ECONOMIC AND SOCIAL COMMISSION FOR WESTERN ASIA (ESCWA)

THE ROLE OF RENEWABLE ENERGY IN MITIGATING CLIMATE CHANGE IN THE ESCWA REGION

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Executive summary

The phenomenon of climate change is a matter of grave concern for the whole world, adversely affecting sustainable development and imperilling the future of humankind. Despite the fact that ESCWA member countries have never been responsible for climate change, the region is expected to be one of the most affected regions in the future, with its water and food security endangered by desertification and water scarcity, along with the rise in sea levels and the threat to the quality of groundwater in a considerable number of sinking lands.

Therefore, it has become necessary for the countries of the region to participate in global efforts to halt climate change, by improving energy efficiency in terms of production, conversion and consumption; using natural gas as a cleaner form of fuel; using nuclear energy when the necessary safety conditions for it are in place; and adopting the applications of renewable energy, especially in most ESCWA member countries, which are rich in sources of this type of energy.

This study reviews the renewable energy technologies that are available worldwide, with a focus on the applications of solar and wind energy used to produce electricity, given that the electricity sector consumes the most energy in the ESCWA region and that its needs are expected to double in the next decade.

The study highlights the enormity of investments required to use solar energy to produce electricity centrally and to supply the electrical grid, as well as at the need to use photovoltaic cells to produce electricity in remote rural areas that are located a considerable distance from the electrical grid. The report also notes that ESCWA member countries use these kinds of energy to varying degrees and in a limited manner overall, given their limited capabilities. The study does not go into ESCWA member countries' use of hydropower, given how minimal the sources of it are and how most available sources have already been exploited.

Considering the low efficiency of electricity production from solar and wind energy, the low efficiency of electricity storage, and the technical and economic difficulty thereof, this study addresses the possibilities of using renewable energy and subsequently the possibilities of reducing emissions by direct use and generating thermal and/or mechanical power from renewable energy without going through electrical power. The study also addresses solar cooling, even below the anticipated level of commercial maturity, especially if the cooling needs exceed the available solar energy by a significant amount.

The electricity sector is the largest consumer of fossil fuels, with the rate of its reliance on them exceeding 95 per cent in ESCWA member countries. Similarly, decisions in this sector are made centrally, and their implementation and effectiveness can be verified at the moment the decisions are made. On that basis, this study addresses a number of scenarios tied to the following: adoption of applications of renewable energy to produce electricity in accordance with what ESCWA member countries have agreed upon; adoption of policies needed to improve the efficiency of electrical power production; or combining the improvement of energy efficiency and adopting natural gas and using the applications of electricity production from renewable energy. The results of these scenarios were compared with the results of the situation remaining as it is, with the increasing needs of the electricity sector anticipated by the electricity companies and institutions in ESCWA member countries. It became apparent that the ceiling for reduction of emissions remains in the vicinity of 21 per cent, and that measures taken to improve energy efficiency and use of natural gas available in some countries in the region are sufficient to meet and provide in excess of the needs of the region, and are more effective in reducing emissions (10.6 per cent) than the declared and planned use of renewable energy applications (5.4 per cent).

Given that the difficulties involved in successfully spreading the applications of renewable energy in ESCWA member countries stem from the rising cost of these applications and the related level of knowledge, this study examines the possibilities of local manufacturing of equipment to produce electricity

using renewable energy, taking into account the sizable investment required for power plants. There are reasonable capabilities to outfit these plants locally. Increasing the local component is expected to reduce the cost and create job opportunities. Moreover, local manufacturing is expected to strengthen the technology transfer process and localization of the technology and to improve capacity building and the gaining of expertise. Nevertheless, these prospects run into several legislative, institutional and financial barriers.

The study stresses the importance of international and regional cooperation in spreading the use of renewable energy in ESCWA member countries in order to halt climate change, given that this is a shared responsibility, even though the degree of responsibility might vary. Such cooperation centres on issues of technology transfer and securing financing. The study reviews the regional and international initiatives, in particular those tied to countries in the region, in addition to the Kyoto Protocol and the Clean Development Mechanism and renewable energy projects funded by ESCWA member countries, which, given their limitations, could benefit from the lessons learned. The study addresses the prospects for developing renewable energy and its future trends in ESCWA member countries, as well as the United Nations position on the matter and the decisions adopted at the Rio+20 Conference, contained in the outcome document, "The Future We Want".

The study also focuses on the importance of legislative, institutional and organizational frameworks, and it reviews existing and working frameworks as well as the steps proposed to improve them in order to strengthen projects to develop renewable energy applications and energy efficiency. Combining those two important points is necessitated by the dialectical relationship between the two, and the priority of guiding the use of energy and improving the efficiency of its production, conversion, distribution and consumption, as an indispensable preliminary step before putting the sizable investments in renewable energy production to use.

The study draws several conclusions regarding the technologies and applications of renewable energy, in terms of the extent of their maturity, their spread and their economic feasibility; as well as the importance of using renewable energy without going through electricity production; the importance of reviewing the energy pricing structure; and the burdens weighing down member countries' national budgets as a result of the adoption of policies to subsidize local energy prices. The study highlights the importance of adopting a comprehensive development approach, as well as that of innovating financing mechanisms, creating a climate that attracts private sector investment, applying standard specifications and strengthening international and regional cooperation, taking into account the priorities of each country and the differentiated responsibilities of each in mitigating climate change.

Introduction

The United Nations Framework Convention on Climate Change, adopted in 1992 (Framework Convention), acknowledges that changes in the Earth's climate are a common concern of humankind and that concern about the increase in the atmospheric concentration of greenhouse gases as a result of human activities is growing, which will enhance the natural greenhouse effect, resulting in an additional warming of the Earth's surface. The primary objective of the Convention is the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous interference with the climate system.

Estimates show a rise in carbon dioxide concentrations in the atmosphere, from 280 parts per million (ppm) in the period prior to the Industrial Revolution to 390 ppm at present. If these numbers continue to rise, it will lead to an unacceptable rise in the Earth's temperature, exacerbating global warming and its consequences, particularly for member countries. The most dangerous of these consequences would be desertification and imperilled water supply, food and social security. The Kyoto Protocol to the United Nations Framework Convention on Climate Change (Kyoto Protocol) contains a list of sectors that produce greenhouse gases, with energy, in which fuel combustion produces carbon dioxide, first on the list.

Within the context of global understanding, following the adoption of these two instruments, the need to stabilize the percentage by which the Earth's temperature rises at less than 2°C was stressed, by stabilizing the level of carbon dioxide concentration at 450 ppm.[1] In light of this, the energy sector, as one of the sectors mainly responsible for emissions, can contribute to mitigating climate change through a number of key actions,[2] chief among them the adoption of measures to promote energy efficiency (24 per cent), the spread of use of renewable energy (21 per cent), carbon capture and storage (19 per cent), expanding the use of cleaner fuels (natural gas), and perhaps also using nuclear energy to produce electricity, on the condition that the process is guaranteed to be safe.

In September 2011, the Secretary-General of the United Nations launched the "Sustainable Energy For All" initiative. One of the three objectives is to double the share of renewable energy in the global energy mix.

The outcome document of the Rio+20 Conference, "The Future We Want", highlighted the need to: renew the commitment to sustainable development and to protect the environment and achieve the Millennium Development Goals; recognize that climate change is a cross-cutting and persistent crisis; express concern that all countries, particularly developing countries, are vulnerable to the adverse impacts of climate change, which undermine their capacity to achieve the Millennium Development Goals; underscore that combating climate change requires urgent and ambitious action, in accordance with the principles and provisions of the United Nations Framework Convention on Climate Change. In the area of energy, the outcomes of Rio+20 stressed the importance of increasing the share of renewable energy technologies in achieving sustainable development; and that climate change is one of the greatest challenges of our time; and that the persistent rise in the global level of greenhouse gas emissions is cause for grave concern. This outcome welcomed the declaration for the launch of the Green Climate Fund, called for its prompt operationalisation so as to have an early and adequate replenishment process, and urged parties to the United Nations Framework Convention on Climate Change and parties to the Kyoto Protocol thereto to fully implement their commitments, as well as decisions adopted under those agreements.

At present in several countries, renewable energy has become an effective tool for environmental preservation and climate change mitigation as it is a source of green energy, as well as a means of ensuring the sustainable energy supply in all energy sectors, electrical, heat and mechanical. The commercial use of some renewable energy technologies is spreading to varying degrees, while others remain at the research and

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[1] ESCWA, *Energy Policies and Measures for Promoting Climate Change Mitigation in ESCWA Member Countries* (E/ESCWA/SDPD/2010/IG.1/4).

[2] *Sciences et Avenir*, June 2010.

development stage.[3] The importance of spreading sustainable energy appropriate for urban, rural and remote regions is all the greater, particularly in light of the fact that 1.3 billion people (roughly 20 per cent of the world's population) are lacking modern energy services.[4]

Despite the fact that the contribution of ESCWA member countries to carbon dioxide emissions is limited, the energy sector in these countries is interested in diversifying its sources of energy and integrating renewable energy into the national energy mix, as evinced by the strategies, policies and measures adopted by a number of member countries.

In that connection, the programme of work for the biennium 2012-2013 calls for the publication of a study on the role of renewable energy in promoting climate change mitigation measures in the ESCWA region. Similarly, at its second session, held on 13 and 14 December 2010, the ESCWA Committee on Energy recommended the adoption of a series of measures relating to promoting the role of renewable energy and climate change mitigation.

To that same end, this study is intended for all private- and public-sector workers and those active in the areas of energy, the environment and sustainable development, whether they be economic engineers, media professionals, businessmen or government officials.

As it is certain that the technologies of renewable energy applications are environmentally-friendly and that their use is at the heart of sound management of natural resources, the scope of this study is restricted to the role of renewable energy, which constitutes a sustainable source of energy, in reducing the emission of global warming gases and thus mitigating global warming, with the precaution that carbon dioxide emissions in ESCWA member countries are chiefly a product of the combustion processes in thermal power plants to generate electricity, which account for 95 per cent of electrical power plants in these countries.

Chapter 1 of the study covers renewable energy technologies for electricity production, giving an overview of the features of industrial development and the global market, with an emphasis on solar and wind energy, given that the applications of these two types of energy have reached technical maturity and have spread through commerce, and that ESCWA member countries are rich in major potential in both. Chapter 2 contains a review of thermal and mechanical applications that can be used in order to use renewable energy sources (with the exception of electrical energy) directly, without passing through electrical energy, in order to avoid losing efficiency in the electricity generation process. Chapter 3 looks at the current rates of carbon dioxide emissions produced by electrical power plants as well as the projected rates for 2020 in a number of scenarios. Chapter 4 examines the possibilities for local manufacture of sustainable energy equipment to produce electricity in an attempt to reduce their cost, which is considered one of the chief weaknesses in their application; to create work opportunities, and to acquire equipment suited to the local environment. This chapter also looks at the existing legislative, institutional, technical and financial barriers. Given the importance of international cooperation in support of spreading renewable energy in order to reduce emissions and mitigate climate change and global warming, chapter 5 covers the existing regional and international initiatives and mechanisms in ESCWA member countries. Chapter 6 reviews the legislative, institutional and regulatory frameworks in place to govern the use of renewable energy, starting with reducing emissions and mitigating climate change and proposing necessary steps to strengthen the role of renewable energy and energy efficiency on indissoluble tracks.

The study concludes with some important results towards conceiving a vision of the role of renewable energy in ESCWA member countries and the possibilities of contributing to climate change mitigation.

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[3] International Energy Agency, *World Energy Outlook 2011*.

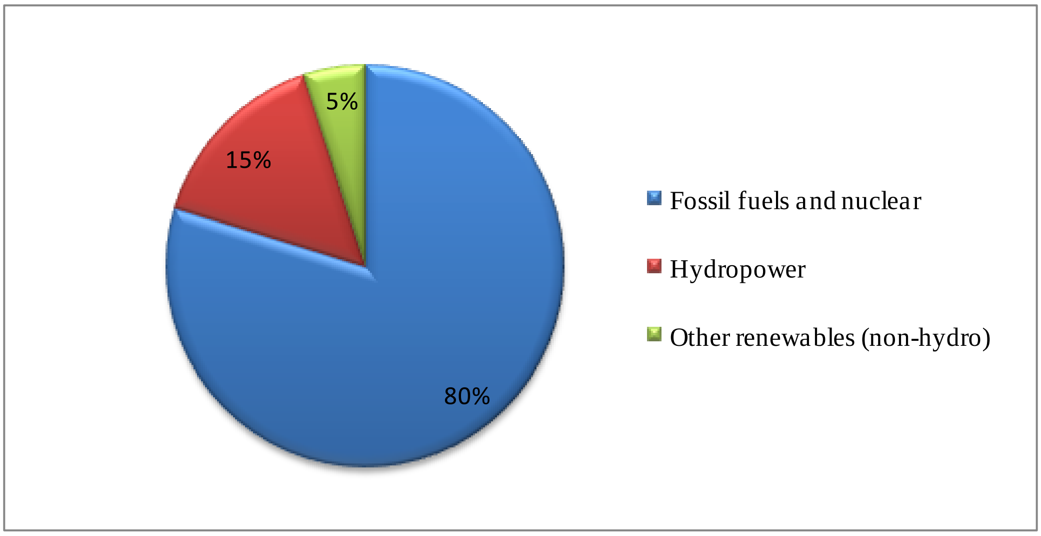
[4] ESCWA, *Enhancing Regional Cooperation in the field of Energy for the Achievement of Sustainable Development and the Millennium Development Goals in the ESCWA Region* (E/ESCWA/SDPD/2009/6).

I. ELECTRICITY PRODUCTION FROM RENEWABLE ENERGY SOURCES

Renewable energy continues to garner international interest, as the markets for equipment related to its applications in a number of developed and developing countries continue to grow, especially in the field of electricity production. The most important features of development in renewable energy markets show an increase in combined capacities for renewable energy applications (with the exception of hydropower) to 390 gigawatts (GW) by the end of 2011, compared to 315 GW in 2010, amounting to an increase in capacity of roughly 23.8 per cent. The increase is noticeable in wind energy projects and in the use of the photovoltaic systems (40 GW and 30 GW respectively during 2011).[5] This would naturally have a positive impact on the reduction of emissions caused by global warming and climate change.

By the end of 2011, the renewable energy share of global electricity production reached 20 per cent, 15 per cent of it from hydropower (figure 1).

Figure 1. Renewable energy share of global electricity production



Source: REN21, Global Status Report 2012.

A. WIND ENERGY

Wind energy use for electricity production first began in the nineteenth century with the introduction of the wind turbine. Since then, considerable research and development on these turbines have been carried out. It is possible to exploit wind energy for electricity production when wind speed is at least 3-5 metre/second (m/s) and no more than 25 m/s.[6] It is possible to establish wind farms on and off shore. The choice of location/site depends upon several factors, among them wind distribution and frequency of wind velocities, the geographical and topographical characteristics of the site, in addition to its distance from the centre of loads and their connection to the grid. The wind turbine can be used in a hybrid system with solar and/or fossil-fuel-based systems to generate electricity.

Electricity production from this source is affected by the change in wind speed (rise and fall), and it requires available reserve capacities from other sources, insofar as it is not possible to rely on wind energy alone as an electricity supply source. In the event that larger wind farms are built, it will be necessary to

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[5] REN21, Renewables 2012, *Global Status Report*, France.

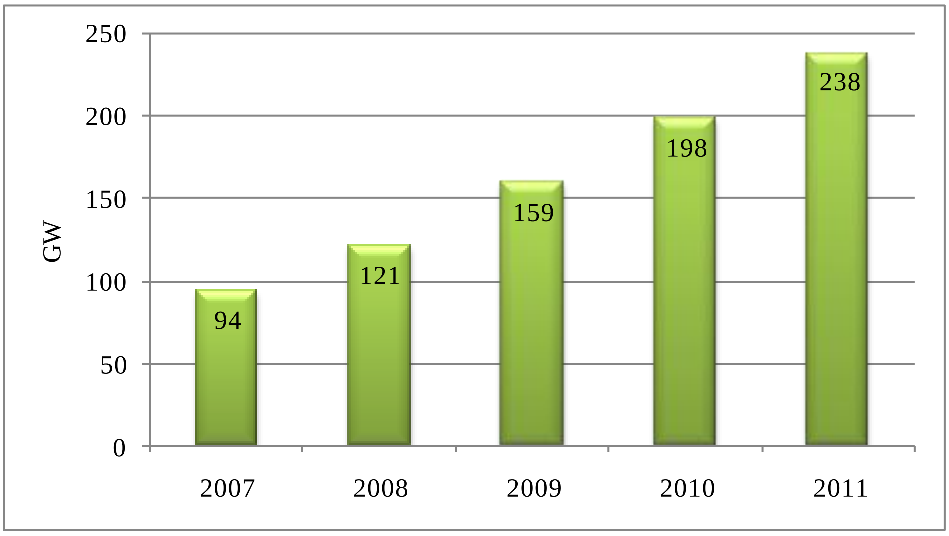
[6] ESCWA, *Promoting Large-Scale Renewable Energy Applications in the Arab Region: An Approach for Climate Change Mitigation* (E/ESCWA/SDPD/2010/WP.2).

conduct a study on climate changes and the use of new programmes to predict wind velocities. It is possible for wind plants linked to the electrical grid to contribute 20 per cent of energy, with minor impact on the stability of the grid. In order to achieve this, wind plants must be distributed throughout a broad geographic area, and other energy sources have to supply the grid with its electrical energy needs,[7] and with reserve energy in the event of a reduction in wind speed. Electricity production from wind energy contributes to reducing emissions and minimizing fossil fuel consumption, but it does not eliminate the need to equip the traditional production groups necessary to meet electricity needs during peak and non-peak periods.

1. *Features of industry and market development worldwide*

In light of the development of turbine manufacturing, individual capacity for single turbines has reached 7.5 megawatts (MW). Currently, the most widely used medium-capacity turbines have a capacity of 1.7 MW onshore and 3.6 MW offshore.[8]

Figure 2. Total cumulative development of installed capacities of wind farms at the global level (2007-2011)



Source: REN21, Global Status Report 2012.

At the end of 2011, the cumulative global total installed wind capacity for wind farms reached 238 GW (of which roughly 4.1 GW accounted for offshore wind farms, or about 1.7 per cent overall, with approximately half of that in the United States), at a rate of annual growth estimated at 20 per cent, as against 198 GW in 2010 and growth rate estimated at 24.5 per cent (figure 2). In terms of the combined capacities, China (62.4 GW), the United States of America (46.9 GW), Germany (29.1 GW), Spain (21.7 GW) and India (16.1 GW) occupy the top five slots.

The wind energy equipment manufacturing sector is comprised of 10 companies that have captured roughly 80 per cent of the global market. Four of those companies are Chinese, four are European, one is Indian and the other is American. Figure 3 illustrates the five largest companies that captured roughly 48 per cent of the global market in 2011: Vestas (Denmark), Goldwind (China), GE Wind (United States), Gamesa (Spain), Enercon (Germany). As a result, these technologies have become common and tested.

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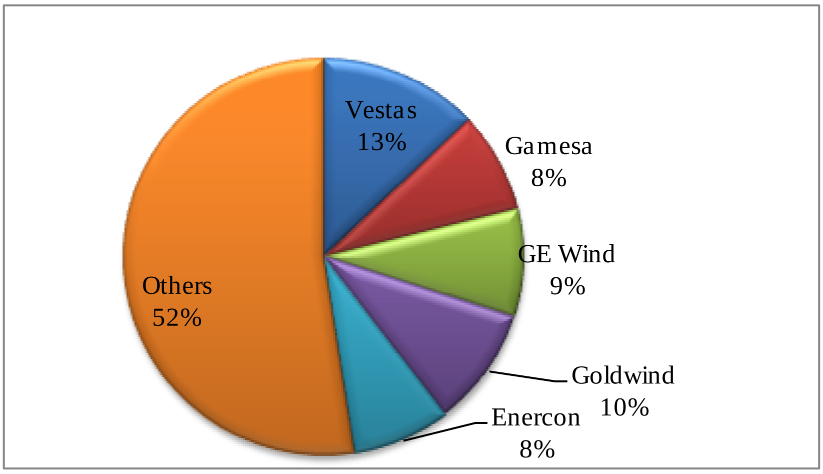
[7] Ibid.

[8] REN21, op. cit.

Figure 3. Market share of the five largest manufacturers of wind turbines (Vestas, Gamesa, GE Wind, Goldwind and Enercon)



Source: REN21, Global Status Report 2012.

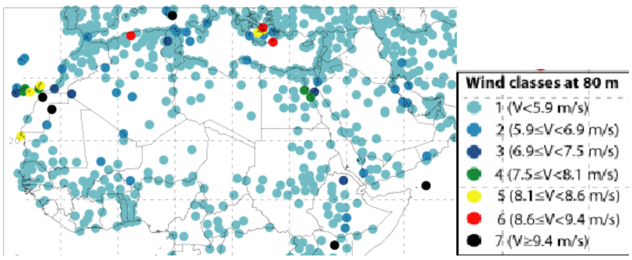
Several factors have contributed to the use of wind energy technologies. The most important factors are the issuance of renewable energy legislation, such as the feed in tariff in China, Germany and Spain, the technical maturation of wind energy technologies, the ease of acquisition resulting from the increase in the number of companies that manufacture them, and a drop in price.

Box 1. General overview of the wind energy market

Wind energy technology is considered one of the most widespread renewable energy technologies (with the exception of hydropower) in terms of cumulative total. The entrance of China into the field has broken the monopoly previously held by Danish, German, Spanish and American companies. The role of China and India is expected to grow in this field. Despite the increase in turbine capacity (which has reached 7 MW), demand for low-capacity turbines (100 kW and below) has continued to grow for use in rural and remote areas.

2. *Wind energy potential in the ESCWA region*

Figure 4. Average wind speeds in the region at an elevation of 80 metres above ground level (2000)



Wind energy is considered a local form of energy, that is to say, a form of energy that is available in sites structurally predisposed to high wind speeds by specific characteristics. Within the Arab world, wind energy can be found at particular locations (figure 4), including Jordan (Gulf of Aqaba), Tunisia and Algeria (Mediterranean coast and some inland locations), the Sudan (Red Sea coast), Oman (Indian Ocean coast), Egypt (Suez Gulf coast), Morocco and Mauritania (Atlantic coast), Yemen and some other sites in the Arab Gulf. There are wind stations connected to the grid in Tunisia, Egypt and Morocco.

Table 1 lists projects that have been carried out, those currently being carried out and those in the planning stage in ESCWA member countries, with the aim of producing electricity using wind energy.

TABLE 1. ELECTRICITY GENERATION PROJECTS USING WIND ENERGY IN ESCWA MEMBER COUNTRIES

Country	Projects
Bahrain[a/]	• In operation: Three wind turbines (660 kW) that contribute to supplying the World Trade Building with electricity; • Planned: Construction of an experimental hybrid solar/wind plant (5 MW). It is expected to be operational in 2013.
Egypt[b/]	• In operation: Wind farms with a capacity of 550 MW. Nearly connected to the grid at the Zafarana and Ghardaqa sites; • Due to be built: 200 MW in the Jabal El-Zayt area on the shores of the Red Sea; • Studies: Carrying out a study regarding construction of a 720 MW (government projects), and wind farms with a capacity of 1,250 MW (private sector, build – own – operate – transfer system), and 120 MW (foreign direct investment), 200 MW (with the Abu Dhabi-based Masdar Corporation); • Planned: Increase in the combined capacity of wind farms to attain 7,200 MW, by the year 2020 or thereabouts.
Jordan[b/]	• In operation: Wind plant with a capacity of 1.5 MW; • In preparation and due to be established: two wind farm projects with respective capacities of 40 and 90 MW; • In planning: Construction of wind plants with a total capacity of 1,200 MW by 2020.
Kuwait[c/]	• Planned: wind plant with a capacity of 10 MW.
Libya[d/]	• Preparation and construction: Three wind farm projects with a total capacity of 240 MW, to be operational in 2014; • Planned: Increase in the combined capacity of wind farms to attain 1,750 MW by 2030.
Morocco[e/]	• In operation: Wind plant with a capacity of 291 MW; • Planned: Increase in the combined capacities to attain 2,000 MW by the year 2020 or thereabouts.
Oman[c/]	• In operation: Experimental project pumping water in remote regions by using wind turbines (10 kW) since 1996; • Studies: Carrying out a study of the situation of dual diesel/wind systems (10 turbines, each of which has a capacity of 100 kW) to produce electricity, and conducting a technical-financial assessment of the wind plant project (with a capacity of 9 MW) in the Duqm area, where average wind velocity comes to 5.33 m/s and the capacity factor reaches 0.36.
Saudi Arabia[f/]	• The feasibility study for the construction of two wind farms with varying capacities in the Yanbu and Dhalm areas is complete.
Syrian Arab Republic[g/]	• Planned: Execution of wind farms with a capacity of 1,000 MW by 2015, and wind farms with a capacity of 2,500 MW by 2030.

TABLE 1 (*continued*)

Country	Projects
Tunisia[f/]	• In operation: Wind farms with a capacity of 174 MW; also 70 additional megawatts that are almost ready for operation but have not been placed in service yet.
United Arab Emirates[g/]	• In preparation and due to be built: Wind station (30 MW) on Sir Bani Yas Island; • Studies: Construction of a wind plant (200 MW) on the shores of the Red Sea in Egypt, in cooperation with the Masdar company and the Egyptian New and Renewable Energy Authority; • Private investments: Collaboration of the Masdar company in implementing an offshore wind farm project in Britain (1,000 MW) and other islands in the Seychelles.
Yemen[b/]	• Preparation and construction: wind plant with a capacity of 60 MW; • Planned: Increase in the combined capacities of wind farms to attain a capacity of 460 MW by 2025.

a/ Imen Jeridi Bachellerie, Gulf Research Center, Renewable Energy in the GCC Countries, Resources, Potential, and Prospects.

b/ Secretariat of the Arab Ministerial Council on Electricity, Guide to the Potential of Arab Countries in the Fields of Renewable Energy and Raising Efficiency in Electricity Production and Consumption.

c/ New and Renewable Energy Authority, Annual Report 2010/2011, Cairo.

d/ Secretariat of the Arab Ministerial Council on Electricity, "Working Paper to Articulate an Arab Vision on Solar Plans and Initiatives", June 2011.

e/ Global Wind Energy Council, Global Wind Report, Annual Market Update 2011.

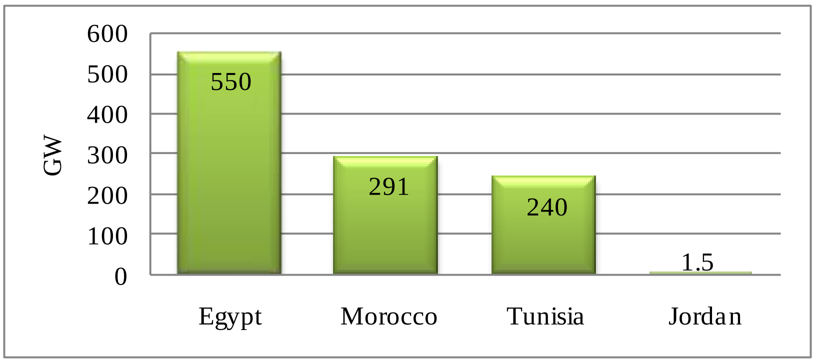
f/ Arab Union of Electricity, Statistical Bulletin 2011 and other sources.

g/ Energy source (on 2 August 2012).

The spread of wind energy has not reached the desired extent in the ESCWA region. The reason for the use of this type of energy in Egypt, Morocco and Tunisia can be traced to government interest in developing wind energy, in light of the countries' remarkable potential and based on prior technical studies. In addition, pioneering countries and international organizations have provided support in the context of bilateral international cooperation, and in the case of Egypt, official interest has encouraged local manufacture of some wind energy equipment components. The United Arab Emirates began to move towards investing in this field through the Abu Dhabi-based Masdar company (established in 2006). Figure 5 shows wind farms in active service in ESCWA member countries.

The role of government is crucial in the initial stages of introducing this technology at the national level, especially given the existence of a government monopoly in the electricity sector in ESCWA member countries, by providing the necessary financing and execution in the context of government investments. It is expected that the private sector (on its own or through a public-private partnership) will have a significant role in this field in most countries, especially in light of stimulus policies, in line with national plans and priorities.

Figure 5. Wind farms for electricity production in ESCWA member countries

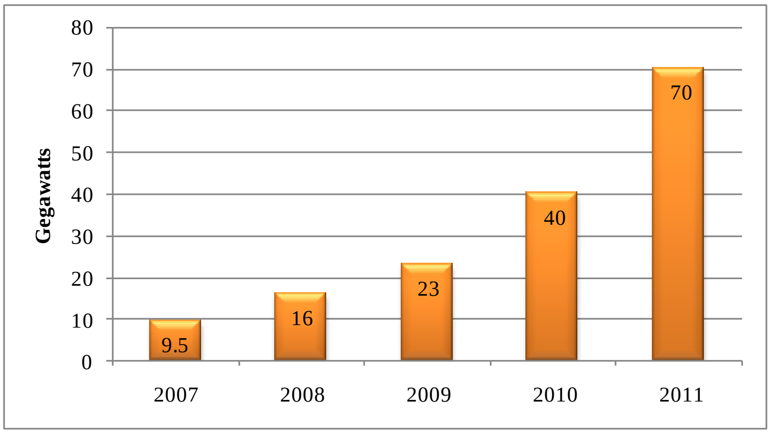


B. SOLAR PHOTOELECTRIC (PHOTOVOLTAIC) ENERGY

The idea of solar photoelectric (photovoltaic) cells relies on the direct use of sunlight, direct or scattered, for conversion to electrical energy. Cells are grouped into modules and then linked to one another in panels, which are then grouped into matrices. The cell systems are considered fit for use in rural and remote areas as isolated systems, and they can also be connected to the grid in the case of larger plants.

Solar photoelectric energy systems (photovoltaic systems) are the fastest growing renewable energy applications for electricity production per year. By the end of 2011, the total installed capacity had reached 70 GW, a 75 per cent increase, as against 40 GW and a 72 per cent increase in 2010. This is due to the financial incentives that many developed and developing countries have provided to assist in spreading the use of renewable energy applications, including these systems. Figure 6 shows the total cumulative development in installed capacity at the global level for the period 2007-2011.[9]

Figure 6. Total global development in installed capacity of photovoltaic systems (2007-2011)



Source: REN21, Global Status Report 2012.

As of the end of 2011, Germany (24.8 GW), Italy (12.8 GW), Japan (4.9 GW), Spain (4.5 GW) and the United States (4 GW) were the global leaders in combined capacity.

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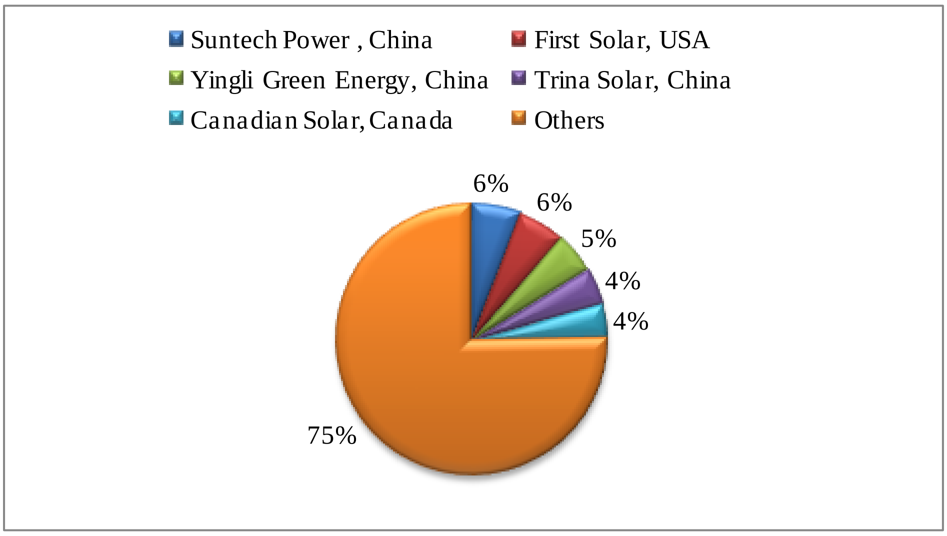
[9] REN21, op. cit.

1. *Features of the industry and the market worldwide*

Demand for photoelectric systems has increased significantly in 2011, and the price of a module has dropped by 40 per cent in the same year. Moreover, the price of cell systems mounted on roofs has dropped by approximately 20 per cent. Costs have dropped due to the increase in production and development of the technology, as well as to competition among manufacturers. The drop in the price of silicone, the chief component of these cells, has also been a factor. Crystalline silicone cells dominate the market, with their production doubling between 2008 and 2010, along with the decline in the market share of thin film cells from 21 per cent in 2009 to 13 per cent in 2011. Interest in concentrating photovoltaic systems, which involve mounting a reflective surface on the cell, be it a lens, a mirror or a side reflector that works to increase the concentration of all solar radiation captured, has also increased. The electricity production projects using these systems were carried out with a total capacity of 33 MW connected to the grid in no fewer than twenty countries (such as Australia, Saudi Arabia, Spain and the United States), and the use of photovoltaic systems in buildings is garnering increasing interest.[10]

Figure 7. Market share of the five largest companies that manufacture photovoltaic cells



There are approximately 15 companies that, between them, have captured 49 per cent of the global market in 2011; 9 of them Chinese, and the remainder are American, Japanese, Canadian and Norwegian. Figure 7 illustrates the market share of the five largest manufacturers, three of them Chinese, a share amounting to a global total of about 25 per cent. This could be beneficial for the market, as it creates competition that leads to lower prices and eliminates the technological monopoly of certain developed countries; it is also considered an indicator of the transfer of the manufacturing of photovoltaic cells to the enormous Asian market, and consequently of an increase in supply and demand.

2. *Potential of photovoltaic solar energy in the ESCWA region*

ESCWA countries are rich in solar energy. Interest in exploiting this resource has increased in recent years, particularly in light of fluctuating energy prices in the global market and interest in environmental issues and global warming, in addition to the role that photovoltaic solar energy systems might play in improving living conditions in rural population centres that are isolated from grids. Factories to assemble the parts of these systems can be found in some ESCWA countries, including Egypt. Jordan, the Sudan, the Syrian Arab Republic, and Tunisia. The largest photovoltaic solar cell system (10 MW) is found in Abu

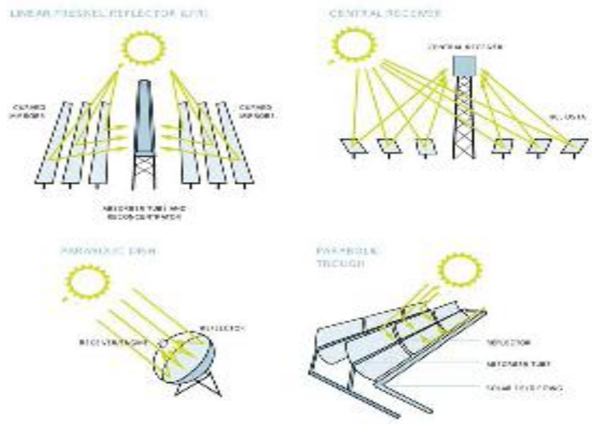
[10] Ibid.

Dhabi, and the applications of these systems can be found in most ESCWA member countries. In 2010, the total capacity of installed systems in the Arab region was approximately 22 MW.[11] One of the companies in Saudi Arabia declared that it had established a power plant with a capacity of 1-2 MW powered by photovoltaic systems, while another announced the launch of a project to establish a 10 MW desalination plant by using photovoltaic systems.[12]

C. THERMAL SOLAR ENERGY

Concentrating Solar Power (CSP) systems collect direct solar radiation and concentrate it onto a given surface (as scattered solar radiation cannot be concentrated) to a temperature typically between 400 and 1,000°C. Thus, the intensity of direct solar radiation at the site of the project cannot drop below 2,200 kWh per square meter per year, with the sufficient surface area and necessary infrastructure including electrical power transfer lines, water sources and paved roads. Fossil fuels may be needed as well if combined cycle plants that contain a solar component are used.[13] The capacity of existing plants ranges from 50 to 280 MW and plants connected to the electrical grid can be designed to operate with a thermal storage system, or in hybrid operation with fossil fuels to meet the load demands. The existing CSP electricity production technologies, each of them characterized by their technical maturity (figure 8), are: parabolic trough, solar tower, parabolic dish and linear fresnel reflector.

Figure 8. Concentrating solar power technologies



Source: Solar PACES, ESTELA & Greenpeace, *Concentrating Solar Power Global Outlook 09: Why Renewable Energy Is Hot,* 2009.

CSP technologies are commercially prevalent to varying extents.

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[11] ESCWA, *Local Manufacturing of Electricity Production Equipment Using Solar and Wind Energy: Potential and Prospects in the ESCWA Region* (Arabic), (E/ESCWA/SDPD/2011/WG.5/2).

[12] REN21, op. cit.

[13] ESCWA, *Energy Policies and Measures for Promoting Climate Change Mitigation in ESCWA Member Countries*, op. cit.

TABLE 2. COMPARISON BETWEEN THE FOUR CONCENTRATING SOLAR POWER TECHNOLOGIES

Technology/ individual capacity (MW)	Yearly average solar efficiency (capacity produced relative to solar radiation captured) (*per cent*)	Cooling by steam condenser	Solar capacity factors (number of hours of operation of the solar component per year/number of hours per year, that is, 8,760 hours)	Thermal storage capacity	Estimated use of land per square metre for each megawatt per hour per year (m^2/MWh/yr)
Parabolic trough (10-200 MW)	10-15, expected to increase to 17-18	Water*/dry cooling (air)	24 per cent, expected to reach 25-90 per cent (as a result of the existence of a thermal storage system)	Yes	6-8 (flat land)
Solar tower (10-150 MW)	8-10, expected to increase to 15-25	Water*/dry cooling (air)	Expected to reach 25-90 per cent (as a result of the existence of a thermal storage system)	Yes	8-12 (flat land suited to the southern slope of the mountains in the northern hemisphere, and vice versa)
Linear fresnel reflector (10-200 MW)	9-10 (expected)	Water*/dry cooling (air)	Expected to reach 25-90 per cent (as a result of the existence of a thermal storage system)	Yes	4-6 (flat land)
Parabolic dish (0.01-0.4)	16-18, expected to increase to 18-23	None	Expected to reach 25 per cent (based on whether clouds appear or if they do so infrequently)	No	8-12 (flat land suited to the southern slope of the mountains in the northern hemisphere, and vice versa)

Source: German Aerospace Center and the Federal Ministry for the Environment, *Nature Conservation and Nuclear Safety, Concentrating Solar Power for the Mediterranean Region*, 2005.

1. *Features of industry and market development worldwide*

In 2011, the global total of installed capacity of thermal power plants reached 1.76 GW, compared to 1.3 GW in 2010, recording around a 35 per cent increase. Spain and the United States are considered the two main markets in CSP in terms of installed capacities worldwide, with the total capacity amounting to 1.15 GW and 0.507 GW, respectively. Steady growth is expected in these two markets.[14]

The market is undergoing an expansion outside of Spain and the United States, as a result of the growing interest in using the parabolic trough CSP technology in the Middle East and North Africa region, as well as in Australia, Chile, China, India, Mexico, South Africa and Thailand. The parabolic trough CSP technology remains the most widespread, by about 90 per cent. Table 3 shows the combined capacity of CSP power plants operating and under construction, for the period until the first quarter of 2012, which includes Egypt, Morocco, Saudi Arabia and the United Arab Emirates in the ESCWA region.

[14] REN21, op. cit.

TABLE 3. INSTALLED CAPACITY OF CSP PLANTS OPERATING AND UNDER CONSTRUCTION UNTIL THE FIRST QUARTER OF 2012

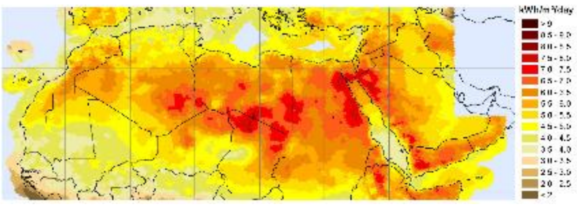
Country	Operating CSP capacity (MW)	CSP capacity under construction(MW)
Total	**1 868.7**	**2 902.2**
Algeria	25	-
Australia	5	47
Chile	-	7
China	2	114
Egypt	**20**	**-**
France	-	1.4
Germany	1.5	-
India	5.5	340
Iran	17	-
Italy	5	-
Mexico	-	14
Morocco	**20**	-
Saudi Arabia	**-**	**0.3**
Spain	1 253.4	952.5
Thailand	5	9
United Arab Emirates	**-**	**100**
United States of America	509.3	1 317

Source: Power Generation Magazine, Energética INTERNATIONAL, No. 123, July-August 2012.

CSP manufacturing activities generally remain the monopoly of a number of companies, most of them based in the United States and Spain, along with a very few German companies. Many institutions are active in the field of technology development, such as the American company Bright Source, which intends to add thermal storage systems (which rely on molten salts) to three CSP power plants in the United States. The American company GE – General Electric unveiled a project to build an integrated solar combined cycle power station, in cooperation with the American company e-Solar. The typical capacity in the United States developed and now ranges from 150 to 250 MW, which may lead to an improvement in the economics of the projects.[15]

2. *Potential of thermal solar power in the ESCWA region*

Figure 9. Yearly rates of direct solar radiation in the ESCWA region



Source: National Renewable Energy Laboratory, http://www.nrel.gov.

ESCWA member countries are located within the range of the sunbelt, which is exposed to direct solar radiation ranging from about 4 to 8 kW/hour/m^2/day (figure 9).

Interest in electricity production using CSP has emerged in some ESCWA member countries since the previous decade, with Egypt and Morocco, in cooperation with the Global Environment Facility, building two electricity production plants using the parabolic trough CSP technology, which is integrated with the

[15] Ibid.

combined cycle, so as to restrict its evening operation to relying on fossil fuels, with a capacity of 470 MW, with a solar component of 20 MW in Morocco and a capacity of 140 MW, with a solar component of 20 MW in Egypt.[16] Interest in this technology has spread to the Gulf region, where the construction of a 100 MW plant is underway in Abu Dhabi (table 3).

Figure 10. Thermal solar power plants under construction and operating in the Arab region

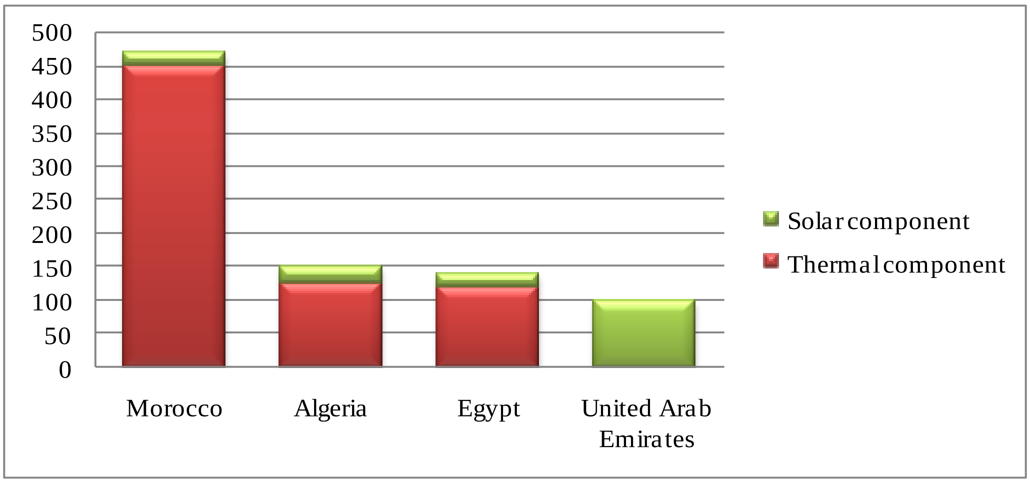


Table 4 lists the most important electricity production projects in ESCWA member countries using solar energy, whether thermal or photovoltaic.

TABLE 4. ELECTRICITY PRODUCTION PROJECTS USING SOLAR ENERGY IN ESCWA MEMBER COUNTRIES

Country	Projects
Bahrain[a/]	• An oil company built a dual solar (4 kW) and wind (1.7 kW) power plant to store energy and produce hydrogen which is converted by a fuel cell (1.2 kW) into electricity used to operate and light one of the factories; • Studies: In July 2011, a contract was concluded with a German consultant to provide consulting services on using renewable energy to produce electricity (using solar and wind energy), connected to the grid.
Egypt[b/]	• In operation: Thermal solar power station with a capacity of 140 MW, and photovoltaic systems with a capacity of 10 MW; • In the study stage: Conversion of a 100 MW capacity thermal solar power station with a thermal storage system in southern Egypt, and conversion of two projects to build two solar stations with photovoltaic systems, each of them possessing a capacity of 20 MW.
Iraq[c/]	• In operation: System to illuminate highways and supply electricity to traffic signs using photovoltaic cell systems; • In preparation: Supplying residential and industrial compounds, and solar power plants for electricity production in isolated areas with a capacity of 50 MW.
Jordan[d/]	• In operation: Photovoltaic cell systems with 5.5 + 0.5 MW capacity; • Confirmed: Construction of a thermal solar plant (8.5 MW) and a solar plant with a 100 MW capacity in the initial phase, which will increase to 200 MW in its second phase.

[16] ESCWA, *Energy Policies and Measures for Promoting Climate Change Mitigation in ESCWA Member Countries*, op. cit.

TABLE 4 (*continued*)

Country	Projects
Kuwait[a/]	• In operation: Total combined capacity does not exceed 400 kW from solar systems; • Underway: The Kuwait Petroleum Corporation announced its intention to launch a bid in the first quarter of 2012 on the implementation of a solar power station (5 MW) run on photovoltaic cell systems, and other stations run on CSP systems to produce steam; • In the study stage: The Ministry of Economy, Trade and Industry charged the Japanese External Trade Organization with drafting a feasibility study on a thermal solar power station project with combined cycle and a capacity of 280 MW, the capacity of the solar component (parabolic trough system) amounting to 60 MW thereof; • Planned: Construction by the Ministry of Electricity and Water of an electricity complex (70 MW) linked to the grid, using renewable energy sources (10 MW photovoltaic station, 10 MW wind farm, 50 MW thermal solar power station) on a site near the border with Iraq.
Lebanon[c/]	• In operation: Photovoltaic systems with a capacity of 3 MW in several government schools; • Confirmed: Construction of photovoltaic cell systems with a capacity of 50 MW, and implementation of a government initiative to light streets using solar power.
Libya[c/]	• In operation: 0.218 MW solar cell systems; • Confirmed: Construction of cell systems with a capacity of 1,000 MW, 100 MW thereof linked to the grid from 2010 to 2015, and Concentrating Solar Power with a capacity of 1,200 MW, 300 MW thereof from 2010 to 2015.
Morocco[e/]	• In operation: Thermal solar power station with a capacity of 470 MW, 20 MW thereof a solar component; • Confirmed: Construction of CSP stations with a capacity of 2,000 MW in 2020.
Oman[a/]	• In operation: Limited applications of cell systems intended for use in lighting and pumping water and in seismological stations; • Underway: In July 2011, Petroleum Development Oman concluded a contract with an American company to implement a thermal solar project using a solar centre with a capacity of 7 MW. It is integrated with a steam production unit that uses gas. In 2011, the Public Authority for Electricity and Water put forth a bid for the thermal solar power plant/photovoltaic system project (200 MW capacity) according to the build-own-operate model, with the aim of completing execution of the project by the end of 2013; • Planned: Private sector investment in the field of direct solar energy, and in the production of silicone, solar panels, metal structure and construction of a solar power station (400 MW).
Palestine[f/]	• In operation: Photovoltaic systems with a capacity of 80 kW, and cell systems with a capacity of 300 kW; • Planned: Electricity production (240 GW/hr) from renewable sources in the West Bank in 2020.
Qatar[g/]	• In the preparation and construction stage: In October 2011, a Qatari company announced that it had signed a contract to build a factory for the production of polysilicon in Qatar, with an approximate value of US$1 billion, with the aim of producing 8,000 metric tons of pure polycrystalline polysilicon globally in the initial phase. The project is slated for completion in the second half of 2013; • Planned: Use of solar power to light and cool sporting arenas and supporters' areas during the 2022 World Cup, which Qatar will be hosting.

TABLE 4 (*continued*)

Country	Projects
Saudi Arabia[c/]	• Under construction: Solar station (10 MW) using photovoltaic systems to feed into a desalination plant using the reverse osmosis method to produce 30,000 m^2 of desalinated water daily by 2012, in the initial phase. The second phase is to culminate in the construction of photovoltaic stations with a capacity of 100 MW to supply the desalination plants, whose aim will be to produce 300,000 m^2 daily, which experiment is to be replicated at the end of the third phase, during which a thermal solar power station with a capacity of 0.3 MW will be built (table 3); • Private investments: Construction of a factory for the production of approximately 3,350 metric tons of polycrystalline silicon panels per year, starting in 2014.
Sudan[d/]	• In operation: Photovoltaic systems with a capacity of 0.5 MW in 1,000 villages.
Syrian Arab Republic[c/]	• In operation: Photovoltaic cell systems with a capacity of 0.08 MW. There is a photovoltaic panel production line with a capacity of 15 MW per year; • Planned: Setting up a photovoltaic system with a capacity of 1 MW, as well as cell systems with a capacity of 700 MW by 2020, and of 2,000 MW by 2030.
Tunisia[c/]	• In operation: Solar photovoltaic with a total capacity of 1 MW; • Planned: Construction of two central thermal solar projects to produce electricity with capacities of 25 MW (public sector) and 75 MW (private sector).
United Arab Emirates[a/]	• In operation: Cell systems on city building roofs as source of their capacity of 1 MW in order to provide 30 per cent of the electrical power supply required, and a solar station using photovoltaic cells with a capacity of 10 MW; • Research and study activities: Beam-Down Solar Tower research project; research project of the solar centre (100 kW) using the central tower solar system, in order to obtain the steam used in turbine management; • Private investments: Share of Masdar company in ownership of the Gemasolar station in Spain (with a capacity of approximately 20 GW, central tower technology), with its official operation beginning in 2011; • Under construction: Thermal solar power plant (Shams 1) with a capacity of 100 MW; thermal solar power plant with photovoltaic cell systems (Nour 1) with a capacity of 100 MW.
Yemen[c/]	• In operation: Photovoltaic cell system project in rural areas; • Planned: Execution of a cell system project in the countryside (approximately 1 MW).

a/ Imen Jeridi Bachellerie, Renewable Energy in the GCC Countries, Resources, Potential, and Prospects.

b/ New and Renewable Energy Authority, Annual Report 2009/2010, Egypt.

c/ Secretariat of the Arab Ministerial Council for Electricity, Guide to the Potential of Arab Countries in the Fields of Renewable Energy and Raising Efficiency in Electricity Production and Consumption.

d/ ESCWA, *Energy Policies and Measures for Promoting Climate Change Mitigation in ESCWA Member Countries*.

e/ ESCWA, Local Manufacturing of Equipment for Electricity Production from Solar and Wind Energy: Potential and Prospects.

f/ Regional Centre for Renewable Energy and Energy Efficiency, Newsletter Issue No. 7, Cairo, June 2011.

g/ Raya Newspaper, http://www.raya.com/site/topics/printArticle.asp?cu_no=2&item_no=632527&version=1&template_id=35&parent_id=34.

Generally speaking, there is significant interest in solar energy technologies in ESCWA member countries. One reason is the trend towards diversifying energy sources and curbing depletion of national oil resources, with the sharp fluctuations in energy prices, in addition to the energy market fluctuation, which is exerting pressure on the development programmes of non-oil-producing countries. The question is limited to the execution of certain pilot projects in a few countries, while interest is greater in others. For instance, solar energy represents an inevitable option for Palestine, which has a single traditional thermal station with a capacity of 140 MW and photovoltaic systems with a capacity of 0.35 MW.[17] This leaves Palestine fundamentally reliant on imported electrical energy from the Israeli authorities in order to meet its energy needs. In the case of Egypt, wind and solar energy are a vital necessity and constitute a strategic dimension, given that fossil fuel resources are limited-term and do not meet the growing development and social needs in the face of consistently elevated population density. Solar energy applications represent an appropriate solution to provide scattered rural and remote areas in the Sudan and Yemen with modern energy services, where, in 2009, ESCWA carried out an electricity project in the remote village of Qawa in the Yemeni countryside, using photovoltaic cell systems to secure electricity for the villagers' basic daily needs (lighting of houses, clinics, mosques and public roads; vaccine refrigeration in clinics; television and radio operation in houses).

Box 2. The competition between photovoltaic systems and thermal solar systems

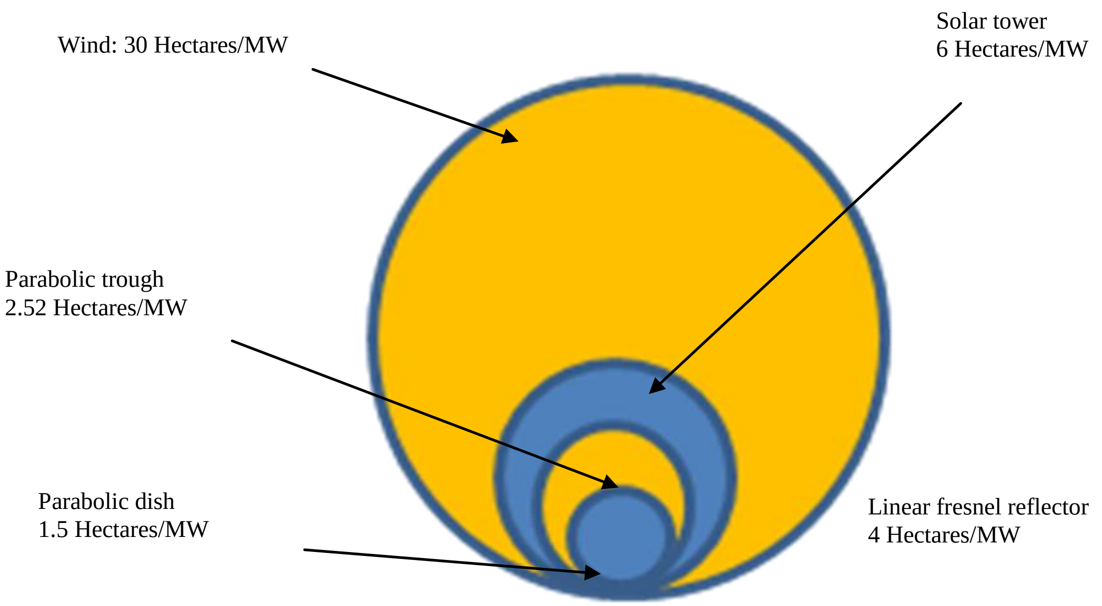
Photovoltaic cell systems are the fastest spreading, taking into account the relative drop in their price. This has led to a drop in the cost of electrical energy produced by means of these systems as well as to the execution of more projects that use them. This trend is expected to persist in the future, further encouraging their use as integrated systems in buildings.

Japanese, Chinese and Korean photovoltaic cell system companies are expected to achieve outstanding growth in the Asian market. The Concentrating Solar Power parabolic trough technology is also expected to maintain its hegemony in the area of thermal solar energy applications for electricity production in the coming period, with a trend towards using thermal storage for a higher number of hours. There is an interest in the use of this technology in Abu Dhabi, Algeria, Egypt, Jordan, Kuwait and Morocco. The intellectual ownership of some of the main components of the Concentrating Solar Power technology remains the monopoly of a very small number of companies,[*] which makes it impossible to lower the price of these components. Photovoltaic cell systems continue to dominate the solar energy market for electricity production, perhaps because the construction of thermal solar power plants takes longer (often no less than three years), given the necessity of available infrastructure and a water source for needs related to cooling and mirror cleaning. As for cell systems, they are the appropriate application for rural and remote areas, given that the burden of those areas is less and that residential compounds are scattered, and that they use solar energy from direct and scattered solar radiation. There is also an interest in technologies that use solar energy to produce electricity in ESCWA member countries, where good experiences exist in the area of collecting components for implementing, operating and maintaining photovoltaic solar systems. The required surface areas for solar energy-powered and wind-energy-powered electricity generation plants vary according to the system used (figure 11).

[*] Two companies have a monopoly on the manufacture of heat absorption worldwide. A number of companies manufacture parabolic trough mirrors, while the number of companies involved in engineering, procurement and construction (EPC) remains small.

[17] Arab Union of Electricity, *Statistical Bulletin 2011*.

Figure 11. Surface areas required for renewable energy-powered electricity generation plants



Source: Global Renewable Energy Forum, Morocco, Menasol 2011.

D. BIOMASS ENERGY

Biomass energy is potential energy contained in plants, crops, forest residues, and human and animal waste. This kind of energy can be used, either by burning in order to produce thermal energy, or by producing liquid or gas fuel, known as biofuel, for use in electricity generation plants. Biofuel has to be extracted from organic waste, but not of food crops, in order to avoid a food crisis in poor countries, especially in light of the scant renewable water resources and lands suitable for farming.

1. *Features of industry and market development worldwide*

At the end of 2011, the total installed capacity of electricity production plants from various biomass energy sources reached approximately 72 GW. Countries that use this kind of energy the most include the European Union countries (26.2 GW), followed by the United States (13.7 GW) and Brazil (8.9 GW). China is the Asian leader in biomass energy use (roughly 4.4 GW), followed by India (3.8 GW). There is interest in biomass as an electrical energy source derived from sugar cane waste in several African countries, such as Cameroon, Kenya, Uganda and others. Compressed forest residues are used in the form of wood pellets as fuel in some electricity generation plants in the United States, European Union countries and China, as well as in South Korea and Japan. Wood briquettes made from crop residues and sawdust (the global production of which has reached approximately 1.3 million tons) are used as plant fuel in China, India, Thailand and Malaysia.[18] Biogas is used in some European countries at the commercial level, as a source of electrical energy in houses and in small private projects like limited-capacity electricity generation plants (4.5-1,000 kW), as well as in plants whose capacities range from 250 kW to 45 MW, to supply facilities and the industry with electricity.[19]

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[18] REN21, op. cit.

[19] Ibid.

2. *Potential in ESCWA member countries*

Precise data and statistics on biomass and its applications in the region are not available, owing to the region limited contribution to electricity generation. There are number of limited electricity production projects in Jordan (using biogas from a solid waste site to run an electricity generation plant with a capacity of 4 MW), Egypt (using biogas from a water and sewage treatment plant to run a plant with a capacity of 18.5 MW), Lebanon (there is the possibility of using biogas produced by the water sewage treatment plant in Tripoli to cover half the plant electrical needs), the United Arab Emirates (electricity production project in a water and sewage treatment plant) and Yemen (electricity production project using urban waste in Sanaa).[20] In ESCWA member countries there exists the possibility of using agricultural waste. For instance, biofuel can be extracted from: (a) waste generated by olive production (6 million trees in Lebanon, 10 million trees in Jordan, and 60 million trees in the Syrian Arab Republic); (b) waste generated by the sugar cane and sugar beet industries (in 2007, the production of sugar crops was estimated at around 21.8 million tons in Egypt, 7.5 million tons in the Sudan, 3.9 million tons in Morocco, 1.1 million tons in the Syrian Arab Republic, 37,000 tons in Lebanon and 55,000 tons in Iraq); and (c) waste generated by the dairy industry.[21]

The commercial spread of electricity production projects using biofuels requires the adoption of government policies that contain encouraging incentives (tax and customs exemptions, provision of lands for the project at a nominal fee, government guarantees to cushion the risks of investment, facilitated administrative procedures) in order to attract the private sector, which can become involved in this arena.

E. OTHER RENEWABLE ENERGY SOURCES

In addition to the above, other renewable energy sources exist, some of them traditional and widely used worldwide at the commercial level, such as water resources; some of them are less widely used and their use is linked to the geographical location, such as geothermal energy; some sources are not commercially widespread due to their high cost. There is a limited number of consultative projects on ocean energy (waves, tides and spring tides).

1. *Hydropower*

Water resources in some 150 countries contribute to around 15 per cent of global electricity production. The total installed global capacity is estimated at 970 GW, and the share of ESCWA member countries accounts for one per cent of that capacity.[22]

(a) *Features of industry and market development worldwide*

The electrical equipment industry is considered to be commercially mature and widespread. China is the world leader in this industry, alongside other countries like Austria, France, Germany and Japan. Manufacturing companies are moving to open factories in Brazil, China and India because of the availability of cheap manual labour and of technical skills in those countries.

Interest in pumped storage technology is on the rise, as this technology is used to capture higher power capacities during times of peak demand and conserve them for times of need of electrical power. The

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[20] Walid Al-Deghaili, ESCWA, *Developing Renewable Energy in the Arab Countries*, presentation for the Lebanon Sustainability Week, Beirut, June 2011.

[21] ESCWA, *Increasing the Competitiveness of Small and Medium-sized Enterprises through the Use of Environmentally Sound Technologies: Assessing the Potential for the Development of Second-generation Biofuels in the ESCWA region* (E/ESCWA/SDPD/2009/5).

[22] REN21, op. cit.

technology is used in China, Europe, Japan and the United States. In 2011, the total installed capacity ranged from 130 to 140 GW.[23]

(b) *Potential in ESCWA member countries*

Egypt, Iraq, Lebanon, Morocco, the Sudan, the Syrian Arab Republic and Tunisia use water resources for electricity production. There is potential to use the waters of the Nile River in the future, in the context of cooperation between Egypt, Ethiopia, and the Sudan (approximately 3,200 MW), in addition to cooperation with the remainder of the Nile Basin countries, with the potential of the Inga Dam in the Democratic Republic of the Congo estimated at 100,000 MW.[24] Lebanon's potential is limited to small plants.[25] With the exception of the waters of the Nile Basin, and in light of climate change and water scarcity in the region, it is difficult to use water resources to generate large amounts of energy, especially since it would be preferable to employ those resources for gravity-fed irrigation and to ensure that water consumption needs are met.

2. *Geothermal energy*

Geothermal energy is produced through cracks and faults in the Earth's crust. Groundwater seeps through these cracks and faults into the depths of the earth, where it comes into contact with high heat areas, is heated and rises to the surface, sparkling and heated. Heated groundwater can be used to generate electrical power using steam turbines. The total global capacity of geothermal power plants for electricity production came to around 11.2 GW by the end of 2011.[26]

(a) *Features of industry and market development worldwide*

The rate of geothermal energy use is affected by the dearth of skilled manual and technical labour, as well as by the unavailability of necessary equipment to drill into the Earth's depths, and the equipment utilized in the field of fossil fuel drilling, a further impediment to discovering additional high-heat sites.

The individual capacities of geothermal power plants range from 50 to 200 MW, with site development taking from five to seven years to declare fit for commercial production. The risks are exemplified by the fact that it is impossible to verify that the site is sound before drilling. American companies currently hold a monopoly in this industry, along with Japanese companies, which control roughly 70 per cent of the market of steam turbines for electricity production using geothermal energy.[27]

(b) *Potential in ESCWA member countries*

Some ESCWA member countries have possibilities that will enable them to use this resource to produce electricity. For instance, in Yemen, the temperature of some sites is estimated at around 295°C at a depth of 5,000 metres below the surface of the Earth, as is the case in Saudi Arabia (275°C) and Egypt (180°C). Studies show that exploitation of this resource is cost-effective for electricity production, if the temperature reaches 180°C at a depth of 5,000 metres.[28]

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[23] Ibid.

[24] ESCWA, *Enhancing Regional Cooperation in the field of Energy for the Achievement of Sustainable Development and the Millennium Development Goals in the ESCWA Region*, op. cit.

[25] Walid Al-Deghaili, ESCWA, *Developing Renewable Energy in the Arab Countries*, op. cit.

[26] REN21, op. cit.

[27] Ibid.

[28] German Aerospace Center and the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, Concentrating Solar Power for the Mediterranean Region, op. cit.

3. *Ocean energy*

Ocean energy encompasses electricity production using the energy of the waves, tides, and spring tides. Total installed capacity has attained roughly 0.5 GW in Spain, France, South Korea, Canada, the United Kingdom and China. With some rare exceptions, this technology has not become commercially widespread yet, and most projects remain pilot projects. Likely reasons for this may be the high cost of implementing the technology and the technical difficulty of running and maintaining equipment, which has to withstand the salinity of ocean water.

To date, ESCWA member countries have not shown any interest in assessing or using this resource.

Box 3. The economic aspect of electricity production projects using renewable energy sources

With the exception of hydropower and wind energy in some locations, the cost of investing in renewable energy projects remains high, in spite of how commercially widespread some applications have become. The cost of a unit of energy produced from the renewable source is one of the main factors that determine how widespread its use becomes and to what extent it is able to entice the private sector to get involved in the field. It is useful to estimate the investment cost of the combined capacity (kW) and the cost of producing a unit of energy (dollar cents/kWh). Table 5 gives a general overview of the typical characteristics, capital cost and cost of a unit of energy produced using various renewable energy sources in 2011.

TABLE 5. CAPITAL COST AND COST OF UNIT OF ENERGY PRODUCED USING RENEWABLE ENERGY SOURCES IN 2011

Source/Type of technology	Typical characteristics	Capital cost (dollar/kW)	Cost of unit of energy (US cents/kWh)
Wind power (onshore)			
• Small-scale power plants	Turbine size (kW): up to 100	3,000-6,000	15-20
• Large-scale onshore wind power plants	Turbine size (MW): 1.5-3.5 Rotor diameter (m): 60-110+ Capacity factor (%): 20-40	1,410-2,475	5.2-16.5
Wind power (offshore)	Turbine size (MW): 1.5-7.5 Rotor diameter (m): 70-125 Capacity factor (%): 35-45	3,760-5,870	11.4-22.4
Solar photovoltaic (rooftop)	Peak capacity: 3-5 kW (residential) 100 kW (commercial) 500 kW (industrial) Conversion efficiency (%): 12-20	2,480-3,270	22-44
Solar photovoltaic (ground-mounted utility-scale)	Peak capacity: 2.5-100 MW Conversion efficiency (%): 15-27	1,830-2,350	20-37
Concentrating Solar Power:			18.8-29
• Parabolic trough	50-500 MW Capacity factor (%): 20-25 (without thermal storage system)	4,500	
• Solar tower	40-50 (with thermal storage system for six hours) 50-300 MW	7,100-9,000	
• Parabolic dish	Capacity factor (%): 40-80 (with 6-15 hours thermal storage) up to 25 kW	6,300-10,500	

TABLE 5 (*continued*)

Source/Type of technology	Typical characteristics	Capital cost (dollar/kW)	Cost of unit of energy (US cents/kWh)
Biomass:			
• Plant running on stoker boiler/steam turbine	25-100 kW Conversion efficiency (%): 27 Capacity factor (%): 70-80	3,030-4,660	7.9-17.6
Other sources:			
• Hydropower			
○ Small capacity (off-grid)	0.1 kW-1 MW	1,175-3,500	5-40
○ Large capacity (grid-based)	10-18,000+ MW; - Plants with more than 300 MW - Plants with less than 300 MW Capacity factor (%): 30-60	 Less than 2,000 2,000-4,000	5-10
• Geothermal power • Ocean energy (tides)	1-100 MW Capacity factor (%): 60-90 Capacity factor (%): 23-29	 2,100-6,100 5,290-5,870	 5.7-10.7 21-28

Source: REN21, op. cit.

Box 4. Factors affecting the definition of the cost of the unit of energy produced from renewable sources

The differentiation in the cost of the unit of energy produced using wind energy generally (land or sea) is owed to a number of factors, among them the location and the topography of a given site, as well as its temperature and humidity; in addition to the wind structure and its average speed in a year; the rise in the cost of building offshore wind plants, taking into account the particular requirements in terms of turbine bases, cables used and drilling equipment, construction and the cost of maintenance. The differences in the cost of a unit of energy produced using solar power (photo/thermal) at its lowest and upper extremes are attributed to a number of factors, including the density of solar radiation on the project site; the humidity and temperature at the site and the geographical nature of the site; the need for batteries/storage system or connection to the electrical grid; and the cost of construction and maintenance. Other factors that affect the cost of a unit of energy produced using renewable sources include the existence of official regulations, policies, or incentives to promote renewable energy; the availability of financing needed for the given project and sources thereof; the cost of the project; the degree of risk; taxes and customs fees; the cost of labour; the rate of inflation; the percentage of local components; the cost of connection to the electrical grid; the level of technical maturity of the technology being used; the profit margin rate required to implement it; the competition factor; and political and administrative efficiency.

II. THERMAL AND MECHANICAL APPLICATIONS FOR DIRECT USE OF RENEWABLE ENERGY SOURCES

Using renewable energy sources to produce electricity remains difficult as a result of the drop in production efficiency and the technical loss, which occur as a result of the transfer and storage of electrical energy and its conversion to mechanical or thermal energy. Therefore, it is more useful to use renewable energy sources to produce thermal or mechanical energy for direct use, without passing through electrical energy. Biomass, solar, geothermal and wind technologies can be used in the form of thermal or mechanical energy without passing through electrical energy, in order to meet heating, cooling, water pumping and vehicle-related (transport sector) needs. A number of ESCWA member countries are benefiting from the use of some of these resources, contributing to reducing gases that cause global warming and mitigating climate change.

A. BIOMASS APPLICATIONS

Biomass is a source of energy whose applications are used worldwide. Heat derived from burning organic waste is used for cooking, heating water and heating in rural and remote areas. Modern biomass energy is utilized to produce heat and for industrial purposes. Statistics show that the combined global capacity for heat production amounted to approximately 290 thermal GW by the end of 2011.[29]

1. *Features of industry and market development*

The European continent is the chief user of modern biomass energy for heating purposes, through the use of biofuel and wood pellets (forest residues and compressed agricultural waste) as fuel for electricity and heat production plants; and for large-scale use in the residential and commercial sectors.

Use of agricultural waste as fuel is a widespread phenomenon in many countries, particularly developing countries. It is a source of biogas used as cooking oil and heating through limited and medium-capacity anaerobic digestion in rural areas.

The role of biomass in the transport sector is growing demonstrably, through (1) the use of biogas/methane for means of transport (trains, buses and vehicles) in some countries; (2) the use of liquid biogas: (a) ethanol, produced from agricultural crops, particularly corn and sugar cane. In 2011, total global production reached 86 million m^2. The United States and Brazil contribute 63 and 24 per cent of that amount, respectively, followed by China, France and Germany; (b) biodiesel fuel produced from oleaginous plants and their residues and animal fats. In 2011, total global production of biodiesel fuel reached approximately 21 billion litres. Germany and the United States are on the list of countries that produce biodiesel, in addition to Argentina, Brazil and France. 2011 also witnessed the opening of two biomass exchanges in the Netherlands and the United States; these exchanges will operate in all areas related to biomass and biomass equipment.[30]

This type of biofuel is known as first-generation biofuel. It is mostly used for land transport after it is mixed with vehicle fuel. At the global level, it amounted to roughly 3 per cent of vehicle fuel in 2011. There is also an interest in using it in the air transport sector, with some commercial airlines (including the Mexican, Finnish, Thai, German and Royal Dutch airlines) mixing it with jet fuel and using it on their flights.

The characteristics of ethanol and gasoline/benzene are similar, as are those of biodiesel and diesel made from oil in terms of specific gravity. There is a limit to the permitted level of the ethanol or biodiesel

[29] REN21, op.cit.

[30] Ibid.

mix with benzene or diesel when these are used as fuel for traditional vehicles. It must not exceed 10 per cent; if it does, as is the case in Brazil where it reached 25 per cent, some modifications must be made in the engine components and design.[31]

Fuels classified as second-generation include biofuel produced from plants rich in oil and sugar, like jatropha and cassava, as well as fuel produced from certain farming waste, like straw, wood and grass. They are used by means of organic chemistry and thermochemical technologies, which remain in the research and development stage. Third-generation biofuel is produced from algae and hydrogen generated from the use of technologies that convert biomass to hydrogen. Technologies in this area also remain in the research and development stage and are not as commercially widespread since investment costs went up.

2. *Potential in ESCWA member countries*

There are no official statistics on the extent of use of biomass energy in ESCWA member countries. However, it is generally certain that in rural and remote areas, wastes are used for cooking and heating, either by burning them directly or in isolation from air in order to produce charcoal. Some projects are carried out in a number of countries to get biogas from agricultural and animal waste, solid waste recycling and treatment for sanitation in Egypt, Jordan, the Sudan, the Syrian Arab Republic and the United Arab Emirates. Great prospects exist for exploiting this resource in countries with agricultural production, such as Egypt, Iraq, Jordan, Lebanon, Morocco, Palestine, the Sudan, the Syrian Arab Republic, Tunisia and Yemen.

The official position of ESCWA member countries enforces the use of organic waste to produce biofuel, and avoiding the production of crops for biofuel instead of food, due to the scarcity of water and limited arable land. The Arab Ministerial Declaration on Climate Change warns of the consequences of the encouragement of developed countries to cultivate agricultural crops that produce biofuel instead of food, and explains how doing so could exacerbate the global food crisis. The ESCWA study titled “Policies and Measures to Promote Sustainable Use of Energy in the Transport Sector in the ESCWA Region”, published in 2011, cited the use of biofuel in the transport sector.

B. SOLAR HEATING AND COOLING SYSTEMS

Solar heating and cooling technology relies on the conversion of solar radiation to thermal energy that is used to heat water or for heating or cooling indoor spaces or heating swimming pools, along with other applications that require low to medium temperatures to operate. These kinds of applications can be used in residential or non-residential buildings, as well as in some industrial or agricultural processes, which may lead to savings in traditional energy use for these purposes, such as electricity, gas and other products derived from oil.

In most cases, water serves as the medium for heat transfer. However, some solar systems use air as the medium for heat transfer, especially those used in the different applications of desiccating processes. The following table lists the systems that use water as the medium for heat transfer.

[31] ESCWA, *Energy Policies and Measures for Promoting Climate Change Mitigation in ESCWA Member Countries,* op. cit.

TABLE 6. APPLICATIONS FOR SOLAR HEATING OF WATER AND BASIC COMPONENTS OF VARIOUS SYSTEMS USED

Temperature in degrees Celsius for use	20 30	40 50 60	70 80 90	100 >100
End-use	Heating of swimming pool water	• Heating of sanitary water; • Heating of indoor air or spaces; • Various industrial uses.	• Heating of indoor air or spaces; • Single-stage solar cooling systems; • Industrial/desalination uses.	• Industrial uses requiring elevated temperatures; • Multi-stage solar cooling systems.
Areas and sectors related to the end-use	Public and private swimming pools (especially outdoor pools)	• Hotels, tourism establishments, restaurants; • Hospital centres, sporting and leisure establishments, public baths; • Food manufacturing plants.	• Office buildings, shops and other buildings; • Industrial establishments.	• Office buildings, shops and other buildings; • Industrial establishments.
Type of solar panel normally used	Solar panels made of flexible plastic materials instead of glass (without a cover)	• Flat glass panels (normal or selective coating); • Medium-efficiency vacuum tubular panels.	• High-efficiency vacuum tubular panels.	• Concentrating Solar Radiation panels; • High-efficiency vacuum tubular panels.
Type of solar systems and water heating and recirculation mechanisms	Water recirculation systems using mechanical pumping, and water tank is a swimming pool	• Individual heater using thermal siphon or a related set of this kind of individual heaters: water recirculation occurs without resorting to pump, and the water tank is part of the individual heater; • The combined solar heating systems have a water tank that is separate from the solar panels that use mechanical pumping to recirculate water between the solar panels and the water tank/tanks.	• Combined solar heating systems rely on an independent water tank, and water recirculation using mechanical pumping.	• Combined solar heating systems rely on an independent water tank, and water recirculation using mechanical pumping.
Observations	Outdoor swimming pools are heated in fall and spring	Use of single-use solar heaters is the most widespread throughout the world.	Single heaters cannot be used in this manner.	It is possible to use a thermal liquid besides water when needed.

Solar heating technologies for water and heating are among the most widely used applications of renewable energy in the world, with an estimated global capacity of 232 thermal GW by the end of 2011, an increase of 27 per cent over 2010 levels.[32]

1. *Solar heating systems*

Solar water heating technology is widespread in many developed and developing countries, given its simplicity and ease of use, in addition to the fact that the necessary equipment can be manufactured locally. Heating water using solar energy is one of the most widespread and most feasible applications from an economic standpoint, especially in ESCWA member countries, where the required temperature (45 to 65°C) can be attained easily using solar flat panels covered with glass or medium-efficiency vacuum tubular panels. Any solar heating system consists of five main components:

- A part that ensures the conversion of solar radiation into thermal energy, basically made up of solar panels;

- A part that ensures the transfer of heat that was captured to the storage site, which is made up of a group of heat channels, pumps and exchangers;

- A part that ensures the storage of the heat that was collected and transferred, made up of water tanks heated using thermal energy produced by solar panels;

- A back-up apparatus that ensures the availability of the thermal energy that the solar system did not provide, in order to continue in service even in the absence of sufficient solar energy. It is suggested that this apparatus should be separate from the panel-based solar heating cycle, so that it does not diminish its efficiency and so that the emergency reserve energy source is used only if absolutely necessary;

- A part that ensures the distribution of heated water to the various points of final use thereof, basically made up of distribution channels and a recycling pump or pumps.

Two types of solar systems are used to heat water:

(a) Systems that use a device or group of devices provided by the factory, individual devices built in particular sizes, which contain a combination of the first three mechanisms listed above, with the back-up device as an optional feature. The most widespread of these systems is the thermal siphon system for solar heating, a device that collects heat from the solar panel or panels and the hot water tank as well as channels that link the two in a single device used either individually for domestic uses or connected with a group of individual devices to provide heated water for mass use;

(b) Systems set up based on need, using the structure of the solar system and the sizes and specifications of its four component parts: the solar panels, the channels that link back to the tank and the required pumping and heat conversion devices, the hot water tank or tanks, and the backup heat device. The design of these systems is based on:

- Defining the needs of the project monthly, daily and weekly;

- Determining the required temperature at final use;

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[32] REN21, op. cit.

- Determining the percentage of solar energy required to meet the needs of the use intended, based on the economic and financial data of the project, in order to enable the solar system to provide the most economically favourable situation for the project owner;

- Determining the size of the solar panel fields and the hot water pump or pumps needed to provide the share of solar energy used and thus determining the size and specifications of the remaining components.

These combined systems are used based on need for all uses that require a certain amount of thermal energy, including water heating, solar cooling and industrial processes.

The panel on the solar collector is the main component of the solar cooling system. There are two main types of these panels that use liquids as their heat conductor: (1) (vertical) flat collectors, the most widely used kind, consist of a thermally insulated metal box (bottom and sides), with a glass cover behind the surface that absorbs solar radiation and that is plated with a black coating or with a selectively absorbent coating that enables the surface to convert a high percentage of solar radiation into thermal energy, minimizing heat loss from the surface. This surface is permeated by metal tubes (copper/aluminium) in which a liquid flows that is used as a heat conductor (usually water); (2) vacuum tubular collectors: these consist of several parallel rows of glass tubes made up of a single or double layer of glass. The vacuum inside the tube contains a surface that absorbs solar radiation, and that is plated with a selectively absorbent coating, and it contains a metal tube through which a heat conductor flows. There are no fewer than five types of these vacuum tube collectors, with an efficiency that ranges from medium (at a temperature below 120°C relative to the heat conductor) to high (with a temperature that reaches up to 200°C relative to the heat conductor). These kinds of panels are used to attain high temperatures.

The second heat reservoir tank is the most important component of solar systems, and it is used to conserve heat that has been collected in the form of hot water. This heat tank is made of a rust-resistant material. Internally plated with a coating (from within) resistant to chemical erosion, it can retain its properties in the highest possible hot water temperatures. The tank is insulated thermally from outside, and an external cover is placed on it that can maintain its thermal insulation. Then, the quality of the material out of which the tank was made and the quality of the inside coating, the thickness of the heat insulation and the quality of its external cover, will all determine the quality of the tank and affect its potential longevity. As for the sizes of a single tank, they range from 100 to 500 litres for factory-made individual systems and from about 800 to 10,000 litres for custom-made systems.

On the other hand, and despite the technical maturity of the use of solar energy for water heating required in industrial processes, this application is still not widely used in the industrial sector for commercial purposes globally.

(a) *Features of industry and market development*

China is the global leader in solar water heating (118 thermal GW), dominating the solar heating equipment market; its aim is to meet the needs of the local Chinese market and to export (to developing countries in particular). Germany leads the European industrial market. As for ESCWA member countries, the market is growing in Egypt, Jordan, Morocco, Palestine, the Syrian Arab Republic and Tunisia. Table 7 illustrates the cost of energy used for solar water heating.

TABLE 7. COST OF A UNIT OF ENERGY ACCORDING TO THE USES OF EQUIPMENT FOR SOLAR WATER HEATING

Technology	Typical specifications	Cost of unit of energy (US cents/thermal kWh)
Solar water heaters (horizontal solar collector/vacuum tube solar collector system)	(1) Small size (home heater): 2-5 m^2;	2-20
	(2) Medium size (water heating for several families/medium-sized system): 20-200 m^2;	1-15
	(3) Large size (large-sized systems/central heating): 0.5-2 thermal MW (vacuum tubes).	1-8

(b) *Potential in ESCWA member countries*

The Arab region enjoys an abundance of solar energy resources. Since the 1980s, a number of Arab countries have had an interest in spreading the use of solar water heating systems for household and service uses. As far as household use goes, Palestine is the regional leader, with solar heaters in use in 70 per cent of houses (some 67.7 per cent of them on the West Bank; 90 per cent of them manufactured locally).[33] Statistics show that there are 1.5 million m^2 of solar water heating systems in service.[34] In Jordan, there is about a million m^2 of combined solar heating systems in the residential and commercial sectors. Egypt contains around 650,000 m^2 of combined solar collectors; the Syrian Arab Republic has some 2,000,000 solar heaters (equal to about 500,000 m^2 of solar collectors). Tunisia contains over 400,000 m^2 of solar collectors and is expected to reach the 750,000 mark by 2014. In Morocco, there are some 240,000 m^2 of solar systems, and around 200,000 in Lebanon, where a facilitated financing mechanism to support the spread of solar heater use was established, with the aim of reaching a million m^2 of solar heating systems by 2020. Libya aims to extend solar collectors to a surface of 40,000 m^2. In the Arab Gulf, Saudi Arabia, in whose mountain regions several applications are proliferating, carried out the initial operation of a system with a capacity of 30 thermal MW to provide heated water and heat to a site that accommodates nearly 40,000 university students.[35]

In 1981, the Arab Organization for Specifications and Measurements, an affiliate of the Arab Industrial Development and Mining Organization of the League of Arab States formed a technical commission on solar energy. This commission published five standard specifications for flat solar heaters and six standard specifications on solar water heating systems for house use.[36] Legislation, regulations, policies and incentives were put in place in a number of countries to support the spread of use of solar water heaters. Egypt, Jordan, Lebanon, Morocco, Palestine and Tunisia have developed specifications concerning these heaters, which led to the establishment of companies for local manufacture and import from abroad. There is great potential for establishing an integrated regional market for the manufacture of solar heaters.

The following two countries apply solar water heating technology in industrial processes: (1) Egypt, which implemented two pilot projects on solar heating for industrial processes, with lost heat recovery systems (60°C) in the food production industry and the textile industry in the early 1990s. The third project

[33] Nader Bitar, Union of Chambers of Commerce, Manufacturing and Agriculture, presentation titled “Sound measurement? Investment prospects, a promising investment horizon”, delivered at the conference on Renewable Energy Investment in Palestine, held on 30 March 2012.

[34] Regional Centre for Renewable Energy and Energy Efficiency, Newsletter, Issue No. 7, Cairo, June 2011.

[35] REN21, op. cit.

[36] Regional Centre for Renewable Energy and Energy Efficiency, *Description of the Current Situation of Standard Specification and Reliability of Water Heating Systems and Solar Energy in the Member Countries of the Regional Centre for Renewable Energy and Energy Efficiency*, 2010.

is a medium-temperature (175°C) trial in the pharmaceutical industry,[37] which began operations in the past decade; and (2) Jordan, which implemented a water heating project in the dairy industry.[38]

2. *Solar cooling systems*

The idea of solar cooling relies on the use of solar heat in cooling devices that run on heat, by means of a system made up of solar collectors (flat or vacuum tube), a tank, a control unit, pipes and pumps connected to the cooling mechanism. The cooling system usually operates at three temperature levels, namely: (1) high heat, in order to provide the needed temperature to operate and as an additional source of heat (a gas stove or other) if necessary; (2) low heat, for cooling operations; (3) medium heat, in order to dispose of the heat produced by the water cooling cycle and the heat generated by operation using the cooling tower.[39] The following three techniques are used to employ the solar heat for cooling:

- Absorption chiller: This technology is based on a closed cooling cycle that uses a liquid solution that consists of two elements: the cooling medium and the material that absorbs it, like water and bromide lithium or ammonia/water. While those two elements are used commercially, the first solution is used more in absorption chillers;

- Adsorption chiller: This technology is based on a closed cooling cycle and adsorption of the cooling medium on the surface of a material that is easy to penetrate, such as water or silicon gel which is used in most adsorption chillers in wide commercial use;

- Desiccant cooling: This system is based on an open cooling cycle to desiccate the air by using desiccated solid (mostly silicon gel) or liquid materials (mostly solution Water/lithium chloride), then it is cooled through vaporization by raising the degree of humidity, and the desiccated air passes directly through a cooling cycle. Given that, when this technique is used in an open cycle, a cooling medium is released into the air to raise the degree of humidity, and water is the only liquid used for that purpose.[40]

Some recent trials involving the use of solar energy for cooling employed compressors used for cooling and heating, which are highly efficient and commercially available, and connected them to the photovoltaic cell system to supply them with electricity (some minor changes to the cooling devices to enable them to use a direct electrical current). These systems operating on compressors are known for their high efficiency, which approaches five times the efficiency of other absorption and adsorption thermal devices, and may reach a total overall efficiency in converting solar energy to its ultimate aim (cooling or heating) exceeding the efficiency of other thermal systems. It is always possible to use generated and excess electrical energy by absorbing it into the electrical grid, though excess thermal energy generated in thermal systems is usually disposed of.

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[37] New and Renewable Energy Authority, Egypt, Annual Report 2006/2007.

[38] ESCWA, *Development of New and Renewable Energy Uses*, Abstract (5), 2002.

[39] European Solar Thermal Industry Federation, *Solar Assisted Cooling- State of the Art*, 2006.

[40] Ibid.

TABLE 8. COMPARISON BETWEEN CLOSED AND OPEN COOLING CYCLE IN SOLAR COOLING TECHNOLOGIES

Open cycle		Closed cycle		Mechanism
Frozen water exposed to weather		Closed		Solidification cycle
Used on desiccated air and cooling by evaporation		Used on cooled water		Principle
Liquid	Solid	Liquid	Solid	Absorption stage
Water – Calcium Chloride; Water – Lithium Chloride.	Water – Silicon; Water – Lithium Chloride.	Water – Water/Lithium Bromide; Ammonia/Water.	Water – Silicon gel	
About to arrive on the market	Dry cooling	Absorption cooler	Adsorption cooler	Commercially widespread technology
-	20-350 kW (typical)	Absorption cooler: 15 kW-5 MW.	Adsorption cooler: 50-430 kW.	Typical cooling capacity
>1	0.5->1	0.6-0.75	0.5-0.7	Factors for typical performance
45-70°C	45-95°C	80-110°C	60-90°C	Operating temperature
Flat surface collectors; air collectors	Flat surface collectors; air collectors	Vacuum tube	Vacuum tube; flat surface collectors	Solar collector

(a) *Features of industry and market development*

Solar cooling and heating technology has not spread worldwide yet, and its applications are almost exclusively limited to hotels, lodging facilities and others, and large plants in Europe.

(b) *Potential in ESCWA member countries*

Despite the availability of a wide range of uses of solar cooling technology in the ESCWA region, in buildings and some food industries (such as the dairy industry), in the agriculture and health sectors (in rural and remote areas to preserve vaccines), the use of solar energy for cooling has only spread to a limited extent, in the United Arab Emirates and Kuwait, where some private companies are working to develop and spread the use of solar cooling technology. In this area, the Emirati company Masdar, established in 2010, stands out for its cooperation with other companies, for its launch of experimental solar systems for cooling office spaces with a surface area of 1,700 m^2 in Masdar city, and thereby curbing roughly 70 tons of carbon dioxide emissions yearly, through a system that, it was decided, would be evaluated over a period of two years.[41] Qatar is planning to use solar energy to cool stadiums and supporter areas during the World Cup that it is to host in 2022.[42]

In spite of the importance of this application as a tool for combating climate change, particularly in the countries of the Arab Gulf with hot climates, it has not garnered sufficient interest, perhaps on account of government subsidies for the price of electrical energy at the consumer level, and the fact that this technology is not yet widespread globally.

C. DIRECT USE OF GEOTHERMAL ENERGY

This resource can be used for water storage when it is close to the surface of the earth or as hot springs where the temperature reaches approximately 65°C, provided the cost of extraction and use is reasonable and that it can be used within some other industrial and agricultural fields through direct heating.

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[41] Masdar Company: http://www.masdar.ae (11 December 2012).

[42] Raya Newspaper: http://www.raya.com/site/topics/printArticle.asp?cu_no=2&item_no=632527&version=1&template_id=35&parent_id=34.

In 2011, direct use of geothermal energy was estimated at around 58 thermal GW. This direct heat is used to heat water for household use and industrial purposes, to dry crops and to melt snow, and 78 countries use it.[43]

Despite the limited prospects for use of this resource in some ESCWA member countries, including Egypt, Saudi Arabia and Yemen, no projects have been implemented in this area to date.

D. USE OF MECHANICAL WIND POWER FOR PUMPING WATER

Wind energy has been in use for some time. It can be used to pump water when wind speeds range from 2.5 to 3 m/s, blowing at a rate not below 60 per cent of the time. It would require the installation of a wind turbine in a place with no hindrances on a tower that stands 4.5 to 6 metres above ground level.[44]

Small-capacity wind turbines, which can be manufactured locally, have been developed to simplify their use and maintenance. For instance, wind rope pumps, which are linked to the modern wind turbine, can be used. They operate at wind speeds of 3.5 m/s and above and are lightweight (a third of the weight of traditional air pumps). Moreover, they can reach depths ranging from 25 to 45 metres, and water flow ranging from 25 to 50 litres per minute (depending on the engineering design and the amount of water required), and they feature a manual reserve system that operates in the absence of wind. The cost of a unit ranges from US$450 to US$800.[45]

The use of windmills to pump water is one of the oldest renewable energy applications used throughout the Arab region. This technology is characterized by its simplicity and ease of operation and maintenance, and it does not require elevated wind speeds. Egypt,[46] Jordan and the Syrian Arab Republic have experience in the operation of wind turbines to pump water and have done studies in this area. There is strong potential in ESCWA member countries to spread the use of this application, along with manufacturing capabilities in some countries that can be bolstered through knowledge transfer.

Box 5. Renewable energy applications that can be spread throughout ESCWA member countries

Solar water heating in the residential and service sectors is one of the applications best suited to the Arab region, which possesses manufacturing capacities, technical expertise and successful practices, as well as public awareness of the importance of solar heating. In order to spread these applications, it is necessary to develop mechanisms in order to facilitate financing; strengthen research and development activities in order to improve the product, reduce the cost of production and stimulate the market to generate demand; provide a methodology and integrated programmes to train and equip engineers, manufacturers and workers in charge of assembly and maintenance, in order to establish a national industry reliant on a supportive environment; strengthen regional cooperation on unifying standard specifications, exchanging expertise related to thermal performance efficiency trials, operation of solar heating systems and issuing regionally recognized certificates of use and then proceeding to the large-scale production stage; and publish information on best practices and lessons learned. Maximizing the use of wind energy is possible by spreading the use of (a) small-capacity wind turbines (less than 100kW) to pump water (as a dual system alongside a traditional system or with a renewable source like solar power); (b) wind rope pumps, which are known for their technical simplicity, ease of use and maintenance and their low cost, all of which make them suitable for rural and remote areas, taking into account the possibility of local manufacturing, as they do not entail large investment costs and can be commercially spread through provision of a reasonable financing mechanism to encourage the small investor to participate. ESCWA carried out an integrated training project to manufacture solar water heating devices, in cooperation with the Lebanese Solar Energy Society and the Lebanese Industrial Research Institute. Over the course of the project, which ran from 2009 to 2012, training sessions were held. In 2009, ESCWA also collaborated with them on the publication of a brochure, "Factory Guide to Solar Heating Devices, Solar Flat Panels".[*]

[*] ESCWA, Lebanese Solar Energy Society, *Factory Guide to Solar Heating Devices, Solar Flat Panel*, Beirut, 2009.

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[43] REN21, op. cit.

[44] www.samsamwater.com.

[45] http://ecosustainablevillage.com.

[46] Euro-Mediterranean Renewable Energy Partnership, Small-scale wind turbines for water pumping and electricity generation (in Egypt), http: www.hy-pa.org.

III. POTENTIAL FOR REDUCING EMISSIONS PRODUCED BY ELECTRICITY GENERATION IN THE ESCWA REGION

Work can be done in several areas to reduce carbon dioxide emissions in ESCWA member countries. In the energy sector, this calls for improving efficiency in production, transport, distribution and consumption; expanding the use of natural gas and using renewable energy applications, in addition to employing carbon capture and storage technologies and producing electricity using nuclear energy.

This chapter addresses the potential for contributing to reducing the severity of climate change in ESCWA member countries, by reducing carbon dioxide emissions that result from electricity generation plants in those countries, based on the following truths:

(a) Emissions of warming gases that cause global warming and climate change have many sources, chief among them (at the global level) the electricity production sector, whose global share amounts to 21.3 per cent, followed by industrial operations (16.6 per cent), the transport sector (14 per cent), agricultural production (12.5 per cent), fossil fuel energy extraction and distribution (11.3 per cent), housing and the commercial sector (10.3 per cent), biomass combustion and exploitation of lands (10 per cent) and waste (3.40 per cent).[47] The electricity sector in ESCWA member countries contributes approximately 38 per cent of emissions;[48]

(b) The electricity sector in ESCWA member countries is unique in that it relies to a degree of about 90 per cent on thermal production from fossil fuel. The average efficiency of thermal power plants ranges from 21 per cent in the Sudan to 40 per cent in Egypt;[49]

(c) The electricity sector in ESCWA member countries is undergoing rapid growth, and projected statistical figures compiled by the Arab Union of Electricity in 2011 indicate that the total amount of electrical energy produced in these countries in 2020 will amount to approximately 216 per cent of the 2011 total;[50]

(d) Power plants can reduce the emissions produced while supplying the needs of the electrical grid by adopting a production efficiency improvement policy, using natural gas, using renewable energy sources to produce electricity, through carbon capture and/or using nuclear energy to produce electricity. It is expected that electricity generation in thermal power plants will continue to rely on fossil fuels for several decades in ESCWA member countries, which own 56.8 per cent of confirmed raw petroleum reserves and 26.15 per cent of confirmed natural gas reserves on the planet;[51]

(e) While most ESCWA member countries have succeeded in providing electricity services to nearly 100 per cent of their citizens, 50 per cent of the population of Yemen and 75 per cent of that of the Sudan (most of them in rural and remote areas) still go without these services. It is possible to meet their electricity needs using renewable energy sources, while at once achieving economic, social and environmental development;

(f) Any real effort on the part of the electricity sector to reduce emissions produced by electricity generation, such as a unified decision to use renewable energy sources, will have positive effects, given the central nature of such a decision, the existence of a specific authority to assume its implementation, and the importance of reviewing policies for pricing and subsidizing traditional energy. Reducing emissions in other

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[47] ESCWA, *General perspective on climate change mitigation in the field of energy* (E/ESCWA/SDPD/2010/IG.1/4(Part I)).

[48] ESCWA, *Producing electricity from renewable energy*, Beirut, 2010, E/ESCWA/SDPD/2010/IG.1/4(Part II).

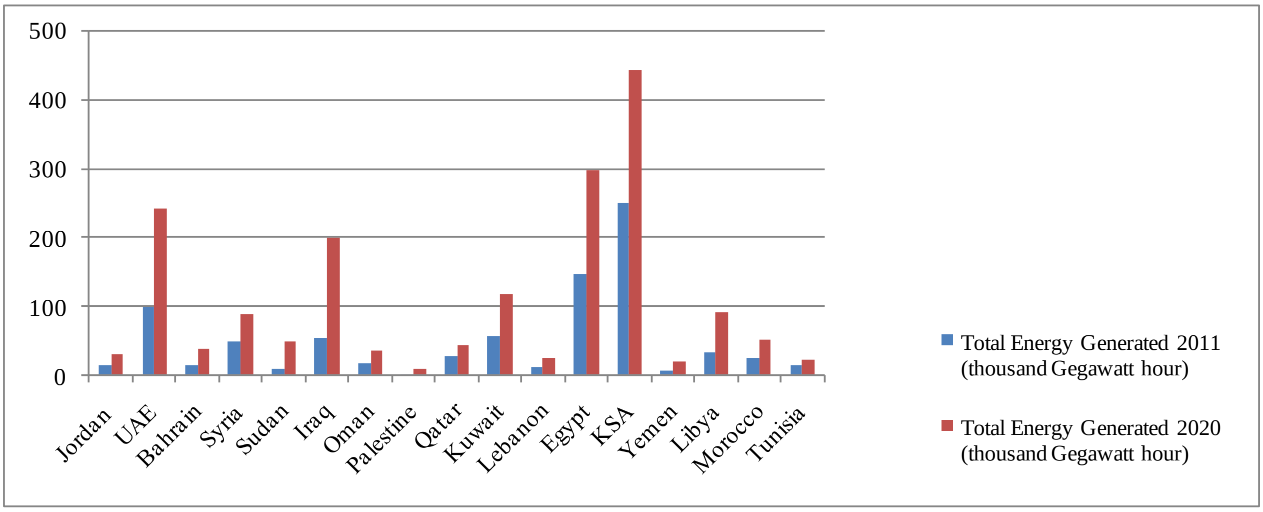
[49] ESCWA, *Enhancing energy efficiency in the electricity sector in the ESCWA region* (Arabic), (E/ESCWA/SDPD/2010/Technical Paper.4).

[50] Arab Union of Electricity, *Statistical Bulletin*, 2010 and 2011.

[51] Organization of Arab Petroleum Exporting Countries (OPEC), *Annual Statistical Report 2011*.

sectors (the residential sector, service sector and agricultural sector) will require convincing millions of users with varying cultural, economic and social levels of the need to do so, in addition to redoubling efforts made by various authorities and companies and coordinating among them, a task that is not without difficulties.

Figure 12. Amounts of electrical energy in ESCWA member countries (2011 and 2020)



A. Carbon dioxide emissions produced by the electricity sector in ESCWA member countries in 2010

Table 9 shows the amounts of electrical energy produced by various sources in ESCWA member countries in 2010 according to statistics compiled by the Arab Union of Electricity.

TABLE 9. ELECTRICAL ENERGY PRODUCED BY VARIOUS SOURCES (2010)

Country	Electrical energy produced by thermal power plants (GWh)	Electrical energy produced from renewable sources (GWh)	Total electrical energy produced (GWh)
Bahrain	13,230	-	13,230
Egypt	124,786	13,996 (hydropower, wind sources)	138,782
Iraq	44,140	4,766 (hydropower source)	48,906
Jordan	14,713	64 (hydropower, solar, wind sources)	14,777
Kuwait	57,029	-	57,029
Lebanon	10,374	837 (hydropower source)	11,211
Libya	32,559	-	32,559
Morocco	18,391	4,290 (hydropower, wind, solar)	22,681
Oman	14,597	-	14,597
Palestine	431	-	431
Qatar	26,362		26,362
Saudi Arabia	239,892	-	239,892
Sudan	1,241	6,275 (hydropower source)	7,498
Syria	43,809	2,604 (hydropower source)	46,413
Tunisia	14,632	189 (hydropower, solar, wind sources)	14,821
United Arab Emirates	88,184	-	88,184
Yemen	6,400	-	6,400
Total	**750 752**	**33 021**	**783 773**

Source: Arab Union of Electricity, *Statistical Bulletin 2010,* No. 19, Jordan.

After calculating the amounts of carbon dioxide produced by burning various kinds of fossil fuels in traditional thermal power plants to produce electricity, the outcome of production of every kW per hour of these emissions was determined, in light of the following data:

Carbon dioxide emissions produced by burning a kilogram of diesel oil = 3.2033 kg; that resulting from burning a kilogram of heavy fuel oil = 3.143 kg; that resulting from burning a kilogram of natural gas = 2.6993 kg; that resulting from burning a kilogram of black coal = 2.6 kg.

TABLE 10. CARBON DIOXIDE EMISSIONS FROM THERMAL POWER PLANTS FOR ELECTRICITY GENERATION IN ESCWA MEMBER COUNTRIES IN 2010

	Heavy fuel oil (in thousands of tons)	Diesel oil (in thousands of tons)	Natural gas (in thousands of tons)	Carbon dioxide emissions from heavy fuel oil (in thousands of tons)	Carbon dioxide emissions from diesel oil (in thousands of tons)	Carbon dioxide emissions from natural gas (in thousands of tons)	Total amounts of carbon dioxide emissions (in thousands of tons)	Carbon dioxide emissions resulting from the generation of kWh (tons)
						Total	516,250	
Bahrain	0	0	3 431	0	0	9 264	9 264	700
Egypt	6 059	171	18 633	19 085	546	50 308	69 940	560
Iraq	4 180	4 930	5 109	13 167	15 775	13 794	42 736	968
Jordan	906	99	2 055	2 855	318	5 548	8 722	593
Kuwait	9 500	1 152	4 537	29 925	3 686	12 251	45 862	804
Lebanon		-	-	-	-	-	7 697	742
Libya	1 692	3 521	3 025	5 331	11 266	8 168	24 765	761
Morocco	1 224	29	0	3 856	93	0	15 424*	839
Oman	0	0	4 095	0	0	11 058	11 058	758
Palestine	0	83	0	0	267	0	267	620
Qatar	-	-	-	-	-	-	16 291	618
Saudi Arabia	22 439	10 529	15 489	70 684	33 894	41 820	146 398	610
Sudan	42	179	59	133	573	160	867	709
Syria	3 919	12	5 337	12 344	39	14 409	26 792	612
Tunisia	1	1	3 197	2	3	8 632	8 632	590
Emirates	1 240	4 326	21 367	3 905	13 842	75 629	75 438	855
Yemen	1 242	272	486	3 912	871	1 312	6 094	952

* Includes 11,474 thousand tons produced by power plants running on black coal.

Figure 13. Amount of carbon dioxide emissions produced by generation of kilowatts per hour of electricity in ESCWA member countries

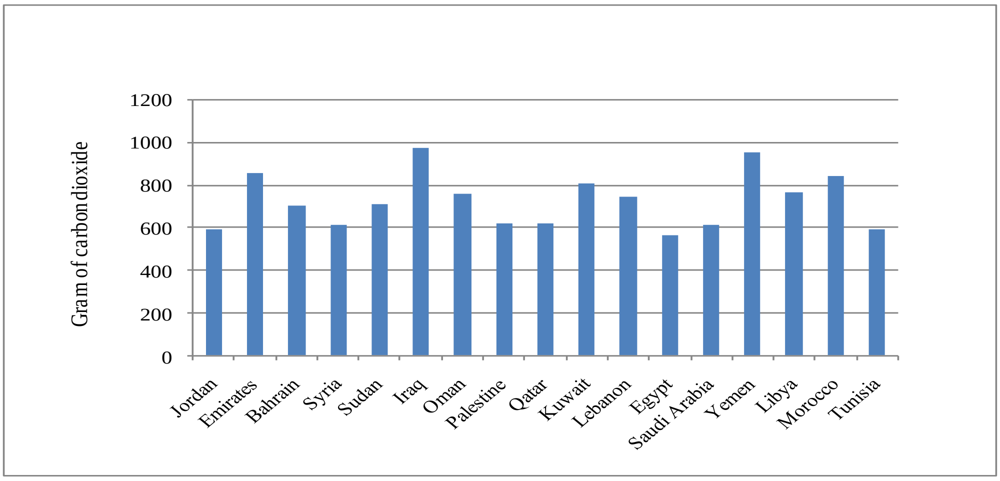


Table 10 and figure 13 demonstrate that emissions per kW per hour are lowest in Egypt (at 560 grams of carbon dioxide per kWh), Tunisia (at 590 grams) and Jordan (593 grams), as a result of use of natural gas as fuel and of the participation of combined cycle power plants (whose efficiency could reach 60 per cent) in electricity generation and in supplying the electrical grid.

B. REDUCTION OF EMISSIONS BY GENERATING ELECTRICAL POWER USING RENEWABLE ENERGY SOURCES

No carbon dioxide is emitted as a result of electricity production using renewable sources. However, manufacturing equipment to produce electricity from these sources (hydropower, wind energy, solar energy...), transporting this equipment to the power plant sites and carrying out the civil engineering works and excavation and reinforced concrete do result in carbon dioxide emissions. Nevertheless, the amount of emissions varies depending on the sources and the means of production of electrical power in the country that is manufacturing the equipment; the supplies and the steel structures (nuclear energy, renewable energy or traditional thermal energy from fossil fuels); the means used to transport this equipment, supplies and structures; the distance between manufacturing centres and plant sites; the nature of the land on which the plants are built (on land or at sea in the case of wind power); and the technology used.

The amounts of carbon dioxide are being reassessed, and distributed among the amounts of energy expected to be produced during the lifespan of technologies to generate electricity from renewable sources, in order to calculate the amount of carbon dioxide produced from the generation of a kW per hour of electricity by means of these technologies.

TABLE 11. CARBON DIOXIDE EMISSIONS RESULTING FROM THE PRODUCTION OF ONE KILOWATT PER HOUR OF ELECTRICAL ENERGY (ESTIMATED FIGURES)

Source/Type of technology	Estimated emissions (gram of carbon dioxide/kWh of electricity)		
	Source A	Source B	Source C
Wind power		9-25	2
• Use of wind turbine with a capacity of 1.5 MW (onshore);	9		
• Use of wind turbine with a capacity of 2.5 MW (offshore).	10		
Solar power		60	
• Thermal solar power plant using parabolic trough technology (80 MW);	13		17
• Photovoltaic solar system (polycrystalline silicon cells).	32		9
Hydropower		8	
• Hydropower plant with a capacity of 3.1 MW and water storage;	13		
• Small hydropower plant 300 kW.	10		
Nuclear power	66	--	5
Fossil fuel			
• Combined cycle power plant using natural gas;	443		403
• Conventional thermal power plant using diesel oil/heavy fuel oil.	778		

Sources: ELSEVIER, *Energy Policy 36 (2008),* 2940-2953. Science et vie, *Le dossier noir des energies vertes,* Mars 2008. International Energy Agency, Energy Technology Perspectives 2010, Scenarios and Strategies to 2050.

These estimates are not precise and can vary from case to case. Therefore, calculating the amount of emissions generated by electricity production from renewable energy sources is globally overlooked, in that emissions resulting from the manufacture of equipment are calculated within the rubric of the manufacturing sector, and those resulting from transport processes fall under the rubric of the transport sector, while those that result from reinforced concrete are calculated within the cement industry. The manufacture of equipment for traditional power plants that run on fossil fuels and the transport and assembly thereof produce emissions that are ignored when the emissions produced by electricity generation are calculated, and so the only emissions accounted for are those resulting from the burning of fossil fuel in these processes.

C. PREDICTED AMOUNTS OF EMISSIONS PRODUCED BY ELECTRICITY GENERATION

The estimates of electricity institutions and companies in ESCWA member countries, which are members of the Arab Union of Electricity, the organization that published those estimates, make it clear that the amount of electrical energy that is expected to be produced in 2020 to meet the steady increase in consumption will increase by large percentages, which range from 43 per cent in Tunisia and 532 per cent in the Sudan, with an average total estimated at 129 per cent.

TABLE 12. PROJECTED RATES OF INCREASE IN ELECTRICITY PRODUCTION 2010-2020 AND CARBON DIOXIDE EMISSIONS RESULTING FROM 1 KW PER HOUR IN ESCWA MEMBER COUNTRIES (2010)

Country	Total electricity production in 2010 (GWh)	Total electricity production in 2020 (GWh)	Percentage of increase in electrical power from 2010 to 2020	Carbon dioxide emissions resulting from production of one kWh of electricity (2010)
Bahrain	13 230	37 796	185	700
Egypt	138 782	297 941	115	560
Iraq	48 906	200 000	309	968
Jordan	14 777	29 625	100	593
Kuwait	57 029	116 055	103	804
Lebanon	11 211	23 108	106	742
Libya	32 559	89 516	175	761
Morocco	22 681	49 890	120	839
Oman	14 597	35 850	145	758
Palestine	431	8 135	179	620
Qatar	26 362	43 380	64	618
Saudi Arabia	239 892	443 825	85	610
Sudan	7 498	47 372	532	709
Syria	46 413	88 490	90	612
Tunisia	14 821	21 170	43	590
United Arab Emirates	88 184	242 619	175	855
Yemen	6 400	17 663	176	952
Total	783 773	1 792 439	128.7	

In light of the above, the carbon dioxide emissions expected to be produced by electrical power generation processes in 2020 were calculated according to the following scenarios:

SCENARIO 1

Assumptions and data

- The share of renewable energy in the energy mix remains at 2010 levels;

- No programmes are adopted to improve the efficiency of electrical power production or to expand the use of natural gas. Accordingly, the carbon dioxide emission factors (amount of carbon dioxide yielded by electricity generation, in grams per kW per hour generated) remain at their same level in each country;

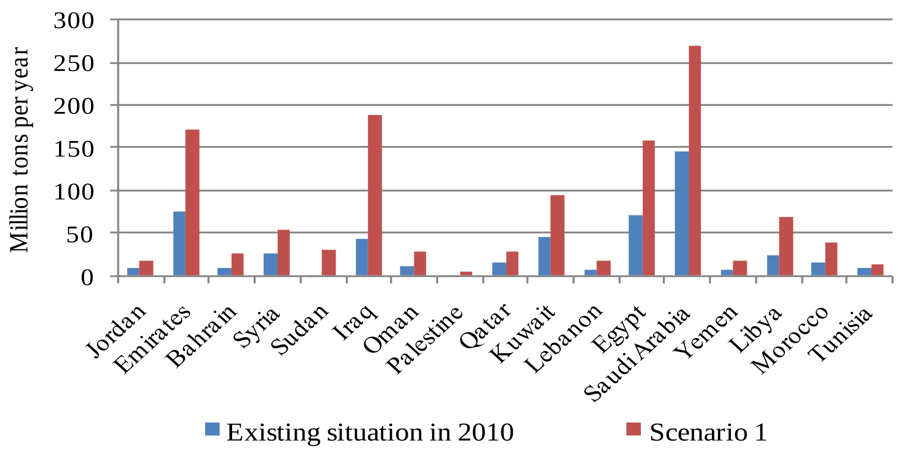
- In the United Arab Emirates, electrical power production using nuclear energy begins. An agreement is concluded with a Korean equipment company regarding four production groups with a capacity of 4 x 1,600 MW, agreed to and with a decision to begin service during the period 2017-2020 to generate an output of 42,000 GW per hour of electrical energy yearly[52] without carbon emissions.

[52] E/ESCWA/SDPD/2010/I.G1/4(Part I).

Result

In this scenario, the total amount of emissions in 2020 comes to 1,208 million tons, as opposed to approximately 516 million tons in 2010, for an increase estimated at 134 per cent.

Figure 14. Anticipated carbon dioxide emissions resulting from electricity generation in ESCWA member countries in 2020, compared to 2010 (Scenario 1)



SCENARIO 2

Assumptions and data

- ESCWA member countries commit to achieving the declared goals regarding the share of renewable energy in the national energy mix by 2020, as follows:

TABLE 13. DECLARED GOALS OF ESCWA MEMBER COUNTRIES REGARDING THE SHARE OF RENEWABLE ENERGY IN ELECTRICAL POWER GENERATION

(13A) GOALS DECLARED IN THE ARAB STRATEGY FOR DEVELOPING THE USE OF RENEWABLE ENERGY (2011)

Country	Declared goals	Period
Egypt	20 per cent of electrical power	2020
Jordan	10 per cent of primary energy	2020
Kuwait	5 per cent of electrical power	2020
Lebanon	12 per cent of electricity and heat production needs	2020
Libya	10 per cent of electrical power 25 per cent of electrical power	2020 2030
Morocco	27 per cent of electrical power (the initially declared figure is for available electrical capacity and equals 42 per cent)	2020
Sudan (without hydropower generation)	1 per cent of total electricity produced	2011
Syrian Arab Republic	4.3 per cent of primary energy	2020
Tunisia	4 per cent of primary energy	2014
United Arab Emirates	7 per cent of electrical power	2030

Source: Secretariat of the Arab Ministerial Council for Electricity, Arab Strategies to Develop the Uses of Renewable Energy, op. cit.

(13B) GOALS SPECIFIED IN REPORTS AND STUDIES

Country	Declared goals	Period
Bahrain	5 per cent of electrical power from renewable sources	2030
Kuwait	In 2011, an official from the Ministry of Electricity and Water announced that an attempt would be made to allot 10 per cent of electrical power produced to production from sustainable resources	2020
Oman	Contribution of renewable energy sources amounts to 10 per cent of energy demand	2020
Palestine	Gradually attain 240 GWh (minimum) of electricity from renewable energy sources, which would amount to 10 per cent of electrical capacity produced locally	2020
Saudi Arabia	Planning to establish 5 GW solar plants, thus achieving the objective of allotting a 6-7 per cent share of total combined capacity to renewable energy	2020
Tunisia	16 per cent of electrical power 40 per cent of electrical power	2016 2030

Sources: Imen Jeridi Bachellerie, Gulf Research Center, *Renewable Energy in the GCC Countries, Resources, Potential and Prospects,* op. cit. *General Renewable Energy Strategy for Palestine,* 2012.

Accordingly, the contribution of renewable energy sources to electricity production in 2020 is estimated below, assuming that the countries that have not declared plans in this area will continue to produce electrical power at current levels:

(13C) RENEWABLE ENERGY SHARE IN ELECTRICITY PRODUCTION

Country	Renewable energy share (in percentage)
Bahrain	2.50
Egypt	20
Iraq	-----
Jordan	5
Kuwait	10
Lebanon	12
Libya	10
Morocco	27
Oman	5
Palestine	3
Qatar	-----
Saudi Arabia	2.50
Sudan	1% in addition to hydropower
Syrian Arab Republic*	3
Tunisia**	22.85
United Arab Emirates	3.5
Yemen	-

* These estimates are based on the objective declared in the strategy, which is 4.3 per cent of primary energy.

** The figures declared are taken from the Tunisian solar programme for the years 2016 and 2030, hence the percentage calculation for the year 2020.

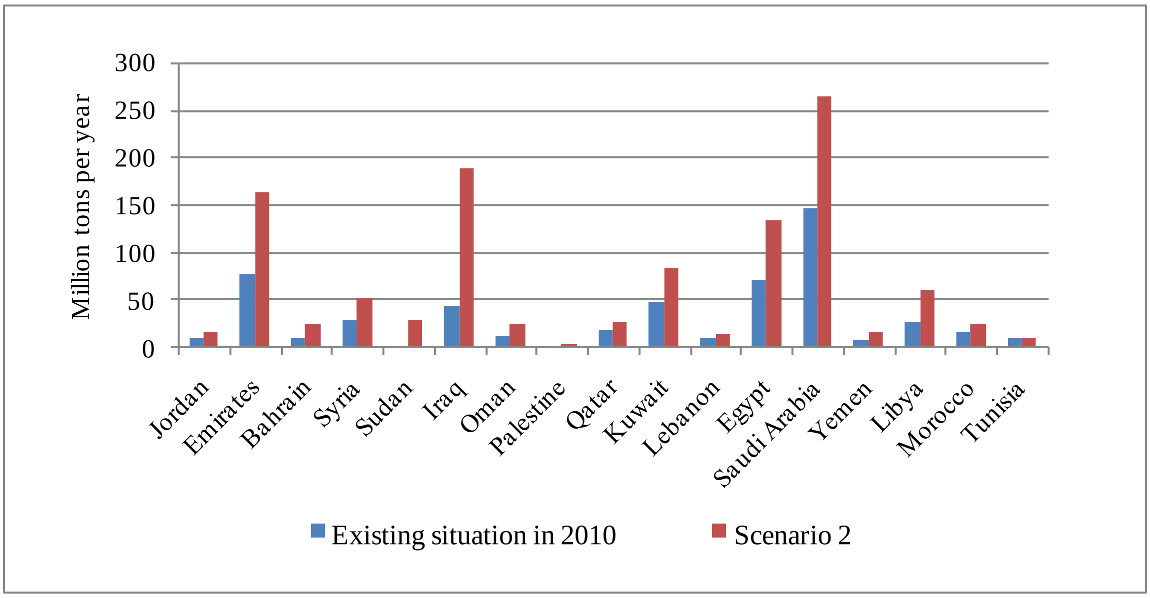
- The efficiency of electrical energy production in power plants that do not expand their use of natural gas will not improve emissions per kWh. Emissions will remain at 2010 levels;

- According to scenario 1, it has been decided that electrical energy will be produced using nuclear energy in the United Arab Emirates.

Result

The total amount of carbon dioxide emissions produced as a result of electricity generation in ESCWA member countries in 2000 is estimated at approximately 1,150 million tons, an increase of 123 per cent over 2010 figures.

Figure 15. Anticipated carbon dioxide emissions resulting from electricity generation in ESCWA member countries in 2020, compared to 2010 (Scenario 2)



SCENARIO 3

Assumptions and data

- Countries will not commit to their declared objectives on increasing the renewable energy share of electrical power production in 2020; amounts are to remain at 2010 levels;

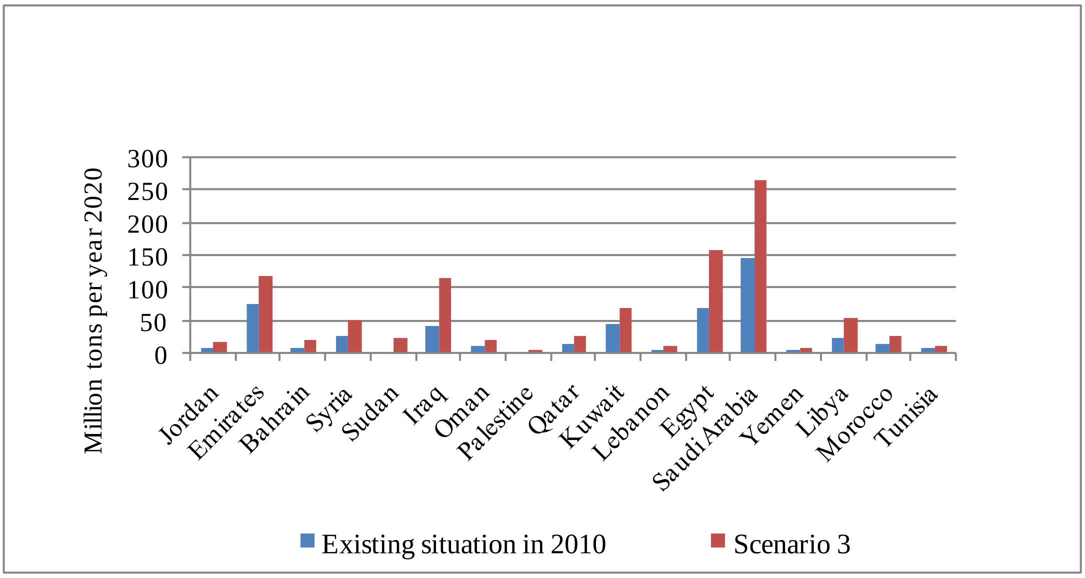
- The use of natural gas is expanded through the construction and outfitting of new generation combined cycle power plants with large capacities, taking measures to improve the efficiency of energy production, in terms of reducing emissions generated by the production of a kW per hour of electricity in traditional thermal power plants to 600 grams per kW per hour. This level can be reached, except in Egypt, Jordan and Tunisia, where current levels (which are better than this benchmark) are supposed to hold at 593 grams in Jordan, 590 grams in Tunisia and 560 grams in Egypt;

- Electricity production from nuclear power in the United Arab Emirates will proceed according to scenarios 2 and 3.

Result

The total amount of carbon dioxide emissions produced by electricity generation in ESCWA member countries in 2020 is estimated at approximately 1,019 million tons, amounting to an increase of roughly 97 per cent over 2010 levels.

Figure 16. Anticipated carbon dioxide emissions resulting from electricity generation in ESCWA member countries in 2020, compared to 2010 (Scenario 3)



SCENARIO 4 (BEST-CASE SCENARIO)

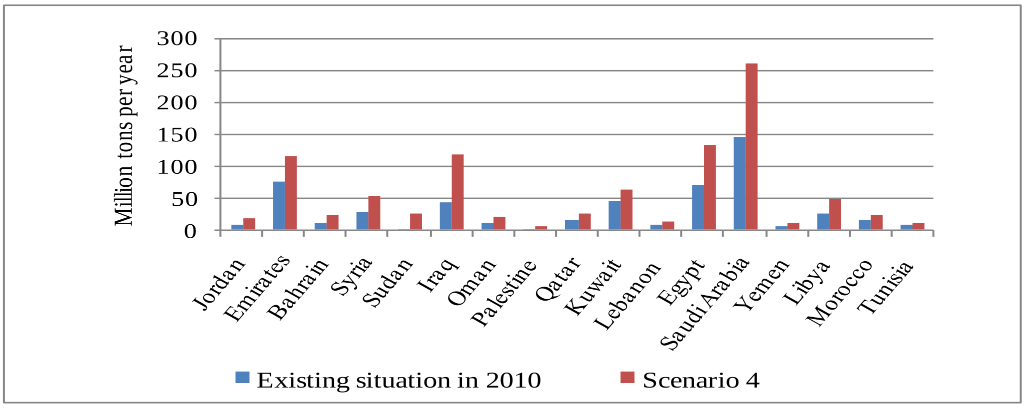
Assumptions and data

- Commitment to the declared goals regarding the use of renewable energy sources (Scenario 2);
- Improved efficiency in energy production, and noticeable expansion in the use of natural gas (Scenario 3);
- The United Arab Emirates produce electrical energy using nuclear power (Scenario 1).

Result

By 2020, total carbon dioxide emissions in ESCWA member countries are estimated at approximately 958 million tons, amounting to an increase of approximately 76 per cent over 2010 levels.

Figure 17. Anticipated carbon dioxide emissions resulting from electricity generation in ESCWA member countries in 2020, compared to 2010 (Scenario 4)



The results of the four scenarios are summarized below:

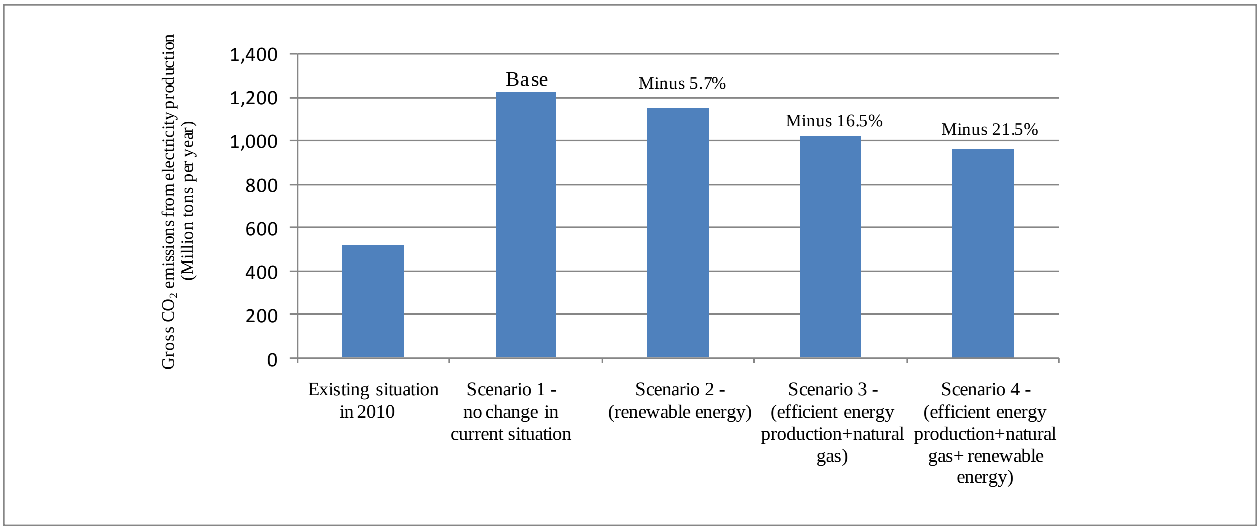
TABLE 14. COMPARISON OF THE FOUR SCENARIOS AND ANTICIPATED DEVELOPMENT FOR THE PERIOD 2010-2020

	2010	2020	Increase (in percentage)*
Total electrical energy (1,000 MW per hour)	783,773	1,792,439	129
Electrical energy from traditional thermal sources (1,000 MW per hour)*	750,752	Scenario 1 – 1,717,418	129
	1,612,655	Scenario 2 – 1,603,510	115
	1,717,418	Scenario 3 – 1,717,418	129
	1,612,655	Scenario 4 – 1,603,510	115
Carbon dioxide emissions (million tons)	516	Scenario 1 – 1,220	136
		Scenario 2 – 1,150	123
		Scenario 3 – 1,019	97
		Scenario 4 – 958	86

* These figures include the amounts of electrical energy produced using nuclear energy (non-traditional thermal energy) and estimated at roughly 42,000 GW per hour yearly.

Table 14 shows that the annual percentage of increase in emissions in the first and second scenarios exceeds the percentage of increase in the overall amounts of electricity generated, since most countries that register a higher increase in electricity generation in the period spanning 2010 to 2020 currently produce relatively higher levels of carbon dioxide emissions upon production of each kW per hour of energy (Bahrain, Iraq, the Sudan, the United Arab Emirates and Yemen).

Figure 18. Comparison between the four scenarios (2010-2020)



The above information makes it clear that efforts have not been made to improve the efficiency of electrical energy production and to use natural gas, nor have renewable energy applications been taken advantage of; thus emissions are due to increase by a percentage exceeding the percentage of increase in electrical energy generated. However, with a reasonable effort, the emissions produced by the electricity sector can be reduced by over 21 per cent by 2020. Nevertheless, even in scenario 4, the best-case scenario, carbon dioxide emissions are expected to increase by 186 per cent over 2010 levels. This means that electrical energy will increase by 129 per cent while emissions increase by only 86 per cent.

In these scenarios, the difficulties of reducing emissions in ESCWA member countries in the coming years emerge, given the anticipated increase in the amounts of electrical energy required to meet development needs. For this reason, it is incumbent upon all to assist those countries in financing, technology transfer and localization, with the ultimate aim of facilitating the improvement of energy efficiency and using renewable energy applications, carbon capture and nuclear energy.

For this reason, it was understandable that the Arab Ministerial Declaration on the United Nations Conference on Sustainable Development (Rio+20) adopted by the Arab ministers for environmental affairs on 18 April 2012 would call on “developed countries to fulfil the commitment to support developing countries to achieve sustainable development by providing adequate funds to support the transfer and localization of appropriate technology and enable developing countries to develop their own technologies and build capacities in line with their national priorities (...) reaffirm the right of Arab countries to diversify energy sources including new and renewable energy and nuclear energy for peaceful uses to achieve sustainable development in the Arab region and commend the achievements that have been made so far”.

IV. POTENTIAL FOR LOCAL MANUFACTURE OF RENEWABLE ENERGY EQUIPMENT USED TO PRODUCE ELECTRICITY

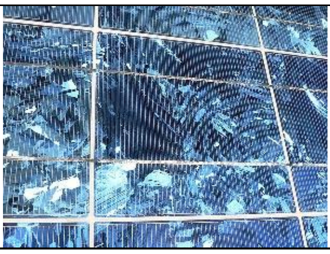
In ESCWA member countries, the cost of producing a unit of electrical energy generated from renewable sources is affected by the cost of manufacturing electricity generation equipment from these sources, which, in turn, directly affects the extent to which the use of renewable energy for electricity production spreads. Renewable energy projects, with their relatively high investment cost, constitute a burden on Governments, institutions and public electricity companies in these countries. For this reason, it is necessary to address the matter of local manufacture of equipment, as one of the elements of green manufacturing, and to discuss the role of the private sector in this matter, which may improve the projects' economies, create new job opportunities and establish a regional market for the equipment whose localization is called for.

Local manufacture of renewable energy equipment to produce electricity contributes to the sustainable development process in ESCWA member countries through the following: creating job opportunities and new sources of income for citizens; strengthening domestic economies and improving the balance of payments; reducing the cost of building plants that produce electricity from renewable energy sources; the emergence of an industrial society versed in renewable energy technologies; interest in the appropriate specifications for local circumstances; insulation, to the extent possible, from the global crises that may exert pressure on domestic economies.

A. LOCAL MANUFACTURE OF COMPONENTS OF SOLAR PHOTOVOLTAIC SYSTEMS

The manufacture of a solar cell depends on silicon, which is found in sand. The material is extracted and converted to wafers by means of a number of chemical and electrical processes, and becomes a solar cell that may be either monocrystalline or polycrystalline (figure 19).

Figure 19. Solar cells



Grade colour polycrystalline cell

Uniform colour monocrystalline cell

Source: http://ar.wikipedia.org/wiki.

Another kind of cell, namely, thin-film cells, is the third most widely used kind, after crystalline silicon cells. Their manufacture entails silicon deposition in thin layers on a glass or plastic surface. This kind of cells varies, according to the connector material in use, knowing that its degree of efficiency (which ranges from 6 to 10 per cent) is less than that of the crystalline cell (between 13.5 and 17.5 per cent), its price is lower, and it is suitable for limited-capacity applications.[53]

Solar cells (wafers) are combined within a unit placed in a reinforced aluminium frame on a metal holder. The wafers are combined in panels tied together in a system that feeds into a current inverter, a charge regulator and a storage battery (in cases involving an isolated system).

In a number of ESCWA member countries, the manufacture of assembly components of solar cell systems is spreading, and research is being done on them, with local companies doing assemblage and maintenance.

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[53] ESCWA, *Energy Policies and Measures for Promoting Climate Change Mitigation in ESCWA Member Countries*, op. cit.

TABLE 15. LOCAL CONTRIBUTION TO EQUIPPING ELECTRICITY GENERATION PLANTS CONTAINING PHOTOVOLTAIC SYSTEMS

Item	Current situation	Vision
Civil and electromechanical work: • Equip the site, internal roads; • Build metal carrying bases; • Annex buildings (workshops, warehouses, residential and administrative buildings); • Assembly and connection to the grid; • Operation and maintenance. Consultative projects: • Feasibility studies including environmental studies	National companies are entrusted with assembly, operation and maintenance works locally, in Algeria, Egypt, Jordan, the Sudan and Tunisia.*	- Facilitate access of consultative offices and national companies eligible to tender bids. - *Short-term goal*: Grant the national consultative office the opportunity to participate in choosing the site and feasibility studies with a foreign consultant in order to share expertise; carry out engineering design or collaborate on it.
Metallic frame (galvanized steel, aluminium brackets)	Manufactured in some countries.	- *Short-term goal*: Achieve integration among countries.
Glass cover of unit	Glass is manufactured in many countries.	- *Short-term goal*: Achieve integration among countries.
Cables and conductors	Manufactured in most ESCWA member countries.	
Charge regulator, current inverter	Manufactured in most ESCWA member countries.	- *Short-term goal*: Achieve integration among countries.
Silicon wafers	- Imported; - It has been decided that the private sector in Saudi Arabia will cooperate with a Korean company to build a factory for the production of roughly 3,350 metric tons of polycrystalline silicon panels per year; - In October 2011, a Qatari company declared that it had signed a contract to build a factory to produce polysilicon in Qatar, at a value of approximately US$1 billion, in order to produce 8,000 metric tons of high-purity polycrystalline polysilicon per year, in the initial phase. Implementation is slated for completion in the second half of 2013.	Local manufacture depends on the following: (1) average yearly demand expected within a given time period; (2) wafer manufacture technology transfer; (3) production line; (4) connecting research and development to manufacturing process; (5) building national technical capacity; (6) coordination. *Medium-term goal*: Achieve integration among countries. Cooperation among countries must be based upon integration among them.
Batteries (in cases of electrical storage)	Manufactured in several ESCWA member countries.	*Short-term goal*: Achieve integration among countries.

* Secretariat of the Arab Ministerial Council for Electricity, *Guide on Potential of Arab States for Renewable Energy and Raising the Efficiency of Energy Production and Consumption*, Cairo, 2011.

B. LOCAL MANUFACTURE OF COMPONENTS OF CONCENTRATING SOLAR POWER SYSTEMS

Parabolic trough thermal solar power plants are the most widely used CSP technology on Earth, in terms of their components and potential for local manufacture. This technology is used in thermal solar power plants in Morocco (470 MW)/2010, Algeria (150 MW), and Egypt (140 MW)/2011. Given the presence of plans for the implementation of CSP projects with a total capacity that comes to 2,700 MW, through 2020 or 2030 in ESCWA member countries, particularly in the case of the Moroccan Solar Plan, which aims to establish solar power plants with a capacity that amounts to approximately 2,000 MW in 2020,[54] the possibility of locally manufacturing some components of these plants must be discussed, given that they are the most widespread.

A parabolic trough thermal solar power plant typically consists of:

(a) Solar field: consists of several parallel rows of parabolic trough collectors with a north-south axis. The dimensions of the high and low edges of the collector range from 5 to 5.77 metres, the collector matrix length is 150 metres and consists of four reflective mirrors made of glass sheets (4-5 mm thick) that contain a minimal amount of steel, to minimize the loss in absorption of solar radiation, and are coated with a layer of reflective silver, and several coats to protect the back surface of the mirror;

(b) Metal support structures (steel/aluminium): placed on the foundations to stabilize the solar collectors;

(c) Receiver: placed on the focal axis of the solar trough collectors. The receiver is an evacuated linear/longitudinal glass tube with a high degree of transmissivity for solar radiation. Inside it is an absorber made of steel coated with a given material in order to absorb most solar radiation, with the lowest level of thermal loss. It contains a heat transfer fluid (oily liquid/soluble salts), and the steel and glass tubes are connected;

(d) Solar tracking system: stabilized by the matrix of concentrators that rotate on their longitudinal axis from east to west to receive solar radiation;

(e) Heat exchanger: connected to both the solar field and the thermal plant to receive the heating liquid and to heat water in order to produce steam (at a temperature ranging from 400 to 500°C);

(f) Thermal power plant (steam turbine, generator, condenser, pumps, heat exchangers);

(g) Thermal storage system (optional): to store heat during the day and for use to produce electricity at night, particularly at peak evening times. It operates based on the idea that the heat transfer fluid in the solar field heats the molten salts in the tank by means of heat exchangers, in order to transfer the heat to the conductor fluid in the absence of sunlight. Heat storage materials vary. Molten salts (the most widespread), synthetic oil, sand or concrete may be used. Storage capacity can reach several hours at the desired temperature when operating at full load.

Equipping CSP electricity generation plants to integrate their primary activities requires: (1) civil works, equipping the site and building foundations for the collectors; (2) parabolic trough receivers; (3) mirrors; and (4) production and assembly of metal structures.

[54] ESCWA, *Local Manufacturing of Renewable Electricity Equipment, Potentials and Prospects in the Arab Region*, op. cit.

TABLE 16. POTENTIAL FOR LOCAL CONTRIBUTION TO EQUIPPING THERMAL SOLAR POWER PLANTS CONTAINING THE PARABOLIC TROUGH TECHNOLOGY WITH THE THERMAL STORAGE SYSTEM

Item	Current situation	Vision
- Civil and electromechanical works: • Site preparation, internal roads; • Build metal structure foundations; • Annex buildings (workshops, warehouses, residential and administrative buildings); • Thermal component. - Installation and connection to the grid - Consultative works (feasibility and environmental studies) - Installation, operation and maintenance of thermal solar plants	- National companies carry out local works in Egypt, Algeria and Morocco, and they can take part in engineering design for the project. - Several countries have a great deal of expertise in building, connecting, operating and maintaining thermal plants. - Several countries have a great deal of experience in technical, financial and environmental areas. - Algeria, Egypt and Morocco have considerable experience in this area.	- Facilitate access to consultative offices and national companies eligible to tender bids. - Work on giving national consultative offices an opportunity to participate in choosing the site and the feasibility studies with the foreign consultant in order to share expertise. - Need to strengthen cooperation between local and foreign companies in the areas of engineering design, development of project execution, plant design and financing structure. - Need for leading countries to provide technical support during the project initial operating period. *Short-/Medium-term goal*: Work on sharing expertise in the area of maintenance and analyzing malfunctions.
- Receiver	- This technology is of a high level and requires expertise not available in the Arab countries.	- Only two countries on the global market hold a monopoly in this field, namely Solel Solar and Schott Solar AG & Sys. - *Uncertain/Long-term goal*: The establishment of a local industry, definition of the yearly rate of demand, large investments, high-level technical expertise and technology transfer.
- Mirrors	- There is a base for the glass industry in Algeria and Egypt.	- This requires the establishment of a production line to attain profit, and large demand (150,000 tons of glass per year). Twelve companies participate in this industry worldwide. - *Medium- and long-term goal*: knowledge transfer.

TABLE 16 (*continued*)

Item	Current situation	Vision
- Metal structures and connectors - Some electrical and electronic equipment (used in solar tracking systems)	- There is an industrial base in Algeria, Egypt and Morocco. - There is a base for the manufacture of some of the components used in other industries. - A number of ESCWA member countries manufacture electrical and mechanical components (distribution boards, cables, converters).	- Algeria, Egypt and Morocco possess expertise in metal structure manufacturing. - *Short- and medium-term goal*: Develop the existing electronic manufacturing and the use of relevant software to manufacture solar tracking systems.
- Thermal component	- There are installation companies in a number of ESCWA member countries.	- *Short- and medium-term goal*: Gradually increase the percentage of local components in light of the demand within the context of the metallurgical industries.
- Assembly of parabolic trough components	- Existing expertise requires technical support (a national company was tasked with the implementation of civil works, assembly, setup of the solar field for the thermal solar plant project in Egypt, in cooperation with foreign experts).*	- Apply comprehensive quality standards to national companies. - Work towards establishing cooperation between national companies and consultative offices and foreign ones specializing in sharing of expertise. - Facilitate the access of national consultative offices and companies eligible to tender bids in ESCWA member countries.
- Thermal storage (optional)	- There is no engineering or manufacturing expertise, but it is possible to contribute to local works (civil and electromechanical).	- *Medium- and long-term goal*: knowledge transfer is required.

* New and Renewable Energy Authority, *Annual Report 2010/2011*, op. cit.

C. LOCAL MANUFACTURE OF WIND ENERGY EQUIPMENT COMPONENTS

There is increasing interest in wind energy in ESCWA member countries, as evinced by the drafting of a wind atlas in several of these countries, including Egypt, Jordan, Libya, Morocco, the Syrian Arab Republic, Tunisia and Yemen. Large-capacity wind plants have also been built and connected to the national grid in Egypt, Morocco and Tunisia. Several countries are planning to use wind energy in electricity production, such as Jordan, the Syrian Arab Republic, the United Arab Emirates and Yemen, in addition to Egypt, where the industrial activity in the wind power equipment area is under way. Listed below are the components of wind turbines, the current manufacturing capacity, and the future vision for the development of this industry.

Wind turbine components[55]

- Tower: Cylindrical in shape, made of steel, installed on a reinforced concrete foundation. Blades are placed on it to take advantage of increase in wind speed with increased elevation;

- Blades: The highest tower is stabilized on a horizontal axis of rotation. Each turbine usually contains three blades (made of fibreglass). Set at a variable angle of rotation, the blades run on conversion of the speed of the wind energy into the kinetic energy of rotation;

- Hub: The part that the blades are installed on. The hub is connected to the main rotation axis. The hub has a cover made of fibreglass or steel and is used to protect the internal parts from dust, sand and rain;

- Nacelle: Placed on the highest tower and contains:

    - Transmission, considered as a link between the low speed shaft and the gear box (high speed shaft);

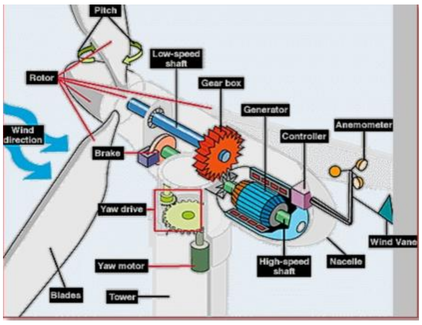
    - Gear box to operate the generator;

    - Air brakes to reduce the rotation speed when the turbine stops regularly or in an emergency. A hydraulic system is used to direct the level of blade rotation of the turbine so as to make it parallel with the direction of the wind in case the turbine contains a control system in the pitch. When the rotation stops, the blade surface operates vertically in the path of the wind;

    - Mechanical brakes are used as a back-up system for the air brake system in the event that a turbine without a control system in the stall stops;

    - Systems to ensure that the turbine operates safely, and the control panel.

Figure 20. Main components of a wind turbine



The cost of the following main elements in manufacturing wind energy equipment is distributed as a percentage of the total cost (by way of guidance) in the following manner: turbine tower (8 per cent); turbine components in blades, gear box, generator, control systems, brakes, main shaft and nacelle body as well as other components (55 per cent); civil and electromechanical works (21 per cent); control unit (1 per cent); spare parts (3 per cent); cargo and transfer to the site (6 per cent); engineering design, procurement, testing, operation, commissioning (5 per cent); training (1 per cent).[56]

[55] ESCWA, *Local Manufacturing of Renewable Electricity Equipment, Potentials and Prospects in the Arab Region*, op. cit.

[56] Ibid.

TABLE 17. POTENTIAL OF LOCAL MANUFACTURING TO EQUIP WIND POWER PLANTS

Item	Current situation	Vision
Civil and electromechanical works: - Site preparation, internal roads; - Build turbine foundations; - Annex buildings (workshops, warehouses, residential and administrative buildings); - Assemble and connect to the grid (consultative offices in most countries work in this area); - Consultative work (prepare studies about the site soil and topography and environmental studies; electrical and mechanical consulting).	- There are national construction companies in Algeria, Egypt, Morocco and Tunisia;* - Consultative offices in this field exist in several ESCWA member countries.	*Short- and medium-term goals*: - Facilitate access for national consultative offices and companies eligible to tender bids on projects; - Grant opportunities to national consultative offices to participate in choosing the site and preparing feasibility studies with a foreign consultant in order to share expertise and participate in engineering design.
Manufacture of metal tower	- There is a national industry in several ESCWA member countries.	- *Short-term goal*: Achieve integration among countries.
Control panel	- There is an electronics industry in several ESCWA member countries.	- *Short-term goal*: Achieve integration among countries.
Electrical equipment (cables, distribution panels, transformers, kiosks)	- There are factories in most ESCWA member countries.	
Blades	- Wind turbine blades are manufactured for a capacity of 100 and 300 kW in Egypt. It was not possible to increase the turbine capacity.	*Short- and medium term goals*: - Determine the capacity required annually; - Determine the turbine capacity for a given time period; - Undertake arrangements for technology transfer.
- Mobile container parts: • Gear box; • Brakes; • Mechanical and electrical parts; • Protection systems.	- There is an industrial base in several ESCWA member countries.	*Short- and medium-term goals*: - Determine the capacity required annually, and undertake arrangements for technology transfer; - Begin manufacturing of some electrical and mechanical parts, after agreeing on technology transfer arrangements.

* Secretariat of the Arab Ministerial Council for Electricity, *Guide to Possibilities of Arab States in Renewable Energy and Improving the Efficiency of Energy Production and Consumption*, op. cit.

D. BARRIERS TO ESTABLISHING A LOCAL INDUSTRY FOR SOLAR AND WIND ENERGY EQUIPMENT FOR ELECTRICITY PRODUCTION

The following is a list of the major barriers that hinder the establishment of a local industry for electricity production equipment using solar and wind energy in ESCWA member countries.

1. *Legislative and institutional barriers*

- The absence of interest in restructuring the electricity sector in some countries, which has an impact on how efficiently this sector performs, and reduces the chances of the private sector to implement electricity production projects using renewable energy, thus reducing the demand for the necessary equipment.

- Limited legislation regarding the spread of the use of renewable energy (linkage to the grid, the provision of State land to investors at nominal prices, commitment to purchasing the energy produced, exemption of renewable energy applications equipment from customs fees).

- The absence of official decisions to ensure that government bids are tendered on solar and wind energy projects as additional points in favour of offers that include a specified percentage of locally manufactured products.

- A lack of strong legislation and institutional working frameworks to support the manufacture of renewable energy equipment (need to establish a chamber of industry for renewable energy equipment, put in place effective customs and tax policies, reduce taxes on wind turbine manufacturers, commit to observe standards and codes, and provide facilities for exporters of renewable energy equipment).

- The absence of an official framework to govern the relationships, oversight and follow-up between all relevant parties, including the granting of production licences and reviewing contracts (the Government, the public and private sectors, the industry, the grid operator, producer/distributor/importer of renewable energy equipment, the consumer).

- Incapacity of functioning frameworks that ensure the establishment of partnerships between the public and private sectors regarding the production, transfer and distribution of electricity produced from renewable energy sources.

- Insufficient legislation on protecting scientific creativity and encouraging innovation.

2. *Technical barriers*

- The absence of a national vision for the establishment of a local industry for some components of solar and wind energy equipment for electricity production in the context of the necessary scientific research and development activities.

- The absence of national strategies and plans on the technologies that must be transferred and nationalized in the medium- and long-term.

- Reliance, more often than not, upon foreign expertise in renewable energy power plant projects (solar/wind).

- Weak infrastructure in the electricity sector, taking into account the potential for export to Europe of electricity produced using renewable energy sources.

- Poor coordination between scientific research centres, universities, the manufacturing sector, energy planners and policymakers and decision makers regarding electricity production from solar and wind energy.

- The absence of programmes defined within a given time frame to build national capacities in areas related to renewable energy.

- The absence of databases on the manufacturing capacities and potential as well as the expertise in the field of equipment to produce electricity using renewable sources.

- Poor manufacturing oversight with regard to renewable energy equipment manufactured locally/imported, due to the lack of experience with standard specifications and trial methods, in addition to limited technical knowledge and a need to apply comprehensive quality standards.

- A lack of interest in developing universities and academic and research institutions, which are disconnected from analogous global networks, as well as a failure on the part of educational curricula to keep up with global scientific developments, taking into account industrial requirements.

- Minimal public awareness of the importance of changing unsustainable modes of producing and consuming energy.

- A failure to carry out both the Eight Country Interconnection Project (the connection between the Syrian Arab Republic and Turkey has not been invested yet, nor has the national coordination centre in Lebanon been established); and the Maghreb Countries Interconnection Project (to date, the connection only links Libya and Tunisia), which reduces the chances of attracting private investment to enter the area of electricity production and export to Europe through Morocco or Turkey.

3. *Financial barriers*

- Price subsidies for oil products and electrical power produced from fossil sources, and a lack thereof for renewable energy, which makes the private sector hesitant to invest in renewable energy projects, adversely affecting the manufacture of equipment and demand for it.

- No incentive for the private sector to invest (such as a temporary exemption from taxes on profit for a given time period, providing State land for industrial installations at nominal prices, and facilitating administrative and banking procedures).

- The national financing structure is hampered from providing appropriate financing mechanisms to support the manufacture of renewable energy equipment to produce electricity.

- Meagre budgets allocated for scientific research and development of equipment to produce electricity from renewable sources.

- Weak banking system in some countries, which results in foreign and domestic capitalists distancing themselves from investing in the manufacturing sector.

- The repercussions of the global financial crisis on the opportunities for international institutions and developed countries to grant concessional financing to developing countries, in addition to the budget cuts in many sectors, including the energy sector, which resulted in a slowdown in the completion of development plans, particularly in non-oil-producing countries, which also had an effect on related manufacturing.

ESCWA is concerned with the dissemination of the concept of green manufacturing in the context of strengthening economic and social development in its member countries, as well as spreading the manufacture of equipment to produce electricity from renewable energy (wind and solar energies). ESCWA makes this one of the priorities of its work programmes and plans by organizing expert forums, meetings and workshops in the relevant fields, in order to build capacities and develop skills with a view to expanding the use of renewable energies and transferring technology in order to nationalize the manufacture of renewable energy equipment for electricity production that is suited to local circumstances.

Box 6. General keys for developing national manufacturing capacities for renewable energy equipment

The development of national capacities for manufacturing renewable energy equipment to produce electricity requires coordination to keep the focus on the desired objective, by means of: (1) evaluating renewable energy sources and their feasibility and testing the appropriate sources in order to develop their use; (2) putting in place a declared national strategy to produce electricity from solar and wind energies based on a comprehensive scheme or road map for the local manufacture of some components of the equipment needed for the technology adopted; (3) putting in place appropriate policies and facilitating administrative measures in order to attract global manufacturers to enter into partnership with the national private sector, and encouraging investment in the manufacture of equipment to produce electricity using renewable energy sources; (4) commitment to abide by technical standard specifications and standards for the components that will be manufactured locally, and applying comprehensive quality standards; (5) promoting the concept of public-private partnerships in order to stimulate the market; (6) strengthening international cooperation to open new markets by concluding cooperation and trade agreements, or by joining economic blocs.

V. THE ROLE OF REGIONAL AND INTERNATIONAL COOPERATION IN SUPPORTING THE SPREAD OF RENEWABLE ENERGY USE IN ESCWA MEMBER COUNTRIES IN ORDER TO MITIGATE CLIMATE CHANGE

Article 3 of the Framework Convention on Climate Change contains an explanation of the commitments undertaken by the States Parties, out of their recognition that "change in the Earth's climate and its adverse effects are a common concern of humankind". All States Parties must work and cooperate to develop, implement, spread and transfer technologies, practices and processes that curb, reduce or prevent anthropogenic gases and those generated by various sectors, including the energy sector. The Convention stipulates clearly the need for developed countries to take all possible practical steps to strengthen, facilitate and finance environmentally peaceful technology transfer and technical expertise to other States Parties, especially developing countries.

For this reason, and since renewable energy applications fundamentally aim to curb emissions and climate change, promoting these applications cannot be done in isolation from regional and international cooperation, which in the cornerstone of technology transfer and financing. Regional and international financing institutions can play an effective role in providing flexible financing packages to developing countries with ambitious plans to incorporate renewable energy into their domestic energy mix.

A. REGIONAL AND INTERNATIONAL INITIATIVES TO SPREAD THE USE OF RENEWABLE ENERGY IN ORDER TO HALT CLIMATE CHANGE

A number of initiatives to spread the large-scale use of renewable energy have emerged on the regional scene. They are based on three studies on renewable energy sources in the Arab region drafted and published by the German Aerospace Center between 2005 and 2007, entitled "Concentrating Solar Power for the Mediterranean Region", "Trans-Mediterranean Interconnection for Concentrating Solar Power", and "Concentrating Solar Power for Seawater Desalination".[57]

Some initiatives fall under the scope of government cooperation between developed and developing countries, and technical and financial support programmes granted by some countries like Spain, Germany, Italy, France, Denmark and Japan to implement renewable energy projects in developing countries. Regional centres were also established, such as the Regional Centre for Renewable Energy and Energy Efficiency in Cairo and the Mediterranean Renewable Energy Centre in Tunisia. Regional cooperation programmes were also organized, such as the Mediterranean Energy Observatory and Mediterranean projects for the integration of energy markets and energy efficiency in the construction sector. Measures were taken to implement the Mediterranean Solar Plan, sponsored by the European Union and within the framework of the activities of the Union for the Mediterranean. The DESERTEC Industrial Initiative was implemented, sponsored by the DESERTEC Foundation, whose aim is to produce electricity using the Concentrating Solar Power technology, and transferring part of it to Europe with the support of private sector investments. Cooperation between Arab countries was strengthened through the Arab Ministerial Council for Electricity of the League of Arab States. Numerous activities were also carried out, including: (a) drafting an Arab strategy to develop the uses of renewable energy (2010-2030); (b) drafting a guide to the potential of Arab Countries in the fields of renewable energy and improving the efficiency of energy production and consumption; and (c) drafting a working paper to formulate an Arab vision towards solar plans and initiatives.

1. *Mediterranean Solar Plan*

The Mediterranean Solar Plan was announced within the framework of development cooperation activities whose implementation was decided on through the Union for the Mediterranean (which was established in July 2008), as a regional response to the challenges faced by the Mediterranean region and the European Union to achieve energy sustainability and to mitigate the phenomenon of climate change, in the face of continuing growth in energy demand in the countries south of the Mediterranean and the increase in

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[57] German Aerospace Center and the Federal Ministry for the Environment, *Nature Conservation and Nuclear Safety, Concentrating Solar Power for the Mediterranean Region*, op. cit.

northern Mediterranean countries' interest in securing their energy supply. All this takes into account the effect of the fluctuating price of fuel on the stability of the global energy market, the economies of developing countries that import energy, and global interest in mitigating the effects of climate change.

The Mediterranean Solar Plan provides for the implementation of projects related to renewable energy and that use solar energy along with wind energy to produce electricity with installed capacity whose total value is to reach 20 GW by 2020. It has been decided that these projects will be implemented in the southern Mediterranean region to meet the local needs and export part of the energy generated to Europe through the Mediterranean interconnection. These projects are not limited to cooperation with governments, but instead are open to the private sector as well. Currently, one of the consultative offices is undertaking the drafting of a study to pave the way for implementation of the above solar plan, with expenses covered by the European Union.[58]

2. *DESERTEC Foundation Initiative*

In January 2009, the establishment of the DESERTEC Foundation,[59] a global civil society, non-profit organization, was announced. It is made up of a group of scientists, politicians and economists from the Mediterranean region, preparing for a sustainable future through strengthening trade in electricity in Europe and the Middle East and North Africa region, through implementing twenty electricity plans, transferring 5 GW each (according to the study of the German Aerospace Center). This is expected to be accomplished through private investments to: meet local needs; export to Europe through the interconnection networks of the Mediterranean Basin at direct current (DC) high voltage; use of the system for the sale of energy produced at a special tariff; promoting the industrial capacities of countries that will be implementing the project; contribute to creating job opportunities; and curbe carbon dioxide emissions. Measures decided on to achieve this include cooperation with the Union for the Mediterranean in implementing the Mediterranean Solar Plan; organizing publicity campaigns; and preparing a solar atlas for the relevant desert regions that is available to all.[60]

In Munich on 30 October 2009, the industrial initiative was launched,[61] in which 12 large energy companies and the DESERTEC Foundation are participating, with the aim of implementing electricity production projects using solar power, with an estimated cost of about EUR400 billion. It is expected that production will commence within 10 years, and that it will contribute 15 per cent of European electricity needs by 2050. The founders aim to add other companies from the Northern and Southern Mediterranean regions.[62]

3. *Clean Technology Fund Plan to expand the use of Concentrating Solar Power in the Middle East and North Africa region*

In 2008, the World Bank established the Clean Technology Fund (as one of the funds for investment in climate-related activities), in order to bolster sources of funding available to expand carbon-dioxide-reducing technologies in the electricity sector (renewable energy and carbon-density-reducing technologies) and to strengthen the efficiency of transfer and use of energy and curb gas emissions that cause global warming. The Fund announced its intention to fund projects that aim to support the spread of solar power through facilitated financing estimated at US$750 million, within the framework of the relevant investment scheme with the allocation of an additional US$4.85 billion from other sources. The Fund is implementing

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[58] ESCWA, *Local Manufacturing of Equipment for the Production of Solar and Wind Power: Potential and Prospects in the Arab Region*, op. cit.

[59] DESERTEC, http://www.desertec.org/en/organization/.

[60] DESERTEC Foundation, *Red Paper: An Overview of the Desertec Concept*, 2009.

[61] http://www.dii-eumena.com/ar/home/diishareholders.html.

[62] Secretariat of the Arab Ministerial Council of Electricity, Energy Department, *Working paper to draft a comprehensive Arab vision regarding the Mediterrenean Solar Plan and similar initiatives* (Arabic), June 2011.

an initiative to scale up the use of solar power plants with a total capacity of about 1 GW to produce electricity from the present time to 2020 in the Middle East and North Africa region, which will enable the region to contribute to mitigating climate change and support infrastructure of electricity transfer networks, in addition to using the public and private sectors to roughly triple the level of global investment in the area of thermal concentrating solar power, and provide support to the countries of the region in achieving their goals in the areas of energy security, industrial and economic development and regional integration. Support for the concentrating solar power plant projects to produce electricity is to begin in Algeria, Egypt, Jordan, Morocco and Tunisia, which have announced their national plans in this area. This is expected to contribute to curbing the emission of the equivalent of 1.7 million tons of carbon dioxide per year.[63]

4. *The Arab vision on the Mediterranean Solar Plan and other initiatives*

In June 2011, the Energy Department of the Secretariat of the Arab Ministerial Council for Electricity, in cooperation with a working group made up of experts in Arab countries, ESCWA and the Regional Centre for Renewable Energy and Energy Efficiency drafted a working paper on formulating an Arab vision on plans and initiatives in the area of solar energy. The paper contains plans announced by a number of Arab countries, and axes of the Arab vision based on these initiatives and general features of the framework for Arab work in this area. The Arab Ministerial Council for Electricity adopted the working paper and the Ministerial Declaration on the vision in December 2011.[64]

5. *International Renewable Energy Agency*

The Agency is an intergovernmental organization established by 75 States on 26 January 2009. [65] Its aim is to ensure that renewable energy and its sustainable use become widespread globally, which contributes to environmental preservation and limiting the pressure on the use of natural resources, in addition to preventing the destruction of forests and desertification, reducing emissions and mitigating climate change, achieving economic and social development and securing the energy supply. The mission of the Agency includes carrying out technical studies and providing scientific consultation to member States, as well as assisting them in improving the regulatory framework, capacity-building, facilitating access to technological information and expertise and technology transfer.

In July 2009, Abu Dhabi was chosen to host the headquarters of the General Secretariat of the Agency, while the German city of Bonn was chosen as the centre of innovation. Vienna was selected to host the liaison office. At present, the Agency has 101 member States, 58 of them are developed countries, along with the European Union.

B. AFTER THE KYOTO PROTOCOL: DEVELOPMENTS AND A VISION FOR THE FUTURE

1. *Kyoto Protocol and the Clean Development Mechanism*

The Kyoto Protocol[66] observes the commitment of developed countries and countries making the transition to market economies (38 industrial countries and 11 countries from Central and Eastern Europe) to work, in the period spanning 2008 to 2012,[67] to reduce total emissions of warming gases (carbon dioxide, methane, nitrous oxide, carbon fluoride hydrogen compounds, saturated carbon fluoride and sulphur

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[63] Climate Investment Funds, *Clean Technology Fund, Investment Plan for Concentrated Solar Power in the Middle East and North Africa Region,* CTF/TFC.IS.1/3, 10 November 2009.

[64] Secretariat of the Arab Ministerial Council for Electricity, 9th session of the Arab Ministerial Council for Electricity, *Report and Decisions,* Cairo, December 2011.

[65] www.irena.org/menu.

[66] ESCWA, *The Impact of Climate Change on the Energy Sector in the ESCWA Region* (E/ESCWA/SDPD/2012/Technical Paper.2).

[67] United Nations Environment Programme, Capacity Development Programme of the Clean Development Mechanism, *Your Guide to the Clean Development Mechanism*, second edition, Egypt, 2004.

hexafluoride) by at least 5 per cent from 1990 levels. The Protocol entered into force when it was signed in February 2005[68] by the specified number of States Parties to the Framework Convention, those countries whose emissions accounted for at least 55 per cent of total emissions in 1990. Periodically, a meeting of States Parties, to the United Nations Framework Convention on Climate Change is held, known as the Conference of Parties, to follow up on all new developments and activities related to climate change issues.

The Kyoto Protocol established three mechanisms, namely, the Joint Implementation of Projects; the Emissions Trade; and the Clean Development Mechanism. They aim to assist States Parties that have not acceded to the first annex of the Convention to achieve sustainable development, and to assist States Parties listed in the first annex (that is, the developed countries) to comply with their commitments set forth in the Protocol. The certificates used equal the amount of carbon dioxide emissions (each certificate equals a ton of carbon dioxide), which was reduced as a result of the projects implemented in developing countries. Developed countries or investor companies can exchange these certificates for financial value agreed upon with the developing country.

The Executive Board is responsible for guiding this Mechanism, delegated by the States Parties to the Framework Convention. The Board is composed of 10 members representing Africa, Asia, Latin America, Eastern and Central Europe, the Organisation for Economic Co-operation and Development and the least developed countries. It also includes representatives of countries listed in Annex I to the Convention and a representative of countries not listed therein. This Executive Board issues final approval and emissions reducing certificates for projects brought before it. The Executive Board's operational entity reviews and adopts papers on reducing emissions, in addition to drafting the final report on the Executive Board's approval of these projects. Clean Development Mechanism projects have to conform to several standards, most important among them the following: (a) additionality, meaning that the project reduces emissions that are additional to any that would occur in the absence of the project activity; (b) sustainable development, allowing developing countries to set their own standards in that respect (quality of life, poverty reduction, gains reaped by the local society hosting the project, preserving natural resources, reducing harmful emissions, and reducing the use of fossil fuel).

In order to implement the projects within the Clean Development Framework mechanism, the following measures must be taken: (1) drafting a document that contains information on the project; (2) the approval of the National Council for the Clean Development Mechanism in the host country for the projects implementation within the framework of the mechanism; (3) drafting a document for design that is in line with the prototype required by the Council, containing details on project activities, the basic methodology for measuring the amount of emissions it is intended to avoid, and the verification, observation and follow-up mechanisms; (4) submission of the design document to the Executive Board's Designated Operational Entity for approval and submission to the Board; (5) Executive Board ratification of project registration; and (6) project registration over eight weeks in exchange for fees assessed in light of the capacity of the project.[69]

However, the number of renewable energy projects registered under the Clean Development Mechanism in ESCWA member countries is small and not suited to the available energy sources.[70] As the table below indicates, efforts to implement projects that use renewable energy applications must be intensified in ESCWA member countries, just as in other regions of the world.

[68] ESCWA, *Role of the Energy Sector in Countering the Potential Impact of Climate Change* (Arabic), (É/ESCWA/SDPD/2009/IG.1/4).

[69] New and Renewable Energy Authority, *Annual Report 2010/2011*, op. cit.

[70] ESCWA, *The Impact of Climate Change on the Energy Sector in the ESCWA Region*, op. cit.

TABLE 18. RENEWABLE ENERGY PROJECTS IN ESCWA MEMBER COUNTRIES REGISTERED IN THE CLEAN DEVELOPMENT MECHANISM

Country	Project	Status
Egypt[a/]	- Wind power plant in Zafarana (120 MW) in cooperation with Japan (produces around 452 GWh annually, and curbs around 275,000 tons of carbon dioxide emissions).	- Registered in June 2007. The necessary measures are currently being taken to draft a report on monitoring and control, for submission to the Executive Board in order for the first set of certificates to be issued.
	- Wind power plant in Zafarana (80 MW) in cooperation with Germany (produces around 30 GWh annually, and curbs around 171,000 tons of carbon dioxide emissions).	- Registered in March 2010, and the necessary measures are currently being taken to verify the amount of emission reduction certificates.
	- Wind power plant in Zafarana (120 MW) in cooperation with Denmark (produces around 399 GWh annually, and eliminates around 225,000 tons of carbon dioxide emissions).	- Registered in September 2010, and the necessary measures are currently being taken to verify the amount of emission reduction certificates.
	- Wind power plant in Zafarana (85 MW) in cooperation with Spain (produces around 283 GWh, and curbs around 150,000 tons of carbon dioxide emissions).	- Registered in August 2011.
	- Use of waste gas to produce electricity and solar energy in Alexandria.[b/]	- Registered in 2008.
Jordan[b/]	- Reduction of methane gas emissions from waste.	- Registered in 2009.
Morocco[c/]	- Eight projects in the renewable energy sector, including five wind farms, a solar cell system project, a biomass project and a project involving solid waste.	- Wind energy projects were registered between 2005 and 2010, the solar cell project was registered in 2004, the biomass project was registered in 2006 and the solid waste project was registered in 2007. The Clean Development Mechanism website: www.iges.or.jp/en/cdm/report-cdm.html.
Syrian Arab Republic[c/]	- Extraction of biogas from landfills in Homs (curbs emissions by roughly 67,900 tons of carbon dioxide).	- Registered in 2009.
	- Extraction of biogas from landfills in Aleppo (curbs emissions by roughly 65,000 tons of carbon dioxide).	- Registered in 2009.
Tunisia[d/]	- Solar assisted water heating programme.	- Registered in 2011.

TABLE 18 (*continued*)

Country	Project	Status
United Arab Emirates[b/]	- Solar cell system stations (10 MW; a Masdar initiative). - Thermal solar station under construction (Masdar initiative). - Low-pressure steam generation by recovering lost heat using a renewable energy source for heating.	- Registered in 2009. - Registered in 2009. - Registered in 2009.

a/ New and Renewable Energy Authority, Annual Report, 2010/2011, Egypt.

b/ ESCWA, Impact of Climate Change on the Energy Sector in the ESCWA Region, 30 March 2012, E/ESCWA/SDPD/2012/Technical Paper.2.

c/ RCREEE, Existing CDM Potential and Perspectives for Carbon Finance in RCREEE Member States Beyond 2012.

d/ Energy Department, Arab Ministerial Council for Electricity, Guide to the Potential of Arab States in the Renewable Energy and Improving the Efficiency of Energy Production and Consumption, Cairo, 2011.

2. *Prospects for the development and future trends involving the role of renewable energy in ESCWA member countries*

At the seventeenth session of the Conference of the Parties to the United Nations Framework Convention on Climate Change, a number of resolutions/decisions were adopted, including the following:

- Drafting the text of an international agreement on climate change by or before 2015, with a view to its entry into force by 2020;
- Governments give their approval, among them 35 industrial States, to committing to the Kyoto Protocol for a second period starting 1 January 2013;
- States Parties define goals regarding the amount of reduction in emissions, and submit them for review in May 2012.

The extension of the Kyoto Protocol for a second period is considered an opportunity through which ESCWA member countries might be able to grasp the importance of technology transfer in the area of clean energy technologies, building technical capacities, agreeing on common priorities, and operationalising technical cooperation among themselves. Coordination of regional efforts is necessary, along with putting in place a shared regional vision regarding the post-Kyoto Protocol era, in particular with respect to technical priorities, national capacities and the position from electrical connection.

3. *The Secretary-General's "Sustainable Energy For All" Initiative*

At its sixty-fifth session, on 20 December 2010, the General Assembly of the United Nations adopted a resolution to declare the year 2012 the international year of sustainable energy for all. The Secretary-General of the United Nations announced a new initiative titled "Sustainable Energy for All" at a General Assembly meeting in September 2011, and issued a document containing the vision of this initiative in November 2011.[71] It outlined three objectives for achieving energy sustainability by 2030, namely, (1) ensuring universal access to modern energy services; (2) doubling the global rate of improvement in energy efficiency; and (3) doubling the share of renewable energy in the global energy mix. Every energy source and technology has a role to play in achieving these three objectives in an economically efficient, socially

[71] Secretary-General Ban Ki-moon, *Sustainable Energy for All, a Vision Statement*, November 2011.

appropriate and environmentally friendly manner, with a view to maximizing development gains and helping to mitigate climate change.

The vision states that improving the chances of achieving these objectives requires the following: (1) commitment of the leadership in the labour sector, the government, financial institutions and civil society on the principle of conversion to clean energy systems, encouraging innovation and setting domestic goals at the State level to serve as a basis for policies aimed to attract the private sector; (2) setting fixed policies and regulatory working frameworks that contain market-friendly incentives, supporting innovation aimed at cost reduction, and putting in place energy policies that lead to social and environmental sustainability, in addition to eliminating approaches that subsidize fossil fuels, encouraging public/private partnerships, and supporting the renewable energy industry; (3) financing the process of conversion to sustainable energy patterns, through innovative coordination, policies and good governance bodies that bring together the government, the private sector and financing institutions, particularly in developing countries; and (4) strengthening national capacities for implementing relevant policies, and supporting innovative solutions that may come from members of society, as well as commencing operation of energy systems and maintaining them and raising public awareness of the importance of these technologies through providing relevant information, and consolidating cooperation and exchange of best practices, especially between developing countries.

4. *Meetings held during the Rio+20 Conference*

On the occasion of the twentieth anniversary of the United Nations Conference on Sustainable Development in 1992, the Rio+20 Conference was held, opening with meetings between Heads of State and Government and high-level representatives (20-22 June 2012), with the participation of civil society organizations. At these meetings, those present renewed their commitment to sustainable development and to encouraging the construction of an economically, socially and environmentally sustainable future. Environmental protection and global climate were accorded the largest share of discussions and of the Conference’s outcome document, “The Future We Want”. The most important points contained in the document on climate change and the energy sector are as follows:

(a) Renewing political commitment by reaffirming the Rio principles and past action plans and assessing the progress to date and the remaining gaps as well as addressing new and emerging challenges. Acknowledging that climate change is a cross-cutting and persistent crisis that requires urgent and ambitious action, in accordance with the Framework Convention and with the participation of all stakeholders and the scientific and technological communities in achieving sustainable development, and closing development gaps between developed and developing countries;

(b) The importance of a green economy in the context of sustainable development and poverty eradication, as well as the importance of technology transfer (renewable energy applications) to developing countries and provision of financing assistance;

(c) The critical role that energy plays in the development process, the importance of universal access to sustainable modern energy services, and the increased use of renewable energy sources; urging Governments to create enabling environments that facilitate public and private sector investment in cleaner energy technologies, and increasing the share of renewable energy technologies in order to address climate change;

(d) Welcoming the launching of the Green Climate Fund and calling for its prompt operationalisation;

(e) Establishing an intergovernmental committee to prepare a report proposing options on an effective sustainable development financing strategy, concluding its work by 2014;

(f) Urging those developed countries to make additional concrete efforts towards the target of 0.7 per cent of gross national product for official development assistance to developing countries, the bulk of which is expected to be allocated for climate change mitigation and adaptation projects;

(g) Addressing financial matters, the provision of necessary technology and capacity-building as necessary means of implementation.

The above makes clear that the adoption of renewable energy technologies plays an important role in United Nations attempts to strengthen international cooperation on containing climate change, with the technology transfer and provision of financing mechanisms that this will require.

VI. EXISTING FRAMEWORKS AND PROPOSED STEPS TO STRENGTHEN THE ROLE OF RENEWABLE ENERGY IN REDUCING THE SEVERITY OF CLIMATE CHANGE

The use of renewable energy applications is one of the keys to reducing carbon dioxide emissions and, it follows, of mitigating climate change. However, this use remains limited in ESCWA member countries. However there are many justified and unjustified reasons for this; and legislative, institutional and regulatory frameworks in place must be examined, as it is through them that the use of renewable energy sources can be improved in order to achieve the desired goals.

A. LEGISLATIVE, INSTITUTIONAL AND REGULATORY FRAMEWORKS NECESSARY FOR THE USE OF RENEWABLE ENERGY RESOURCES

TABLE 19. STATE OF FRAMEWORKS

Country	State of relevant frameworks
Bahrain[a/]	**Relevant authority**: The Electricity and Water Authority.
Egypt[b/]	**Relevant authority:** • New and Renewable Energy Authority, under the Ministry of Electricity and Energy. **Legislation/Policies/Measures:** • Establishment of the Electric Utility and Consumer Protection Regulatory Agency (est. 2000); • Exemption of renewable energy equipment from customs fees and sales tax; • Preparation of new draft law on electricity that contains articles on encouraging investment in renewable energy, chief among them the article on building, owning and running power plants on renewable energy sources, as well as the article on selling electricity to the Egyptian Electricity Transmission Company, in accordance with a price agreement adopted and declared valid for 15 years. The Egyptian Electricity Transmission Company commits to purchasing the energy available at renewable energy-run power plants, in addition to establishing a "fund for the development of electricity from renewable energies", with the aim of helping the Egyptian Electricity Transmission Company to purchase electrical energy from renewable energy power plants; • The Supreme Council of Energy adopted a package of policies including the following: (1) Implementation of a wind energy programme in two phases. *Phase 1*: Use of a competitive bidding process to solicit bids – build – operate – transfer, by inviting investors to submit competitive bids to build, own and operate wind power plants and to sell the energy produced to the Egyptian Electricity Transport Corporation at a price agreed upon with the investor; *Phase 2*: Apply the special tariff system subsequently, going by the prices and expertise gained in the first phase. (2) Conclusion of agreements on the purchase of energy produced by wind plants over a period ranging from 20 to 25 years, with governmental guarantee of financial commitments made by the Egyptian Electricity Transport Corporation. (3) Investor benefit from the sale of emission reduction certificates; the operation of the project itself can prevent emissions; granting of State lands to the investor under the right of use system, whereby the State can reclaim the effective cost of equipping the land after commercial production of the project begins. (4) Government commitment to strengthen the capacities of the electricity transport system so as to make room for private plants. (5) Provision of technical data and information and ensuring that the investor obtains administrative approvals. (6) Ensuring standards of assessment of competitive bidding, competitive advantage, and preferential terms on the percentage of local components of wind turbine equipment;

TABLE 19 (*continued*)

<table>
<tr><th>Country</th><th>State of relevant frameworks</th></tr>
<tr><td>Egypt[b/] (continued)</td><td>Egypt has been host country to the Regional Center for Renewable Energy and Energy Efficiency since its establishment in June 2008. At present, 13 Arab countries are members of the Center.</td></tr>
<tr><td>Iraq[a/]</td><td>Relevant authority:
Planning and Study Section under the Ministry of Electricity.
Legislation/Policies:
In the process of being considered and drafted.</td></tr>
<tr><td>Jordan[a/]</td><td>Relevant authorities:
Ministry of Energy and Mineral Resources, Directorate of Alternative Energy and Energy Conservation;
National Energy Research Center, which conducts activities and research on renewable energy;
Jordan has been the host country of ESCWA Technology Centre since its establishment in 2011. The Centre is responsible for research and development of clean and renewable energy technologies.
Legislation/Policies/Measures:
In February 2010, the Temporary Law on Renewable Energy and Energy Efficiency entered into force, with the aim of putting in place a working legal framework to expedite the development of renewable energy use and improve energy efficiency, through providing access to investors. In accordance with this decree, the Fund for the Financing of Renewable Energy Projects was officially established, and its work will be overseen by a council whose membership includes representatives from the public and private sectors, headed by the Minister of Energy and Mineral Resources;[c/]
Renewable energy-related equipment is exempted from customs feels and sales tax, and plots of State land are to be allocated for wind projects. The private sector is encouraged to establish wind farms.</td></tr>
<tr><td>Kuwait[a/]</td><td>Relevant authorities:
Ministry of Electricity and Water;
Research institutions and centres are carrying out activities and preparing research studies and projects in some fields related to renewable energy.</td></tr>
<tr><td>Lebanon[a/]</td><td>Relevant authorities:
Ministry of Energy and Water;
The Lebanese Centre for Energy Conservation carries out some activities in the field of renewable energy, particularly relating to solar water heating and energy efficiency, under the guidance of the Ministry of Energy and Water. The Centre was founded with financing from the United Nations Development Programme, after preparing a draft law for its official establishment. However, no laws have been adopted regarding its establishment to date.</td></tr>
</table>

TABLE 19 (*continued*)

Country	State of relevant frameworks
Lebanon[a/] (*continued*)	**Legislation/Policies/Measures:** • In 2010, the Ministry of Energy and Water, in cooperation with the United Nations Development Programme and the Lebanese Center for Energy Conservation, launched an initiative on solar heating, by providing interest-free loans (with a repayment period of five years, and a grant in the amount of 200 dollars to each person who purchases a solar heater); • The Central Bank of Lebanon recently passed Circular No. 236 on permitting the provision of interest-free loans (with a repayment period of up to 14 years) to energy efficiency and renewable energy projects. • Drafting a national strategy for bioenergy in 2012.
Libya[a/]	**Relevant authority:** • Ministry of Electricity and Renewable Energy – Renewable Energy Authority.
Morocco[c/]	**Relevant authorities:** • Ministry of Energy, Mines, Water and Environment – Directorate for Electricity and Renewable Energies; • Centre for the Development of Renewable Energy, National Electricity Office, Moroccan Agency for Solar Energy. **Legislation/Policies/Measures:** • Law No. 09-13: Stipulates the methods of electricity production from renewable sources, connection with the national electricity grid, acquisition of permit or licence for electricity production in advance, sale of energy produced, and export of renewable energy; • Law No. 09-16: Concerns the National Agency for the Development of Renewable Energy and Efficiency, especially with regards to its restructuring and expansion of the following missions: Conceiving programmes on the development of renewable energy and energy efficiency as well as environmental conservation; following up on development programmes, projects and activities in the two aforementioned fields; defining renewable energy maps and the energy efficiency points; following up on energy verification and operationalisation of relevant recommendations; • Law No. 09-57: Regarding the establishment of the Moroccan Agency for Solar Energy, whose mission is to carry out electricity production projects using solar energy with a capacity of up to 2000 MW; preparing the necessary technical, economic and financial studies; determining the appropriate locations; seeking sources of financing; • Establishing the Energy Development Fund (with capital in the amount of one billion dollars) to strengthen production capacities using renewable sources, reduce customs fees by 2.5 to 10 per cent on certain renewable energy equipment, and reducing the added value from 20 to 14 per cent on solar water heaters.
Oman[a/]	**Relevant authority:** • Public Authority for Electricity and Water. **Legislation/Policies/Measures:** • A number of policies and incentives were put in place to encourage the optimal use of renewable energy.

TABLE 19 (*continued*)

Country	State of relevant frameworks
Palestine[c/]	**Relevant authority:** • The Palestinian Energy and Environmental Research Centre, one of whose missions is putting in place policies to regulate the energy sector. **Legislation/Policies/Measures:** • Adopting policies to spread the use of renewable energy. The private sector plays a crucial role in this process, over two phases. *Phase 1* (2012-2015): Entails the study and implementation of small-capacity projects with a total capacity of 25 MW, in the context of the Palestine Solar Initiative, whose duration is three years and whose aim is to spread solar cells on the roofs of houses; *Phase 2* (2016-2020): Aims to implement projects with a total of 105 MW. It has been decided that the purchase price of electricity produced from renewable sources and linked to the grid will be fixed and reviewed on an annual basis; • Adoption of a draft decision by the Council of Ministers regarding the Public Renewable Energy Strategy. This draft encourages the use of renewable energy and increasing its share in the total energy mix by 25 per cent by 2020; it also provides for imposing a special tax on renewable energy (solar energy, wind energy, and biofuel extracted from waste and residues produced by living things); and for the conclusion of agreements on the price of energy by subscribers who depend on a renewable source to produce energy and by investors who obtain a licence to establish a project to produce electricity using renewable energy. It was also decided that these agreements would enter into force after their ratification by the Council of Ministers (they were ratified in March 2012), and they would remain in force for 20 years.
Qatar[a/]	**Relevant authorities:** • Ministry of Energy and Industry (Strategic Planning and Policy), and Qatar Petroleum (Renewable Energy Department); • The Qatar Science and Technology Park, Qatar University and a number of scientific and industrial centres are charged with undertaking research and development activities; • Qatar is host to the nineteenth session of the Conference of Parties to the United Nations Framework Convention on Climate Change, which is to be held in November-December 2012.
Saudi Arabia[a/]	**Relevant authorities:** • Electricity Affairs Agency – Department of Studies and Research, Ministry of Water and Electricity; • King Fahd University of Petroleum and Minerals and King Abdulaziz City for Science and Technology are conducting research activities and studies, in order to assess the potential of the renewable energy field (solar/wind); • On 17 April 2010, a royal decree was passed regarding the construction of Abdallah City for Atomic and Renewable Energy, in order to strengthen efforts to implement the National Renewable Energy Plan. **Legislation/Policies/Measures:** • Work on formulating a national policy to promote the share of renewable energy in the energy mix is under way.

TABLE 19 (*continued*)

Country	State of relevant frameworks
Sudan[a/]	**Relevant authority:** • Department of Renewable Energy, Ministry of Energy and Minerals, Ministry of Electricity and Dams. **Legislation/Policies/Measures:** • Adoption of a draft law on biofuel.
Syrian Arab Republic[a/]	**Relevant authority:** • The National Energy Research Centre under the Ministry of Electricity. **Legislation/Policies/Measures:** • Energy Conservation Law No. 3/2009, with requires the assembly of solar heaters on new buildings and expansion of the adoption of renewable energy and its technologies; • Electricity Law No. 32 of 2010 on the general policy of the electricity sector contains articles on supporting and encouraging the use of renewable energy in different fields and nationalizing its manufacture, in addition to allowing the local, Arab and foreign private sector to invest in that field. The State may purchase electricity produced from a renewable source that is pumped into the grid at incentive rates, in accordance with the relevant rules and conditions. It commits to purchase from the investor who carries out a renewable energy project based on a ministerial declaration that calls for making offers, according to the price agreed upon with the investor. The State also commits to linking electricity generation plants or systems running on renewable energy to the grid. The licensee must take care of the requirements of connecting to the grid and bear the costs that this entails. It is possible to put in place wind turbine towers and devices to measure it on State land without compensation, fees or taxes; • Adoption of a draft law on the establishment of a national fund to promote solar heaters; • Facilitated payment in instalments for house water heating devices for Syrian workers.
Tunisia[a/]	**Relevant authority:** • The Ministry of Industry and Technology is the national agency that governs energy. **Legislation/Policies/Measures:** • Law No. 72 of 2004: Stipulates, inter alia, the promotion of renewable energy, especially wind energy, to generate electricity and use of thermal solar energy; • Law No. 106 of 2005: Stipulates, inter alia, the establishment of the National Fund for Energy Management, whose mission is to provide grants to support projects for the optimization of energy consumption and substitution, and to promote renewable energy; • Law No. 7 of 2009: Stipulates, inter alia, the granting of concessions to institutions that produce electricity using renewable energy for self-consumption; • Decree No. 2773 of 2009: Stipulates, inter alia, fixing the conditions for the transport of electricity produced using renewable energy and the sale of surpluses to the Tunisian Company for Electricity and Gas.

TABLE 19 (*continued*)

Country	State of relevant frameworks
United Arab Emirates[a/]	**Relevant authorities:** • Department of Electricity within the Ministry of Energy; • The Abu Dhabi Future Energy Company (Masdar), the private company owned by the governmental Mubadala Company, carries out many activities in the renewable energy area, encompassing the implementation of commercial projects and research through Masdar's Institute of Science and Technology, in cooperation with several universities; • In cooperation with American, European and Japanese research institutions, several authorities/entities in Abu Dhabi, Dubai, Sharjah, Ras Al-Khaymah and Fujairah are conducting research on solar and wind energy and biofuel. **Legislation/Policies/Measures:** • The Ministerial Council for Services decree 12/155 m/2009 on diversification of energy resources and focusing on renewable energy use; • The establishment of a programme to create incentives for solar cell system use on the roofs of buildings and houses; • The Emirate of Abu Dhabi hosts the International Agency for Renewable Energy since its establishment in 2010.
Yemen[a/]	**Relevant authority:** • Renewable Energy Department under the Ministry of Electricity and Energy. **Legislation/Policies:** • Electricity Law of 2009, and adoption of the Renewable Energy and Energy Efficiency Strategy; • Application of incentives set out in the Investment Law (Temporary income tax exemption, exemption from import fees on all items intended for use in private/government/mixed renewable energy projects, provision of facilitated loans, conclusion of agreement for exploitation of State land).

a/ Secretariat of the Arab Ministerial Council for Electricity, Guide on the Potential of Arab States in Renewable Energy and Improving Energy Efficiency and Consumption, Cairo, 2011.

b/ New and Renewable Energy Authority, Annual Report, 2010/2011, Cairo.

c/ Regional Centre for Renewable Energy and Energy Efficiency, Newsletter Issue No. 7, Cairo, 2011.

B. PROPOSED STEPS TO STRENGTHEN PROJECTS RELATING TO RENEWABLE ENERGY AND ENERGY EFFICIENCY APPLICATIONS IN ESCWA MEMBER COUNTRIES

Most of ESCWA member countries have defined their objectives in terms of using renewable energy sources by adopting the necessary legislation, policies and institutional frameworks. However, these goals and the steps taken to implement them remain below the level aspired to (with the exception of Egypt, Morocco and Tunisia). Even the executive mechanisms and plans needed to follow up are, for the most part, lacking in clarity, and the financing and regional and international cooperation mechanisms are not being taken advantage of, all of which raise questions about the possibilities of attaining the defined objectives. The emergence of the role of renewable energy in mitigating climate change, improving the security of the energy supply and achieving sustainable development requires a comprehensive examination of development in general and of sustainable modes of consumption and production in particular.

Any reasonable approach in this area must be based on energy management from the demand side, that is, to treat the energy issue from the standpoint of the needs of each sector and to manage and fill those needs. It is also necessary to achieve integration between energy efficiency and renewable energy, that is, to achieve energy efficiency in order to limit the end consumer's needs and, subsequently, to resort to renewable energy sources to meet a significant portion of the remaining need. That can be achieved by using this renewable energy directly without passing through the phase of conversion to electricity, and by generating electricity from renewable sources. A system that unites energy efficiency and renewable energy must be developed within an integrated framework that acknowledges the fundamental contribution of each field to securing energy services in the countries of the region. For this reason, the following measures must be adopted:

1. *Formulating a clear strategy to rationalize the production and use of energy:*

This is the first step that must be taken, taking into account the need for the following:

(a) *Passing a strong policy decision*

This decision makes it possible to place energy efficiency and renewable energy within policy priorities related to energy production and use. At the Arab level, the Executive Office of the Arab Ministerial Council for Electricity adopted, at its twenty-sixth session on 23 November 2010 the Arab Strategy for the Development of Renewable Energy Uses: 2010-2030,[72] in accordance with its Decision No. 192. This decision provides for the periodic update of this strategy, in line with the future objectives that the Arab countries will declare. The Strategy contains a series of objectives related to the share of renewable energy from primary energy sources for each country by 2014, 2020 or 2030. At the session, "The Arab Guideline for Improving Electricity Efficiency and Rationalizing its Consumption at the End User", pursuant to Decision No. 195. This Guideline contains a number of recommendations aimed at preparing a national programme for energy efficiency in each country, spanning three years as of the date of adoption of the Guideline.[73]

While those two documents constitute a regional benchmark for all decisions that may be taken at the relevant policy level, it is necessary to take the reference decision in each country, on the basis of exhaustive studies of the reality of the country and the development of its needs and possibilities at the short- and long-term levels, as well as to provide for the adoption of an integrated system that strikes the ideal balance of energy efficiency and renewable energy.

(b) *Preparation of studies on each economic sector in the country*

These studies concern the demand for energy and its short- and long-term development, the potential to acquire and save energy, or to diversify the sources of energy used without affecting the level of services provided through the methods of energy use currently employed in these sectors. These studies must define the fields in which they may carry out energy efficiency and renewable energy activities, and they must also define the particularities of some energy uses in order to take them into account within the proposed strategy under consideration.

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[72] Secretariat of the Arab Ministerial Council for Electricity, *Arab Strategy for the Development of Renewable Energy Uses*, op. cit.

[73] Secretariat of the Arab Ministerial Council for Electricity, *The Arab Guideline for Improving Electricity Efficiency and Rationalizing its Consumption at The End User* (Arabic), March 2011.

The needs of different sectors must be limited to energy according to its end uses, so as to make it possible to define the best ways to meet those needs in the short- and long-terms, particularly those uses aimed at improving energy efficiency and the use of renewable energy without passing through electrical energy.

It is also necessary to prepare these studies to determine the best fit between the end use of energy and its source, and consequently, to examine the substitution of existing sources (if they differ from the ideal sources) with more efficient sources in making use of primary energy, such as co-generation, also known as electricity and thermal energy generation; or tri-generation, otherwise known as electrical thermal and cooling energy in many industrial establishments and buildings with high energy use; or use of natural gas or thermal pumps to meet heating needs instead of using electricity directly to generate thermal energy.

(c) *Preparation of studies on the current state of energy efficiency and renewable energy in the concerned country, and putting a roadmap for possible development in the short- and long- terms*

It is proposed that these studies address the following themes:

- Analysis of past trials in the country in these two areas and evaluation of those trials, determining the extent to which they met its needs and reasons for their success or failure. These studies must be used to determine the means of ensuring success in both areas within the economic system of the country and in the legislative and institutional mechanisms required to do so. These studies should address climatic characteristics, as well as the possibilities as far as renewable energy is concerned, and putting in place and updating maps that specify the capacities of various energy sources in various regions;

- Analysis and assessment of relevant global trials, in order to learn from their success or failure, assess the possibilities of adapting them to the local level, and determine the extent to which they are suited to the concerned country’s needs and climatic and natural characteristics. The characteristics of the country that established the trials and the extent to which its particularities resemble or differ from those of the targeted country must also be analysed;

- Determining the potential developments, in the long term, in the fields of energy efficiency and renewable energy in various sectors. These studies must address relatively long-range prospects (2030, for instance), in order to make it possible to grasp the economic and environmental impact as well as the required energy resources, starting from several scenarios. These scenarios correlate with the rate at which the measures needed to achieve energy efficiency and renewable energy and integration between the two are universalized; and the financial savings that can be gained as a result of a drop in the value of the subsidies yielded by savings in non-renewable energy, which must be taken into account in defining the financial incentives required to encourage and support the proposed programmes in the areas of energy efficiency and renewable energy.

These studies will enable decision makers to define their objectives as well as the human and material resources needed to achieve them. Consequently, a strategic plan may be formulated, on which the programmes and activities to support energy efficiency and renewable energy systems and their integration into the sustainable development system will focus.

2. *Means of formulating and implementing the strategy*

(a) *Preparing work programmes*

Strategic goals must be set within a programme of work that makes it possible to turn those goals into clearly defined programmes to be implemented, according to the sector and after coordination with stakeholders in each sector. These programmes must be characterized by order and inclusiveness, so as to cover all necessary aspects of sectoral development and thereby make it possible to attain most of the desired results of certain measures. Consequently, these programmes must be put in place, taking into account the three fundamental points that follow:

- Causing a qualitative leap in the approaches taken to implement measures proposed and disseminate them on the widest scale possible;

- Operationalisation of partnerships with stakeholders, so that they contribute to the conception of programmes in their sectors. Capacity-building, raising the level of awareness and providing material and moral incentives are all necessary tasks, so as to entrust stakeholders with implementation of the decisions taken, the desired objectives and the proposed activities;

- Formulating an integrated series of mechanisms to disseminate and provide incentives and using said mechanisms in a timely and orderly manner so as to ensure the success of the proposed programmes. These mechanisms are to contain the legislation and laws that the programmes require, as well as media and awareness-raising campaigns, capacity-building, decision-making tools, sector studies, financial and moral incentives, regional and international cooperation and applied studies that make it possible to come up with appropriate solutions that meet the country's needs and match its characteristics.

(b) *Establishment and operationalisation of mechanisms to implement the strategy*

The institutional and legislative framework is considered the cornerstone of any development project. It is impossible to implement any programme of work without supporting it by providing a fortified institutional framework and a package of applicable laws and legislation. The framework must be binding upon all public and private institutions, and fundamental within the regulatory framework that aims to govern the formulation and implementation of programmes emerging from the strategy.

(c) *Defining stakeholders and their means of participation in ensuring the strategy's success*

Optimizing energy production and consumption, or, in other words, improving energy efficiency and use of renewable energy sources, is based on a horizontal approach that includes all economic sectors. This approach is not limited to adopting technical measures, but rather it is a new method of addressing the subject of energy as a whole, in order to transfer it from a system based on supply and demand to one based on an ongoing examination of the nature of demand and a dialectical review of the existing relationship between demand and supply, within a framework that aims to create a sustainable system that combines the two.

For this reason, optimizing energy production and consumption includes all economic fields without exception, and achieving it is the responsibility of all economic and social actors: central administration, private and public economic institutions, local authorities and the end user in the residential sector. This is why the success of the programmes of work is linked to the effectiveness of consultation and partnership with stakeholders. Defining these parties and operationalising these partnerships constitute challenges that must be taken into account in the formulation of the programme of work. This matter requires a clear idea of the potential role of stakeholders in the programme, and a clarification of their role through their participation in shaping and monitoring the necessary human and financial resources.

3. *The organizational framework and its role in operationalising the strategy*

In order for the existing approach to optimizing energy production and consumption, that is, for promoting energy efficiency and using renewable energy applications, to succeed, all relevant activities must be subsumed within a central regulatory framework with a unified vision that directs sectoral studies and brings their results to the stakeholders. Then, the decisions adopted are translated into an integrated strategy, after which the framework oversees the drafting and implementation of programmes of work arising from the strategy. This central regulatory framework may be based on a group of regulatory frameworks or it may rely on contracted specialists to carry out the mission.

(a) *Central regulatory framework*

This central regulatory framework governs the following:

- Drafting the articles of laws and legislation relating to energy efficiency and renewable energy applications in the country;
- Drafting various sectoral studies and assessing what can be done in the energy efficiency and renewable energy area, and relaying the results to decision makers;
- Turning the decisions adopted into an integrated, coordinated strategy that can be implemented through time-bound programmes of work, while determining the human and material resources and the relevant authorities;
- Overseeing relevant media and awareness-raising campaigns;
- Capacity-building related to energy efficiency and renewable energy.

In order for this regulatory framework to carry out its mandate, it must be executed in compliance with a legislation or law that defines its regulatory structure and purview, and it must take the form of an independent public institution subject to direct policy oversight by the head of Government and to the mandate of the ministries of energy and of the environment. Such an institution should have a board of directors representing all concerned stakeholders, such as the ministries of finance, planning, industry, and transport as well as other bodies concerned with construction in addition to local authorities and the central bank.

This institution must be established upon a fundamental, capable administrative core, and it must have a degree of flexibility that allows it to put together working teams with time-bound missions and in charge of specific subjects. The institution must be allowed to draw upon the capabilities of those outside it to whom it falls to oversee certain aspects of its activities. The central administration of the institution may include several entities in charge of each of these aspects separately, energy efficiency, renewable energy (in the context of specialized sectoral departments), and studies containing forecasts, follow-up on implementation of the projects, media, awareness-raising and dissemination, regional and international relations and legal and legislative issues.

(b) *Special work teams and other types of support*

(i) Working groups with expanded powers: these groups provide support in such areas as energy efficiency in the manufacturing/industrial field and dissemination of renewable energy technologies. These groups are formed in the initial stages of establishment of the approved programme. Their tasks include fact-checking of studies that set out future prospects, defining the items on the prospective agenda, studying potential barriers and mechanisms to eliminate and/or overcome them, proposing complementary legislation and incentive mechanisms to facilitate dissemination of the proposed solutions. Each working group must be made up of representatives of stakeholders in the relevant institutions charged with taking the necessary decisions without consulting their supervisors, save in certain cases. These groups also include representatives of the central regulatory framework, representatives of relevant sectors, and a select group of experts. The groups define the necessary activities and their implementation and organize periodic follow-up meetings. The groups are to be disbanded once their mission is complete.

(ii) Project administration teams: These teams consist of about 5-10 members, and their responsibility is to manage every aspect of the adopted agenda, devoting themselves to technical and administrative oversight of the project. A special funding budget is put in place from the financial resources allocated for the project. This team is either disbanded or its help is sought in implementing a new project once the current project has ended.

(iii) Experts for follow-up and mutual support: A contract is concluded with them to cover the relevant sector or specific geographic destination. They are tasked with providing technical and, in some cases, administrative frameworks for some important projects.

Summary

Protecting the global environment is a humanitarian and moral duty, and reducing carbon dioxide emissions is necessary in order to halt global warming. The energy sector plays a fundamental role in this process, by expanding renewable energy applications, especially electrical energy. Natural resources must be conserved, consumption of fossil fuels must be reduced as these resources are vulnerable to depletion, and adoption of the uses of renewable energy must be introduced.

In its outcome document, “The Future We Want”, the Rio+20 Conference affirmed that combating climate change required urgent and ambitious action, in accordance with the principles and provisions of the United Nations Framework Convention on Climate Change. This requires action in line with the principle of common yet differentiated responsibility. In that context, ESCWA member countries are exerting intensive yet varying efforts in the area of adopting renewable energy applications. There is still much to be done towards legislative, institutional, regulatory and procedural development, or in terms of exerting efforts to regulate and create incentives for participation between the public and private sectors, in order to put to use investments and revitalize the local manufacture of components of renewable energy systems and applications, especially wind and solar power, and towards benefiting from technology transfer and localization as well as promoting regional and international cooperation. In that connection, attempts must be made to implement the following measures:

- Confirm that these technologies are suited to member countries. Their commercial spread will depend on their economic feasibility, which has been confirmed in the case of solar-assisted water heaters, and possibly in the case of using wind energy to produce electricity. Nevertheless, it is necessary to lower the cost of equipment for the use of solar energy to produce electricity, and the time has come to do so. It is advisable to use renewable energy directly, without passing through electricity production before consumption, given the drop in efficiency of renewable energy applications (with the exception of hydropower) in electricity production;

- Strengthen the role of measures to improve the efficiency of electricity production, transfer, conversion, consumption and expansion of the use of natural gas, so as to curb emissions, especially in the electricity sector;

- Review of the price structure of energy and policies that support traditional energy with the aim of reducing this support and eventually phasing it out. This is fundamental to ensuring the success of policies to improve energy efficiency and introduce renewable energy applications;

- Support energy efficiency with the aim of using renewable energy applications, so that the sustainable development process can continue without harm to the global climate and the environment, given that gas and oil resources are prone to depletion. There is no doubt that doing so would lighten the burden borne by the budgets of ESCWA member countries as a result of subsidies of the price of gas and products derived from oil and electricity;

- Adopt a comprehensive approach to renewable energy, and choose feasible resources, according to the level of technical maturity of the technologies and their potential for localization, according to the availability of the necessary technical capacities and raw material to manufacture some of their components, and putting in place benchmarks to assess and analyse the progress achieved;

- Innovate local mechanisms for financing to support renewable energy projects and to encourage small and medium investors to enter this field, as well as regional mechanisms for investment in large projects. The difficulty arises from the enormity of the investment needed to implement them in comparison with traditional energy projects. Carbon trade has not achieved the desired result in past years, and the price of a ton of carbon dropped after rising, and it is unclear what its situation will be, post-Kyoto;

- Create a climate conducive to attracting investments and supportive of partnerships between the public and private sectors, by putting in place supportive legislation and policies and facilitating administrative measures. This calls for creating powerful incentives, among them a commitment to purchase energy generated from a renewable source at preferential prices, or imposing the extraction of a percentage of the energy produced from a renewable source, and facilitating the linkage of renewable energy projects to the grid, as well as exemptions from customs fees and taxes, granting State land allotted for these projects at nominal fees or free of charge, and providing government guarantees against investment risks, under continued legislative, policy and security stability;

- Apply measurement specifications and validity certificates for renewable energy equipment, in order to avoid commercial fraud and the propagation of defective equipment on the domestic market;

- Strengthen regional and international cooperation and policy coordination, particularly given that mitigating climate change is a shared responsibility.