ELECTRICITY AND WATER OUTLOOK IN THE MIDDLE EAST AND NORTH AFRICA

HIGHLIGHTS

- To meet rapidly expanding electricity demand, MENA electricity generation is projected to increase by 3.4% per year on average in 2003-2030, reaching 1 800 TWh. The region will need some 300 GW of new generating capacity, about 6% of the world total.
- The share of gas in electricity generation will rise from 56% now to 58% in 2010 and to 69% in 2030 in the Reference Scenario. The share of oil will fall, but in some countries, notably Kuwait, Saudi Arabia, Iraq and Libya, it will still be fairly high in 2030.
- The power sector in most MENA countries is not commercially viable. Under-pricing is particularly marked in Iran, Egypt and the Gulf countries. Revenue collection is very poor because of low retail prices and illegal connections. Power companies rely on government budgets to cover their costs and finance investment. Price reforms are essential.
- Investment needs for power generation, transmission and distribution in MENA countries are projected to amount to $458 billion (in year-2004 dollars) – nearly as high as the upstream investment in the oil sector. Power generation will take $203 billion, while networks will need $255 billion. Saudi Arabia's power sector will need the largest investment, some $110 billion.
- In the absence of market reforms, these investments will remain a burden on government budgets. Investing in the demand side may be more cost-effective than investing in new power plants and networks. Pricing reforms would cut demand by encouraging the purchase of more efficient appliances.
- Desalination plants will be increasingly relied upon to meet freshwater needs, especially in Saudi Arabia, the UAE, Kuwait, Qatar, Algeria and Libya. Energy use in such plants will account for more than a quarter of the total increase in fuel use in the power and water sector in these countries. Desalination capacity in these countries will more than triple over 2003-2030, requiring investment of $39 billion. More than half of new power-generation capacity will be in combined water-and-power (CWP) plants.

Introduction

On the assumptions in the Reference Scenario, MENA electricity use will grow by two-and-a-half times in 2003-2030. Installed generating capacity will grow from 178 GW in 2003 to 447 GW in 2030. Gas-fired plants will provide almost 70% of the new capacity. The investment required in the sector is equivalent to 1% of GDP. Over half of this is required for transmission and distribution.

Water supply is a critical issue for the region and more than a quarter of the increase in energy consumption in the power and water sector will be in new water desalination plants. For this reason, this chapter concludes with a section examining water demand and supply, looking particularly at the prospects in the six MENA countries which are most water-stressed.

Electricity Demand[1]

Demand for electricity in the countries of the MENA region (as measured by generating output) is projected to increase from 724 TWh in 2003 to 1 799 TWh in 2030, a rate of 3.4% per year. The share of MENA in global supply will increase from 4.3% to almost 6%. Estimated demand in 2004 was 770 TWh.

Table 6.1: **MENA Electrification Rates, 2002**
(% of population with access to electricity)

Kuwait	100	Lebanon	96
Israel	100	Qatar	96
Bahrain	100	Jordan	95
Libya	100	Iraq	95
Iran	99	Tunisia	95
Algeria	99	Oman	95
Saudi Arabia	98	Syria	87
Egypt	98	Morocco	77
United Arab Emirates	97	Yemen	50

Source: IEA (2004).

1. There is a particular problem of definition in discussing MENA electricity supply. Conversion losses always create a disparity between primary energy demand for electricity generation and electricity output; and transmission and distribution losses reduce final demand below the level of output from generation. However, losses in MENA countries before the supply reaches the final customer, whether for technical or other reasons, are particularly high. This makes it necessary sometimes, in discussing electricity demand in MENA countries, to discuss output from generation rather than measured final demand.

Figure 6.1: **Per Capita Electricity Demand in MENA Countries and the OECD, 2003**

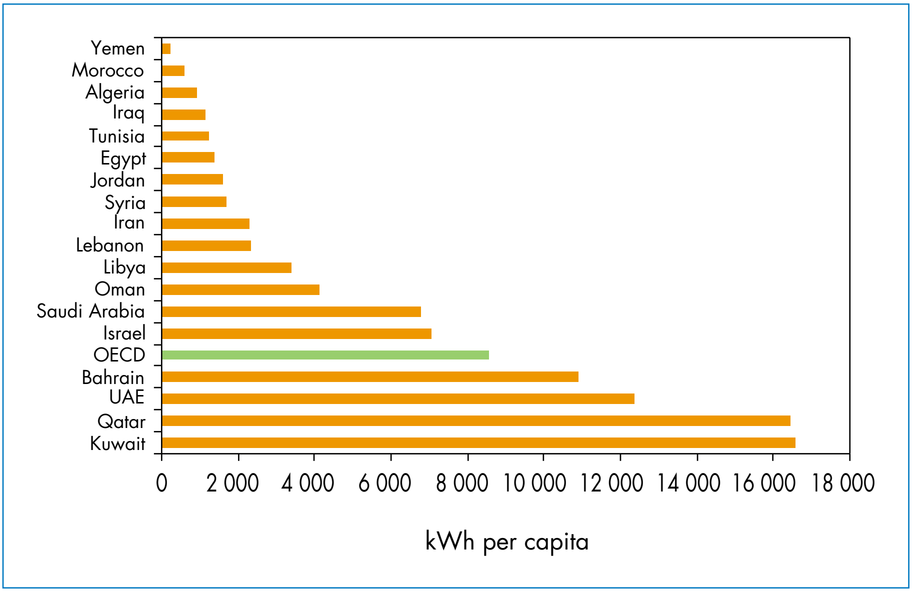
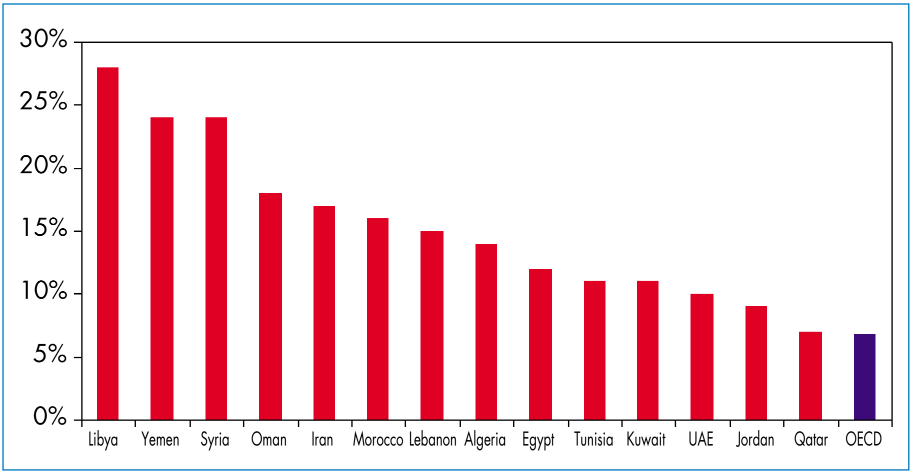


Figure 6.2: **Electricity Losses in MENA and the OECD, 2003**



Per capita electricity demand in the Gulf countries was already high in 2003, in some cases higher than in the OECD (Figure 6.1). Kuwait then had the fourth-largest per capita consumption in the world (after Iceland, Norway and Canada) and Qatar the fifth. By contrast, the countries of North Africa, except Libya, were at the low end of the range. Yemen, the poorest country in

MENA, has the lowest per capita electricity demand. The region as a whole already enjoyed some of the highest electrification rates outside the OECD (Table 6.1).

Demand for electricity in the region grew rapidly in recent years. The average growth rate in the period 1998-2003 was 6.3% per year, very close to the growth rate across all developing countries in the same period. In some

Box 6.1: **Network Losses in MENA**

Technical and non-technical losses are high almost everywhere in MENA. In general, networks are well maintained but because of the climate, there are some problems which affect the performance of networks, such as sandstorms that stress transmission lines. Further, because of the high temperatures in the summer, networks often operate in extreme conditions.

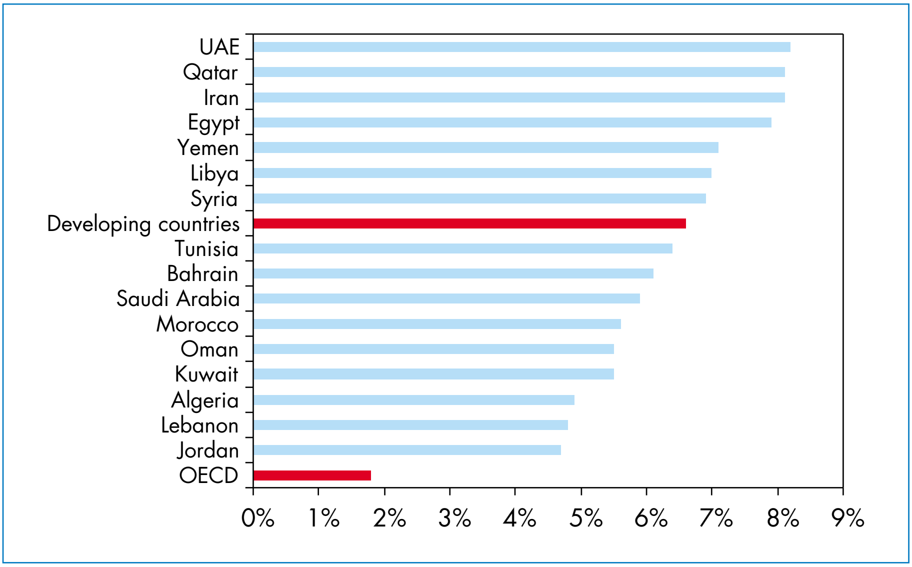
The main cause of high losses is, however, illegal connections. Some countries also include unpaid electricity in their losses. Figure 6.2 clearly illustrates the problem. The share of transmission and distribution losses across all OECD countries was 7% in 2003. This share is higher in all MENA countries.[2] One extreme case – although not the only one – is that of Libya, where over a quarter of electricity produced is considered as lost in the system. Some sources suggest that about 60% of Libyans do not pay their electricity bills, although the residential electricity price is one of the lowest in the region. Often, the largest share of receivables does not come from residential consumers but from the public sector, where utilities may face difficulties in getting paid from public consumers such as the army or some government institutions.

Despite the significance of the problem, few countries are making efforts to remedy the situation because of strong resistance from citizens and the potentially high political cost. Better subsidy targeting will, therefore, be essential if price reform is to be politically feasible. Algeria is one of the countries trying to address the non-payment problem. SONELGAZ, the electricity company, has taken action against fraud and retrocession and is trying to improve electronic metering.[3] The rate of losses, however, remains high, at around 14% in 2003.

2. Because of data problems, some countries appear to have extremely low losses, which is not the case. These countries have been omitted from the chart.

3. Ministry of Energy and Mines (2004). Retrocession is a practice where a household connects to a neighbour's electricity supply, sharing the electricity bill and avoiding the fixed charges or the trouble of obtaining the connection.

Figure 6.3: **Average Annual Growth Rates in Electricity Demand, 1998-2003**

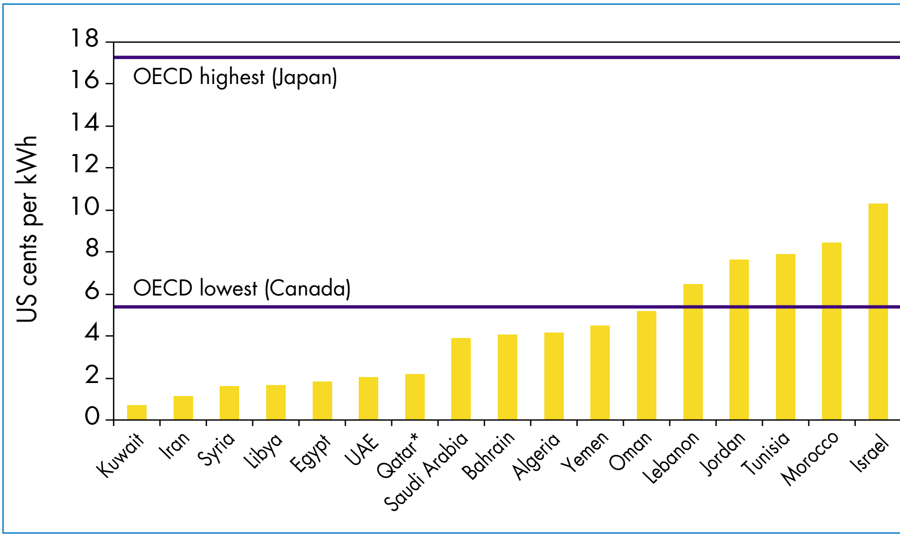


countries, such as the UAE, Iran, Qatar and Egypt, electricity demand grew at rates as high as 8% per year (Figure 6.3). In Iraq (not shown in the chart), exceptionally, electricity demand decreased in 2003 because of the conflict.

One reason for this has been that electricity prices in most MENA countries are far below OECD prices and often they do not even cover the long-run marginal cost of supply (Figure 6.4). This is because electricity is considered as a service that the government provides to its citizens and subsidies are a way to distribute the oil rent in resource-rich countries. For example, electricity is free to Qatari nationals. In summer 2005, Kuwait's parliament approved unanimously a law waiving 2 000 Kuwaiti dinars (about $6 800 in current dollars) worth of electricity bills for each Kuwaiti family. The total cost to the government is expected to be around $1 billion.

Fully cost-reflective electricity prices would not be much lower than in OECD countries, because a large part of the electricity price is related to the investment cost. Though operating costs are low in MENA countries, mainly because fuel, accounted for at prices below the opportunity cost, is cheap, charges related to generation, transmission and distribution infrastructure should be close to those of the OECD. For example, distribution network charges in Europe range between 3 and 5 US cents per kWh in most areas. These charges are not reflected in electricity prices in most countries in the

Figure 6.4: **Residential Electricity Prices in MENA and the OECD, 2003**



*The price shown is for expatriates.

Sources: Arab Union of Producers, Transporters and Distributors of Electricity (AUPTDE); national power companies; IEA estimates.

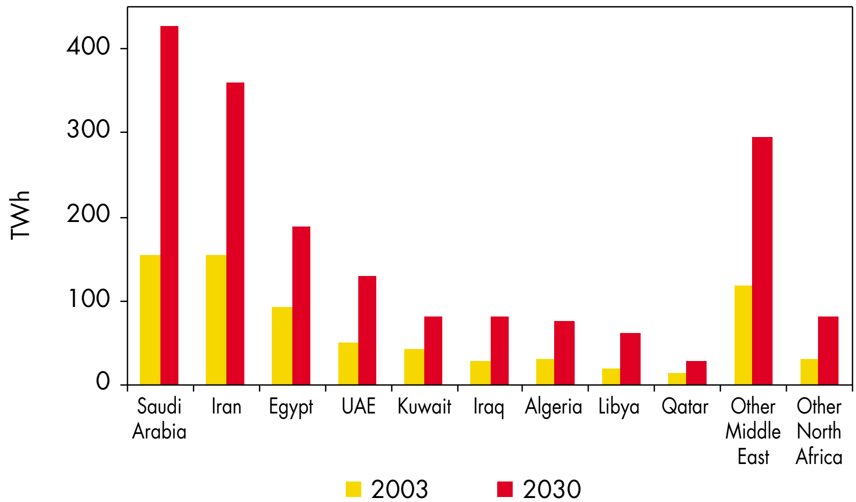
MENA region. The projections assume only slow progress in tackling this issue.

In the period to 2010, electricity demand is projected to increase by 5.1% per year. This growth is underpinned by current high oil revenues and the resulting economic boom, which on the one hand allows consumers to purchase more appliances and on the other hand facilitates investment in new power plants.

Saudi Arabia and the UAE are expected to see the highest growth rates in this decade. Although per capita electricity demand is already very high in the UAE – over 12 000 kWh per person in 2003 – demand for electricity will continue to grow. This is the combined result of high oil revenues and the current construction boom, particularly in the services sector.

Longer term, Iraq, Libya and Saudi Arabia are expected to have the highest growth rates. Iraq's electricity demand is projected to rise gradually as the country recovers politically and economically and new capacity is commissioned. Given the current difficulties and instability facing the country, this projection is highly uncertain. Libyan demand is also expected to grow rapidly, following the removal of sanctions. In Saudi Arabia, demand will grow fast in response to rapidly growing population.

Figure 6.5: **Electricity Demand in MENA Countries**



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The projected increases in electricity demand will bring some changes in the relative weights of the electricity sectors of the countries in the region. Saudi Arabia's and Iran's electricity demand were almost equal in 2003. But Saudi Arabia's electricity demand is projected to increase much faster than Iran's, largely because of its rapid population increase. Consequently, Saudi Arabia will have the largest electricity market in MENA in 2030 (Figure 6.5). Its annual production level is expected to hit 426 TWh in 2030, more than the current level in the United Kingdom.[4] The country's electricity sector is likely to maintain its position as one of the ten largest outside the OECD.

The strong growth in electricity demand has, hitherto, come mainly from the residential and services sectors. In Saudi Arabia, the residential sector currently accounts for 56% of total electricity consumption (mainly because of air-conditioning). The services sector is very strong in the United Arab Emirates, accounting for 43% of the total. The share of industry is high in just a few countries, such as Morocco, where industry consumed almost half of total electricity in 2003.

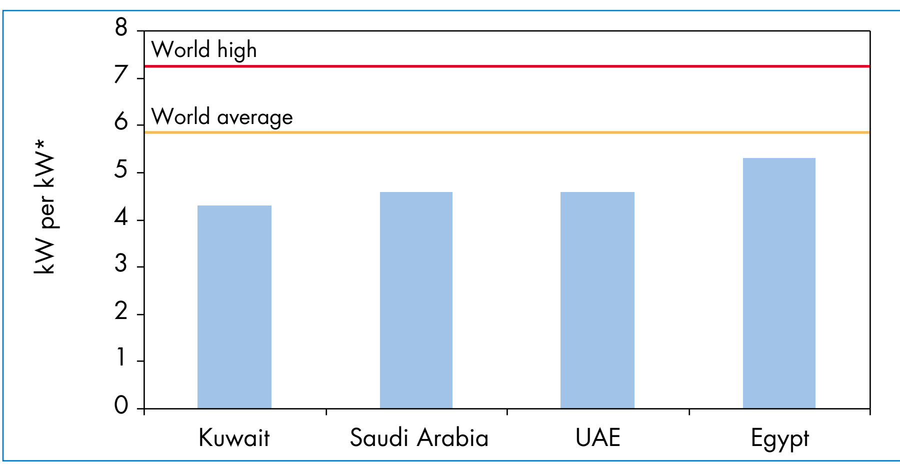
4. In terms of per capita consumption, Saudi Arabia and the UK are now at about the same level.

Over the projection period, the residential sector will grow the most rapidly, increasing its share in electricity consumption from 41% now to 44% in 2030. Demand for air-conditioning will contribute substantially to this increase (Box 6.2). Industry is projected to maintain its current share of about 25%, while the share of the services sector will drop slightly, from 29% to 28%.

Box 6.2: **Air-Conditioning in MENA**

Among various uses of electricity, cooling contributes substantially to demand for electricity in the summer when temperatures and humidity are high. Air-conditioning is widespread in the Gulf and rising in other MENA countries and the severe conditions in which these systems operate make their efficiency deteriorate quickly. Figure 6.6 shows that the efficiency of chillers used in commercial buildings in MENA is below the world average. This is also the case for smaller size systems used in households. Low electricity prices give no incentive to consumers to purchase more efficient appliances and building efficiency standards are, in general, absent in MENA. District cooling can improve the efficiency of the system, but its use is very limited now and it will remain so in the absence of price signals.

Figure 6.6: **Comparison of Chiller Efficiency**



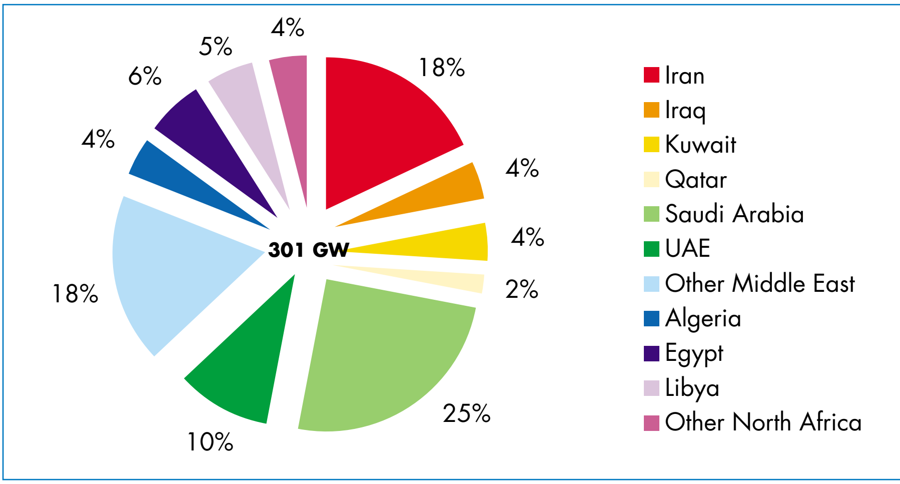
* The energy efficiency ratio of a cooling system is the ratio of the appliance's cooling capacity divided by the watts of power consumed at a specific outdoor temperature and is commonly measured in kW per kW.
Note: Chillers are large air-conditioners used in buildings.
Source: UNEP (2004).

Electricity Supply

Power Generation Capacity

Installed capacity in MENA is projected to increase from 178 GW in 2003 to 447 GW in 2030. During that period, some 18% (32 GW) of existing power plants will be retired. Total gross capacity additions in Middle East and North Africa will be 301 GW, which is roughly 6% of global capacity additions and 12% of the additions needed outside the OECD in the period to 2030. The region will need 78 GW in the period to 2010, 105 GW in the period 2011-2020 and 118 GW in the last decade. The largest increases will be in Saudi Arabia and Iran (Figure 6.7). These two countries represent over 40% of the requirements.

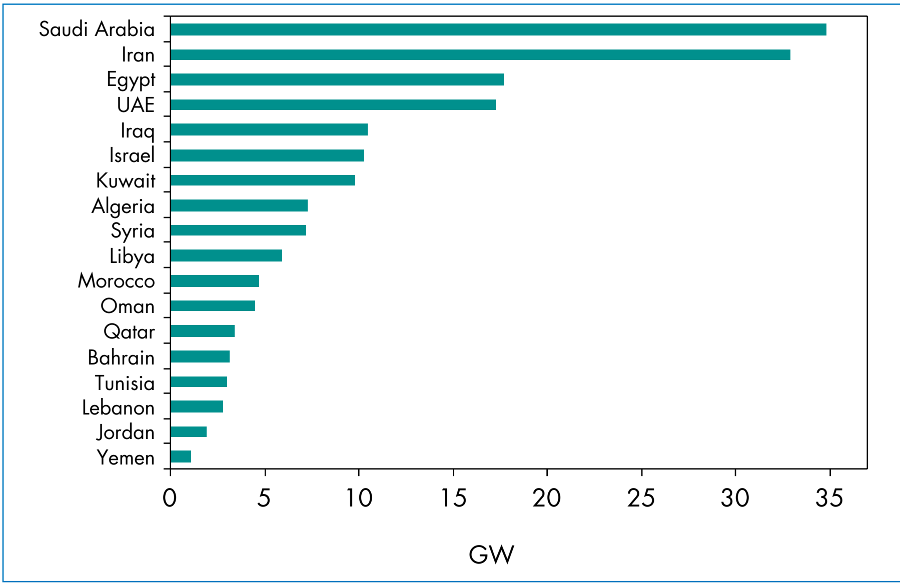
Figure 6.7: **MENA Power-Generation Capacity Additions by Country, 2004-2030** (GW)



Installed capacity in MENA had reached 178 GW in 2003, less than 5% of the world total. Iran and Saudi Arabia, with 33 GW and 35 GW respectively, had the largest installed capacities in the region (Figure 6.8). Installed capacity was estimated to have reached 186 GW in 2004.

Generating capacity in the Gulf area has to be planned to cover peak demand for power, which more than doubles in the summer because of the air-conditioning load. In Abu Dhabi, for example, the winter peak (that usually occurs in January/February) was about 2 100 MW in 2004 but reached 4 300 MW in the summer (peak demand occurs in July/August). The seasonal variation is even more pronounced in some other Gulf countries. This uneven demand pattern means that the load factors of power plants in these countries

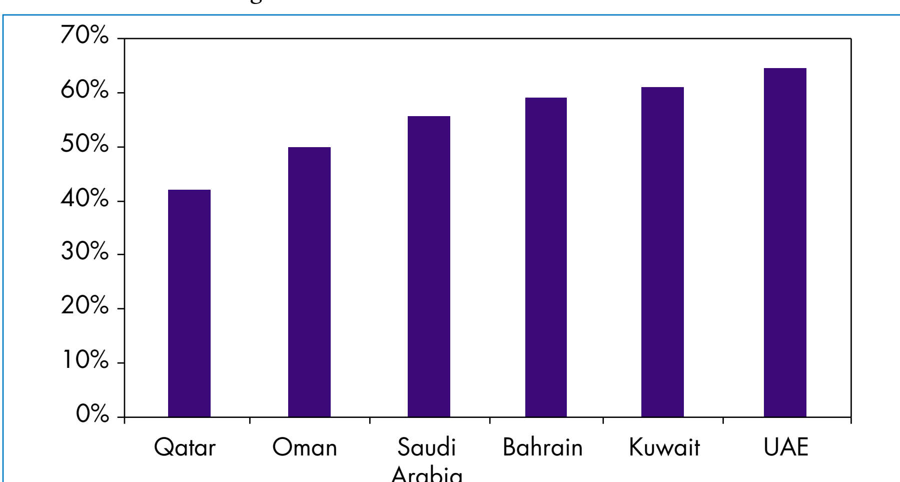
Figure 6.8: **MENA Installed Power-Generation Capacity by Country, 2003**



Source: Platt's (2003).

are low (Figure 6.9).[5] As a result of the high demand in the summer, MENA power plants are built to operate mostly in the summer. Further, the high summer load makes it more difficult to match electricity and desalination in countries that operate combined water and power facilities, as the water

Figure 6.9: **Load Factors in MENA, 2003**



Sources: AUPTDE (2004) and IEA databases.

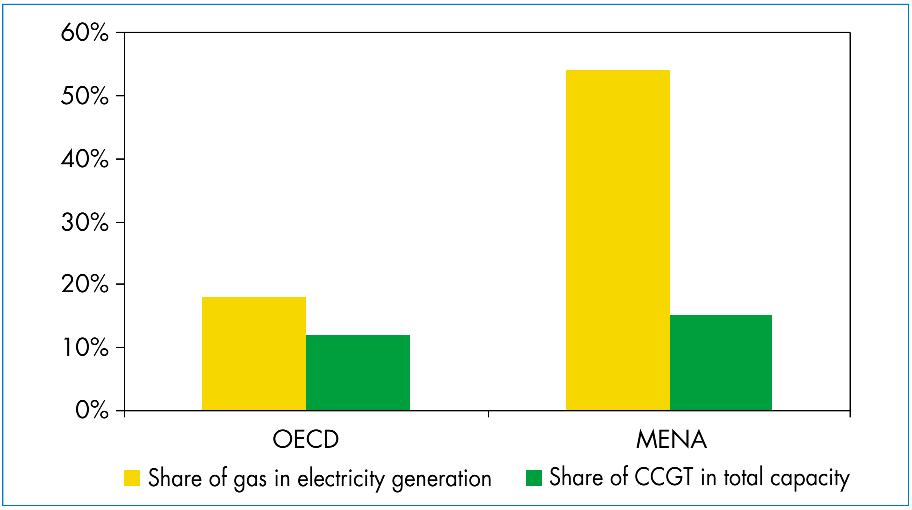
5. The load factor is the ratio of average load to peak load. The higher it is the better.

demand profile is much flatter throughout the year and storing excess water produced during the summer for use in the winter is not economically viable.

Although a number of countries in the region, particularly in the Gulf area, have state-of-the-art power plants, their reliance on open-cycle gas turbines (OCGTs) and boilers has kept power generation efficiency below the levels observed in OECD countries. On average, the efficiency of gas-fired power plants in MENA is 33% compared with 43% across the OECD region. Similarly, the efficiency of oil-fired generation is 34%, against 42% in the OECD. Besides the technology, the use of combined water and electricity production in the Gulf countries requires some additional fuel and this is another factor reducing the apparent electrical efficiency of power plants.

Combined-cycle gas turbines (CCGTs), which are generally considered the most economic way to produce electricity in OECD countries (see discussion of power plant economics below), make up a small share of MENA capacity (Figure 6.10). OECD countries have built about 250 GW since 1990. During this period, MENA countries built mostly OCGTs, attracted by their lower capital costs than CCGTs despite their lower efficiency. This was the most economic option for MENA, because all countries needed to make large investments and because the abundance of cheap fuel made operating efficiency less of a consideration. Another reason why OCGT has been the technology of choice is the short construction time, which enables rising electricity demand to be met rapidly.

Figure 6.10: **Natural Gas Use in Power Generation and Role of CCGTs in MENA and the OECD, 2003**



The high temperatures and humidity which characterise the climate of most MENA countries affect the performance of power plants. These two factors reduce the effective capacity of power plants: more MW of capacity must be installed to obtain the same amount of electricity as in other parts of the world with temperate climates. Fuel efficiency is also negatively affected.

Over the projection period, gas-fired power plants will meet over two-thirds of new capacity needs in the region (Table 6.2). Most of the new gas-fired power plants will be CCGTs (137 GW, roughly two-thirds of total gas-fired capacity). The use of open-cycle gas turbines will be increasingly concentrated on meeting peak load requirements, although some will be used for base- to mid-load electricity generation as well. Altogether, open-cycle gas turbine capacity additions are projected to be of the order of 54 GW. Some new combined water and power (CWP) facilities may also use OCGTs. The remaining gas-fired capacity, some 14 GW, is expected to be in steam boilers. This technology is now becoming obsolete everywhere in the world. Some heat-recovery boilers may be constructed where flexibility to burn gas or crude is needed or to repower existing open-cycle gas turbines, improving the efficiency of the power plant at a lower cost than building a new CCGT power plant.

Table 6.2: **MENA Capacity Additions by Fuel, 2004-2030**

	GW additions	**Share**
Coal	8	3%
Oil	63	21%
Gas	205	68%
of which:		
CCGT	*137*	*46%*
OCGT	*54*	*18%*
Nuclear	0.9	0.3%
Hydro	13	4%
Other renewables	10	3%
of which:		
Wind power	*6*	*2%*
Solar power	*2*	*1%*
Total	**301**	**100%**

Oil-fired capacity additions represent 63 GW, or a little more than 20% of the total. New oil-fired power plants will be in the form of open-cycle turbines and diesel engines, or boilers using fuel oil or even crude (mainly in Saudi Arabia). New hydropower capacity will reach 13 GW, while 10 GW will come from other renewable energy sources (including over 6 GW of wind farms and about 2 GW of solar). Coal-fired capacity increases will amount to 8 GW, while Iran's nuclear power plant will add almost 1 GW of new capacity.

Power Plant Economics

Until the late 1980s, most electricity generation in MENA was by firing crude oil or oil products, particularly heavy fuel oil (sometimes even in open-cycle gas turbines). In recent years, there has been a widespread switch to firing natural gas, where this is available.

Gas-fired electricity generation is now the most competitive way to produce electricity in MENA. While both oil and gas are extremely cheap to produce, oil has a particularly high opportunity cost as an export commodity. Figure 6.11 shows indicative base-load electricity generating costs for three technologies used in MENA. The fuel costs in this example are assumed to be $4 per barrel for oil and $0.50 per MBtu for gas.[6] Electricity generated by oil boilers is more expensive than gas because of the higher investment required, higher operating costs and lower fuel efficiency.

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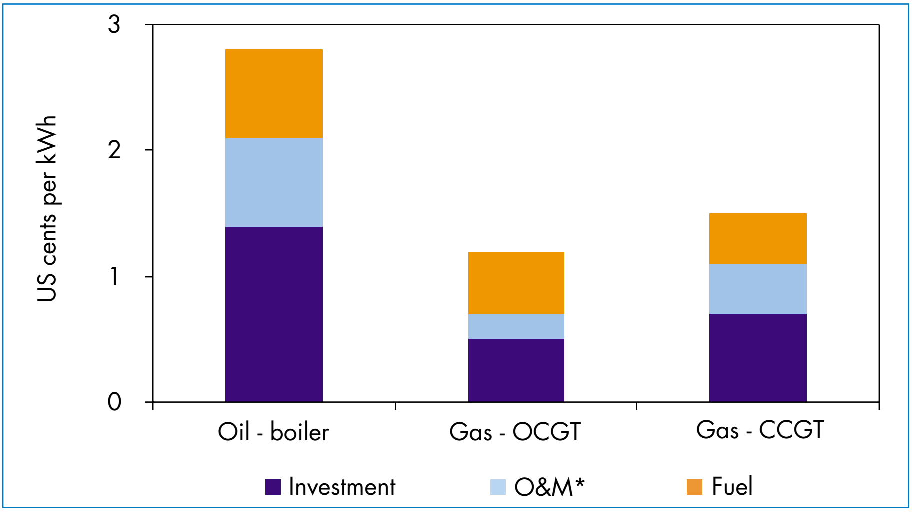
Figure 6.11: **Average MENA Electricity Generation Costs by Technology**

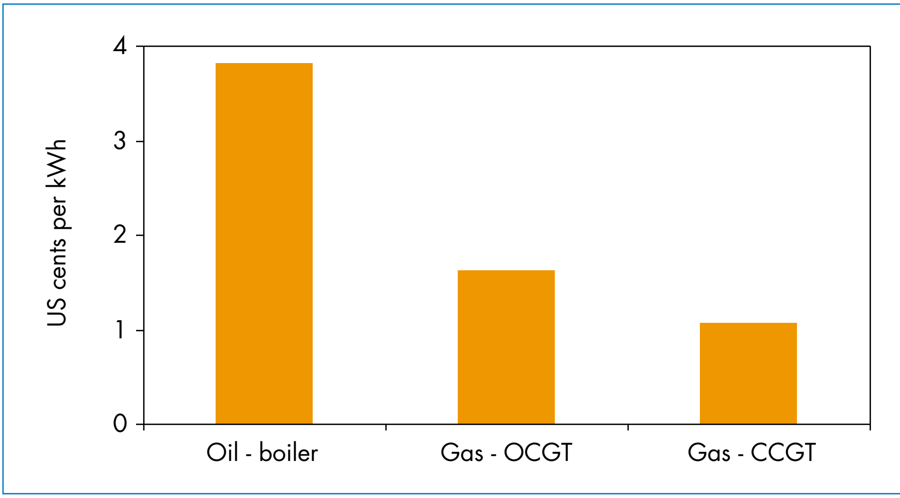


* Operation and maintenance costs.

If prices of fuel inputs were adjusted to take account of international market values, natural gas would become even more economic (Figure 6.12). Assuming an opportunity cost of $23 per barrel for oil and $1.50 per MBtu for gas, the cost of a kWh of electricity based on oil is up to four times higher than a kWh of electricity based on gas.[7] In other words, it is much more attractive to use gas for domestic power generation, since oil brings greater export earnings. This largely explains policies to switch from oil to gas.

6. The assumed price for gas is taken as an average across the region. This price is higher in some countries, reaching $1 per MBtu. Even at this higher price, gas-fired electricity is cheaper than oil.
7. Average IEA import price over the past five years, exclusive of transport costs (assumed to be $6 per barrel). Gas prices are for 2004.

Figure 6.12: **Cost of Electricity Generation Based on Fuel-Export Values**



Note: Refers to the fuel component of electricity-generating costs only.

The opportunity cost of gas is now low because of the abundance of reserves and because the export potential is still small. To date, this has resulted in countries building open-cycle gas turbines instead of combined-cycle power plants, mainly because of their lower investment cost. With demand for gas from outside MENA rising, the opportunity cost of gas is expected to increase to between $1 and $1.50 per MBtu or more, making CCGTs more competitive (Figure 6.13).[8] Economic pricing of gas, which is now subsidised or available free in most gas-producing countries in MENA, will also encourage the use of CCGTs.

Several countries in the region, particularly in the Gulf, are already switching to CCGTs, so as to co-generate steam for desalination. Figure 6.14 compares the additional investment cost for a CCGT with the potential earnings if the fuel saved (because of the higher efficiency of a CCGT plant) is exported. The total undiscounted value of this fuel over the lifetime of the power plant is at least six times higher than the additional initial investment required to build a CCGT power plant.

In the Gulf region, an additional incentive for investing in CCGT is the generation of steam for combined electricity and water production. Co-generation is most important for the countries of the Gulf and is growing in importance in other MENA countries suffering from water shortages.

8. These figures also reflect the market price of gas in MENA countries, where data are available.

Figure 6.13: **CCGT and OCGT Electricity Generating Costs**

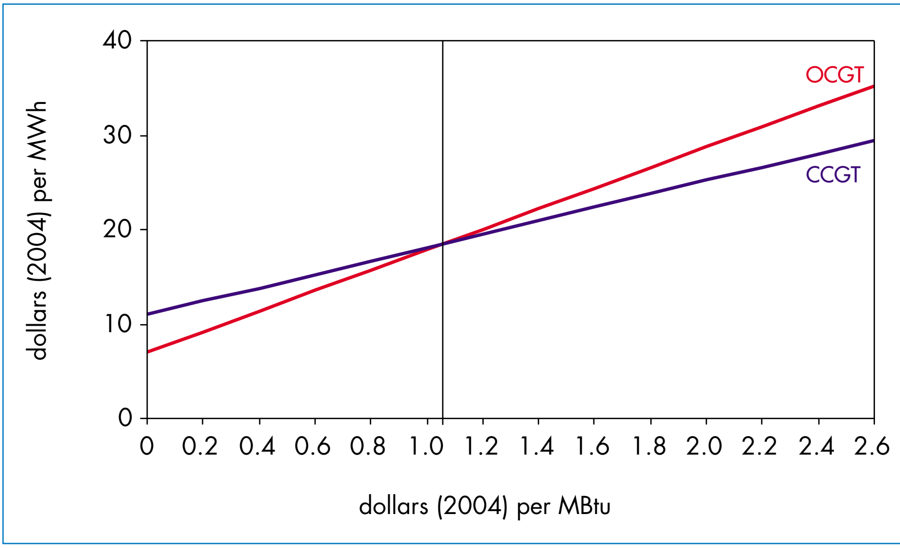
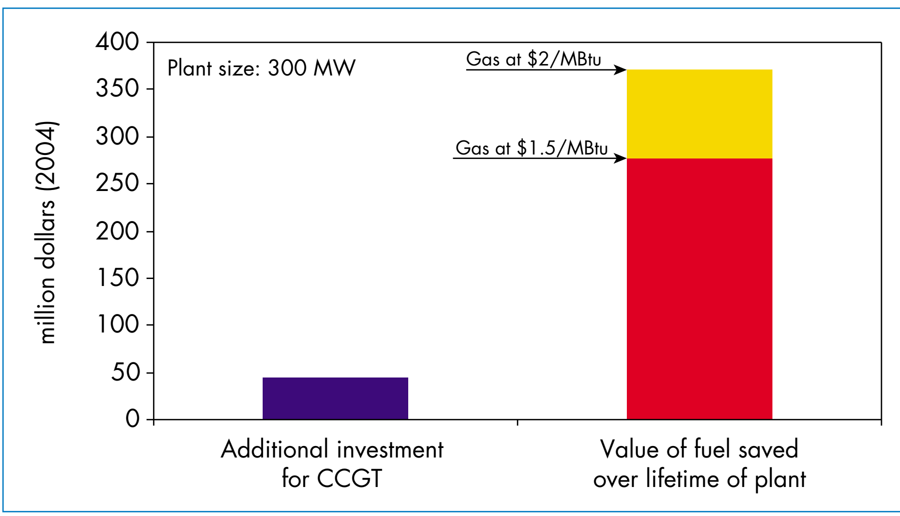


Figure 6.14: **Additional Investment for CCGT versus the Value of Fuel Savings**



Note: The following assumptions have been used: CCGT has a capital cost of $500 per kW and efficiency of 52%; OCGT has a capital cost of $350 per kW, efficiency of 34% and plant lifetime of 25 years. The additional value of steam for desalination is not taken into account.

Another reason for using CCGTs instead of OCGTs is the reduced environmental impact of the former because of their higher efficiency. Since many power stations are built around large cities, the pressure to reduce NO_x

emissions will increase. In many OECD countries it is now very difficult to build OCGTs near towns because they do not meet environmental standards. Carbon dioxide emissions from OCGTs are also higher. Although MENA countries have no obligation to reduce such emissions under the Kyoto Protocol, projects based on the Protocol's clean development mechanism (CDM) would favour CCGTs over OCGTs. For those countries seeking to borrow money in international markets, pressure to invest in CCGTs may also come from international lending institutions, which tend to favour cleaner technologies.

Electricity Generation Mix

The MENA region will continue to rely predominantly on hydrocarbons to produce electricity. The share of hydrocarbons in total electricity generation will remain at almost 90% throughout the projection period, but the oil and gas mix will change. The region will continue to move away from oil in power generation. The share of oil in total electricity generation was maintained above 50% until 1990 and then declined faster in the 1990s, falling to about a third of the total by 2003. It is projected to drop to 20% by 2030. In absolute terms, however, oil-fired electricity generation is projected to increase from 239 TWh in 2003 to 366 TWh in 2030. Oil use includes heavy fuel oil, diesel and crude. Some countries may continue to use heavy fuel oil that they cannot export because of its quality. Crude oil will continue to be used, particularly in Saudi Arabia, although much less than in the past. Building crude oil-fired power stations may pose specific challenges, since they are based on a technology for which global demand is low, with fewer experienced suppliers and limited product development. Total oil consumption in power stations is projected to increase from 60 Mtoe in 2003 to 92 Mtoe in 2030, approximately equivalent to 1.2 mb/d and 1.9 mb/d.

Gas-fired electricity generation is expected to increase substantially at the expense of oil, the gas share in the electricity mix rising from 56% in 2003 to 69% by 2030 (Table 6.3 and Figure 6.15). Natural gas consumption for electricity generation is projected to increase from 107 Mtoe (129 bcm) in 2003 to 277 Mtoe (335 bcm) in 2030. This amount represented 44% of MENA primary gas consumption in 2003 and will be 46% in 2030.

In 2003, natural gas was used in 14 countries in the region, its share ranging from 100% in Qatar and Bahrain to 9% in Jordan and to 0.5% in Israel. In eight out of the 18 countries in the region, gas accounted for more than two-thirds of total electricity generation (Figure 6.16). Lebanon, Yemen and Morocco used no gas. Iraq had a large gas pipeline connected to many of its power plants but it was not clear how much gas Iraq used. Problems of underinvestment, pipeline sabotage and other breakdowns often affect gas pressure and the ability to supply. For the countries that hold oil and gas reserves, the main reason for shifting to natural gas is to free up oil for export. Gas-based electricity generation is often the most competitive option.[9] Oil brings greater earnings if exported and is easier to transport. For countries without domestic gas supplies, imported natural gas is the most economic way to produce electricity.

Table 6.3: **Shares of Oil and Gas in Electricity Generation** (%)

	2003		2030	
	Oil	**Gas**	**Oil**	**Gas**
Middle East	**38**	**52**	**24**	**66**
Iran	16	77	7	80
Iraq	98	0	36	53
Kuwait	80	20	59	41
Qatar	0	100	0	100
Saudi Arabia	54	46	34	66
UAE	1	99	1	99
Other Middle East	39	27	27	41
North Africa	**15**	**68**	**9**	**78**
Algeria	2	97	1	96
Egypt	6	80	2	86
Libya	80	20	42	56
Other North Africa	17	36	8	60
MENA	**33**	**56**	**20**	**69**

While all countries in MENA seek to increase the use of gas, some are facing difficulties. The western region of Saudi Arabia, for example, has no easy access to gas supplies and building the necessary gas infrastructure will be costly. The situation could improve gradually in the future, if gas networks are developed and particularly if Saudi Arabia's new efforts to develop its non-associated gas reserves – located essentially in the Rub Al-Khali (the Empty Quarter) region – begin to bear fruit. In Kuwait, projects to switch to natural gas are facing delays. Iraq's shift to gas is also likely to be slow in the near term and is not likely to start before 2010. In Libya, the switch to natural gas will also be

9. See the previous section on power plant economics.

Figure 6.15: **MENA Electricity Generation Fuel Mix**

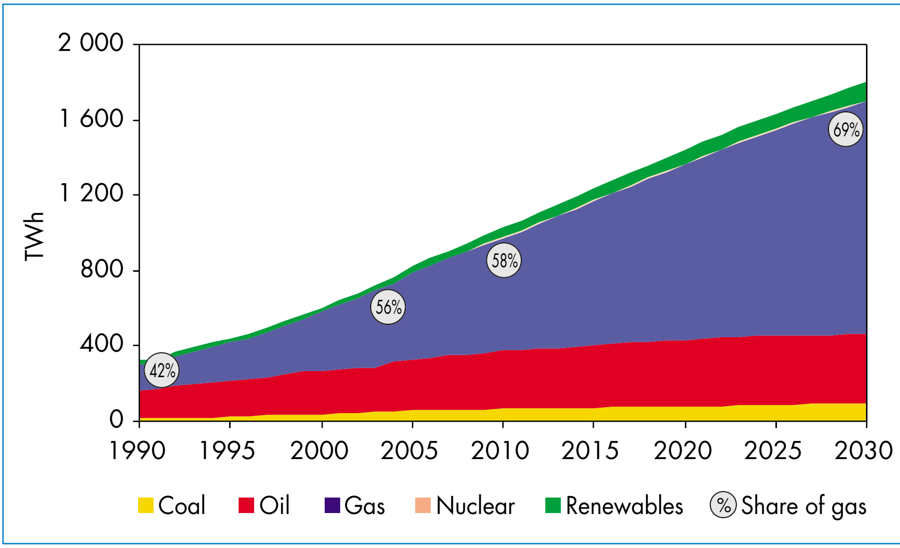
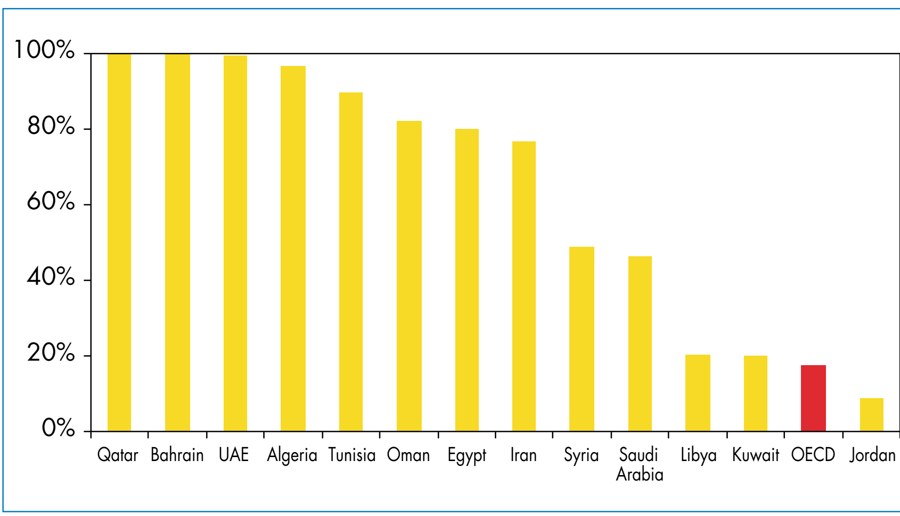


Figure 6.16: **Share of Natural Gas in MENA Electricity Generation, 2003**



Note: Israel is not included in this chart. Its share of gas in electricity generation in 2003 was 0.5%.

somewhat slow and will depend on how fast foreign investment in gas projects comes in.

A few countries in the region today use resources other than oil and gas to produce electricity. Morocco and Israel, which do not have rich hydrocarbon reserves, rely mostly on coal to produce their electricity. Hydropower is used in eight countries in the region. Its share is fairly significant in Egypt (14% of total electricity in 2003), Lebanon (13%), Syria (9%), Morocco (8%) and Iran (7%), but very small (less than 2%) in Iraq, Algeria, Tunisia and Israel. Some countries use solar and wind power, but in very limited applications. Only in Morocco did wind power account for more than 1% of total electricity generation in 2003.

Total coal-fired generation is projected to double, from 48 TWh in 2003 to 96 TWh in 2030. Coal will continue to be used in Israel and Morocco, but it is likely to lose share in both countries, as more gas projects are developed.

There is no nuclear power in MENA now, but Iran's Bushehr power plant is expected to be the first nuclear reactor for electricity generation to come on stream in the region.[10] Nuclear power is expected to reach 6 TWh by 2010 and remain at this level to 2030. A number of countries in the region operate research nuclear reactors and some of them have in the past expressed their interest in developing nuclear power plants for electricity production. The UAE's ADWEA (Abu Dhabi Water and Electricity Authority) signed a Memorandum of Understanding in 2004 with South Korea's Ministry of Science and Technology to carry out a feasibility study about constructing a nuclear power plant. Under the Reference Scenario assumptions, such a project has not been included in our projections.

Hydropower will increase at 3.1% per year, maintaining its current share of 4% in the electricity generation mix. The largest increase will be in Iran, where several projects are underway. But the region's hydro potential is rather small, and consequently, hydropower development is projected to slow over time.

The use of non-hydro renewables is expected to remain limited, although their share will rise from 0.1% now to 1.5% of total generation output in 2030. Wind and solar will account for the majority of this increase. Wind power is projected to increase from less than 1 TWh now to 16 TWh in 2030. Several countries in the region, including Morocco, Tunisia, Egypt, Iran, Israel, Jordan and Syria, have developed wind farms. The region's overall wind potential is, however, somewhat limited. The solar potential, on the other hand, is exceptional. Iran and most countries in North Africa have solar thermal projects under development. Most of these projects are combined gas and solar facilities. Israel has several solar demonstration projects. Photovoltaics are used in rural areas for electrification. However, the use of solar energy in the region

10. See Chapter 11 for a discussion about Iran's power sector.

is likely to remain limited by 2030 under the Reference Scenario assumptions, reaching 5 TWh. The main reason for this is the high cost of such power plants. Box 6.3 analyses MENA's solar power prospects.

Box 6.3: **Solar Power Prospects in MENA**

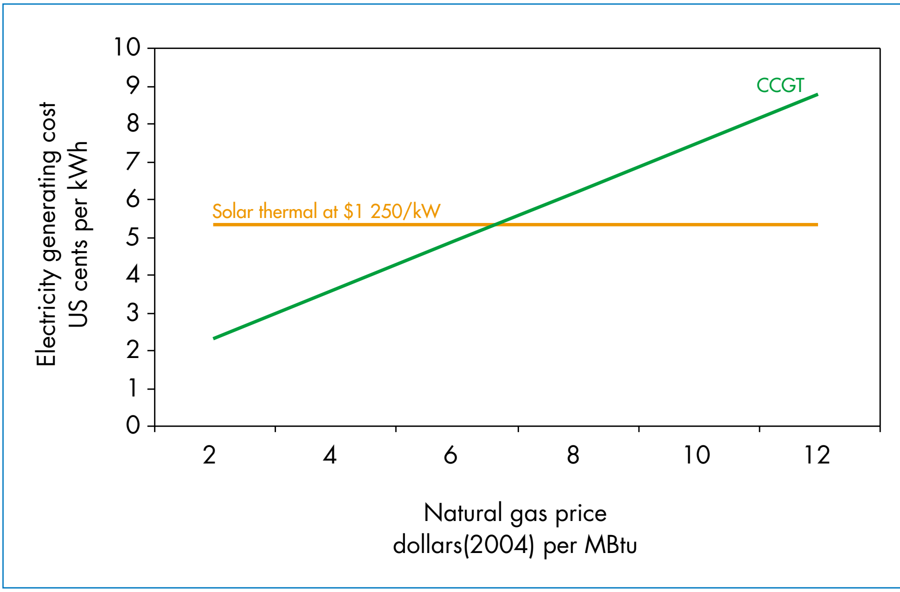
Global solar energy potential is estimated to be between 1 575 and 50 000 exajoules (EJ) per year, depending on land availability assumptions. This is between 3.5 and 110 times higher than the world's current energy consumption.[11] About a quarter of this potential is concentrated in the MENA region.

The economic potential is, however, much lower at present because of the high costs of producing electricity from solar thermal or photovoltaics (PV) power plants compared with conventional alternatives and, notably, natural gas. Electricity from solar thermal power plants is cheaper than PV but still about three times higher now than the generating cost of a CCGT power plant. The capital cost of solar thermal is expected to fall to around $1 250 per kW in 2030 in the World Alternative Policy Scenario – about 40% less than now – and the generating cost to about 5 cents per kWh. Figure 6.17 compares the generating costs of solar thermal and CCGT. It shows that solar thermal will still not be competitive in 2030 for gas prices under $6.5 per MBtu. This price is much higher than the international price of gas in 2030 in the Alternative Policy Scenario, but is in line with the price level reached in the Deferred Investment Scenario.

In this context, large increases in solar thermal in MENA can happen only if these countries seek to diversify their electricity mix or if they can generate more income by exporting gas instead of using it to produce electricity. Increases in solar are also possible if MENA countries participate in global emission reduction projects (for example, an international emissions trading scheme), since solar thermal electricity is much cheaper in MENA than in other world regions (for example it is a third less than in Europe). This, however, will require new policies within and outside MENA. Among various policies, the clean development mechanism under the Kyoto Protocol can provide substantial opportunities for investment in such projects.

11. IPCC (2001).

Figure 6.17: **Solar Thermal and CCGT Electricity Generating Costs in 2030**



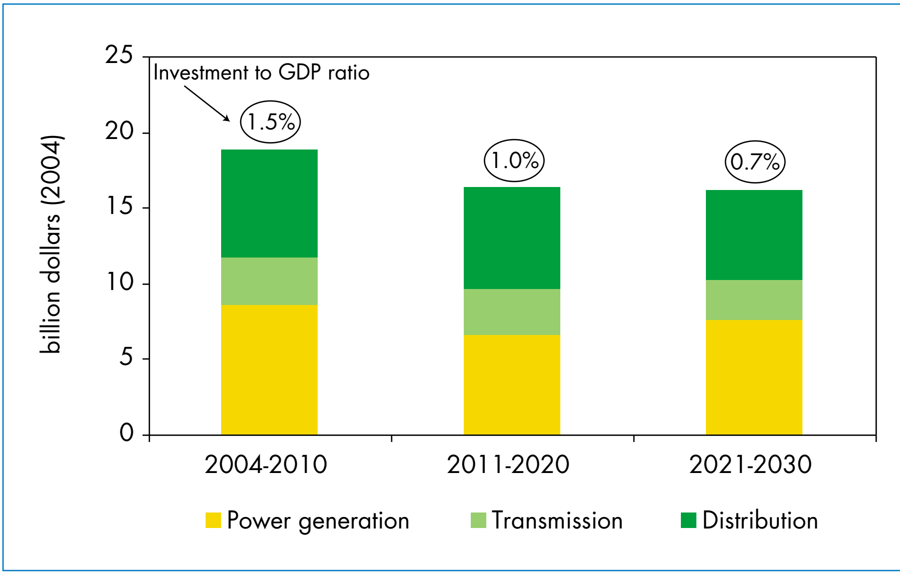
Electricity Investment

The total investment needed in the region's power sector is expected to reach $458 billion (in year-2004 dollars), nearly as high as the investment in upstream oil. In Iran, investment in the electricity sector will be higher than investment in oil or gas and in Egypt about the same as investment in the gas sector. On average, power sector investment makes up more than 30% of energy-related investments, about 5% of total domestic investment and nearly 1% of GDP.[12]

Investment in the period to 2010 is expected to reach $19 billion per year and then fall to about $16 billion per year in the rest of the projection period (Figure 6.18). During the first period, expenditure in electricity infrastructure will also be the highest relative to GDP, at 1.5%. In Iran, this share will be the highest, reaching 2.2%, indicating that this country may face a challenge in attracting the necessary investments.

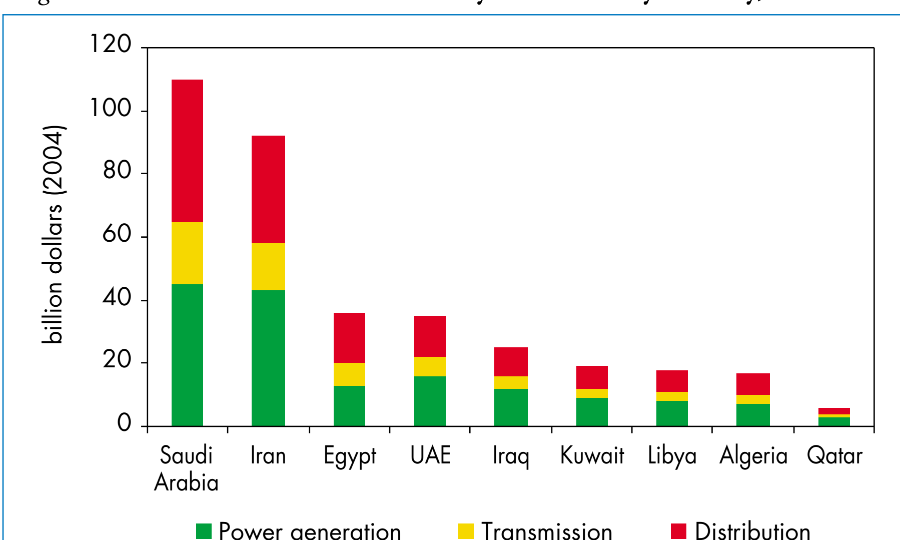
12. Domestic investment refers to gross capital formation and is assumed to be around 20% of GDP (median across MENA over the past ten years).

Figure 6.18: **MENA Average Annual Electricity Investment**



About 80% of the total investment will be in the Middle East and 20% in North Africa. Investment in Saudi Arabia's power sector will reach $110 billion, the largest in the region, while Iran will need some $92 billion (Figure 6.19). Egypt and the UAE will need about $35 billion each. The countries grouped together as other Middle East and other North Africa will need almost $100 billion.

Figure 6.19: **MENA Cumulative Electricity Investment by Country, 2004-2030**



Investment in power generation is expected to reach $203 billion, including some $26 billion in refurbishment. Investment in electricity transmission and distribution networks will be higher, at $255 billion or 56% of the total. Distribution networks alone will cost $176 billion, more than twice as much as transmission. On average, one kilowatt of new capacity added in MENA will cost almost $600[13] and the accompanying investment in networks will be almost $850 per kW. Table 6.4 summarises the capacity additions and investment needs by country. Although a large number of projects are underway in MENA, a shortage of EPC (engineering, procurement and construction) contractors has been observed in some cases over the past few years. This shortage is pushing up the cost of projects but it is not likely to be a problem in the long term.

Table 6.4: **MENA Capacity Additions and Investment, 2004-2030**

	Capacity additions (GW)	**Investment** ($ billion)			
		Total	**Power generation**	**Transmission**	**Distribution**
Middle East	**242**	**368**	**166**	**63**	**139**
Iran	54	92	43	15	34
Iraq	12	26	12	4	9
Kuwait	13	19	9	3	7
Qatar	5	6	3	1	2
Saudi Arabia	75	110	45	20	45
UAE	31	35	16	6	13
Other Middle East	53	80	38	13	29
North Africa	**59**	**90**	**37**	**17**	**37**
Algeria	12	17	7	3	7
Egypt	19	36	13	7	16
Libya	15	18	8	3	7
Other North Africa	12	19	9	3	7
MENA	**301**	**458**	**203**	**79**	**176**

The investment estimates in this *Outlook* do not take explicitly into account the cost of future interconnections. This cost is not expected to change significantly the investment figures given here, which are hundreds of billions

13. This figure is the result of the projected technology mix with different capital costs by technology.

of dollars. Any additional increase in transmission investment because of interconnections is expected to be offset to a large extent by reduced investment in power generation (Box 6.4).

Box 6.4: **Regional Interconnections in MENA**

Several interconnections exist between MENA countries, as well as with countries outside the region, but total exchanges are rather limited. Most interconnections are between North African countries, where the first links were developed a few decades ago. Transmission lines link Iran with Turkey, Azerbaijan, Turkmenistan and Iraq. The EIJLST project links the grids of Egypt, Iraq, Jordan, Lebanon, Syria and Turkey. Interconnections are absent in the Gulf area. Two major developments could significantly improve interconnections in MENA.

The *GCC Grid* (Gulf Cooperation Council Grid) will link the power grids of the six Gulf states (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the UAE). The project has three phases and is expected to improve security of supply in the Gulf area:

- Phase I: Interconnection of Kuwait, Saudi Arabia, Bahrain and Qatar. This system is the GCC North Grid.
- Phase II: Interconnection of the independent systems in the UAE as well as Oman. This is the GCC South Grid.
- Phase III: Interconnection of the GCC South Grid with the North Grid. This phase will complete the interconnection of the six Gulf states.

This project has for a long time been on the agenda of the Gulf countries, but was delayed mainly because of political differences. Contracts for the first phase were awarded in October 2005. The completion of the first phase, scheduled for 2008, is expected to cost over a billion dollars, but it will save investment in power generation since interconnections are expected to reduce the requirements for spinning and stand-by reserves as well as simultaneous combined peak demand. At the moment, there is no timing for the second phase, but the third phase is scheduled for 2010. Consequently, the second phase is likely to be completed between 2008 and 2010.

The *MEDRING* (Mediterranean Ring) project will link the power grids of Spain, France, Italy, Greece, Turkey, Jordan, Egypt, Syria, Algeria, Tunisia. The project, which will involve over 10 000 km of transmission lines, will facilitate power exchanges between countries around the Mediterranean. Countries in the south and east Mediterranean, in particular, hope to become competitive exporters of cheap electricity. While this is an ongoing project (Morocco, Algeria and Tunisia are already connected to Europe through a submarine cable between Morocco and Spain), there still remain several impediments, such as operational questions and compliance with the European transmission co-ordinator, UCTE (Union for the Coordination of Transmission of Electricity) guidelines, political sensitivities, competition with other countries which potentially supply electricity to Europe (for example Russia) and concerns in Europe about over-reliance on imports from distant countries. If these obstacles are overcome, MEDRING could be operational in 2010. However, because of the large distances involved and the limitations of current transmission technology, the exchanges are not likely to be very large. Further, some of the countries involved are finding it already difficult to build enough power plants to meet domestic demand, let alone for export.

In MENA countries, the electricity sector has typically been exclusively publicly owned, controlled by a ministry or a vertically-integrated power company (Table 6.5).[14] Some industrial companies (mainly the oil and gas industry) own power plants in most MENA countries, but their share in total capacity is, on average, small. The share in total electricity generation is even smaller, as they prefer to take subsidised electricity from the grid. In Saudi Arabia, where electricity tariffs have been increased, the share of autoproducer electricity is one of the highest in MENA, reaching 16% in 2003.

The electricity supply industry in most MENA countries is not commercially viable. This is because power companies do not have sufficient revenues to cover their expenses and to invest in new projects, resulting from heavily subsidised electricity prices, the non-payment of electricity bills and illegal connections.

Power companies accordingly have to rely on government budgets to carry out their investment programmes. To alleviate this burden, some countries, particularly in the Gulf region, turned to the private sector in the late 1990s, adopting the single-buyer model. This process was initially slow in most countries. Recently, however, despite regulatory frameworks not characterised by independence, transparency and accountability (World Bank, 2003), there has been a surge of new independent power producer (IPP) projects and independent water and power producer (IWPP) projects, particularly in the

14. See the country chapters for more details about the structure of the power sector in each country.

Table 6.5: **Main Electricity Suppliers in MENA Countries**

	Main electricity supplier	**Remarks**
Algeria	SONELGAZ	Vertically-integrated
Bahrain	Ministry of Electricity and Water	Ministry will be single buyer of output from first IPP* (awarded in 2004)
Egypt	Egyptian Electricity Holding Company (EEHC)	Joint-stock company, controls generation, distribution and transmission through subsidiaries Single buyer of IPP output
Iran	Tavanir	Controls generation, distribution and transmission through subsidiaries
Iraq	Ministry of Electricity	Established in 2003, replacing the Commission of Electricity
Israel	Israel Electric Corporation	Vertically-integrated
Jordan	Central Electricity Generation Company (CEGCO) for generation	Unbundled activities, remaining government-owned; CEGCO and EDCO will eventually be privatised
	National Electric Power Company (NEPCO) for transmission	NEPCO is the single buyer of electricity produced by CEGCO and IPPs
	3 distribution companies: EDCO, JEPCO and IDECO	
Kuwait	Ministry of Electricity and Water	Vertically-integrated
Lebanon	Electricité du Liban (EDL)	Vertically-integrated
Libya	GECOL	Vertically-integrated
Morocco	Office National de l'Electricité (ONE)	Distribution in rural areas is controlled by ONE, while in urban areas by the Ministry of Interior
Oman	Ministry of Housing, Electricity and Water	Privatisation underway following 2004 power privatisation law Newly established Power and Water Procurement Company single buyer of IPP/IWPP** output

Table 6.5: **Main Electricity Suppliers in MENA Countries** *(continued)*

	Main electricity supplier	**Remarks**
Qatar	Qatar Electricity & Water Corporation (QEWC) for generation Qatar General Electricity & Water Corporation (QGEWC) for transmission and distribution	Partial unbundling QGEWC single buyer of IPP output
Saudi Arabia	Saudi Electricity Company (SEC)	Vertically-integrated Water and electricity facilities are controlled by the Saline Water
Syria	Public Establishment for Generation and Transmission of Electricity Public Establishment for Distribution of Electricity	Conversion Corporation (SWCC) Partial unbundling with the separation of distribution
Tunisia	Société Tunisienne de l'Electricité et du Gaz (STEG)	Vertically-integrated
UAE Abu Dhabi	Abu Dhabi Water and Electricity Company (ADWEC) TRANSCO (Transmission Company) Abu Dhabi Distribution Company (ADDC) Al-Ain Distribution Company (AADC)	Abu Dhabi Water and Electricity Authority (ADWEA) is the state holding company for ADWEC, TRANSCO, ADDC and AADC
UAE Dubai	Dubai Electricity and Water Authority (DEWA)	Vertically-integrated
UAE Sharjah	Sharjah Electricity and Water Authority (SEWA)	Vertically-integrated
UAE Other	Federal Electricity and Water Authority (FEWA)	Vertically-integrated
Yemen	Public Electricity Corporation	Vertically-integrated

* IPP: independent power producer.
** IWPP: independent water and power producer.

Gulf area. Iran has also started developing projects on a build-operate-own (BOO) and build-operate-transfer (BOT) basis. Countries in North Africa are seeking to increase or to introduce private investment in their power sectors. The exception here is Egypt, which, having led the development of two large IPPs, is turning again to the public sector, reflecting the current availability of public investment funds.

IPP projects carry certain advantages, notably they are often built faster and can result in lower production costs.[15] IPPs are also the easiest way to introduce competition. But they have considerable drawbacks (World Bank, 2001). IPPs in MENA are requesting sovereign governmental guarantees and high returns. Rich MENA countries are offering 8%-12% rates of return, while investors are pressing for 15% to 18%. This means that these projects may turn out to be very expensive, as has been the case in other countries in the world. A typical structure of an IPP project in MENA is as follows (Khatib, 2005):

- 80:20 debt/equity ratio.
- Ownership: 20 years.
- Regulated power-purchase agreement.
- Equity from developers (possibly with government and utility participation).
- Debt from local and/or international financial institutions.

The long-term impact of recent reforms aimed at attracting private investment remains unclear but it seems likely that governments will continue to provide the bulk of financing or the guarantees for future projects. Loans will come principally from Arab development banks (such as the Arab Fund, which loaned $654 million, over 60% of all loans, to the MENA power sector in 2003) or international banks (including the World Bank and the European Investment Bank). The poorer members of the region may also rely on development agencies.

MENA countries have given little consideration to demand-side measures, such as more efficient equipment in industry and buildings. These measures can be cost-effective and can substantially reduce energy consumption and the accompanying need for investment in power supply (Box 6.5).

Since 2003, high oil prices have created an abundance of liquidity in these countries and many regional banks are more than willing to finance new projects, although some of the large projects are becoming more difficult to

15. In MENA countries, the electricity and water sectors are often used as sectors to place nationals in, which leads to gross overstaffing. IPPs can operate with fewer staff, which helps keep generation costs low.

Box 6.5: **Supply and Demand Side Investments in the World Alternative Policy Scenario**

The World Alternative Policy Scenario (WAPS), described in Chapter 8, analyses the impact of a more efficient and more sustainable energy future compared with the Reference Scenario.[16] WAPS shows that investing in energy efficiency requires increased capital expenditure on end-use equipment, but this is offset by lower investment on the supply side.

World electricity generation in WAPS in 2030 is 13% lower than in the Reference Scenario because of policies to improve end-use efficiency. In the residential sector, these policies include measures relating to lighting, electric appliances, space heating, water heating, cooking and air-conditioning. In the services sector, they include lighting, space heating, air-conditioning and ventilation.

Investment by final consumers in more efficient electrical equipment in the industrial, residential and commercial sectors is more than $600 billion *higher* in the Alternative Scenario. The capital costs of more efficient and cleaner end-use appliances are generally higher, but the result of such investment is to drive down energy demand, thereby reducing consumption, global energy bills and investment requirements for energy-supply infrastructure. Savings in electricity-supply investment amount to $1.4 trillion and they more than offset the increase in demand-side investments.

MENA countries have rapidly growing supply-side investment needs. At the same time, they have an enormous potential to save energy. Promoting end-use efficiency policies may be a cost-effective way to reduce investment in power infrastructure.

finance because of their complexity. At the same time, the favourable investment climate has delayed the need for deeper reforms, which would involve making the electricity sector commercially viable, starting with reforms in the distribution sector. Such reforms are difficult and take considerable time, at least five years and more likely ten (IEA, 2003). The current surge of liquidity will not be indefinite and MENA countries need to plan for future needs if they do not want to face the same difficulties as they did in the 1990s.

16. WAPS was first developed in *WEO-2004*.

Water Desalination

Overview

Water desalination is used around the world where sources of freshwater are limited. It is an energy-intensive process and will, accordingly, account for a growing proportion of energy use in the MENA region as the importance of desalinated water continues to grow over the projection period. Figure 6.20 shows global renewable water resources per capita on a WEO regional basis. The Middle East is the most water-stressed region in the world.

Desalination is the process of removing dissolved solids from sea-water, groundwater or waste water. The World Health Organization recommends that water for human consumption should have total dissolved solids (TDS) of less than 500 parts per million (ppm). Sea-water typically has salinity of about 35 000 ppm or more while brackish water has salinity of about 1 500 ppm.

The MENA region accounted for over half of global desalination capacity in 2003 (Table 6.6). Global planned additions to desalination capacity from 2004 to 2013 amount to 8 300 million cubic metres, an increase of about 75% over current capacity. The MENA region will account for almost 70% of these capacity additions. In that time-scale, desalination capacity will double in the region, from about 5 700 million cubic metres per year in 2003 to more than 11 400 mcm per year in 2013.

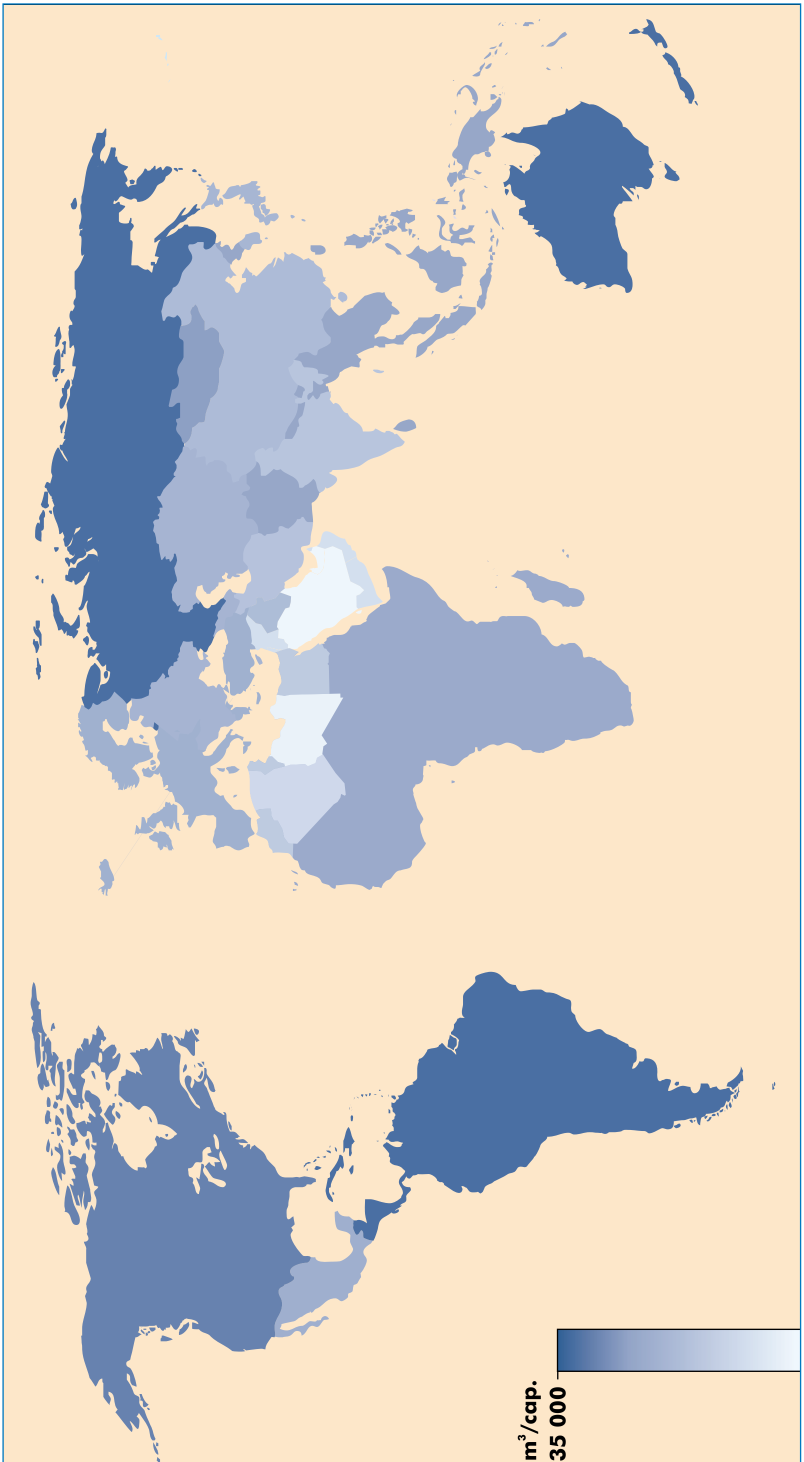
The cost of producing desalinated water is fairly high and depends on the level of salinity and on energy costs. Desalination costs are going down and further reductions are likely in the future along with technological and energy efficiency improvements.

The most widely used desalination processes are thermal separation through distillation and membrane separation through reverse osmosis (RO). There are three predominant types of distillation processes – multistage flash (MSF), multiple effect distillation (MED) and mechanical vapour compression (MVC). The MSF and RO processes dominate the global market for both brackish water and sea-water desalination, with a share of more than 80%.

Distillation plants account for about 40% of global capacity. Another 47% of global desalination capacity is from the reverse osmosis process. RO is widely used in sea-water, brackish water and water reclamation projects and is the fastest growing segment of the desalination market. In the Middle East, MSF plants account for 68% of desalination capacity, while in North Africa, MSF and RO plants capture about 40% each of the desalination market.

A rule of thumb for capital investment costs is about $1 000 per cubic metre per day of capacity installed for both distillation and membrane processes (Table 6.7). For distillation units, the investment required for the co-generation plant can more than double the overall investment requirements.

Figure 6.20: **Global per Capita Renewable Water Resources**



Note: logarithmic scale.
Source: FAO Aquastat database.

Table 6.6: **Global Water Desalination Capacity, 2003**

Country/region	**Desalination capacity** (million cubic metres/year)	**Share in global capacity** (%)
OECD North America	2 067	18%
OECD Pacific	753	7%
OECD Europe	1 399	12%
Transition economies	264	2%
China	191	2%
India	164	1%
Other Asia	310	3%
Latin America	323	3%
MENA	**5 692**	**51%**
North Africa	*572*	*5%*
Middle East	*5 120*	*46%*
Other Africa	67	1%
Total	**11 229**	**100%**

Source: IEA analysis based on Wangnick (2004).

The main environmental impacts arising from the desalination process are brine concentrates and discharges of added chemicals. These effluents can harm coastal and marine ecosystems or pollute aquifers, wadi flows and soils. In the Persian Gulf, the increased amount of brine discharge could lead to a build-up of salt concentrations given the enclosed nature of the sea.

Table 6.7: **Capital Costs for Desalination Processes** ($ per cubic metre per day)

Process	**2000**	**2005**
MSF	1050 - 3150	1000 – 3400
MED	925 - 2120	1000
MVC	1580 - 3170	1000 - 1650
ED	637	n.a.
RO (sea-water)	925 - 2100	800 - 1200
RO (brackish water)	n.a.	500

Note: MSF – multistage flash; MED – multiple effect distillation; MVC – mechanical vapour compression, ED – electrodialysis; RO – reverse osmosis; n.a. – not available.
Source: Middle East Desalination Research Centre, various journals.

Box 6.6: **Energy Requirements and Economics of Desalination Systems**

The energy requirements for the reverse osmosis (RO) process, mostly electricity to operate a pump, are less than for distillation processes. Depending on the salinity, for one cubic metre of freshwater produced through RO, 0.5 kWh to 1.5 kWh is required to purify brackish water, and 3 kWh to 8 kWh to purify sea-water. The electricity required for distillation systems is about 2 kWh to 4 kWh per cubic metre, but the thermal energy requirements are much higher. As the distillation process is highly energy-intensive, requiring a lot of low-grade steam, co-generation plants are often used in order to utilise low-grade steam from power plants. These dual-purpose, combined water and power (CWP) plants reduce plant construction and permitting costs and are more efficient than single-purpose plants.

RO system capital costs tend to be lower than those of evaporative processes. Membrane processes are also more economical for use with brackish and less saline raw water. Poor water quality, however, tends to favour evaporative processes because pre-treatment requirements for thermal processes are much lower than those of RO. The distillation process can better deal with more saline water than membrane processes. Pre-treatment, membrane and energy recovery technologies, however, have improved considerably and the use of RO is likely to expand in the future.

The distillation and membrane systems can be combined in a hybrid desalination system. The hybrid concepts have been proposed for over a decade, but today there are very few applications of the systems. These systems are estimated to offer considerable cost savings over current plants. They are also expected to reduce installed capacity requirements because they allow for more flexibility between water and electricity production. With a hybrid system, water production can be maintained efficiently in winter time when electricity demand is low.

MENA Water Demand and Supply[17]

The MENA region has been facing dwindling water supplies and growing demand for many years, as a result of high population growth, improvements in the standard of living, industrial development in urban centres and efforts to increase food self-sufficiency. The population in several countries in the

17. The projections for desalinated-water demand are for the six most water-stressed countries, Saudi Arabia, the UAE, Kuwait, Qatar, Algeria and Libya. The share of desalinated water in total water demand is highest for these countries. More details can be found in the country chapters.

region is expected to grow by about 2% or more per year over the period 2003-2030. The population of the region's cities is growing even faster, increasing the need for other water options, like sea-water desalination and waste water reclamation.[18]

Desalination is used extensively in the Gulf countries, where natural renewable sources of water are too low to meet demand. There is already considerable desalination capacity in Saudi Arabia, the UAE, Kuwait, Qatar, Bahrain and Oman. There is also reasonably high interest in the technology in Algeria and Libya.

The Persian Gulf has the highest salinity of any body of water, ranging from 45 000 to 50 000 ppm, compared with salinity in the Mediterranean Sea of about 40 000 ppm and average ocean salinity of 35 000 ppm.[19] This is one of the main reasons for the high share of distillation units in the Gulf countries.

This section focuses primarily on residential and industry water demand because these two sectors are the main consumers of desalinated water. In countries that have little agriculture or industry, such as Kuwait, most water is used in households. Household demand is affected by a variety of factors, such as per capita income, household size, distance from a source of water and consumption patterns. Some industries that use large amounts of water are food, paper, chemicals, refined petroleum and primary metals. The petrochemical industry is considered the most water-intensive in the Middle East. Industry's share of water use is quite low in most countries.

The agricultural sector's share of water use in most MENA countries is more than 70%, largely for irrigation of crops. Irrigation water is mainly supplied by groundwater and by renewable surface water. Rapid expansion of irrigated areas has resulted in substantial groundwater extraction. Many countries have a policy goal of self-sufficiency in agricultural consumption and the pressure to supply potable water is intense.

Due to substantial losses in the distribution network, unaccounted-for water represents about 30% to 40% across the MENA region. Efficiency in the water system is also low because of poor maintenance of water reservoirs and frequent theft of water. Technical improvements to the water infrastructure are needed to reduce losses. Repairing leaking distribution systems and water pipes,

18. The waste-water infrastructure of the MENA region is significantly underdeveloped. Less than half of households are connected to a sewage system, low by international standards. Only a small proportion of the waste water is treated.
19. Pankratz and Tonner (2003).

expanding central sewage systems, metering water connections and rationing water use could all be important. Improving the efficiency of water use in the agricultural sector is also necessary. But the most cost-effective means of achieving greater efficiency in water use is effective water pricing. Water supply is heavily subsidised in MENA countries (Table 6.8).

Table 6.8: **Average Water Tariffs in Selected Countries** ($ per cubic metre)

Saudi Arabia	0.03
Kuwait	0.65
Qatar	1.20
United States	1.30
France	3.15

Sources: Global Water Intelligence (2005); OECD (2003).

The rate of depletion of surface water and renewable groundwater in the Middle East is phenomenal and water scarcity is a major issue for Kuwait, Qatar, the UAE, Libya, Algeria and Saudi Arabia. These six countries are among those with the lowest natural renewable water resources in the world. Groundwater depletion across the Middle East is such that salinity is a problem in many coastal areas. All countries will face a reduction in the availability of potable groundwater over the coming decades.

In 2003, total installed desalination capacity in the MENA region was 5.7 billion cubic metres per year. Saudi Arabia accounted for about 40% of total capacity. Water production from desalination plants was nearly 3.7 billion cubic metres in 2003 in Saudi Arabia, the UAE, Kuwait, Qatar, Algeria and Libya, meeting some 10% of total water demand in these countries.

In general, countries with small-scale desalination plants and with relatively high natural freshwater availability favour the smaller, more cost-effective RO plants. Large-scale sea-water desalination plants in the Middle East tend to use the MSF process (Table 6.9).

Total water demand (in agriculture, industry and residential) in the six countries analysed is projected to rise to 44 billion cubic metres in 2030, from 37 billion cubic metres in 2003, representing growth of 0.6% per year over the projection period. Residential water demand, however, is projected to grow by 2.5% per year. Rising demand in this sector will be the driving force behind expected growth in desalination capacity. Water from desalination plants will rise to almost 12 billion cubic metres, increasing the share of desalinated water in total water demand from 10% in 2003 to 27% in 2030.

Table 6.9: **Water Demand and Desalination Capacity in Selected MENA Countries, 2003**

	Water demand (mcm)	**Water demand per capita** (litres/day/capita)	**Water supply from desalination** (%)	**Reverse osmosis capacity** (mcm)	**Reverse osmosis capacity** (%)	**Distillation capacity** (mcm)	**Distillation capacity** (%)	**Total capacity** (mcm)
Saudi Arabia	22 484	2 734	8	780	35	1 427	65	2 207
UAE	2 694	1 843	42	75	5	1 390	95	1 465
Kuwait	679	775	64	62	11	519	89	582
Libya	4 867	2 401	2	71	26	201	74	272
Qatar	375	1 408	38	5	3	201	97	206
Algeria	6 244	537	2	67	54	58	46	125
Iran	92 000	3 798	0.2	58	32	124	68	182
Egypt	73 533	2 975	0.1	92	86	15	14	107
Iraq	43 208	4 768	0.2	82	95	4	5	86

Note: Due to the lack of accurate data by sector and by country, water consumption for 2003 is estimated for some countries, on the basis of previous years.

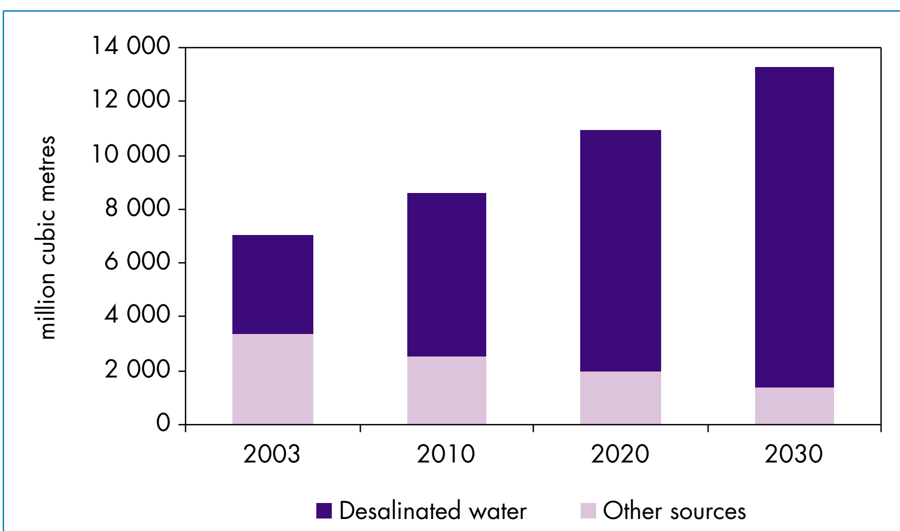
The projections are based on assumptions for growth in population and per capita income and efficiency improvements. Population and GDP assumptions are in Tables 1.2 and 1.4. Efficiency improvements in water losses are assumed to average 1.5% per year over the projection period, reflecting government policies to enforce strict conservation measures and price mechanisms to reduce water demand.

Figure 6.21 shows the evolution of water demand in the residential and industry sectors in the six most water-stressed MENA countries. The graph shows the rising share of desalinated water supplies in residential and industrial water demand. Total water supply in these sectors will increase to 13.3 billion cubic metres in 2030, an annual increase of 2.4% from the 2003 level of 7 billion cubic metres. The supply of water from desalination plants in these countries is expected to grow by 4.5% per year.

6

One of the main uncertainties for water supply over the next thirty years is the rate of depletion of the non-renewable groundwater resources. Non-renewable water reservoirs in Saudi Arabia and Algeria are assumed to deplete at about 0.5% per year. Libya and Kuwait's resources are assumed to deplete at a slightly faster rate over the *Outlook* period. Faster rates still are assumed for the UAE and Qatar, at around 1%. Trade in water resources is not included in the projections, but it is likely to remain limited, given current policies.

Figure 6.21: **Water Demand* in Saudi Arabia, Kuwait, the UAE, Qatar, Algeria and Libya**



* Projections do not include water demand in the agricultural sector.

Water Desalination Production and Capacity

In the Reference Scenario, production of desalinated water in the six water-stressed countries is expected to grow from 3.7 billion cubic metres in 2003 to 11.9 billion cubic metres in 2030, growth of 4.5% per annum (Table 6.10). Over the projection period, desalination capacity doubles in the UAE, Kuwait and Qatar, and triples in Saudi Arabia and Libya. Desalination capacity will increase substantially in Algeria.

Table 6.10: **Projected Desalination Capacity in Selected MENA Countries**
(million cubic metres per year)

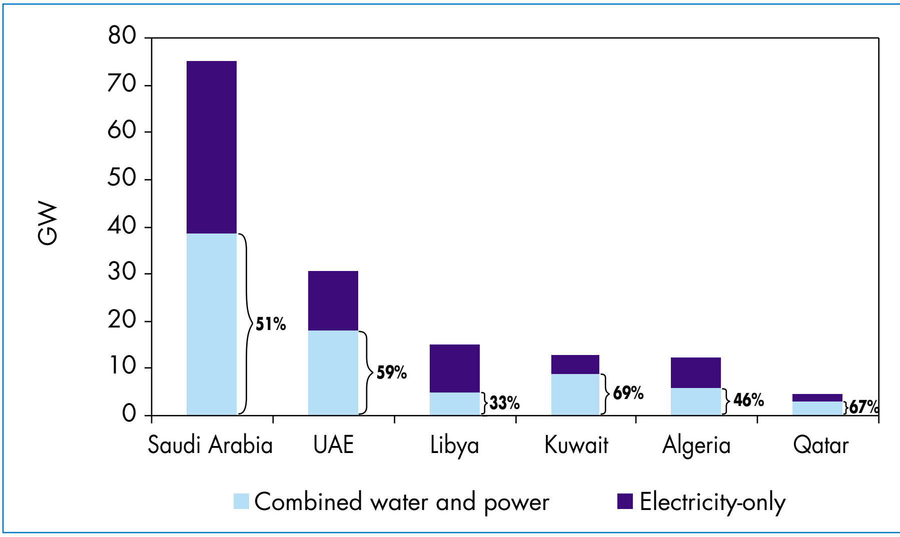
	2003	**2010**	**2020**	**2030**
Saudi Arabia	2 207	3 523	5 593	7 794
UAE	1 465	2 482	2 684	2 948
Kuwait	582	934	1 006	1 088
Libya	272	465	532	772
Qatar	206	282	336	401
Algeria	125	542	1 307	2 004
Total	**4 857**	**8 227**	**11 458**	**15 007**

The rate of growth in water production from the RO process, at 6.7% per year, is much faster than water production from distillation plants (3.7%). Technological improvements, as well as increasing cost-effectiveness, will favour the RO process, particularly in the long term.[20] The share of RO in total desalination capacity is expected to increase from 22% in 2003 to 27% in 2010 and to 37% in 2030.

The percentage of new CWP plants in total power generation plant additions in 2030 is illustrated in Figure 6.22. New CWP capacity will account for more than half of capacity additions in the power sector in Saudi Arabia, the UAE, Kuwait and Qatar, for almost half in Algeria and for one-third in Libya.

20. In the past, RO plants had operational problems in the MENA region due to higher salinity and more abundant marine life in the Persian Gulf. But the industry has gained experience with design and operation of pre-treatment systems, and RO technology will increasingly be perceived as the cost-effective and competitive option.

Figure 6.22: **Share of CWP in Power-Generation Capacity Additions in Selected MENA Countries, 2004-2030**



Primary energy requirements[21] for water desalination will increase from 26 Mtoe in 2003 to 61 Mtoe in 2030, growth of 3.2% per year. In 2030, the energy required to meet expected water demand will account for 10% of total primary energy demand in the six most water-stressed countries, about the same share as today. The additional fuel requirements for water desalination will account for more than a quarter of the total increase in fuel requirements in the power and water sector over the projection period.

Electricity consumption in new desalination plants will be 3.2 Mtoe (37 TWh) in 2030, or 6% of total electricity consumption. The electricity needs for new distillation plants will be 1.3 Mtoe, or 42%. Electricity required in new reverse osmosis plants will be 1.9 Mtoe.

Table 6.11 shows the total fuel requirements for steam and for the electricity consumption in the desalination process. Energy demand to purify water in Saudi Arabia will account for over half of the total requirements for desalination in the six most water-stressed countries.

The predominant fuels used for electricity and water production are oil and natural gas. Gas will be the preferred fuel for water desalination in the Middle

21. The primary energy requirements include both the fuel used to generate the electricity consumed by the desalination plants and the fuel requirements for the steam production. For a detailed description of the fuel-allocation methodology, see the discussion of the World Energy Model on www.worldenergyoutlook.com.

Table 6.11: **Energy Use for Water Desalination in Selected MENA Countries**
(Mtoe)

	2003	2010	2020	2030
Algeria	0	1	3	4
Kuwait	3	4	4	5
Libya	1	1	2	3
Qatar	1	2	2	2
Saudi Arabia	11	17	24	31
UAE	9	13	15	16
Total	**26**	**38**	**50**	**61**

East over the next 25 years, as it is more efficient, less costly and more environmentally acceptable than oil. Gas will gain share in countries that currently use oil for CWP.

Water Desalination Investment Needs and Financing

Table 6.12 shows investment needs for additional desalination capacity in the water sector over the projection period. The figures refer to the investment needs for desalination plants, excluding the power generating capacity. A total investment of $39 billion will be needed over the projection period in the six water-stressed countries in order to add almost 14 billion cubic metres of desalination capacity. The total investment for desalination plants accounts for 30% of the total investment in the power and water generation sector. Required investments in Saudi Arabia overwhelm the other countries, accounting for more than half of the requirements in the six most water-stressed countries in 2030.

Table 6.12: **Cumulative Investment in Water Desalination in Selected MENA Countries** ($ billion in year-2004 prices)

	2004-2010	2011-2020	2021-2030	2004-2030
Algeria	1.3	2.2	1.9	5.4
Kuwait	1.4	1.2	0.3	2.9
Libya	0.8	0.5	0.8	2.1
Qatar	0.2	0.5	0.2	0.9
Saudi Arabia	4.4	8.9	7.6	20.9
UAE	3.2	1.5	1.7	6.3
Total	**11.3**	**14.8**	**12.5**	**38.6**