable sites are situated at long distances from the main electricity-consumption centres).

The increase in FDI assumed in the MED–EU cooperation scenario extends beyond power generation and also covers the crucial areas of hydrocarbon prospecting, production and export infrastructure.

With regard to oil, this would result in higher volumes of output in most countries of the region, especially Libya, Algeria and Egypt (Table 23). In Jordan, it would culminate in a more rapid exploitation of shale oil resources. The increased output combined with the reduction in consumption resulting from the participation of the region in the ETS would produce favourable results in terms of oil trade. The main beneficiary would be Libya, which by 2030 would see its exports increase by 17% compared with the reference-QI case. Algeria's exports would increase by 9.5%. For the same year, Syria would turn from being a small net importer to a net exporter of oil (3.2 Mtoe of exports instead of 0.5 Mtoe of imports). Net imports in Egypt would be nearly 33% lower than in the reference-QI case. Jordan's imports would halve, while a steep reduction would also be registered for Lebanon.

Foreign direct investment also affects the natural gas sector. Yet, the domestic market in the MED–EU cooperation scenario contracts to the tune of 15% compared with the reference-QI scenario in the year 2030 mainly because of changes in the role of gas in power generation. Furthermore, the natural outlet for MED-10 gas exports is the EU, which would also undergo some substitution away from gas. This renders the EU a more competitive market, especially with regard to imports from Russia, which would compete with North African gas in a reduced market. The main exporters of the region (Algeria, Libya and Egypt) would divert some of their output outside the MED–EU region in the form of LNG (Table 24). These intercontinental LNG exports, however, would not be sufficient to offset the contraction of regional and EU demand, and the net result would be a reduction in volumes produced.

Table 22. Evolution of CSP production for domestic needs and exports (in TWh)

		ALG	MOR	TUN	EGY	LIB	ISR	LEB	SYR	JOR	TUR	MED-10
Domestic needs	**2020**	5.9	4.7	0.8	4.6	1.1	1.1	0.0	1.0	1.7	0.1	21.0
	2025	20.5	8.4	2.4	26.6	7.0	3.1	0.5	5.9	3.4	0.4	78.0
	2030	39.7	20.5	10.6	52.2	19.3	7.7	3.3	12.2	6.8	1.2	173.5
Exports	**2020**	0.0	3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1
	2025	27.6	7.7	0.0	0.0	27.6	0.0	0.0	0.0	0.0	0.0	62.9
	2030	115.6	33.0	28.9	0.0	57.8	0.0	0.0	5.7	5.7	0.0	246.7

Table 23. Primary production and consumption of oil in the reference-QI and cooperation scenarios in 2030 (in Mtoe)

		ALG	MOR	TUN	EGY	LIB	ISR	LEB	SYR	JOR	TUR	MED-10
Reference-QI	**Primary production**	74.4	0.0	2.7	32.0	165.3	0.0	0.0	17.5	1.8	0.4	294.2
	Primary consumption	22.3	16.0	6.2	54.1	16.8	16.9	4.2	18.0	7.9	75.1	237.5
MED–EU cooperation	**Primary production**	78.9	0.0	2.8	33.5	187.7	0.0	0.0	17.9	3.1	0.4	324.1
	Primary consumption	21.8	13.2	6.0	48.2	14.6	16.7	2.7	14.2	6.1	73.9	217.3

Table 24. Primary production and consumption of natural gas in the reference-QI and cooperation scenarios in 2030 (in Mtoe)

		ALG	MOR	TUN	EGY	LIB	ISR	LEB	SYR	JOR	TUR	MED-10
Reference-QI	**Primary production**	144.2	0.0	3.4	119.5	34.9	20.0	0.0	10.4	0.2	0.1	332.8
	Primary consumption	50.7	10.0	9.5	89.2	12.7	10.0	3.8	20.9	5.7	71.8	284.3
MED–EU cooperation	**Primary production**	128.8	0.0	3.1	93.9	30.4	20.6	0.0	12.5	0.2	0.1	289.6
	Primary consumption	38.2	9.7	7.1	67.9	8.8	10.8	4.2	16.4	4.9	74.0	242.1

5. The sustainable development scenario

This scenario is assumed to occur in a framework that is in line with the "blue transition" scenario presented in Ayadi and Sessa (2011) and in particular with the "Euro-Mediterranean Alliance(s)" scenario. The main distinction between this scenario and the MED–EU cooperation scenario is that in the latter the MED-10 countries are assumed to integrate into EU policies and structures, particularly the ETS system for climate mitigation, while in the sustainable development scenario there is no common initiative or collaboration occurring on a multilateral basis.

Still, the sustainable development scenario assumes that MED-10 countries individually undertake vigorous measures to promote energy efficiency, the development of renewable energy sources, a reduction of import dependence for net importers of energy and an enhancement of the export capability of the energy-exporting countries. It also assumes that the relations of individual MED-10 countries with the EU deepen and as a consequence perceived risks diminish, thus encouraging FDI originating from the EU and other parts of the world. The scope of such investment, however, is more limited than in the MED–EU cooperation scenario. Likewise, the promotion of renewable electricity exports to Europe is assumed to be on a much more limited scale compared with the massive effort assumed in the MED–EU cooperation scenario.

The reference-QI scenario assumes a steady but cautious pace of price reform in countries where the consumers were charged below opportunity costs or generation and distribution costs. In the sustainable development scenario this process is accelerated. The higher prices are not by themselves sufficient to produce the efficiency gains that are consistent with the scenario framework. It is therefore assumed that a number of other measures, especially in the form of efficiency standards, are adopted gradually during the forecast period. Countries such as Algeria, Libya, Egypt and Syria, which in the reference-QI case are characterised by low prices and slow price reform, register the biggest impacts in the sustainable development scenario. With the exception of Algeria and Libya, where industrial consumers face very steep price rises in the scenario, the industrial sector has more limited potential for efficiency gains compared with residential/commercial uses. This mainly stems from the fact that in the reference-QI scenario, industrial consumers – which generally make inter-temporal decisions using much lower implicit discount rates than private individuals – already achieve a considerable amount of energy efficiency gains. In the residential/commercial sectors, the scope for specific reductions in energy consumption is large and materialises primarily through the introduction of standards for lighting and appliances as well as the insulation of buildings. Regarding transport, the efficiency gains are somewhat more limited, especially in countries like Morocco, Israel, Lebanon and Turkey, where prices in the reference-QI case are already high. The scenario assumes the earlier retirement of vehicles and hence a faster turnover of the fleet, with new vehicles generally having lower, specific consumption characteristics than older vintages. This is also reflected in the higher proportion of new technologies like hybrid vehicles in the total car fleet (Table 25).

Table 25. Share of hybrid vehicles in the car stock in 2030

	ALG	MOR	TUN	EGY	LIB	ISR	LEB	SYR	JOR	TUR	MED-10
Reference-QI	8.7	8.9	9.2	8.9	7.8	12.4	9.2	8.6	9.6	10.5	**9.1**
Sustainable	12.9	12.1	12.4	13.2	12.3	16.8	13.9	13.7	13.3	14.4	**13.6**

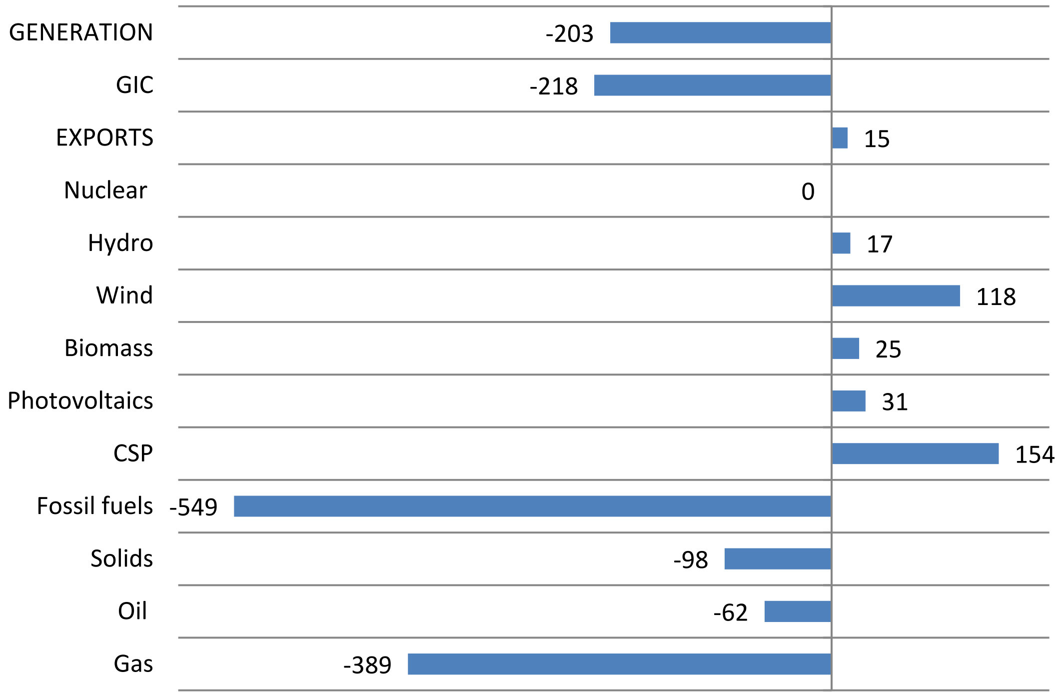
Table 26 summarises the impact of the scenario assumptions on final demand in 2030.

Table 26. Change from the reference-QI case in final energy demand in 2030 (in %)

	ALG	MOR	TUN	EGY	LIB	ISR	LEB	SYR	JOR	TUR	MED-10
Total	**-28**	**-11**	**-12**	**-18**	**-22**	**-10**	**-11**	**-17**	**-14**	**-11**	**-16**
Industry	-34	-9	-13	-13	-24	-4	-6	-8	-10	-8	**-13**
Residential	-36	-12	-9	-21	-24	-11	-12	-24	-16	-15	**-20**
Services	-21	-14	-16	-18	-22	-12	-13	-22	-17	-18	**-18**
Agriculture	-22	-15	-17	-19	-18	-10	-7	-18	-12	-10	**-14**
Transport	-19	-9	-11	-19	-21	-9	-12	-19	-15	-8	**-13**

In 2030, MED-10 final demand for electricity in the sustainable development scenario stands 10.8% lower than the reference-QI scenario. On the other hand, the sustainable development scenario implies an accelerated improvement in terms of losses and own use of the power generation sector and gross inland consumption of electricity drops by 14% (Figure 4). Electricity exports from the region as a whole are expected to be very modest (15 TWh) compared with the MED–EU cooperation scenario, where they reach 235 TWh in 2030. This is due to the much more limited trans-Mediterranean grid expansion implied by the sustainable development scenario. Nuclear output would be unaffected while hydroelectricity would provide an additional 17 TWh by 2030 (14 TWh of them in Turkey). Wind generation would get an important boost (45.6 additional GW of installed capacity compared with the reference-QI case and 12.3 GW higher than in the cooperation scenario). Egypt would account for more than a third of MED-10 wind capacity, while important increases are also registered for Turkey, Morocco and Algeria. The biomass contribution would increase more than eightfold compared with the reference-QI scenario. Among the MED-10 countries, 21 out of a total 29 TWh are projected for two countries: Turkey and Israel. Generation from photovoltaics would expand vigorously in almost all the countries of the region, assisted by active promotion in the form of subsidies or high feed-in tariffs (or both). At the same time, the contribution of PVs to meeting total electricity needs would remain rather limited, addressing small-scale development needs. They would provide for 2.7% of the total electricity needs in the MED-10 region as a whole and achieve shares of 4.8% in Morocco, 3.9% in Tunisia, 3.6% in Algeria and 3.5% in Israel. In 2030, for the MED-10 region as a whole electricity production from CSP would reach 187.3 TWh compared with 33 TWh in the reference-QI case and 420 TWh in the MED–EU cooperation scenario. In terms of its contribution to the final electricity demand, CSP in the sustainable development scenario would reach 13% (28% in Libya and 26% in Algeria and Morocco). The scenario implies an increase in storage capabilities for this technology, allowing for high penetration rates without destabilising the total supply system. The brunt of the generation reduction and renewable expansion would naturally be taken by fossil fuel-based generation, which would be reduced by 549 TWh in 2030 compared with the reference-QI scenario.

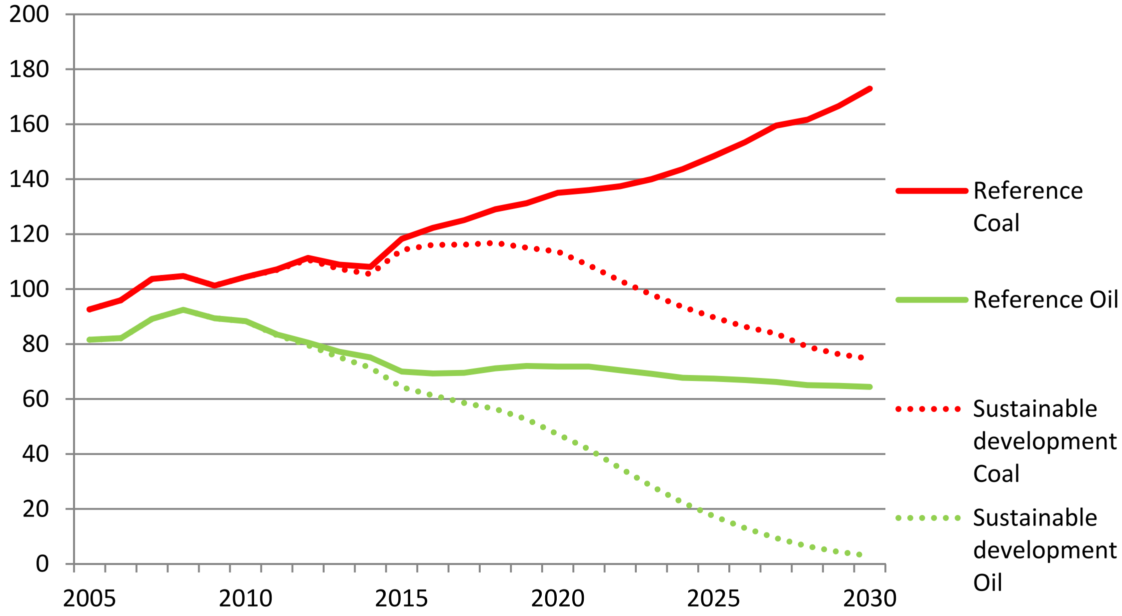
Figure 4. Changes in power generation between the sustainable development and the reference-QI scenarios in 2030 (in TWh)



Coal-based production in the scenario registers a slight increase in the period to 2018 because of expansion plans that are firmly in the pipeline. Beyond that date it stabilises until 2020 and starts declining steadily, as no new plants would come on line, early retirement would be accelerated and the utilisation rates of existing plants would drop on economic grounds. By 2030, Turkey and Morocco would produce only 60 and 11 TWh respectively from coal (comparable to 2010 production), while in Israel coal production would effectively be eliminated. The tendency of backing away from oil in the power generation sector would accelerate substantially, so that by 2030 there would virtually be no oil used for generation purposes throughout the region (Figure 5).

Natural gas-based power generation is in a way the swing option in the region (supplying the remainder once renewable contributions and backing away from coal and oil are determined). For the region as a whole, the share of gas is projected to peak around 2018 and start declining thereafter (Table 27). The decline is slow until around 2021 and subsequently accelerates with the deployment of renewables on a large scale. This general pattern masks marked differences among countries. In Algeria, where power generation is currently overwhelmingly dominated by natural gas, its share would fall steadily and reflect the penetration of production by renewable energy sources (RES). In Tunisia, the high share would be maintained until 2020 but drop sharply thereafter. In Egypt and Libya, there would be a noticeable increase in share in the medium term, as oil-based generation is dramatically reduced. In the longer term, the deployment of RES would allow for natural gas conservation for export purposes. In Israel and Lebanon, there would be a sharp increase in its share in the medium term and slight growth beyond 2020 due to the more limited potential for renewable energy (notably CSP).

Figure 5. Oil and coal-based generation in the MED-10 region: Comparison between the sustainable development and the reference-QI scenarios (in TWh)



In Turkey, apart from the increased RES contribution, the gas share between 2020 and 2030 is expected to decline because of the coming into production of a considerable amount of nuclear capacity.

In Morocco, which currently produces very small amounts of electricity from gas, gas would benefit in the short to medium term from the loss in share of coal and oil. Massive deployment of wind and solar thermal power in the 2020s would mean that the share of gas would stabilise at below a quarter of production, which is by far the smallest share in the region.

Table 27. Share of natural gas in power generation in the sustainable development scenario (in %)

	ALG	MOR	TUN	EGY	LIB	ISR	LEB	SYR	JOR	TUR	MED-10
2010	97.7	9.6	86.6	70.1	51.5	42.3	23.6	68.7	68.9	46.7	**57.5**
2020	87	22.8	86.1	81.5	64.8	60.2	71.9	85	70.1	57.1	**67.8**
2030	58.7	23	59.8	55.3	49.5	63.7	76.3	73.9	60.2	45	**52.1**

6. The 'Euro-Mediterranean area under threat' scenario

This scenario is assumed to occur in a framework that is in line with the "red transition" scenario presented in Ayadi and Sessa (2011) and in particular with the "Euro-Mediterranean area under threat" scenario. The MED-10 area in this scenario is characterised by increased fragmentation, sporadic and festering conflicts, and a failure of cooperation with the EU. In terms of the energy economy, the main implications are a shortage of capital, increased investment risks leading to high risk premiums and a stalling of market reforms, including the price reform that was assumed to be introduced gradually in those countries where prices do not at present reflect real costs. Under these circumstances of course there is no scope for investing in interconnections to enable the export of renewable electricity to the EU. The perceived risks assumed in this scenario are not evenly associated with the different countries and they depend on their current condition and their recent history; thus the risks are most strongly felt in countries like Syria and Lebanon and less so in countries like Turkey, Israel and Tunisia.

The overall net effect of the scenario assumptions is an increase in primary consumption of energy due to an increase in the cost of capital *vis-à-vis* the cost of energy and the much weaker policies favouring energy efficiency and fuel substitution. For the MED-10 region as a whole, the difference between the scenario of the Euro-Mediterranean area under threat and the reference-QI case builds up gradually to reach more than 10% by 2030 (Table 28). This implies a reversion to the situation in recent history, where the implicit energy demand elasticity with respect to GDP has been close to unity: i.e. there is no improvement in the energy intensity of GDP. The increase in primary consumption would be particularly sharp in Syria, Lebanon, Libya and Algeria, where the failure to reform pricing would discourage any attempt to improve energy efficiency. Israel and Turkey would be less affected, because they have already established a more rational pricing regime and at any rate, by assumption, are less influenced by the instability implied in the scenario.

The increase in final demand (compared with the reference-QI scenario) is very pronounced in both the industrial and the residential sectors, while it is more modest for agriculture and particularly transport (Table 29). The transport sector as a whole and more specifically road transport, which accounts for almost 90% of the total transport demand, would be characterised by relatively low responsiveness to price signals. On the other hand, in the scenario the average life of vehicles would increase, thus rendering the renovation of fleets and the subsequent improvements in efficiency slower. This is well illustrated by the shares obtained for the only new vehicle technology that appears in any significance in the reference-QI case: hybrid vehicles. Compared with the reference-QI scenario, which anyway projects a modest increase, the share of hybrids collapses in the scenario of the Euro-Mediterranean area under threat, attaining only niche market status in all countries with the possible exception of Israel (Table 30).

Table 28. Primary energy consumption in the scenario: Changes compared with the reference-QI case (in %)

	ALG	MOR	TUN	EGY	LIB	ISR	LEB	SYR	JOR	TUR	MED-10
2015	2.5	1.7	1.6	2.1	2.2	1.0	1.6	1.8	0.8	0.8	**1.8**
2020	5.3	2.7	3.1	4.9	4.1	1.6	5.7	3.8	3.7	1.6	**4.0**
2025	9.2	6.1	6.3	7.8	9.6	2.0	9.4	7.7	7.3	3.5	**7.4**
2030	15.4	9.4	10.5	13.6	16.8	3.9	16.7	17.6	13.8	5.1	**10.6**

Table 29. Final energy demand in the MED-10 region: Changes compared with the reference-QI case (in %)

	2015	2020	2025	2030
Final demand	**1.7**	**4.0**	**7.1**	**9.9**
By sector				
Industry	1.3	3.4	7.2	11.7
Residential	1.9	4.3	7.9	12.5
Services	1.4	3.4	6.5	9.5
Agriculture	1.1	3.1	6.1	7.6
Transport	2.5	3.9	5.9	6.9
By fuel				
Solids	0.5	1.0	1.8	2.5
Oil	2.2	4.6	6.4	7.5
Gas	3.7	4.9	6.5	9.0
Electricity	1.9	3.6	8.4	12.8
Traditional biomass	6.1	11.9	17.9	23.9

Table 30. Share of hybrid vehicles in the car stock in 2030

	ALG	MOR	TUN	EGY	LIB	ISR	LEB	SYR	JOR	TUR	MED-10
Reference-QI	8.7	8.9	9.2	8.9	7.8	12.4	9.2	8.6	9.6	10.5	**9.1**
Threat scenario	1.7	1.9	2.1	1.5	1.7	5.2	2.5	1.2	2.1	2.9	**2.1**

Coal in final demand would play a small role in the region and be overwhelmingly concentrated in Turkey, which would be less affected by the scenario assumptions. Hence the increase of final demand for coal relative to the reference-QI case would be rather modest. The increase in final demand for oil primarily reflects the impact of the scenario on road transport. The scenario for the Euro-Mediterranean area under threat also has an impact on the use of traditional biomass in the region. In the reference-QI case, it is projected to drop from 7.1 Mtoe in 2010 to 4.7 Mtoe in 2030. In the threat scenario the reduction is slower and traditional biomass in the MED-10 region would still account for 5.8 Mtoe by 2030.

Natural gas registers a big increase in the scenario, especially given that in many countries (Egypt, Algeria and Libya) gas prices for consumers remain very low throughout the projection period. Electricity would experience a major expansion with regard to the reference-QI case. This is particularly the case in the residential sector, where the combination of subsidised electricity prices and low credit for the purchase of more efficient electrical equipment would lead to an increase of 16.8% compared with the reference-QI scenario.

In the year 2030, the threat scenario would result in gross inland consumption of electricity that stands 15.2% higher than the reference-QI case (Figure 6). This increase is bigger than the one registered for final demand (12.8%), because in the threat scenario improvements in terms of the reduction of distribution losses and own use in the electricity sector are much slower. This would particularly affect countries like Syria, Algeria, Libya and Turkey, where total generation considerably exceeds final demand. The lack of significant incentives together with increased risk premiums mean that investment in renewable forms of electricity, which in general are capital-intensive, would become much less attractive than it is even in the reference-QI case. The most severely affected options would be the solar technologies (photovoltaic and CSP), which are reduced to less than a third of their contributions in the reference-QI case. Wind power would also be strongly affected throughout the region, accounting for a mere 1.9% of total power generation in 2030 instead of 4.2% in the reference-QI case and 13.5% in the sustainable development scenario. The scenario for the Euro-Mediterranean area under threat also implies that the exploitation of remaining hydroelectric potential in Turkey and Morocco would take place at a somewhat slower pace. The impact of this is rather limited, however, compared with other renewable sources (i.e. -4% in Turkey and -12% in Morocco).

The increase in generation requirements together with the failure of RES to make an impact on generation structures mean that fossil fuel-based generation registers a major increase in the scenario compared with the reference-QI case (almost 300 TWh by 2030). Coal would experience some expansion, mainly in Morocco, but it would remain geographically limited because its introduction tends to be capital-intensive and the scenario implies deteriorating investment conditions. In the reference-QI scenario, the share of oil would decline over the projection period from 15.6% in 2010 to 4.1% in 2030, due to competition from combined cycle gas turbines on economic grounds. In the threat scenario, this backing away would still occur in major gas-producing countries like Algeria, Egypt, Libya and Israel (with Algeria already almost completely backing away from oil) as well as in Tunisia, where ample gas supplies are available as the country is a major transit route for Algerian exports. In the uncertain political climate assumed for the threat scenario, other countries would become reluctant to commit themselves to receive large volumes of gas imported via pipeline. These countries, namely Lebanon, Syria, Jordan and Morocco, would attempt to diversify their supplies by maintaining and expanding oil-based capacity (and in the case of Morocco also coal-based capacity).

This shift away from gas and to oil would cancel to a large extent the considerable expansion of natural gas generation in countries such as Algeria, Egypt, Libya, Turkey and Tunisia, which would occur as a consequence of higher electricity needs and failure to invest significantly in RES (see Figure 7).

Figure 6. Changes in power generation between the 'threat' and the reference-QI scenarios in 2030 (in TWh)

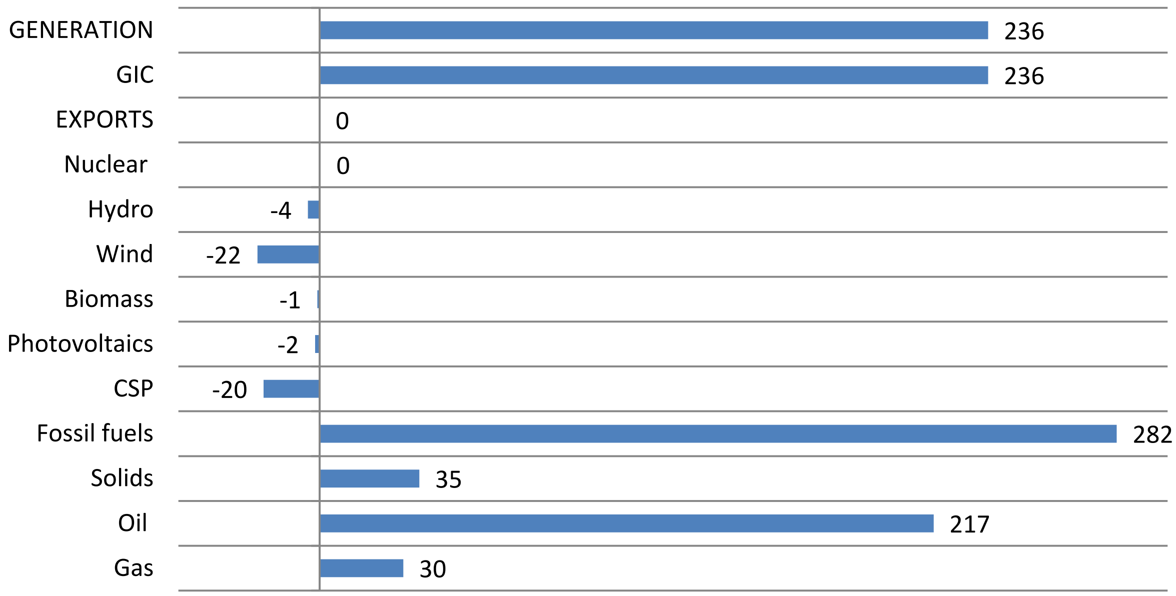
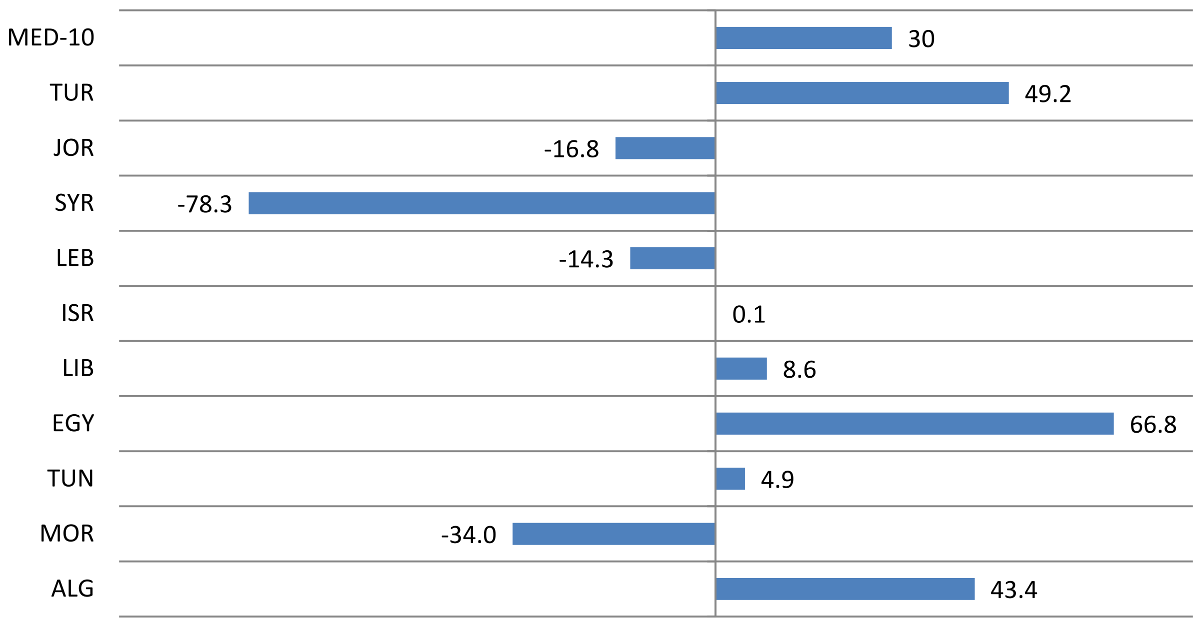


Figure 7. Changes in natural gas-based power generation between the 'threat' and the reference-QI scenarios in 2030 (in TWh)



In terms of CO_2 emissions, the scenario for the Euro-Mediterranean area under threat represents a particularly serious situation. CO_2 emissions would increase steadily and in 2030 stand 165% higher than their 2005 level with no sign of deceleration. Such an outcome would mean that the MED-10 region's emissions would represent 58% of the emissions projected for the EU-27 in the reference-QI case. Emissions per capita in the MED-10 region would be 5 tCO_2 compared with 5.8 tCO_2 for the EU.

7. Scenario comparison

7.1 Cost implications

The MED–EU cooperation and the sustainable development scenarios imply drastic changes in the structure of total generation costs (Table 31). Substitution away from hydrocarbons and towards capital-intensive RES means that investment costs would increase considerably, especially in the sustainable development scenario, where this substitution goes further (the calculations in the table do not include the export projects, the costs of which are assumed to be borne by EU operators). On the other hand, the costs for operation and maintenance (which include fixed operation and maintenance costs, variable operation costs and fuel costs) would drop very sharply. Because of the persistence of fuel price distortions in at least part of the projection period at differing degrees depending on the scenario, the fuel prices used to determine fuel costs are set at international levels, i.e. the fuel costs used represent opportunity costs. The net result of these contradictory movements, however, is a reduction in total generation costs.

Because both scenarios involve a contraction of the gross inland consumption of electricity, the total cost per kWh generated for the domestic market drops more modestly (12.5% in the cooperation scenario and 11% in the sustainable development scenario).

Despite the much-reduced role of renewable energy sources, total cumulative investment costs in the threat scenario would be slightly higher than in the reference-QI case. This is because the threat scenario projects much higher electricity generation for the domestic market. Variable costs, on the other hand, rise very sharply, primarily due to the increase in fossil fuel use in the scenario. Overall, cumulative generation costs would stand 21.2% higher than in the reference-QI case (but only 5.2% higher if generation costs per kWh produced are considered).

Electricity prices are projected to increase in both the MED–EU cooperation and the sustainable development scenarios as a result of policies towards pricing reflecting true costs, which also aim at promoting energy efficiency (Table 32). Thanks to the gains in energy efficiency produced in these scenarios, total energy expenditures by households as a percentage of their income would evolve smoothly, raising no significant concerns regarding affordability in the pursued policies. This contrasts with the threat scenario, for which affordability issues could arise owing to failure to improve efficiency and cost-effectiveness (Table 33).

Table 31. Cumulative investment in power generation (2012–30) and total cost of power generation in the MED-10 region

	Investment costs		Variable costs		Total power generation cost	
	in billions €'05	% change from reference-QI	in billions €'05	% change from reference-QI	in billions €'05	% change from reference-QI
Reference-QI	486.1		579.0		1065.1	
MED–EU cooperation	649.1	33.5	179.2	-69.1	828.4	-22.2
Sustainable development	698.0	43.6	117.5	-79.7	815.5	-23.4
Threat	491.4	1.1	799.4	38.1	1290.8	21.2

Table 32. Average electricity prices in the MED-10 region (in €'05/MWh)

		ALG		MOR		TUN		EGY		LIB	
		Indus-try	**Resi-dential**	**Indus-try**	**Resi-dential**	**Indus-try**	**Resi-dential**	**Indus-try**	**Resi-dential**	**Indus-try**	**Resi-dential**
	2010	*25*	*45*	*142*	*106*	*75*	*128*	*14*	*17*	*25*	*45*
Reference-QI	**2020**	37	74	121	138	80	142	43	59	39	77
	2030	47	99	98	161	89	155	72	106	51	100
MED–EU cooperation	**2020**	41	82	135	141	87	147	46	62	43	82
	2030	72	122	107	178	95	168	80	120	67	136
Sustainable development	**2020**	37	76	118	138	79	139	41	56	37	78
	2030	51	119	86	180	83	163	74	118	46	124
Threat	**2020**	31	61	132	110	87	155	49	66	48	70
	2030	29	58	122	99	88	143	45	63	41	61

		ISR		LEB		SYR		JOR		TUR	
		Indus-try	**Resi-dential**	**Indus-try**	**Resi-dential**	**Indus-try**	**Resi-dential**	**Indus-try**	**Resi-dential**	**Indus-try**	**Resi-dential**
	2010	76	108	119	58	55	12	52	84	112	135
Reference-QI	**2020**	94	136	113	101	59	37	72	117	109	142
	2030	106	156	108	131	69	77	92	146	112	159
MED–EU cooperation	**2020**	109	146	114	101	63	41	78	124	115	149
	2030	119	173	110	140	77	95	100	153	117	159
Sustainable development	**2020**	94	131	108	95	59	38	70	113	113	140
	2030	108	158	112	123	73	85	83	157	114	160
Threat	**2020**	92	130	107	80	61	23	56	111	114	123
	2030	92	134	104	87	65	47	56	108	108	118

Table 33. Energy expenditure as a share of income (proxy to affordability) (in %)

		Energy expenditures (% of household income)										
		ALG	**MOR**	**TUN**	**EGY**	**LIB**	**ISR**	**LEB**	**SYR**	**JOR**	**TUR**	**MED-10**
	2010	1.09	4.65	2.48	1.66	0.94	3.44	1.78	1.56	4.90	2.96	**2.48**
Reference-QI	**2020**	1.46	4.68	2.72	2.82	1.58	3.30	2.83	2.68	5.74	4.23	**3.36**
	2030	2.14	5.04	3.25	4.29	2.22	2.86	3.79	5.18	7.00	4.51	**4.02**
MED–EU cooperation	**2020**	1.24	4.80	2.69	2.74	1.56	3.35	2.76	2.65	5.82	4.17	**3.30**
	2030	2.16	4.97	3.27	4.35	2.26	2.86	3.72	5.29	6.89	4.44	**3.98**
Sustainable development	**2020**	1.37	4.57	2.54	2.39	1.39	3.08	2.45	2.14	5.19	3.93	**3.07**
	2030	1.88	4.71	2.81	3.42	1.87	2.46	2.74	3.57	5.80	3.71	**3.32**
Threat	**2020**	1.28	4.49	3.19	2.82	1.45	3.24	2.59	2.21	5.59	5.22	**3.70**
	2030	2.20	5.72	3.24	4.60	2.21	2.95	3.93	5.24	7.57	5.16	**4.47**

Impacts on primary energy supply

The sustainable development scenario assumes an increase in FDI but not to the same extent as the MED–EU cooperation scenario. Consequently, primary production of oil would increase compared with the reference-QI case but stand below the cooperation scenario (Table 34). On the other hand, the sustainable development scenario has a much wider scope for reduction in oil demand because efficiency gains are not limited to the ETS sectors, but affect the whole energy system. Concerning oil demand, the efficiency gains in the transport sector would play a key role in determining the overall demand reduction. The exportable surplus for Libya in 2030 would go from 148.5 Mtoe in the reference-QI case to 166.9 Mtoe in the MED–EU cooperation scenario, and 173.1 Mtoe in the sustainable development scenario. The quantities for Algeria would be 52.1, 56.2 and 58.4 Mtoe respectively. Yet, even the higher figure for the sustainable development scenario would not prevent a reduction in Algerian oil exports between 2020 and 2030.

According to the sustainable development scenario, Syria clearly remains in a net oil-exporting position by 2030 (with exports representing a third of primary production). In 2030, the import dependence of Egypt would be 18% in the scenario compared with 41% in the reference-QI case. All other countries would experience considerable reductions in net imports in the scenario compared with the reference-QI case. This is particularly the case for Jordan, which would end up producing approximately half of its oil requirements from shale oil instead of 23% in the reference-QI case.

The sustainable development scenario has even more pronounced impacts on gas demand–supply balances (Table 35). Unlike the cooperation scenario, where the participation of Europe in a major decarbonisation effort means a substitution away from gas and hence a contraction of this crucial market for MED-10 suppliers, the sustainable development scenario sees an expansion in export markets combined with higher production due to more investment in productive capacity as well as a sharp reduction (compared with the reference-QI case) in domestic demand due to the efficiency gains in final demand sectors and substitution towards renewables in the power generation sector. In 2030, Algerian natural gas exports would increase to 117 Mtoe, compared with 93.5 Mtoe in the reference-QI case, and account for 56% of the MED-10 region's total exports. In the same year, sharp increases compared with the reference-QI case are registered for Libya (up 52%), Egypt (up 43%) and Israel (up 30%). The expansion of Egyptian exports would be somewhat moderated by the fact that a non-negligible proportion would be directed towards countries in the region (Syria, Lebanon, Jordan and Israel until 2025), which in the scenario would reduce their imports. Syria would become 80% self-sufficient in the sustainable development scenario, compared with 50% in the reference-QI case. The changes in the balance of trade in hydrocarbons that result from the sustainable development and the MED–EU cooperation scenarios would produce a major economic impact. The implication for Libya is that its economy would become considerably more specialised in hydrocarbon production and exports. Syria and Jordan would receive an important boost in their overall balance of trade, implying a considerable loosening of the energy import constraint.

The negative investment climate assumed for the scenario of the Euro-Mediterranean area under threat produces pronounced effects on the supply of crude oil in the region. The effects are particularly strong in Libya, which is the major oil-producing country of the region (Table 36); the effects are due to delays in exploration programmes, shrinking reserves and more limited expansion of productive capacity. Investment in productive capacity would also be a problem for the other oil producers in the region: Algeria, Egypt and Syria. In this scenario, Jordan would not undertake shale oil production by the end of the forecast period.

The drop in production in conjunction with increased primary consumption of oil would lead to major changes in hydrocarbon trade for the countries of the region. In the threat scenario, net importers would increase their dependence and net exporters reduce exported volumes as a consequence of higher domestic use.

Table 34. Comparison of primary production and consumption of oil in the different scenarios examined in 2030 (in Mtoe)

		ALG	MOR	TUN	EGY	LIB	ISR	LEB	SYR	JOR	TUR	MED-10
Reference-QI	**Primary production**	74.4	0.0	2.7	32.0	165.3	0.0	0.0	17.5	1.8	0.4	294.2
	Primary consumption	22.3	16.0	6.2	54.1	16.8	16.9	4.2	18.0	7.9	75.1	237.5
Sustainable development	**Primary production**	77.1	0.0	2.8	32.8	178.9	0.0	0.0	17.9	2.6	0.4	312.4
	Primary consumption	18.7	12.5	5.3	40.2	12.0	15.2	2.4	11.9	5.2	68.4	191.8
MED–EU cooperation	**Primary production**	78.9	0.0	2.8	33.5	187.7	0.0	0.0	17.9	3.1	0.4	324.1
	Primary consumption	21.8	13.2	6.0	48.2	14.6	16.7	2.7	14.2	6.1	73.9	217.3
Threat	**Primary production**	70.0	0.0	2.3	29.5	98.3	0.0	0.0	15.9	0.0	0.4	216.4
	Primary consumption	24.2	23.5	7.0	62.8	20.1	18.4	8.7	41.4	14.1	80.8	300.9

Table 35. Comparison of primary production and consumption of natural gas in the different scenarios examined in 2030 (in Mtoe)

		ALG	MOR	TUN	EGY	LIB	ISR	LEB	SYR	JOR	TUR	MED-10
Reference-QI	**Primary production**	144.2	0.0	3.4	119.5	34.9	20.0	0.0	10.4	0.2	0.1	332.8
	Primary consumption	50.7	10.0	9.5	89.2	12.7	10.0	3.8	20.9	5.7	71.8	284.3
Sustainable development	**Primary production**	149.9	0.0	3.0	104.4	42.4	22.6	0.0	11.5	0.2	0.1	334.2
	Primary consumption	33.3	6.3	6.3	60.9	8.7	9.6	3.8	14.4	4.5	57.8	205.6
MED–EU cooperation	**Primary production**	128.8	0.0	3.1	93.9	30.4	20.6	0.0	12.5	0.2	0.1	289.6
	Primary consumption	38.2	9.7	7.1	67.9	8.8	10.8	4.2	16.4	4.9	74.0	242.1
Threat	**Primary production**	139.2	0.0	3.7	113.5	28.3	9.6	0.0	9.0	0.2	0.1	303.5
	Primary consumption	61.5	5.8	12.5	102.2	15.8	9.6	1.6	9.0	3.0	85.7	306.7

Table 36. Balance of trade in hydrocarbons as a percentage of GDP in 2030

	ALG	MOR	TUN	EGY	LIB	ISR	LEB	SYR	JOR	TUR	MED-10
Reference-QI	20.7	-6.8	-3.8	-0.1	63.6	-2.0	-6.3	-4.0	-11.5	-5.4	**1.6**
MED–EU cooperation	21.2	-5.9	-2.9	0.3	73.0	-2.0	-5.2	-0.6	-7.3	-5.4	**2.4**
Sustainable development	24.6	-5.0	-2.4	2.0	73.9	-1.2	-4.6	0.8	-6.6	-4.7	**3.6**
Threat	17.6	-8.2	-5.3	-2.2	33.7	-3.7	-9.0	-12.9	-18.6	-6.0	**-1.5**

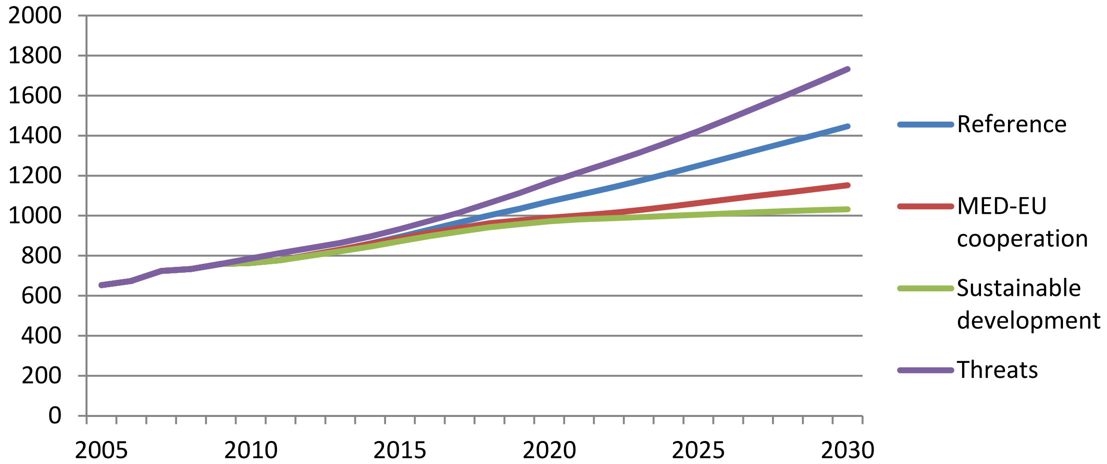
By 2030, Libya's oil exports would stand at nearly half of the reference-QI case levels. Algeria's exports would drop by 12%. Turkey's imports in the scenario would expand by a relatively modest 5.6 Mtoe, but Egypt's would increase by 50%. The countries that increase their oil consumption in the power generation sector would experience big increases in their imports (e.g. 106% in Lebanon and 134% in Jordan). Syria is expected to turn from being a marginal net importer of oil (2.7% of consumption) to a significant importer (61.6% of consumption). Viewing the MED-10 region as a whole, it is worth noting that in the reference-QI scenario it would continue to be a net exporter of oil (56.7 Mtoe in 2030), while in the scenario of the Euro-Mediterranean area under threat the situation is reversed and it would become a net importer to the tune of 85 Mtoe.

Morocco, Lebanon, Syria and Jordan, which are assumed to reduce their pipeline gas imports as a matter of policy, register sharp reductions in net imports in 2030 according to the scenario (50% for Jordan, 58% for Lebanon and 42% for Morocco compared with the reference-QI case). Syria is forecast to eliminate all imports and cover its requirements from domestic production, which is nonetheless reduced by 14% due to underinvestment in the primary hydrocarbons sector. In the scenario, Israel does not develop its LNG export capability and hence produces for the local market – which is slightly reduced compared with the reference-QI case. Algeria would register a relatively small reduction in production; however, its primary consumption would increase by more than 20% and exports to Morocco would reduce. Consequently, its total exports are expected to drop from 93.5 Mtoe in the reference-QI case to 77.6 Mtoe in the scenario. Egypt registers a bigger drop, from 30.4 Mtoe to 11.2 Mtoe, mainly as a consequence of the contraction of its export markets in Syria, Jordan and Lebanon. Turkey would import an additional 13.9 Mtoe from outside the MED-10 region. The net result of these changes is that the region as a whole would turn from being a net exporter of natural gas to the tune of 48.5 Mtoe in the reference-QI scenario to being a marginal net importer (3.2 Mtoe) in the threat scenario.

7.2 Impacts on emissions

The MED–EU cooperation and the sustainable development scenarios project similar evolutions of carbon emissions, which lie significantly below the reference-QI scenario projections. This is due to renewables and growing energy efficiency. The results obtained for the MED–EU cooperation and the sustainable development scenarios indicate that given greater stability in the region and the will to address the problems associated with the evolution of the energy system in cooperation with the EU, the MED-10 countries could derive substantial economic benefits as well as achieve environmentally more sustainable development. By contrast, the threat scenario fails to reduce emissions and shows an emission pace above the reference-QI scenario (Figure 8).

Figure 8. Evolution of energy-related CO_2 emissions in the MED-10 region under the different scenarios (in $MtCO_2$)



8. Conclusions

Despite a deceleration in population growth, the MED-10 region is set for very rapid growth in energy consumption. The main driver of this growth is economic activity, bringing in its wake increased prosperity and standards of living. A few countries apart, the next 20 years are unlikely to see a significant deceleration in energy consumption due to saturation effects.

Electricity demand is projected to increase even faster as a result of the continuing electrification of industry, but especially owing to improvements in standards of comfort in households.

Energy demand for transport is forecast to grow vigorously in all the scenarios. The most dynamic segment in this respect is road transport and in particular the rate of private motorisation, which is projected to increase by more than 2.5 times in the region as a whole despite some signs of saturation in the more prosperous countries.

Natural gas is expected to increase its share in meeting energy needs, assisted by an expansion of distribution grids, competitive pricing and increased intraregional trade premised on improving stability in the region. Oil use, on the other hand, is projected to be more and more concentrated on the transport segment of the market.

The region as a whole is characterised by huge potential for renewable energy sources, especially solar thermal, photovoltaics and wind. The extent to which these untapped resources are exploited will depend to a very large degree on active government support, an improved investment climate favouring local initiatives as well as FDI and an engagement in climate mitigation efforts, especially in cooperation with the EU. Such cooperation can lead to massive exports of the region's RES power production accompanied by mutual benefits. Even very high RES penetration rates are feasible given higher storage capabilities for solar thermal and the complementary use of natural gas.

Large-scale deployment of RES implies a massive increase in investments in the power generation sector (cumulative investments of €700 billion (€'05), significantly above the sum of €486 billion (€'05) projected in the reference-QI case). Yet, this increased investment cost is accompanied by a drastic reduction of variable, operating and maintenance costs, especially fuel costs. On balance they result in a reduction of total generation costs.

In the reference-QI scenario, the share of natural gas is projected to increase in the region's power generation from 56% at present to 70% in 2030. In the scenarios, natural gas assumes a swing role, with reduced contributions in the proactive and cooperation cases because of the penetration of renewables, but also in the pessimistic scenario because of limitations in intraregional gas trade.

In the proactive and cooperation scenarios, regional demand for hydrocarbons is lower. The same scenarios assume a better investment climate, which facilitates the development of resources into productive capacity. As a result, exports would expand for the main producers, while import dependence would decrease in countries without a major resource base. This situation would produce important economic benefits for all the countries in the region. An expansion of natural gas production, however, depends on the evolution of domestic demand, intraregional exchanges and the gas market situation in Europe. The latter constitutes the natural outlet for the bulk of MED-10 gas exports. LNG exports beyond the EU are possible, but would only partially compensate for an eventual contraction of the European market. In the pessimistic case examined, higher demand for hydrocarbons together with delays in the development of resources would result in a drastic reduction in the export capabilities of the region, which, viewed as a whole, would end up becoming a net importer of both oil and gas.

In the reference-QI scenario, which purports to be a median case, energy-related CO_2 emissions nearly double between 2010 and 2030. The problem becomes more serious in the pessimistic scenario, where price reforms are stalled and there is no specific effort to improve energy efficiency and reduce CO_2 emissions. The situation is very different in the other two scenarios evaluated: one emphasising integration with the EU's climate mitigation efforts and trade in renewable electricity, and the other assuming vigorous unilateral action on a broad front to improve energy efficiency and enhance the deployment of RES. Clearly, to the extent that the scenarios are complementary, a combination of the respective assumptions would produce stronger results.

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Additional sources and websites

Enerdata energy reports and database (http://www.enerdata.net/)

German Aerospace Center (DLR) DESERTEC Project (http://www.dlr.de/dlr/en/desktopdefault.aspx/tabid-10200/)

IEA database (http://www.iea.org/)

Paving the Way for the Mediterranean Solar Plan project (http://www.pavingtheway-msp.eu/)

About MEDPRO

MEDPRO – Mediterranean Prospects – is a consortium of 17 highly reputed institutions from throughout the Mediterranean funded under the EU's 7th Framework Programme and coordinated by the Centre for European Policy Studies based in Brussels. At its core, MEDPRO explores the key challenges facing the countries in the Southern Mediterranean region in the coming decades. Towards this end, MEDPRO will undertake a prospective analysis, building on scenarios for regional integration and cooperation with the EU up to 2030 and on various impact assessments. A multi-disciplinary approach is taken to the research, which is organised into seven fields of study: geopolitics and governance; demography, health and ageing; management of environment and natural resources; energy and climate change mitigation; economic integration, trade, investment and sectoral analyses; financial services and capital markets; human capital, social protection, inequality and migration. By carrying out this work, MEDPRO aims to deliver a sound scientific underpinning for future policy decisions at both domestic and EU levels.

Title	MEDPRO – Prospective Analysis for the Mediterranean Region
Description	MEDPRO explores the challenges facing the countries in the South Mediterranean region in the coming decades. The project will undertake a comprehensive foresight analysis to provide a sound scientific underpinning for future policy decisions at both domestic and EU levels.
Mediterranean countries covered	Algeria, Egypt, Israel, Jordan, Lebanon, Libya, Morocco, Palestine, Syria, Tunisia and Turkey
Coordinator	Dr. Rym Ayadi, Centre for European Policy Studies (CEPS), rym.ayadi@ceps.eu
Consortium	Centre for European Policy Studies, **CEPS**, Belgium; Center for Social and Economic Research, **CASE**, Poland; Cyprus Center for European and International Affairs, **CCEIA**, Cyprus; Fondazione Eni Enrico Mattei, **FEEM**, Italy; Forum Euro-Méditerranéen des Instituts de Sciences Economiques, **FEMISE**, France; Faculty of Economics and Political Sciences, **FEPS**, Egypt; Istituto Affari Internazionali, **IAI**, Italy; Institute of Communication and Computer Systems, **ICCS/NTUA**, Greece; Institut Europeu de la Mediterrania, **IEMed**, Spain; Institut Marocain des Relations Internationales, **IMRI**, Morocco; Istituto di Studi per l'Integrazione dei Sistemi, **ISIS**, Italy; Institut Tunisien de la Compétitivité et des Etudes Quantitatives, **ITCEQ**, Tunisia; Mediterranean Agronomic Institute of Bari, **MAIB**, Italy; Palestine Economic Policy Research Institute, **MAS**, Palestine; Netherlands Interdisciplinary Demographic Institute, **NIDI**, Netherlands; Universidad Politecnica de Madrid, **UPM**, Spain; Centre for European Economic Research, **ZEW**, Germany
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