MED-CSP

Concentrating Solar Power for the Mediterranean Region

Executive Summary

by

German Aerospace Center (DLR)
Institute of Technical Thermodynamics
Section Systems Analysis and Technology Assessment

Study commissioned by

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The full **MED-CSP Study Report** can be found in the corresponding files with the individual reports of all work packages at the website: http://www.dlr.de/tt/med-csp

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One must never stop to imagine the world
as it would be in the soundest way

Friedrich Dürrenmatt

Introduction

To keep global warming in a tolerable frame, the Scientific Council of the German Government for Global Environmental Change (WBGU) recommends in its latest study based on a scenario of the IPCC (Intergovernmental Panel for Climate Change) to reduce CO_2-emissions on a global level by 30 % until 2050. According to this, developing countries and countries in transition may increase their transmissions by about 30 % considering their still growing infrastructure, while industrial countries will have to reduce their emissions by 80 %. Because a fair access to energy for everybody is also a sustainability criteria, by 2050, global per capita emissions of 1-1.5 tons of CO_2 should be achieved. However, environmental sustainability must go hand in hand with economic wealth, business opportunities and development. A special interest lies on the electricity sector which is responsible for a considerable share of greenhouse gas emissions. A further field of interest is the increasing demand for technically desalted water, which will require increasing energy input to the water supply sector.

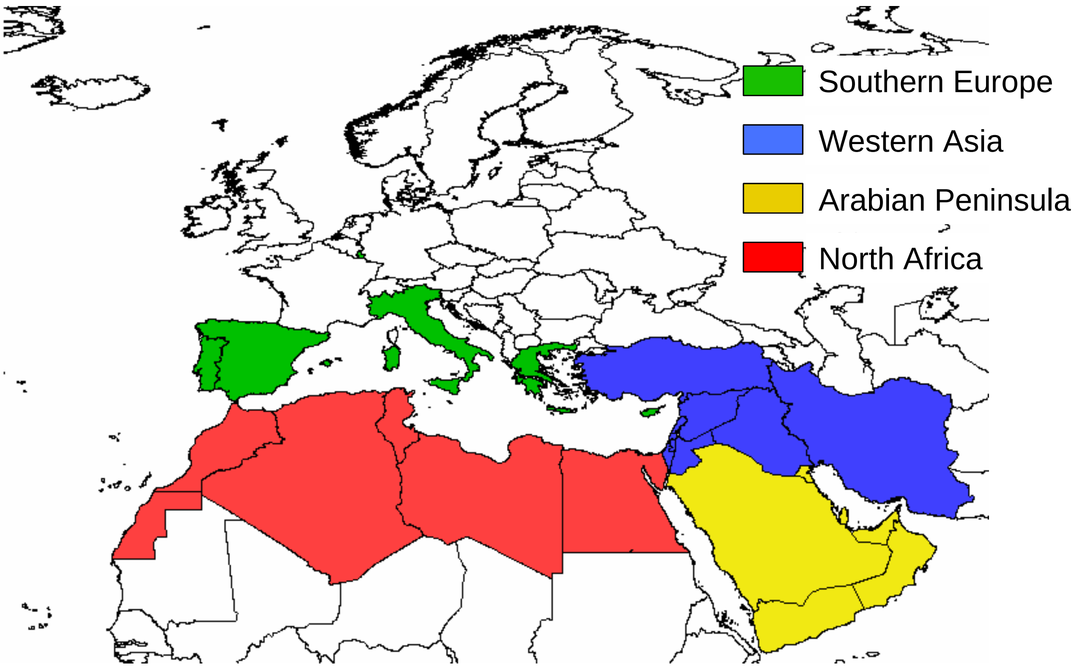

Figure 1: Countries of the EU-MENA region analysed within the MED-CSP Study

In front of this background, the WBGU recommends to establish model projects to introduce renewable energies on a large scale as a strategic lever for a global change in energy policies. A strategic partnership between the European Union (**EU**), the Middle East (**ME**) and North Africa (**NA**) is a key element of such a policy for the benefit of both sides: MENA has vast resources of solar energy for its economic growth and as a valuable export product, while the EU can provide technologies and finance to activate those potentials and to cope with its national and international responsibility for climate protection – as documented in the Johannesburg agreement to considerably increase the global renewable energy share as a priority goal.

International and national policies must establish appropriate frame conditions for the expansion of renewable energies. Only then industry and investors will support such projects and provide the necessary large investments, as demonstrated by the success of the German and Spanish renewable energy acts.

In order to establish appropriate instruments and strategies for the market introduction of renewables in the European and MENA countries, well founded information on demand and resources, technologies and applications is essential. It must further be investigated if the expansion of renewables energies would imply unbearable economic constraints on the national economies of the MENA region.

The present study provides such information as data basis for strategic development in the EU-MENA region in order to achieve sustainable long-term energy and water security.

Main Results of the MED-CSP Study

The MED-CSP study focuses on the electricity and water supply of the regions and countries illustrated in Figure 1 including Southern Europe (Portugal, Spain, Italy, Greece, Cyprus, Malta), North Africa (Morocco, Algeria, Tunisia, Libya, Egypt), Western Asia (Turkey, Iran, Iraq, Jordan, Israel, Lebanon, Syria) and the Arabian Peninsula (Saudi Arabia, Yemen, Oman, United Arab Emirates, Kuwait, Qatar, Bahrain).

The results of the MED-CSP study can be summarized in the following statements:

- Environmental, economic and social **sustainability in the energy sector can only be achieved with renewable energies**. Present measures are insufficient to achieve that goal.
- **A well balanced mix** of renewable energy technologies can displace conventional peak-, intermediate and base load electricity and thus **prolongs the global availability of fossil fuels for future generations** in an environmentally compatible way.
- Renewable energy **resources are plentiful** and can cope with the growing demand of the EU-MENA region. The available resources are so vast that an additional supply of renewable energy to Central and Northern Europe is feasible.
- **Renewable energies are the least cost option** for energy and water security in EU-MENA.
- Renewable energies are the **key for socio-economic development and for sustainable wealth** in MENA, as they address both environmental and economical needs in a compatible way.
- Renewable energies and energy efficiency are the main pillars of **environmental compatibility**. They need initial public start-up investments but no long-term subsidies like fossil or nuclear energies.
- An adequate set of **policy instruments must be established** immediately to accelerate renewable energy deployment in the EU and MENA.

Chapter 1 (Sustainability Goals) gives an overview of the present efforts and achievements in EU and MENA to reach sustainability in the energy sector. It shows that the measures taken up to now do not suffice to avoid increased climate gas emissions by the power sector (Figure 2).

Although climate change is a serious concern, sustainability must also be achieved in terms of economy, affordability, technology, health and social compatibility. A strategy for power and water security must match the time horizon of all sustainability considerations, which is at least 50 - 100 years and more. Strategies optimising a pathway within a smaller time horizon may lead to the wrong direction, because measures necessary to achieve the long-term goal may be ignored or delayed.

The sustainability goal proposed by WBGU of emitting not more than 1 ton of carbon dioxide per capita by 2050 to avoid drastic climate change is a challenge, because all EU countries are still far above this level today, and most MENA countries already show this level of emissions too, but their demand will still grow. Affordable access to energy and water for a growing population is as well a requisite for economic sustainability. The fair and affordable access to energy and water for a fast growing population is another important sustainability goal in MENA.

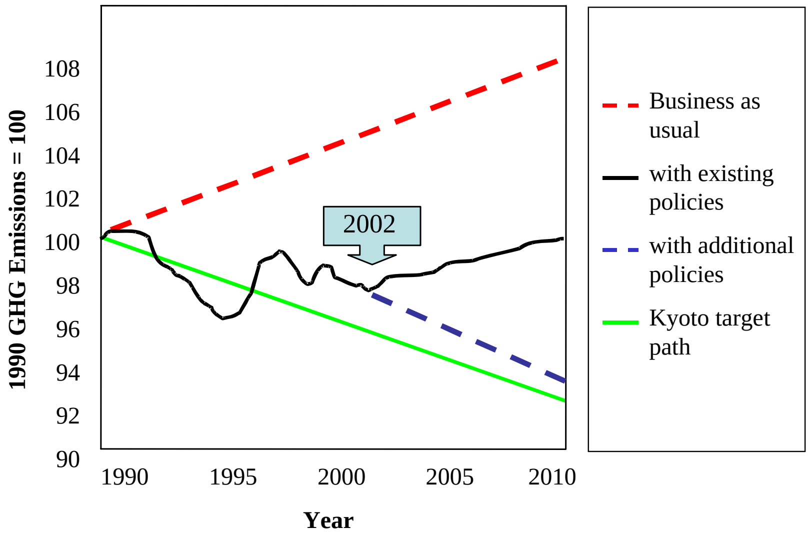

Figure 2: UE-15 greenhouse gas emissions until 2002 and projections until 2010 /Lefevere 2004/

The instruments for the market expansion of renewable energies applied today – mainly in the EU – range from the Kyoto instruments to quota models and feed-in tariffs like those applied in Germany and Spain. At the same time, there is a general trend for the liberalisation of the electricity market. In spite of the global leading role of the EU in terms of climate protection, those measures do not yet suffice to achieve the long-term goals (Figure 2).

Climate protection has only an ancillary role in the MENA region, and only a few countries have ratified the Kyoto protocol. In this region, economic and social development is the first priority. At a first glance, the higher initial cost of renewable energies suggests that there is a contradiction between environmental and economic sustainability goals. However, renewable energies can cope with both challenges, if adequate policy instruments are implemented to immediately initiate their broad application.

Intensive international collaboration is a main requisite for success. The global tasks usually overstrain the capabilities of national governments, although they are the one who must initiate international collaboration without delay.

Chapter 2 (Renewable Energy Technologies) provides an overview on the renewable energy technology portfolio and presents renewable energy applications in the electricity sector including co-generation and sea water desalination.

Although the focus of the study is on concentrating solar thermal power, other renewable energies like wind energy, hydropower, biomass, wave and tidal power, photovoltaic and geothermal energy are also represented, which in principal are also concentrated solar energy, with the exception of geothermal energy, of which 50 % stems from nuclear decomposition in the interior of our planet. Biomass can be obtained from municipal and agricultural waste and from solid biomass, mainly wood. Due to the competition of energy crops with food and water for the region, this option has been neglected. Renewable energy technologies can only be seen in the context of all other technology options. Even fossil fuels are solar energy concentrated over millions of years in an ideal, storable form. A main task of the study was to find a well balanced mix of technologies that leads to a sustainable and secure supply.

Electricity must be delivered on demand. Fluctuations of wind and photovoltaic electricity must be compensated by sources that can deliver power on demand, like biomass, hydropower, geothermal power and solar thermal power plants that can operate on base-, intermediate- and peak load demand. Each technology is characterised by a specific capacity credit that is their contribution to secured power capacity (Table 1). By 2050, fossil fired plants will only be used for what they are best suited for: peaking demand. Because of this reduction to their key function, their use will become environmentally compatible, and their availability will be prolonged for centuries. The expensive and energy consuming sequestration of carbon dioxide from flue gases becomes obsolete.

The core base and intermediate load electricity will come from renewables, which altogether can provide this function without constraints, sometimes even showing a better adaptation to the time pattern of the load than conventional base load plants with their typical flat capacity curve. Solar thermal power plants with their capability of thermal energy storage and of solar/fossil hybrid operation can provide firm capacity and thus are a key element for grid stabilisation and power security in such a well balanced electricity mix (Figure 5 to Figure 8).

Large nuclear plants cannot be easily applied to peak load due to their economical and technical constraints and will not have a considerable role in such an energy supply system.

Chapter 3 (Renewable Energy Resources) analyses the renewable energy potentials available in the EU-MENA region for each technology and for each country (Figure 3 and Figure 4). The results are a detailed mapping of resources and a quantification of the technical and economic potentials by country in terms of renewable electricity. The quality of the different resources of each country is represented by special performance indicators.

The renewable energy sources in the countries analysed in the MED-CSP study can cope with the growing demand of the developing economies. Wind, geothermal power from hot dry rocks, hydropower and biomass power potentials are each in the order of about 400 TWh/y. Those resources are more or less locally concentrated and not available everywhere, but can be distributed through the electricity grid. The by far biggest resource in MENA is solar irradiance, with a potential that is by several orders of magnitude larger than the total world electricity demand.

This resource can be used both in distributed photovoltaic systems and in large central solar thermal power stations. Thus, both distributed rural and centralised urban demand can be covered by renewable energy technologies.

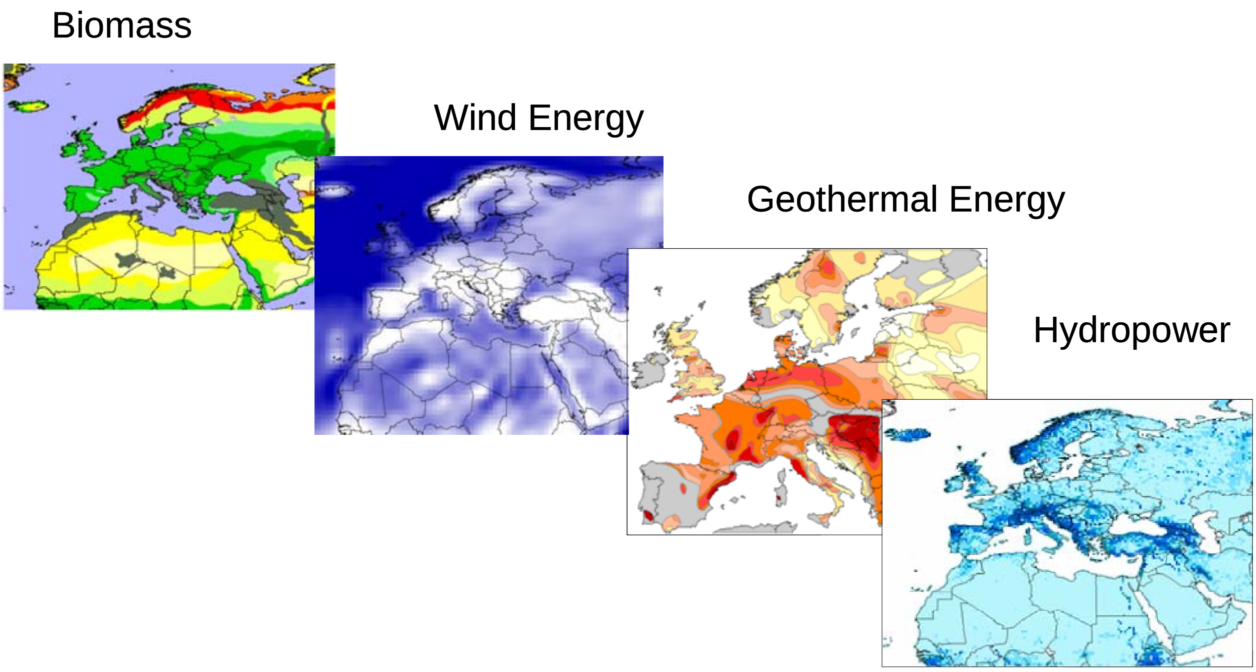

Figure 3: Maps of the renewable energy yield of the different resources in EU-MENA (darker colours indicate higher potentials per unit area, the colour code is described in the main report).

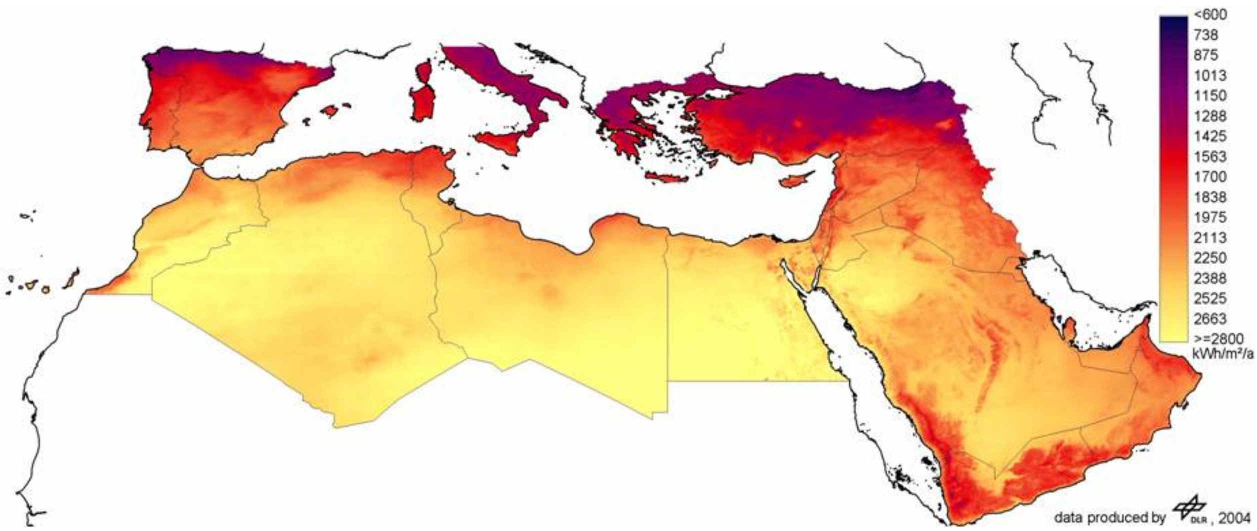

Figure 4: Annual Direct Solar Irradiance in the southern EU-MENA Region. The primary energy received by each square meter of land equals 1 – 2 barrels of oil per year.

	Unit Capacity	Capacity Credit	Capacity Factor	Resource	Applications	Comment
Wind Power	1 kW – 5 MW	0 – 30 %	15 – 50 %	kinetic energy of the wind	electricity	fluctuating, supply defined by resource
Photovoltaic	1 W – 5 MW	0 %	15 – 25 %	direct and diffuse irradiance on a fixed surface tilted with latitude angle	electricity	fluctuating, supply defined by resource
Biomass	1 kW – 25 MW	50 - 90 %	40 – 60 %	biogas from the decomposition of organic residues, solid residues and wood	electricity and heat	seasonal fluctuations but good storability, power on demand
Geothermal (Hot Dry Rock)	25 – 50 MW	90 %	40 – 90 %	heat of hot dry rocks in several 1000 meters depth	electricity and heat	no fluctuations, power on demand
Hydropower	1 kW – 1000 MW	50 - 90 %	10 – 90 %	kinetic energy and pressure of water streams	electricity	seasonal fluctuation, good storability in dams, used also as pump storage for other sources
Solar Chimney	100 – 200 MW	10 to 70 % depending on storage	20 to 70 %	Direct and diffuse irradiance on a horizontal plane	electricity	seasonal fluctuations, good storability, base load power
Concentrating Solar Thermal Power	10 kW – 200 MW	0 to 90 % depending on storage and hybridisation	20 to 90 %	Direct irradiance on a surface tracking the sun	electricity and heat	fluctuations are compensated by thermal storage and fuel, power on demand
Gas Turbine	0.5 – 100 MW	90 %	10 – 90 %	natural gas, fuel oil	electricity and heat	power on demand
Steam Cycle	5 – 500 MW	90 %	40 – 90 %	coal, lignite, fuel oil, natural gas	electricity and heat	power on demand
Nuclear	1000 MW	90 %	90 %	uranium	electricity and heat	base load power

Table 1: Some characteristics of contemporary power technologies

Chapter 4 (Demand Side Analysis) quantifies the demand side potential for electricity and water for each country of the region. The growth of population and economy will lead to a considerable growth of energy demand in the MENA countries. By 2050, the MENA countries will achieve an electricity demand in the same order of magnitude as Europe (3500 TWh/y). Although our scenario considers efficiency gains and moderate population growth or even retrogressive population figures in some of the analysed countries, electricity demand will almost triple from shortly 1500 TWh/y today to 4100 TWh/y in 2050 (Figure 5). This is moderate considering that electricity demand has also tripled in the past 20 years.

The water demand of the MENA countries will increase from today 300 billion cubic meters per year to over 500 billion m^3/y in 2050. Most countries show stagnating or even retrogressive figures in the agricultural sector and strong growth in the domestic and industrial sector. In many MENA countries and also in some Southern European regions, natural water resources are already now exploited beyond their sustainable yield.

The excessive use of freshwater resources is only possible for a transient time. In spite of a growing demand for water, overexploitation must be reduced in the mid term future and avoided afterwards. This will require efficient and environmentally compatible desalination technologies and a plentiful, sustainable and affordable energy source.

Fossil or nuclear fuels cannot cope with any of these criteria. On the contrary, already today they are subsidised due to their high cost, they are causing serious national and international conflicts and climate change, and oil, gas and uranium are expected to become increasingly scarce and expensive within the next 50 years. Even in the oil exporting countries there is an increasing conflict between oil exports and internal consumption. A strategy for energy and water security can therefore not be built on fossil fuel resources, but they can be a component of a strategy for sustainability.

Chapter 5 (Scenario for Energy & Water Security) quantifies the possible step-by-step expansion of renewable energies in the Mediterranean region until 2050 (Figure 5). Each country shows a different balanced mix of renewable and fossil energies to obtain a sustainable supply system (Figure 8). Every country in EU-MENA has its own specific natural sources of energy and water and very different patterns of demand. The MED-CSP scenario shows a way to match resources and demand in the frame of the technical, economic, ecologic and social constraints of each country in a sustainable way. The following potential barriers and frame conditions have been taken into account to narrow down the course of market development of renewable energies in the MED-CSP scenario (**scenario guard rails**):

- renewable energy resource potentials
- maximum growth rates of renewable energy technology production capacities
- annual electricity demand and water demand based on the growth of population and economy
- peaking power demand and firm capacity requirements
- replacement of old plant capacities (investment cycles)
- cost of electricity in comparison to competing technologies
- opportunities of finance

- policies and energy economic frame conditions
- existing grid infrastructure and cost of interconnection

All those parameters were not treated as static constants, but were analysed in their dynamic transition towards a sustainable energy scheme. Renewable energies will initially need public support but will steadily grow within niche markets and become cheaper due to learning and economies of scale. After 2025, electricity from most renewable energies will be cheaper than electricity from fossil fuels (Figure 9), even not accounting for the societal external costs of fossil fuel consumption. Renewable energies are the only way to stabilise energy costs in the long term on a low price level.

Most MENA countries show a strong economic growth that will lead to an approximation to the European economies by the middle of the century. However, business-as-usual strategies for energy and water would lead to a depletion of fossil fuel and natural water resources within a few years, to unaffordable costs of energy and water and to social conflicts. Economic development would be increasingly burdened by subsidisation and conflicts. To this add possible impacts from climate change like desertification, losses of arable land and floods. Due to the increasing lack of water, food imports would increase, but it is unclear how this should be financed.

Only a change to renewable energies can lead to affordable and secure energy and water. This will not require long term subsidies like in the case of fossil or nuclear power, but only an initial investment in the frame of a concerted action of all EU-MENA countries to put the new renewable energy technologies in place. Comparing Figure 7 and Figure 8 it becomes obvious that the satisfaction of the growing electricity demand in MENA can only be satisfied in a sustainable way by renewable energies. In the year 2050, the electricity consumption of many MENA countries like Egypt and Turkey will by far exceed the consumption of present EU countries like e.g. Italy. Also many oil exporting countries like Iran, Iraq and Saudi Arabia will follow that trend, with an increasing conflict between internal consumption and export of that precious commodity.

In a later stage of the MED-CSP scenario, a considerable reduction of fuel consumption for electricity takes place in the European countries. However, in most MENA countries, the consumption of fuels will grow or at best stagnate, in spite of an intensive use of renewable energies. In Europe biomass, hydropower, wind energy and to a lesser extent other renewables will become the most important suppliers of power. The by far biggest energy resource in MENA is solar power from concentrating solar thermal power plants, which in most countries will provide the core of electricity. This is due to the fact that they will be able to provide not only the required large amounts of electricity, but also firm power capacity on demand.

In addition to that wind energy is a major resource in Morocco, Egypt and Oman, while geothermal power is available in Turkey, Iran, Saudi Arabia and Yemen. Major hydropower and biomass resources are limited to Egypt, Iran, Iraq and Turkey. Initially, photovoltaic electricity will be mainly used in decentralised, remote applications. Further cost reductions will lead to increasing shares of PV in the electricity grid. In a later stage, also very large PV systems in desert regions will become feasible. However, their contribution to firm capacity is very limited, while concentrating solar power plants can deliver firm capacity on demand.

Comparing Figure 5 (Electricity Generation) with Figure 6 (Installed Capacity) reveals that the installed concentrating solar power capacity by 2050 is as large as that of wind, PV, biomass and geothermal plants together, but due to their built-in solar thermal storage capability, CSP plants deliver twice as much electricity per year as those resources.

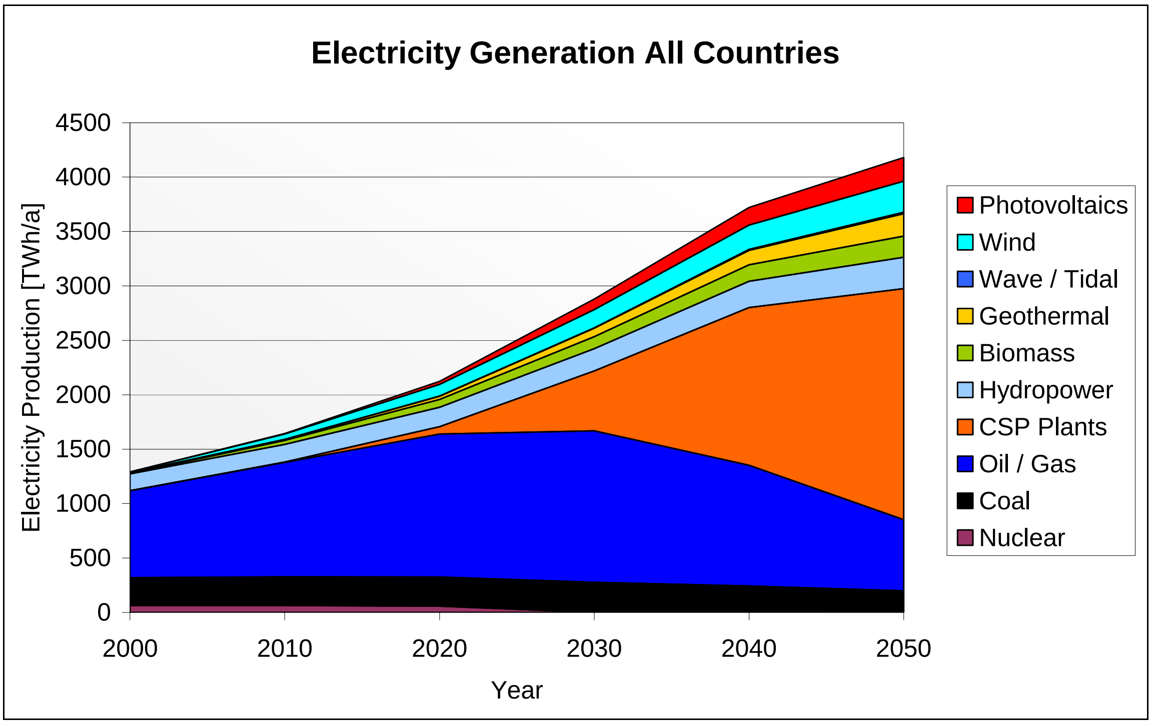

Figure 5: Annual electricity demand and generation within the countries in the MED-CSP scenario

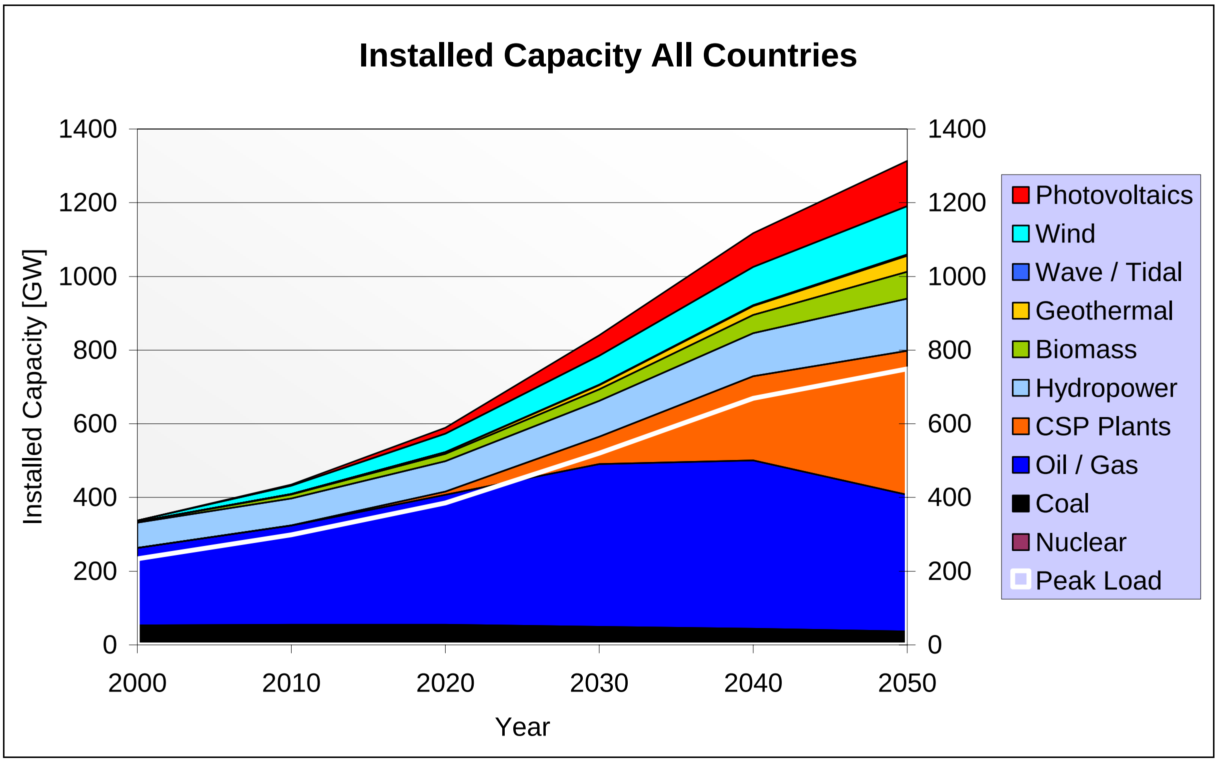

Figure 6: Installed power capacity and peak load within the analysed countries in the scenario CG/HE

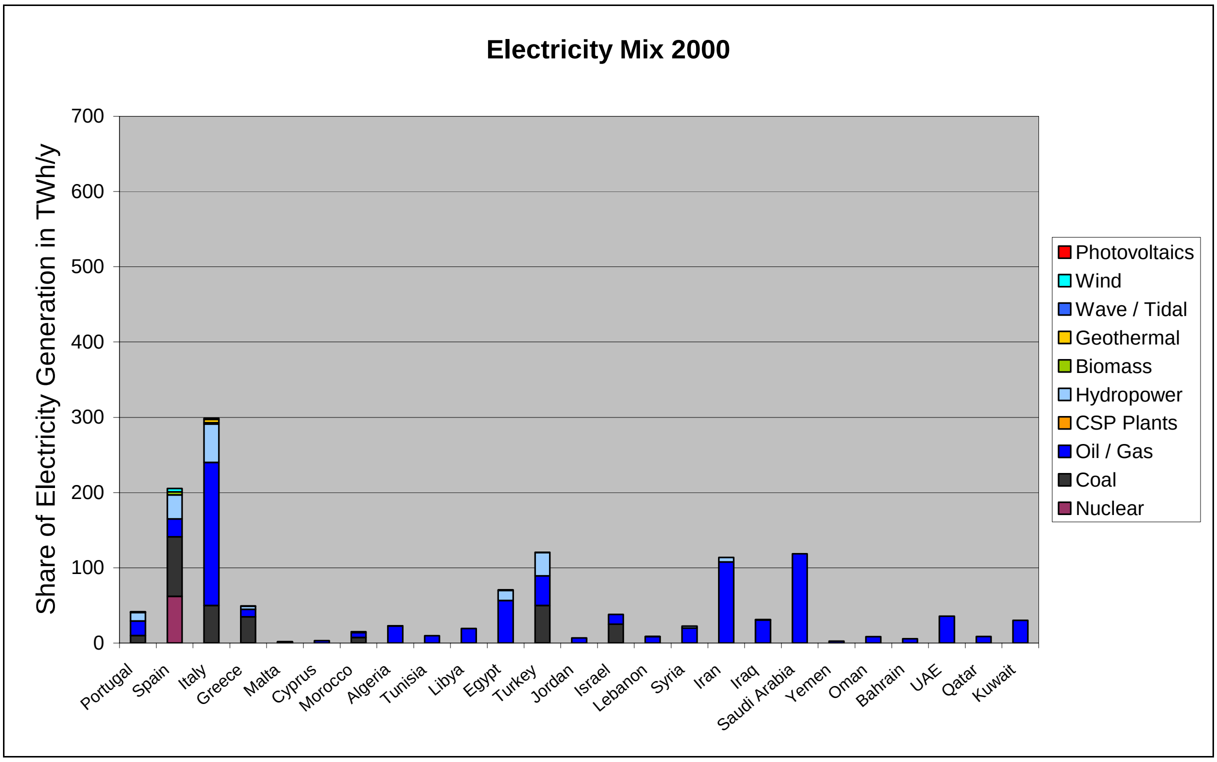

Figure 7: Share of different technologies for electricity generation in the year 2000.

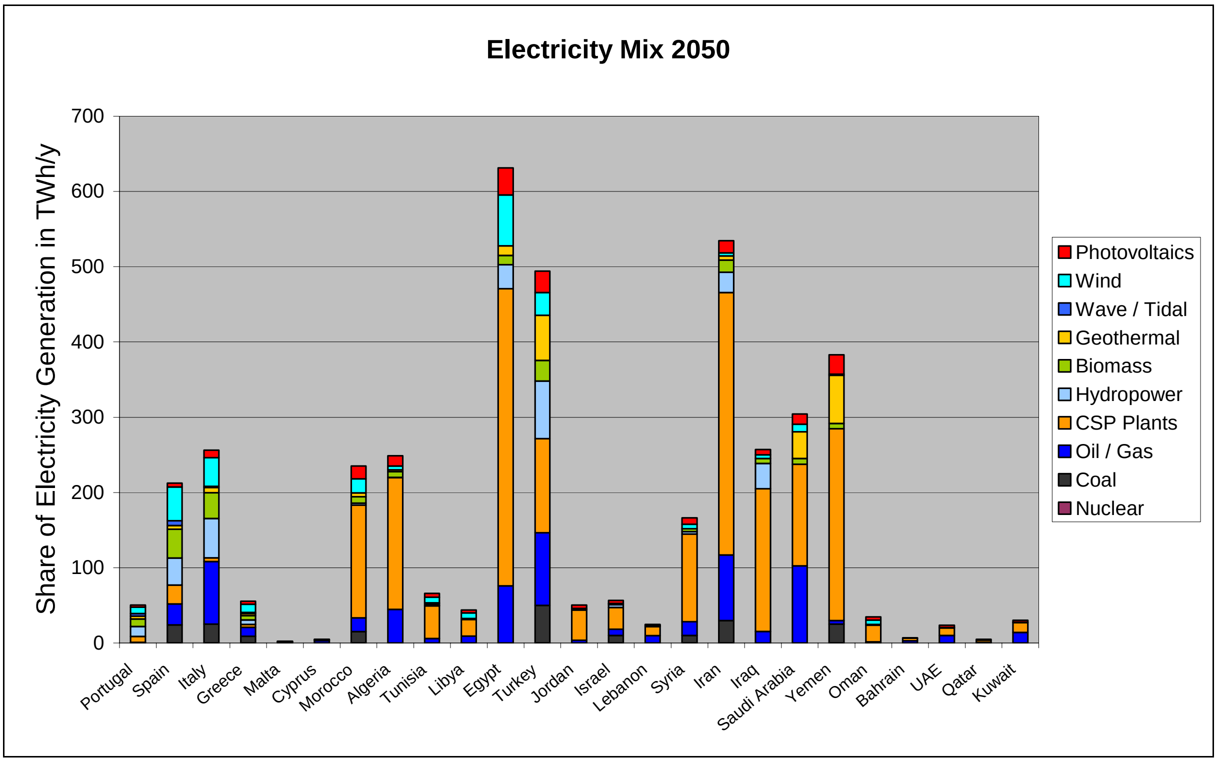

Figure 8: Total electricity consumption and share of different technologies for electricity generation in the analysed countries in the year 2050 according to the MED-CSP scenario.

Chapter 6 (Socio-Economic Impacts) describes the socio-economic impacts of the scenario developed in the study. The most important benefit is a stabilisation of electricity costs at a low price level and the reduction of subsidy requirements in the energy sector. In most countries, the dependency on energy imports is reduced, opening new business opportunities for industrial development. In the total EU-MENA region there may be 2 million direct and indirect jobs in the renewable energy sector by the year 2050.

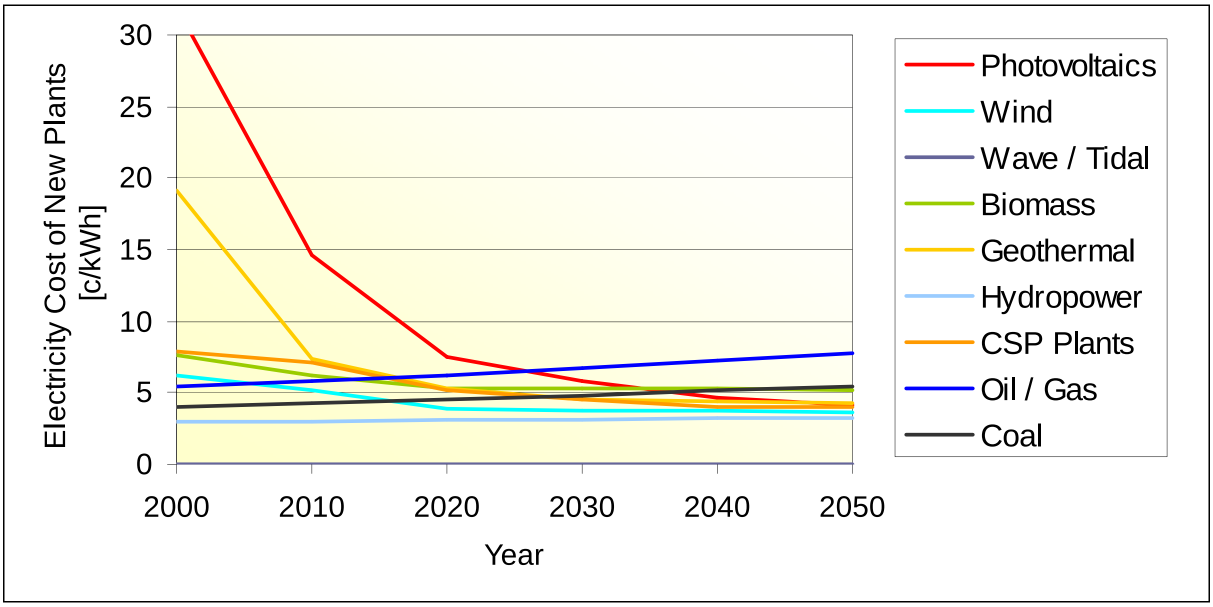

Figure 9: Example of electricity costs and learning in the MED-CSP scenario

There is often an insinuation of a conflict between economy and the environment, assuming that renewable energies will require large amounts of public subsidies. This is true for measures like CO_2-sequestration, which add a certain cost to power generation. However, this is not the case for renewables. Renewable energies will only require a transient initial support in order to be established in the power market, but in short term will become the less expensive option for electricity generation (Figure 9 and Figure 10), even not accounting for the external costs of fossil fuels, which were accepted by the European Commission to be in the order of 5 cent/kWh. The transient support for renewables must be considered as a public investment into a better – and cheaper – supply system, in contrast to the long-term, steadily increasing subsidies actually required by and readily applied to fossil and nuclear power in the present.

The calculation of the cumulated initial cost leads to a total amount of 75 billion $ needed to bring the renewable energy mix to cost break-even with fossil fuels before the year 2020 (Figure 10). From that point until 2050, the analysed region will save 250 billion $ with respect to a business as usual policy scenario. It must be noted that the reference case of a fossil fuel based policy scenario departs from the assumption that fuel prices start at 25 $/bbl for oil and 49 $/ton for coal and escalate by only 1 %/y, which from today's point of view seems to be rather conservative (present fuel prices are at a level of 55 $/bbl and 65 $/ton, respectively, and escalation rates amounted to 40 %/y since 2003).

In a business as usual scenario, the growth of economy and the resulting electricity demand in MENA would lead to greenhouse gas emissions equivalent to those of Europe, causing significant external costs to the national economies. Rising fuel prices and additional costs for CO_2-sequestration would seriously burden economic development. In contrary to fossil fuels, all renewable energy technologies show degressive costs (Figure 9) that only depend on the actual state of the art and knowledge, but not on scarce resources. High economic growth will lead in this case to a better applicability of efficiency measures and to a faster reduction of energy demand and energy costs than a stagnating economy. Renewable energies will thus foster economic growth instead of burdening it.

MENA countries will benefit from renewable energies by reducing their energy subsidies, especially those who have to buy fuels on the world market, like Jordan and Morocco. They will be able to foster their national economies through low cost, secure energy supply. Oil and gas exporting countries will be relieved from burning their export product number one, and in the long term may additionally come to export solar electricity. A strong renewable energy industry in MENA will lead to highly qualified labour options and alleviate MENA from the brain drain occurring today.

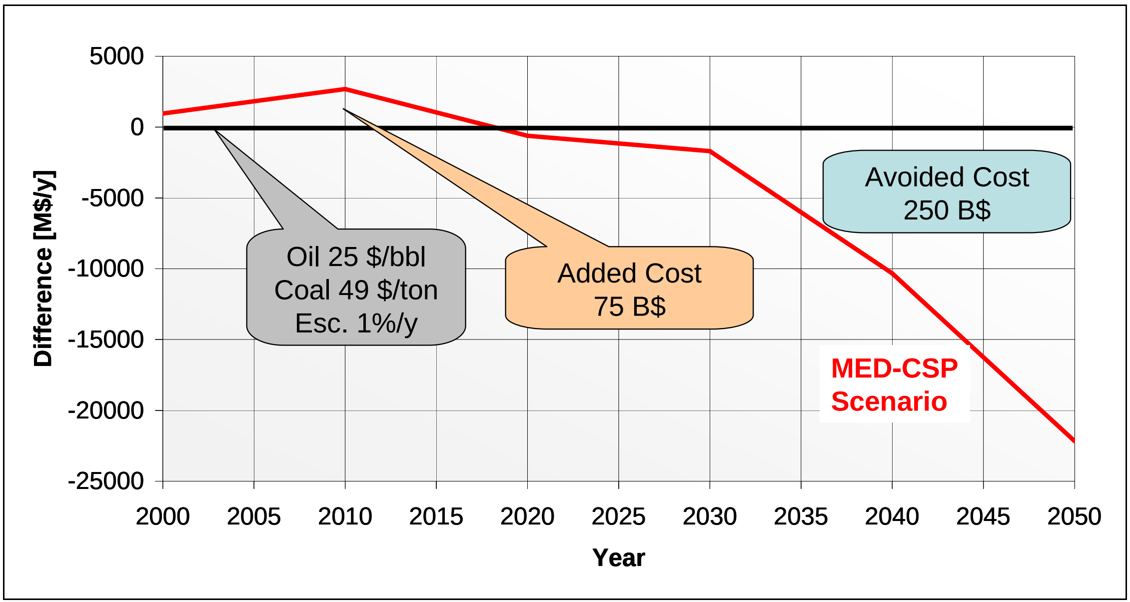

Figure 10: Total annual difference of electricity expenses between the MED-CSP scenario and a business as usual policy scenario based primarily on fossil fuels, summarised for all countries analysed in the study. Positive values = initial additional cost, negative values = avoided cost with respect to a business as usual policy. The cumulated initial cost amounts to 75 billion $, while 250 billion $ are avoided until 2050. The added and avoided costs vary with different assumptions made for fuel prices, escalation rates, CO_2-policy, etc. which are described in the main report. However, the break-even of renewable energies and fuels is achieved sooner or later under all variants.

The water supply situation in MENA is very critical. At some places the groundwater level falls 6 meters per year. Large cities like the capital of Yemen Sana'a may come to a point where their water supply runs dry and their groundwater resources may be exhausted within a 10 years period. A solution can only be seen in using large amounts of energy for seawater desalination. However, a strategy based on fossil or nuclear energy would not lead to an affordable and secure water supply system. Again, renewables and in a first place solar thermal power are the key to reduce the conflict potential of energy and water scarcity in MENA.

Chapter 7 (Environmental Impacts) highlights the main environmental impacts of the scenario. Carbon emissions from electricity generation are reduced by about 40 % in spite of the growing demand (Figure 11). It is a common misbelieve that renewable energies require large land resources. Among all electricity generating technologies including all nuclear and fossil systems, solar power technologies are those with the smallest land requirements. This is due to the fact that nuclear and fossil power plants not only require the land where they are placed, but additional infrastructure for mining, transport and disposal, which must be considered in an overall lifecycle balance, and which is much smaller for solar systems.

Moreover, wind parks can still be used for other purposes like agriculture and pasture, photovoltaic systems are often integrated to roofs and facades, and concentrating solar collector fields - acting similar to a blind - offer a partially shaded space below, that might be used for agriculture, as chicken farm, as greenhouse or for other purposes. Instead of consuming land, such plants would gain additional useful land from the desert.

Most renewable energy technologies have no emissions during operation. On a life cycle basis, emissions occur only during the production of the plants. However, if renewable shares increase in the power sector, also the emissions during construction will be subsequently reduced, as they origin from fossil energy consumption.

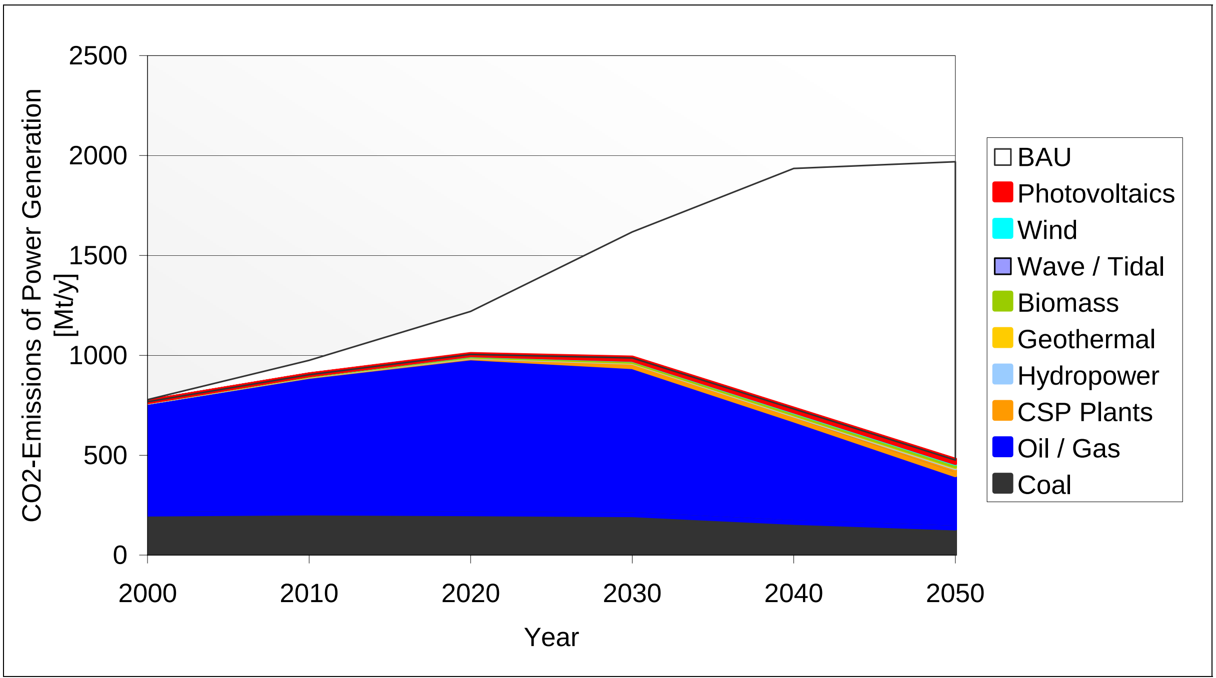

Figure 11: CO_2-emissions of electricity generation in million tons per year for all countries for the MED-CSP scenario and emissions that would occur in a business as usual case (BAU)

Fossil power systems show emissions that are one or two orders of magnitude higher than those of renewables. CO_2 sequestration will require extra energy and thus will lead to higher emissions, which must additionally be disposed off, entering a kind of vicious circle. However, it can be a component of a strategy for sustainability.

In a business-as-usual scenario, the growth of population and economy would lead to an increase of carbon dioxide emissions in the analysed countries from 770 million ton per year today to 2000 million tons per year in 2050, with devastating effects on the global and regional climate. The strategy outlined by our study leads to emissions of only 475 million tons per year in 2050 in line with the goal established by WBGU (Figure 11), achieving per capita emissions of 0.58 tons/cap/y in the power sector. Thus, 28 billion tons of carbon dioxide are avoided until 2050, which is equal to the present total annual emissions world wide.

Chapter 8 (Policy Instruments) describes policy instruments and possibilities of finance from Kyoto-instruments to tax reductions, feed-in-laws and international grants. In the MENA region a RES deployment strategy is mandatory. It should be based on an international agreement which offers the single countries incentives to act and reduces the perceived risk of investors with respect to fundamental policy changes. Due to the different regulations of the electricity sector it is appropriate to use different instruments adapted to the different countries. The instruments used within a country should be specifically related to technologies or technology-bundles. A concerted grid expansion and a fair grid access are mandatory. Support by financial institutions shall be complementary to other instruments and shall be project-dependent. As an international agreement is required to introduce RES-technologies there seems to be a case to found a special financial institution or to change the duty of an existing financial institution to handle financial flows between states or to offer special credits.

In project planning true opportunity costs for fossil fuels – typically derived from world market prices – have to be used, also in countries where fossil fuels are subsidized.

It is a legitimate question to ask who should afford the initial investments of 75 billon $ required to bring renewables into the market within the 15 years time span needed to reach cost break-even with fuels. In principle, the electricity consumers are those who benefit directly from this strategy. If the initial investment would be equally distributed among all electricity consumers in the region, each of them would have to afford additionally 10 $/y for electricity payments for a period of 15 years in order to finance the total market introduction of renewables. After those 15 years, all consumers will benefit from stable and low electricity costs, avoiding to be exposed to volatile and rather high electricity costs in the case of a business as usual policy.

The required amount of 75 billion $ is comparable to the amount of investments needed (and actually spent) from now on to develop and build the first commercial nuclear fusion reactor expected for the year 2050. If a first commercial fusion plant is realised by 2050, it will not have avoided any CO_2 by that time, while the renewable energy mix will have avoided 28 billion tons of CO_2 and in addition to that, will have relieved the EU-MENA economies by expenses of about 250 billion $ otherwise required for fossil energies (without accounting for external costs). According to the developers of fusion, the electricity cost of a first commercial reactor would be in the range of 10-12 cent/kWh. This will probably be competitive with fossil fuel plants by 2050, but it is about twice as much as required for the average cost of the renewable energy mix by that time (Figure 9). Therefore, a wise and responsible energy policy must support renewable energies as well.

It is the responsibility of national governments and international policy to organise a fair financing scheme for renewable energies in the EU-MENA region in order to avoid the obvious risks of present energy policies and change to a sustainable path for wealth, development, and energy and water security.