Distr.
LIMITED
E/ESCWA/SDPD/2013/Technical Paper.9
2 January 2014
ORIGINAL: ENGLISH

ECONOMIC AND SOCIAL COMMISSION FOR WESTERN ASIA (ESCWA)

FACT SHEET

GREEN TECHNOLOGIES IN THE ENERGY SECTOR FOR CLIMATE CHANGE MITIGATION IN THE ESCWA REGION

United Nations
New York, 2013

13-0389

1. Introduction

- Climate change is one of the main issues on the international agenda. To avert its negative impacts on the future of our planet, the world needs to reduce its heavy dependency on fossil fuels, which are the main source of greenhouse gas (GHG) emissions.

- GHG emissions, as defined in the Kyoto Protocol, are: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulphur hexafluoride (SF_6), and other synthetic chemicals, namely, hydrofluoro-carbons (HFCs) and perfluoro-carbons (PFCs).[1]

- The term **"**green technologies" is used for technologies that have the potential to ensure environmental protection, reduced pollution, efficient and sustainable use of resources, increased recycling of waste and products, and handling of residual wastes in a more environmentally friendly manner than conventional technologies. Green technologies, in brief, are technologies "whose use is intended to mitigate or reverse the effects of human activity on the environment".[2]

- Objectives of green technologies:[3]
  - Sustainability: meeting the present needs of the society without compromising the ability of generations to come to meet their own needs;
  - Optimum design: creating products that can be reclaimed or reused;
  - Source reduction: minimizing waste and pollution by changing patterns of production and consumption;
  - Innovation: developing alternatives to technologies that have been demonstrated to damage health and the environment;
  - Viability: enforcing economic activities relevant to technologies and products that benefit the environment.

2. Green technologies for climate change mitigation

- Green technologies are tools that, on the one hand, mitigate climate change by reducing GHG emissions, particularly CO_2, and on the other, contribute to sustainable energy in the region. These technologies cover a broad area of energy technologies in the fields of power generation, transportation, industry, construction, and agriculture, among others. Green technologies include, but are not limited to:
  - Renewable energy applications, including electricity production, water heating, water pumping and desalination, air heating and cooling, crops drying, and solar cooking;
  - Energy efficiency and energy saving;
  - Carbon capture and storage (CCS).

- Despite the growing interest of most Gulf Cooperation Council countries (GCCs) in CCS technologies, which stems from the use of CO_2 for enhanced oil exploration, this Fact Sheet will focus on renewable energy technologies for electricity generation, mainly from solar, wind and biomass resources, and energy efficiency technologies in the electricity sector for climate change mitigation, in light of the fact that, in the region of the Economic and Social Commission for

[1] See: www.unfccc.int/ghg_data/ghg_data_unfccc/items/4146.php.

[2] See: www.oxforddictionaries.com/definition/english/green-technology.

[3] See: www.green-technology.org/what.htm (accessed on 26/8/2013).

Western Asia (ESCWA), this sector is ranked as the first source of CO_2 emissions, accounting for 39 per cent of the total emissions from all sectors, as specified in the following table.

TABLE. CO_2 EMISSIONS BY SECTORS, 2013
(Million tons of CO_2)

Countries	Electricity and heat production	Other energy industry own use**	Manuf. industries and construction	Transport	Other sectors	of which: residential
Algeria*	28.5	11.1	13.5	32.3	18.4	14.5
Egypt	71.6	14.4	40.3	40.0	22.1	15.1
Libya	17.6	1.1	2.7	12.0	1.6	1.6
Morocco	18.1	1.4	8.0	14.3	8.4	3.5
Sudan	1.8	0.6	2.5	7.6	2.0	0.6
Tunisia	7.3	0.1	4.7	5.7	3.3	1.7
Bahrain	8.3	4.4	6.8	2.9	0.2	0.2
Iraq	49.0	4.3	9.5	34.2	11.2	11.2
Jordan	9.3	0.7	2.1	5.3	2.4	1.5
Kuwait	45.2	13.9	13.5	11.6	0.5	0.5
Lebanon	11.6	-	1.2	5.0	0.7	0.7
Oman	16.2	8.6	29.2	8.8	0.7	0.3
Qatar	15.0	29.4	12.2	14.5	0.3	0.3
Saudi Arabia	188.7	52.7	102.0	109.2	4.7	4.7
Syria	24.7	1.4	8.2	11.9	6.9	4.0
UAE	59.5	2.2	72.6	30.9	0.7	0.7
Yemen	3.9	2.1	3.4	5.8	5.6	1.6
ESCWA members	548	137	319	320	71	48
Arab countries	576	148	333	352	90	63
Share by sectors in the ESCWA region (%)	39	10	23	23	5	

Source: International Energy Agency (IEA) (2013). CO_2 Emissions from Fuel Combustion: Highlights.

Notes: * Algeria is not yet an ESCWA member country.

Includes emissions from own use in petroleum refining, the manufacture of solid fuels, oil and gas extraction and other energy-producing industries.

3. Power generation through commercialized renewable energy technologies for climate change mitigation

By the end of 2012, the power facilities generating energy from renewable sources in the ESCWA region, including hydropower, reached a capacity of approximately 9,188 megawatt (MW). At the beginning of 2013, the total capacity of renewable energy projects installed was 1,292 MW, utilizing the following energy sources: 86 MW from photovoltaic (PV) systems, 145 MW from concentrated solar power (CSP), 1,015 MW from wind farms, and 46.5 MW from biomass. The total pipelined projects reach a capacity of some 5,530 MW, with 4,073 MW from wind farms, 1,329 MW from solar energy plants and 127.6 MW from biomass. The following figure illustrates the shares of the present and pipelined installed renewable energy capacity in the ESCWA region.

Figure. Present status of installed renewable energy capacity and pipelined projects, by technology, in the ESCWA region

Figure a. Percentage of installed renewable energy capacity in the ESCWA region

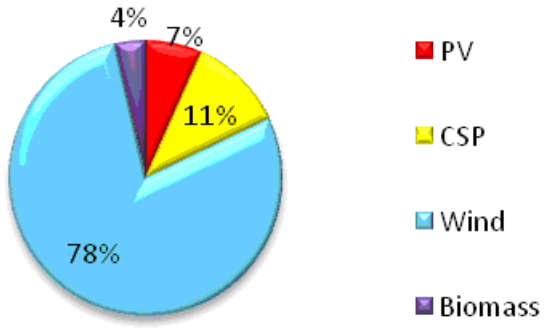
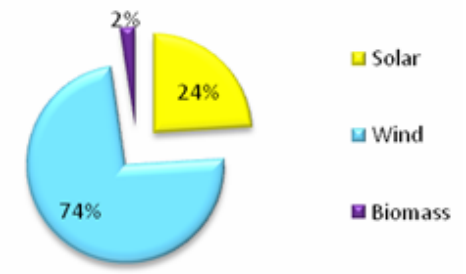


Figure I b. Percentage of pipelined renewable energy projects in the ESCWA region



Source: Calculated by ESCWA, based on data from REN 21 (2013a). *MENA Renewables Status Report*, pp. 11-12.

(a) Solar energy technologies

(i) *Photovoltaic technology*

- Concept: PV power plants produce electrical power through the direct conversion of solar energy into electrical energy. A PV cell is mainly made of silicon and other conductive materials. When solar radiation strikes the cell, it releases electrons from its atoms, allowing the electrons to flow through the material to produce direct electric current (DC) that can be converted into alternate current (AC) by adding an inverter to the electric circuit. The performance of a PV cell is measured in terms of its efficiency in converting sunlight into electricity. However, much of the light energy is reflected or absorbed by the material that makes up the cell, leaving a typical commercial PV cell with an efficiency range of 6-17 per cent.[4] Batteries are usually linked to smaller decentralized PV systems to store the electricity generated during the period of solar radiation availability.
- By the end of 2012, the total installed capacity in the ESCWA region, used for such purposes as electrification, wireless communication, commercials, and water pumping, was 86.4 MW,[5] compared to a global capacity of 100 Gigawatt (GW).[6]
- Assembly facilities for PV technology exist in a number of ESCWA member countries, including Egypt, Jordan, Morocco, and Tunisia. Other countries, such as as Qatar and Saudi Arabia, have signed contracts with PV companies to build factories for the production of polycrystalline silicon PV panels. Several local companies in the ESCWA region carry out the engineering, procurement and construction involved in PV projects as well as related studies. Relevant civil and electromechanical works as well as operation and maintenance expertise are available almost everywhere in the region. Certain components of PV systems, including structures, cables, inverters, batteries, and electronic devices, are manufactured in a number of ESCWA member countries.

[4] ESCWA (2013). *The Adoption and Application of Renewable Energy Technologies in the ESCWA Region* (E/ESCWA/SDPD/2013/IG.2/5), p. 5.

[5] REN 21, 2013a, p. 11.

[6] REN 21 (2013b). *Global Status Report*, p. 14.

- It is envisaged that, during this decade, the PV market will progress significantly in a number of ESCWA member countries in light of the international decrease of PV prices due to the growing economy of scale, technological advancements and the remarkable development in the implementation of projects to realize the goals of national strategies on renewable energy, some examples of which are as follows: Abu Dhabi/United Arab Emirates are aiming to reach 100 MW by 2014; Libya 100 MW by 2015; Oman 200 MW; and Lebanon 50 MW.[7] In the case of Egypt, two 20 MW PV power plants are under consideration and a 200 MW power plant (10x20 MW each) to be undertaken by the private sector is scheduled to be operative by 2016/2017.[8]

(ii) Concentrated solar power technologies

- Concept: CSP power plants produce electrical energy by converting concentrated direct solar radiation into thermal energy, which is then converted into mechanical energy and into electricity.
- There are two types of CSP technologies, differentiated according to the principle of concentration used: first, line-focusing systems, which track the sun position in one dimension, and include such technologies as the parabolic trough collector and the linear Fresnel collector; and, second, the point-focusing system, where mirrors track the sun position in two dimensions, including such facilities as solar towers and solar dishes. The most commercialized CSP technology that will continue to dominate the market for the next decade is the parabolic trough supported by a thermal storage system. Even though the technology of solar towers is more advanced and more efficient, solar towers are utilized less frequently than parabolic troughs, due to the high upfront cost involved.
- Two CSP projects associated with power plant combined cycle units based on parabolic trough technology are operative in the ESCWA region. One is in Egypt, with a capacity of 140 MW, and the other is in Morocco, with 470 MW; the solar share for each project is 20 MW.[9] The total CSP installed capacity in the Arab region reached 65 MW, compared to some 2.5 GW globally by the end of 2012.[10] "Shams 1", a new 100 MW exclusively solar parabolic trough power plant, has been operative in Abu Dhabi since March 2013.[11]
- CSP business has not yet gained considerable ground in the ESCWA region. This may be due to the high upfront cost of such projects; limitation of know-how, particularly as concernng the production of the main components of the solar field, including mirrors and receivers, to a certain number of companies; lack of information exchange between national research bodies and industry; and the lack of national skills.
- The following points are also worth noting:
  - Countries that operate CSP projects have gained reasonable expertise from learning by doing;
  - In some countries, the private sector is involved in CSP technology. For instance, in Egypt, a national company led the consortium in charge of the engineering, procurement

[7] ESCWA (2012). *The Role of Renewable Energy in Mitigating Climate Change in the ESCWA Region* (E/ESCWA/SDPD/2012/1), pp. 15-17 and 49.

[8] See: www.nrea.gov.eg/arabic1.html.

[9] Algeria, which has not yet joined ESCWA, has a 150 MW CSP plant, with a 25 MW solar share.

[10] REN 21, 2013b, p. 14.

[11] REN 21, 2013a, p. 11.

and construction of the solar component of the first CSP project (140 MW Kuraimat project). By now, some 60 per cent of the value of the solar field is locally produced;

- Apart from Algeria, Egypt is the only country in the ESCWA region that is able to upgrade its float glass industry to meet the standards and specifications required in the production of solar field mirrors;

- The development of the industrial capabilities in the region to promote the local manufacturing of certain CSP components (including float glass, metallic structure, cables, electronic devices, and certain electrical and mechanical parts as well as the relevant civil and electromechanical works) depends on the annual demand side in the region. For instance, Morocco aims to produce 2,000 MW from solar technologies by 2020; Libya, 300 MW from CSP technologies by 2015;[12] and Saudi Arabia's ambitious target is to produce 25 GW from CSP technologies by 2032.[13] Therefore, it is important to attract investment by means of securing annual demand for an extended period of time, integrated markets, technical skills, regulations and incentives, and more.

(b) Wind energy technologies

- Concept: Wind energy can be exploited on and off shore to operate a wind turbine at a wind speed (cut-in) of 3-5 meters/second (m/s) up to 25 m/s (cut-off). Modern wind turbines extract energy from wind, mostly for electricity generation, by rotation of a propeller-like set of blades that drive a generator by means of appropriate shafts and gears. Control systems maintain the correct functioning of the turbine to safeguard maximum efficiency and constant electricity production. Wind turbines are equipped with aerodynamic and mechanical brake systems for emergency and maintenance cases. Horizontal axis wind turbines are the most common, with the promoted commercial sizes ranging between 1.5-5 MW, with an average lifespan of 20 years.[14]
- Owing to the intermittent and unpredictable nature of wind, wind power is non-dispatchable. Consequently, it is important to limit the wind energy penetration of the national grid.
- By the end of 2012, the total commercial installed capacity of wind projects in the ESCWA region reached 1.015 GW, representing 0.004 per cent of the world total of some 283 GW.[15] Wind projects are mostly concentrated in Egypt (550 MW), Morocco (291 MW) and Tunisia (174 MW). Presently, most ESCWA member countries have completed their wind atlases to identify promising sites for wind power plants and set up national plans to develop the use of these resources. Egypt, for instance, is aiming at 7,200 MW by 2020, Jordan at 1,200 MW by 2020, Libya at 1,750 MW by 2030, and Morocco at 2,000 MW by 2020.[16]
- The following are the main components of wind turbines: tower, blades and nacelle, the latter holding the gear box, generator, rotating shafts, and brakes; such electrical and mechanical parts as cables, transformers, circuit breakers, and control systems; and civil works, including concrete foundations, internal roads, storehouses, and administrative

[12] ESCWA, 2012, pp. 16-17.

[13] REN 21, 2013a, p. 13.

[14] ESCWA (2010a). *Promoting Large-scale Renewable Energy Applications in the Arab Region: An Approach for Climate Change Mitigation* (E/ESCWA/SDPD/2010/WP.2), p. 2-3.

[15] ESCWA, 2013, p. 12.

[16] ESCWA, 2012, pp. 7-8.

buildings. There is significant potential to create a local market in the region for a number of components of wind turbine equipment.

- It is worth mentioning that the wind energy industry in Egypt is emerging, with national contractors in charge of concrete foundations, erection and procurement, towers, transformers, and cables. A private Egyptian company established a factory to manufacture components of wind turbines, under the licence of European firms. Most ESCWA member countries have classic electricity equipment industries producing cables, wires, transformers, electronic devices, precaution systems and more, as well as a wide expertise in the business, which could be a good basis for a long-term strategy aiming to enhance the wind energy industry based on market integration.[17]

(c) Biomass energy technologies

- Concept: Biomass sources include animal and human waste; organic, forestry and agricultural residues; and trees and crops that are grown specifically to produce biomass fuels. Currently, various technologies exist to convert biomass into energy. There are five fundamental uses of biomass energy: (i) traditional domestic use, particularly in developing countries, mostly of charcoal and agricultural residues for cooking, lighting and space heating, with and efficiency of biomass-to-energy conversion of between 5 and 15 per cent; (ii) traditional industrial use for the processing of bricks, with the biomass feedstock-to-energy conversion efficiency commonly at 15 per cent or less; (iii) biological conversion techniques, including anaerobic digestion for biogas production and fermentation for alcohol; (iv) newer chemical conversion technologies by means of fuel cells which are capable of bypassing the maximum theoretical conversion efficiencies of thermal units; and (v) advanced thermal biomass conversion technologies used in industry, with an expected conversion efficiency of between 30 and 55 per cent. [18]

- Two technologies exist to produce electrical energy from biomass: (i) combustion of biomass residues to produce such biofuels as methane, methanol and ethanol, which can be used for heating in a power plant with a capacity of 20-100 MW, with an efficiency range of 20-40 per cent, and electricity frequently being cogenerated with heat and steam; and (ii) co-firing, whereby biomass is burnt together with another material, for instance fossil fuels, which may be a means for sustainable and affordable electricity production and for better meeting emission reduction targets.

- The total installed capacity for the modern production of energy out of biomass and waste in the ESCWA region is 46.5 MW; the estimated capacity of projects in the pipeline, which are located mainly in the United Arab Emirates (101 MW), Bahrain (25 MW) and Morocco (1.6 MW), is 127.6 MW.[19] It must be noted, however, that in most ESCWA member countries, information on the national biomass and waste targets is not as clear as that on solar and wind energies, Projects in the region are limited and include Jordan, where biogas from a solid waste landfill operates a 4 MW power plant; and Egypt, where biogas from a water and sewage treatment plant contributes to operate a 18.5 MW power plant.[20]

- In most ESCWA member countries, unlike wind and solar energies, biomass has not yet been prioritized as part of the renewable energy sources, despite its potential, particularly in

[17] ESCWA (2011a). *Local Manufacturing of Solar and Wind Energies Equipment to Produce Electricity in the Arab Region: Potential and Prospects* (E/ESCWA/SDPD/2011/WG.5/2), pp. 14 and 24 (Arabic).

[18] ESCWA (1999). *Promotion of New and Renewable Energy Sources of Energy, with Particular Emphasis on Rural and Remote Areas* (E/ESCWA/ENR/1999/24), p.34-35.

[19] REN 21, 2013a, pp. 11-13.

[20] ESCWA, 2012, p. 19.

the household sector, with an estimated availability of some 80 million tons/year.[21] The utilization of biomass is relatively difficult to measure and, therefore, data on it is not very reliable. It is important to state, however, that relevant potential industry is available in such countries as Egypt, Jordan, Morocco, the Sudan, the Syrian Arab Republic, and Yemen, including incinerators, digesters and combustion machines.

- To avoid exacerbating the difficulties already facing the ESCWA region with regard to food and water security, however, it is advised to limit the biomass used to animal and vegetal wastes.

4. Energy efficiency technologies in the electrical energy sector

Energy efficiency includes both active measures focusing on the improvement of the efficiency of electricity production, transmission, distribution, and consumption; and passive measures focusing on the rationalization of energy consumption.

- The electricity sector is considered one of the main sources of polluting emissions with a share of some 25 per cent at the global level. In the ESCWA region, the contribution of the electricity sector to GHG emissions is 39 per cent,[22] and 98 per cent of the thermal power plants in the region are dependent on fossil fuels. Electricity losses in the power sector differ from one country to the next. For instance, the total electrical energy loss is 10.79 per cent in Egypt and 16.3 per cent in Tunisia, compared to 44 per cent in Yemen, 35 per cent in Iraq, 32 per cent in the Syrian Arab Republic and 25 per cent in Kuwait. Measures to reduce electricity loss at all levels must be included in the national energy policies and need to address, among other issues, the efficient use of natural resources, power plant economics, sector restructuring and reform, quality of the services of the sector, monitoring and evaluation, and the reduction of GHG emissions.

- The production efficiency of thermal power plants in the ESCWA region ranges between 25.6 per cent in Iraq and 41.9 per cent in Egypt.[23] The relatively high efficiency in Egypt is attributed to the use of natural gas, which powers some 86 per cent of all thermal power stations in the country, and combined cycle plants, which represent 34.7 per cent of the total installed capacity and which have an average efficiency rate of 55 per cent.[24]

- Losses during the transmission and distribution of energy in ESCWA member countries range between 12 per cent in Egypt, 28 per cent in the Syrian Arab Republic, 30 per cent in Iraq, and 39.5 per cent in Yemen.[25] The losses in the distribution grids are far from reaching the international standards of less than 5 per cent. Therefore, enhanced programmes at the level of transmission and distribution are urgently required.

- All forecasts indicate that electricity demand will rise in the near future. Therefore, it is important to focus on energy efficiency technologies.

- Technologies to improve energy efficiency include, but are not limited to:[26]

[21] Environment and Development (2012), vol. 17, No. 174 (September), p.23.

[22] IEA, 2013.

[23] Arab Union of Electricity (2012). *Statistical Bulletin*, issue 21, item B, pp. 6, 14 and 20.

[24] Ministry of Electricity and Energy, Egyptian Electricity Holding Company. *Annual Report 2011/2012*, pp. 16, 18 and 22.

[25] Arab Union of Electricity, 2012, item L, p. 20.

[26] ESCWA (2010). *Improving Energy Efficiency in the Electricity Sector in the ESCWA Region* (E/ESCWA/SDPD/2010/Technical Paper.4), pp. 9-10.

- At the production level:
  - Complete combustion process in the boiler by efficient regulation of excess air;
  - Technologies to avoid water and steam leakage;
  - Good insulation;
  - Devices to regulate the temperature of the combustion gases leaving through the chimney, which should be as low as possible;
  - Equipment to avoid corrosion;
  - Equipment to avoid air leakage to the condenser;
  - Equipment to retain the heat transfer area free of any deposits, to be monitored periodically;
  - Testing devices with relevant software for the regular revision of temperature and pressure values, which should remain constant over the years;
  - Heat recovery technologies, especially the combined cycle units.
- At the transmission and distribution level:
  - Capacitors and/or synchronous machines to improve the power factor of the grid, to avoid transmitting the reactive power;
  - Cables with the conductors' area appropriate to the voltage, taking into consideration the economic factor and the distance of the loads;
  - Advanced metering infrastructure, programme pricing and customer devices;
  - Efficient transformers to reduce losses through copper and iron;
  - Remote monitoring systems;
  - Technologies related to smart grids.
- At the end-user level:
  - Net metering systems, solar water heaters, efficient energy saving lamps, energy labeling for home appliances to enhance the use of efficient technologies, and more.[27]

- ESCWA has already issued the following reports: Available Opportunities for Energy Efficiency in the Existing Buildings in the ESCWA Region, 2012; Policies and Measures for Promoting Sustainable Use of Energy in the Transport Sector in the ESCWA Region, 2011; Improving Energy Efficiency in the Electric Power Sector in the ESCWA Region, 2010; Energy Efficiency in Green Buildings, 2011; and Guidelines for Energy Efficiency in the Tourism Sector: Strategy, Design, Systems, and Operations Approach, 2009.

5. Challenges facing the adoption of green technologies for climate change mitigation

- Lack of strategic insight at the national level;
- Absence of regulations, policies and incentives;
- Limited expertise in monitoring, assessment, control, and remediation processes;
- Lack of knowledge and programmes tailored to build the national capacity;
- Large international companies that refuse to license their patents to other companies.

[27] ESCWA (2011b). *Energy Efficiency in Green Buildings* (E/ESCWA/SDPD/2011/Technical Paper.4).

6. Requirements to promote green energy technologies for climate change mitigation

- Strengthening institutional arrangements and governance in terms of transparency, accountability, participation and follow-up to facilitate transition to green technologies;

- Providing a favourable environment for promoting green technology industries in terms of flexible financing schemes for small and medium enterprises, public private partnerships, simplified administrative arrangements, supervision, assessment, governmental technical assistance, and more;

- Linking green technology industries to relevant national activities in the field of research and development;

- National capacity-building to develop green technology industries and raise public awareness of their benefits.

7. ESCWA activities to promote green technologies for climate change mitigation

- Green technologies in general: ESCWA, in cooperation with national counterparts, has established national green help desks in Egypt, Jordan, Lebanon, Oman and Tunisia and is facilitating the exchange of expertise and knowledge needed in this respect among member countries, on the one hand, and between ESCWA and other United Nations regional committees, on the other hand.

- Green Technologies for Climate Change Mitigation: A Renewable Energy Training and Educational Centre, hosted by the Agriculture Research and Education Centre and affiliated to the American University in Beirut (AUB), is currently under implementation. This centre will provide access to operational small-scale models of renewable energy technologies appropriate for rural areas and is expected to be operative before mid-2014. ESCWA is planning to carry out training programmes in capacity-building and related field activities for participants nominated by member countries, with a view to increasing technical knowledge of green technologies for climate change mitigation.

- Based on previous ESCWA activities in the area of energy efficiency,[28] ESCWA will launch, in 2014, a regional initiative on energy efficiency in buildings in the Arab region. This project aims to improve energy efficiency in the residential and services sectors in the ESCWA region by upscaling energy efficiency programmes in the existing residential and non-residential building stock. This will allow for an increasing local and regional integration of green technologies and of goods and services associated with energy efficiency to foster new employment opportunities and upscale energy efficiency programmes and projects in these two sectors.

- ESCWA provides a platform for public awareness campaigns for green technologies, especially in the area of climate change mitigation, in cooperation with such international and regional organizations as the United Nations regional commissions, the United Nations Environment Programme, the United Nations Development Programme, the United Nations Industrial Development Organization, the United Nations Educational, Scientific and Cultural Organization, the League of Arab States, and the Regional Centre for Renewable Energy and Energy Efficiency, to name a few.

[28] For more information on ESCWA activities in this field, see the following technical papers: *Guidelines for Energy Efficiency in the Tourism Sector* (E/ESCWA/PI/2009/14), *Energy Efficiency in Green Buildings* (E/ESCWA/SDPD/2011/Technical Paper.4) and *Available Opportunities for Energy Efficiency in Existing Buildings in the ESCWA Region* (E/ESCWA/SDPD/2012/Technical Paper.4).