UNITED NATIONS **E**

ECONOMIC AND SOCIAL COUNCIL

Distr.
LIMITED
E/ESCWA/SDPD/2010/IG.1/4(Part IV)
20 September 2010
ENGLISH
ORIGINAL: ARABIC

Economic and Social Commission for Western Asia (ESCWA)

Committee on Energy
Eighth session
Beirut, 13-14 December 2010

Item 5 (d) of the provisional agenda

ENERGY POLICIES AND MEASURES FOR PROMOTING CLIMATE CHANGE MITIGATION IN ESCWA MEMBER COUNTRIES

PRODUCING ENERGY FROM WASTE

Summary

This document aims at highlighting how to benefit from solid and liquid waste treatment to generate energy and reduce emissions. It reviews the types of waste/residues and their characteristics and treatment benefits, as well as the possibilities of generating thermal and electric power through many techniques, mainly: direct incineration, methane extraction and biogas production or alcoholic liquid bio-fuel production from solid or liquid waste and sewage networks. It also exposes some experiments and pilot projects in the field.

The document further sheds light on the constraints and challenges that prevent from using waste treatment to generate energy and reduce environmental pollution. It underlines policies and commitments that stimulate public and private sectors to increase investments in that field and benefit both the environment and energy sectors.

10-0352

CONTENTS

Introduction

1. Transporting, treating and disposing of liquid and solid waste pose considerable challenges in the majority of countries. Challenges increase with the growing turn to consumer society and civic life, and their lifestyles which cause an increase of organic and inorganic waste/residues. The management and treatment of such waste/residues have become among the most important concerns in the field of environmental conservation and pollution reduction. It is no more sufficient to amass residues in specific spaces (dumps) or places without any treatment, for many reasons mainly their increasing volume and the resulting high pollution rates in the air, soil and surface and ground water.

2. In that context, waste management constitutes one of the five thematic areas (along with transport, chemicals, mining, and the Ten-year Framework of Programmes on Sustainable Consumption and Production patterns) that will be addressed by the United Nations Commission on Sustainable Development at its eighteenth (May 2010) and nineteenth (May 2011) sessions to review the progress achieved in implementing agreed commitments, objectives and goals, and formulate policies related to those areas.

3. At its 130th regular session (Cairo, 6-8 September 2008), the Council of Ministers of the League of Arab States approved the Statute of the Arab Environment Facility, one of its missions being to "develop adequate techniques for the treatment of sewage and disposal and reuse of solid waste".

4. Also, the Arab Regional Strategy for Sustainable Consumption and Production adopted by the Council of Arab Ministers Responsible for the Environment at its 21st session (Marsa Alam, Egypt, 10-11 November 2009)[1] lists waste management as one of its priority implementation areas which included energy for sustainable development, water resources management, rural development and poverty eradication, education and sustainable lifestyles, and sustainable tourism.

5. Thus, the issue of producing energy from waste was included in the agenda of the eighth session of the Committee on Energy under the item on energy policies and measures for promoting climate change mitigation in ESCWA member countries.

I. TYPES OF WASTE

6. The disposal and treatment of domestic and municipal waste in big cities pose major challenges. That type of waste includes: solid waste containing organic and inorganic substances, and liquid waste resulting from the sewerage. There is also the waste resulting from agriculture, harvest, food industry and animal residues, especially in farms.

7. The term "biomass" covers all kinds of fuel derived from wood, agriculture, waste, and the processing of food and fuel from crops, especially those which are grown specifically for energy generation. It can also include the sewage sludge and animal dung. Biomass fuel derives from remnants of living humans, animals, and plants. It is considered to be a source of renewable energy due to its ability to be renewed.

8. This document covers only those types of waste and residues and does not address industrial, medical, electronic or any other types of waste because of their respective special characteristics.

A. SOLID WASTE

1. *Municipal waste/residues*

9. Municipal waste/residues include waste thrown daily by households and companies such as food residues, bags, cans, cleaning materials, bottles, paper, old clothes, household appliances, and others. They

[1] Available at: http://www.arableagueonline.org/lasimages/picture_gallery/agenda25-10-2009.doc.

do not include hazardous hospital, health, industrial, and chemical waste that should be disposed of in a scientific and proper way according to their respective properties.

10. Solid domestic and municipal waste consists of organic materials such as food residues and inorganic materials such as glass and metal. According to the Arab Regional Strategy for Sustainable Consumption and Production, 50 to 60 per cent of solid municipal waste is organic, while 10 per cent consists of paper, 7 per cent of plastic, 4 per cent of glass, 4 per cent of metal and 4 per cent of textiles. The quantity and composition of waste vary from country to country and from region to region within the same country depending on the living standard, social and economic conditions, and level of urbanization. According to the Environment Outlook for the Arab Region prepared by the United Nations Environment Program,[2] each Arab individual produces between 0.5 kg and 1.75 kg of waste daily. The municipal solid waste is generally characterized by its high level of humidity (30 to 40 per cent) which reduces the heating value resulting from combustion. Besides, the heating value varies according to the economic and social conditions and ranges between 750 kilocalories (kcal) and 5,000 kcal per kilogram of waste.

11. The municipal waste is often collected by the municipality or its contractors, and accumulated in special spaces (dumps) relatively far from communities. In some countries of the ESCWA region, approximately 50 per cent of the waste might not be collected, especially in remote and rural areas. That waste poses an environmental threat if thrown in dumps without treatment, for it produces methane, a greenhouse gas that spreads in the air when organic materials are decomposed. In addition, some countries of the region use primitive disposal methods, by either burning waste in open air or throwing it in the sea or watercourses.

2. *Agricultural waste*

12. Agricultural waste includes vegetable and animal waste/residues, namely the residues of crops and of vegetable and animal food processing. The past decades witnessed a dramatic increase in the quantities of agricultural waste due to the significant expansion of agricultural production and food industry.

13. The quality and amount of crop residues vary from country to country and from year to year depending on the natural factors, quantity of rain and other falls, and the adopted cultivations. According to a study on recycling agricultural residues in the Arab States published by the Arab Organization for Agricultural Development in June 2009, crop residues in the Arab countries consist of hay, logs, rice straw, vines, palm fronds, sugar cane leaves, citrus and olive trimming residues, and remnants of banana leaves and stems and of other plants. Residues of vegetable food processing differ in terms of their chemical composition and include bagasse, bran, date kernels, olivepits, bakery remnants and waste resulting from pickling, fermentation, canning, and wrapping, drying, freezing, washing and peeling. They also differ in terms of quality of processing and efficiency of use, and are characterized by the presence of carbohydrates, starch, pectin, and very concentrated quantities of inorganic salts. Animal residues include dung, remnants of cattle and animals, and residues of slaughter houses and fish and dairy factories.

14. The quality and amount of crops and animal waste vary from one country to another depending on the local resources and their exploitation methods. Nevertheless, that waste is rich in organic materials that can be used as soil fertilizers, and in feeding animals and producing energy.

B. LIQUID WASTE

15. Liquid waste includes wastewater and sewage of homes and institutions. There is also the toxic and harmful liquid waste produced in hospitals and factories, which should be disposed of properly to avoid the damages stemming from it.

[2] English version is still in process. Arabic version is available at: http://www.unep.org.bh/Publications/Files/EOAR%20brochure_ar_low%20res.pdf.

16. In cities and populated areas, liquid waste is transferred from homes and institutions to disposal places through sewerage. In villages and rural areas, wastewater is disposed of in sanitary pits, mostly because of lack of sewerage. Disposing of wastewater directly in sea shores or in rivers and other natural waterways has negative effects on the environment. Also, pouring it into underground cracks allows the leakage of contaminated substances into the groundwater, which affects the sources of water. Consequently, wastewater should be treated properly before being disposed of.

17. According to the Environment Outlook for the Arab region, 85 per cent of people have access to improved sanitation in urban areas, against 60 per cent in rural areas. Thus, the treatment of liquid waste may be carried out by the municipal and local authorities.

II. TREATING WASTE AND REDUCING EMISSIONS

A. WASTE MANAGEMENT METHODS

18. Waste management methods currently adopted vary from a place to another. Some of them rely on outdated ways that are harmful to the environment, while others use new technologies that reduce pollution and emissions and generate other usages which benefit from the by-products of treatment processes.

1. *Domestic and municipal solid waste*

19. The management of solid waste consists of a preliminary sorting with a view to recycling parts of it and using others in the production of fertilizers. What remains is either burnt or grouped in open spaces or sanitary landfills.

(a) *Open spaces (dumps)*: Grouping waste in open spaces poses an environmental threat which consists of the spread of odors, insects, and harmful microbes in the surrounding areas. The decomposition of organic substances results in the emission of large quantities of greenhouse gases, which raises the risk of fires and leakage of contaminants into groundwater;

(b) *Sanitary landfilling*: It consists of wrapping waste to prevent the spread of contaminants in the air, and amass it in insulated places to prevent the leakage of liquid contaminants into groundwater. Sanitary landfilling is less polluting than open dumps. Nevertheless, the treatment process is more expensive and does not offer the possibility of using its by-products such as methane to generate energy;

(c) *Incinerators*: Waste is collected and burnt in places equipped for that purpose. Such process must therefore abide by the international standards set to reduce harmful emissions associated with the incineration smoke. Burning waste produces thermal energy that may be used directly or transformed into electrical energy through the production of steam necessary to feed the turbines.

2. *Solid agricultural waste*

20. Solid agricultural waste management and treatment methods vary according to the economic value of that waste. Straw waste for instance is the essential element of animal feed. It may be treated by adding to it some constituents of other agricultural residues to increase its nutritional value. Some agricultural residues are also used in fertilization either by burying them in the soil as organic fertilizers or by mixing them with animal residues for the purposes of fertilization and land reclamation; in some industries such as wood and paper and small rural industries; and in the generation of energy as solid fuel for combustion, biogas/methane, or liquid bio-fuel. However, the economic feasibility remains the most important factor in deciding whether to use agricultural waste in fodder and fertilizer production or in energy generation.

3. *Liquid waste*

21. Liquid waste management methods currently adopted by the countries of the region are either polluting and harmful or friendly to the environment, depending on the plant location and the methods used even within the same country. Those methods include:

(a) Discharging sewage and wastewater directly in the nearest waterway: this method pollutes rivers and the environment, including the sources of fresh and irrigation water and the soil, disrupts the ecological balance on the banks of rivers and increases emissions in the air and the proliferation of insects;

(b) Discharging sewage and wastewater through outlets in the sea: this method pollutes the surrounding beaches, and disrupts the ecological and environmental balance of the area directly affected by open outlets;

(c) Using sanitary pits, which are quasi-tanks, for the collection of wastewater in rural areas lacking sewage systems. When saturated, those pits are emptied through tankers in the valleys, rivers, or the sea or in the closest point reached by the sewage network. In some areas, pits are directly emptied in the rainwater streams, which increases pollution and greenhouse gas emissions;

(d) Establishing sewage treatment plants where wastewater is purified from pollutants and its gases are extracted before it is diverted to the rivers or the sea. This method is environment-friendly, for it decreases the rates of pollution resulting from human waste and provides methane that can be used as a source of energy.

B. BENEFITS OF WASTE TREATMENT

22. The treatment of waste and residues reduces pollution and greenhouse gas emissions, which contributes to the achievement of the Millennium Development Goals related to health (Goal 4: Reduce child mortality; Goal 5: Improve maternal health; and Goal 6: Combat HIV/AIDS, malaria, and other diseases), and those related to environmental sustainability (Goal 7: Ensure environmental sustainability). Waste treatment has many benefits, including the following:

(a) Reducing the use of natural resources by reusing and recycling some waste such as paper, cardboard, plastic, glass, metals, and others;

(b) Reducing the reliance on synthetic and chemical fertilizers by using organic fertilizers, thus increasing land productivity and fertility;

(c) Reducing the need to larger areas for dumping or assembling waste;

(d) Limiting the proliferation of insects and harmful microbes that reside and multiply in waste;

(e) Reducing environmental pollution and the spread of greenhouse gases, namely carbon dioxide, methane and other gases produced during the digestion (fermentation) and interaction of organic waste;

(f) Reducing air pollution and repugnant odors around dumps and places of collection discharge by isolating and using methane;

(g) Mitigating climate change by producing energy from waste/residues, especially that they are considered as renewable sources of energy.

III. ENERGY GENERATION

A. DIRECT COMBUSTION

23. Direct combustion produces thermal energy, as is the case of fossil fuel. Such energy may be transformed by known systems into mechanical and electrical energy. The thermal power of one kilogram of waste ranges between 750 and 5,000 kcal.

24. It is usually advised to treat solid waste before combustion. Pre-combustion treatment is not always the same, but it is generally required to remove metals and other non-combustible and big-sized materials, and then cut the waste with a view to using it as fire fuel. The effective environmental management of solid waste combustion processes shall exclude toxic substances, if any, before combustion, to prevent air pollution.

25. In rural areas, all kinds of originally dry or dried up agricultural waste are used as conventional fuel (cotton stalks, corn straw, remnants of tree trimming and dried up trees). Some vegetable residues and trimming remnants are used to produce coal that is used later as special fuel. The waste of food industries is also used to generate thermal energy as in burning the peat resulting from olive oil production in Jordan, Lebanon and the Syrian Arab Republic.

1. *Benefits of direct combustion*

26. Direct combustion of solid waste has the double benefit of generating energy and reducing the volume of waste by up to 90 per cent. However, there remains the concern of disposing of ash and controlling air pollutant emissions resulting from combustion.

27. Solid waste combustion in the waste-to-energy conversion plants causes carbon dioxide emissions. However, that process remains less hazardous than waste decomposition and the emission of methane which causes global warming with a capacity 25 times higher than that of carbon dioxide.

28. Producing energy from waste has an advantage over other renewable energy applications because it allows access to energy at any time, unlike the wind energy and solar energy which are produced respectively when the wind blows or in daytime, under specific climatic conditions.

2. *Problems of direct combustion*

29. Direct combustion causes emissions in the air, which vary according to the type of fuel and technology used. Quantities of nitrogen oxides emitted differ greatly from a combustion facility to another, depending on the design of the facility, the set criteria, and the type of burnt materials. Sometimes, carbon monoxide emissions may exceed those emanating from coal factories.

30. The diffused particles represent an additional concern for being air pollutants, but they can be easily controlled through available technologies.

31. Emissions may contain such toxic substances as metal traces including lead, cadmium and mercury, in addition to organic traces like dioxin. Those toxic substances create an environmental problem if diffused in the air or absorbed by the soil reaching the groundwater. Consequently, the environmental laws that govern energy production from solid waste should include provisions on the control of such toxic substances and air pollution.

32. It is thus requested to exercise utmost pollution control using available technologies, including curbing hazardous particles and gas emissions, cleaning the tools, controlling acidity levels, monitoring the combustion efficiency continuously, and testing smokestacks periodically.

B. METHANE EXTRACTION

1. *Methane extraction mechanism*

33. Large landfills produce Methane. In fact, micro-organisms that live in organic materials such as food waste or scratches of paper cause decomposition leading to the production of landfill gas composed of 60 per cent of methane and 35 per cent of carbon dioxide. That gas is extracted by drilling "wells" in landfills, and is collected by pipes.

2. *Benefits of methane extraction*

34. Compared to direct combustion, extracting methane from landfills has a major benefit: its multipurpose usage in power plants. When processed, methane can be combined with natural gas to be used as fuel for boilers that supply turbines with steam or for diesel engines. It can also be used in the combined cycle system and in fuel cell technologies which use chemical reactions to generate electricity.

35. One of the benefits of using landfill gas in generating electricity is that it reduces the adverse environmental effects. In fact, power plants operating on landfill gas limit methane emissions, for they burn the methane that was supposed to be uselessly diffused in the air or burnt. It should be noted that methane is a major contributor to global climate change, for the effect of each kilogram of methane on global warming is equivalent to that of 25 kilograms of carbon dioxide,[3] while the combustion of one kilogram of methane leads to the emission of only 3.66 kilograms of carbon dioxide.

3. *Problems of methane extraction*

36. Equipment operating with landfill gas produce nitrogen oxides that vary from location to another, according to the type of equipment and the measures taken to control and limit their emission.

C. BIOGAS PRODUCTION

37. The anaerobic digestion (fermentation) of organic waste, such as food and food processing waste, and human and animal residues, is a biological process that produces a gas consisting mainly of methane and carbon dioxide, and known as biogas. The anaerobic digestion reduces odors and limits the problems related to waste disposal. It produces biogas as fuel that can be used for heating and/or generating power.

38. The anaerobic digestion may happen either naturally or in a controlled environment such as the biogas plant where organic waste containing different types of bacteria is put in an air-isolating container called digester (fermenter). According to the waste sources and system design, the biogas formed is usually constituted of 60 to 65 per cent of pure methane, 30 to 35 per cent of carbon dioxide and a percentage of other gases such as hydrogen sulfide. It is currently possible to produce a biogas constituted of more than 95 per cent of pure methane.

39. The anaerobic digestion process consists of three phases:

- Phase I: Decomposition of plant and animal materials (hydrolysis), in which organic substances are broken into usable molecules such as sugar;
- Phase II: Transformation of decomposed materials into organic acids;
- Phase III: Transformation of acids into methane.

40. The process temperature affects the digestion rate and should be kept between 35 and 38 degrees Celsius. It can also range between 57 and 63 degrees Celsius when air-isolated holes are used for fermentation and biogas generation.

41. Numerous technologies are used for generating biogas. They range from the most simple to the most complicated and are available in many sizes: small-sized familial, medium-sized semi-industrial and big-sized industrial digesters. They are all manufactured in developing countries (India, China, Bangladesh, and others) for their suitability for rural areas; therefore all their technologies are commercially available. They were successfully used to generate energy for cooking and lighting through the processing of agricultural,

[3] Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2007*, Contribution of Working Group I to the Fourth Assessment Report, chap. 2, p. 212. Available at: www.ipcc.ch.

animal and sewage waste. It should be noted that the 2009 Zayed Future Energy Prize (United Arab Emirates) was granted to the owner of the project on providing clean energy solutions to rural areas in Bangladesh where more than six thousand plants for biogas production from the cow and chicken waste were created to be used for cooking and lighting. Residues of anaerobic digestion are often rich in agricultural nutrients that can be used as organic fertilizers.

42. The thermal power of each standard cubic metre of generated biogas is about 5,600 kcal, while it is about 9,100 kcal per litre of kerosene. For some other common biomass energy sources, the thermal power in kcal per kg[4] is as follows:

Wood	Cotton stalks	Corn stover	Rice straw	Dung
5000	4000	3600	3500	2700

43. Each kilogram of poultry manure treated in digesters produces about 1.6 m^3 of digested organic material, while each kilogram of swine manure and cow dung produces 1.1 m^3 and 0.8m^3 respectively. To ascertain the possibility of fulfilling the energy needs of rural families, table 1 shows the biogas needed for different uses.[5]

TABLE 1. BIOGAS NEEDS FOR DIFFERENT USES

Purpose	Specifications	Gas consumption rate
Cooking for an average family	5 members	1.5 m^3/day
Small stove	3 cm of diameter	230 liters/hour
Medium stove	4.5 cm of diameter	300 liters/hour
Big stove	6 cm of diameter	390 liters/hour
Oven	medium size	500 liters/hour
Lighting	lamp	100 liters/hour
Internal combustion machine	horsepower	450-600 liters/hour
Refrigerator	6 ft^3	1200 liters/hour

D. LIQUID BIO-FUEL PRODUCTION

44. It is possible to make use of vegetable waste rich in sugar and starch, such as sugar-cane residues, by preparing it for the production of alcohol (ethanol) that can be effectively used as a cleaner fuel in transport engines either alone or mixed in specific proportions with traditional fuel oil to reduce emissions.

IV. EXPERIENCES IN COUNTRIES OF THE ESCWA REGION

45. The ESCWA study entitled "Potential and Prospects for Renewable Energy Electricity Generation in the ESCWA Region"[6] included a part on the biomass systems and applications, and reviewed the cases of Egypt, Jordan, Lebanon, the Syrian Arab Republic and Yemen.

46. There are numerous power generation units from waste/residues in the villages for individual domestic use. Those units are anaerobic digesters of animal waste and sludge. The biogas produced during digestion is used directly for heating and cooking. Those digesters are built near the houses and are fed with animal and

[4] The League of Arab States, *Deliberations of the training session on studying the design, creation, operation and maintenance of biogas generation units in rural Arab communities*, Arab Center for the Studies of Arid Zones and Dry Lands, Damascus, 22 June-20 July 1996.

[5] Ibid.

[6] ESCWA, *Potential and Prospects for Renewable Energy Electricity Generation in the ESCWA Region-Volume I, Overview of Wind and Biomass Systems*, E/ESCWA/ENR/2001/4.

human waste such as dung and wastewater. Their use contributes significantly to reducing the pollution and emissions that would have resulted from the exposure of waste to air or disposing of it in the rivers.

47. Since the late 1980s, ESCWA has worked on disseminating that technology. It carried out, in that context, an experimental project in southern Yemen. That is considered a useful way to provide rural areas with energy and ensure their energy security, and to contribute to reducing emissions and improving health, economic and social conditions in order to achieve the Millennium Development Goals. There are currently many digesters in the countries of the ESCWA region, including: the individual digesters of the "Biogas" project in Manshiet Nasser in Egypt, where waste and fermentation equipment is used to produce enough gas for two hours of cooking from each equipment and a quantity of fertilizer that is resold; dozens of domestic 14 m^3 digesters in the Syrian governorates; and in Jordan, the competent authorities are planning to generate electricity from biogas in farm using small units of a capacity of 1 kW each. There are also local manufactures of biogas production units in Jordan and the Syrian Arab Republic.

48. Compared to the achievements of China and India in that field, those projects are still in their early stages in the ESCWA region. In China for example, at the end of 2007, more than 26.5 million rural families were using biogas produced in domestic digesters, saving thus the equivalent of 16 million tons of coal yearly and their associated carbon dioxide emissions totaling 44 million tons.[7]

49. Big-sized units are usually used in governmental or local projects, and aim to generate energy from solid and liquid waste treatment in communities, mainly in big cities, in an environment-friendly way and with fewer emissions.

50. Thermal or electrical energy production projects are still very few in the countries of the ESCWA region. The most important projects are located in the following countries:

- Jordan: A 4 Megawatt (MW) electricity production plant in Ar-Russayfah using biogas produced from landfills;
- Egypt: A plant in the Yellow Mountain village for the treatment of sewage and wastewater, producing 18.5 MW, the equivalent of 70 per cent of its needs estimated at 26.6 MW;
- Lebanon: A sewage treatment plant in Tripoli equipped to produce half of its needs in energy from the extracted biogas;
- United Arab Emirates: A project to generate energy in a plant treating 6,500 tons of waste daily;
- Yemen: A plan to create a landfill in Sana'a to generate energy from waste, financed by the Clean Development Mechanism.

51. In some rural areas in the ESCWA region, wastewater treatment plants are managed by the local authorities (municipalities). Nevertheless, the generated energy is not used as a by-product and the municipalities are therefore baring all the costs of energy required to run the plants. That financial burden threatens their sustainability.

52. Also, many small industrial projects took place in the ESCWA region such as the Lebanese company Indevco which equipped lately a number of 25 kW boilers that operate on burning olive pits and waste in parallel with other boilers that operate on diesel oil. Experiences of some countries of the region in that field are exposed below.

---

[7] Information Office of the State Council of China, *China's Policies and Actions for Addressing Climate Change*, October 2008. Report presented at the Technical Consultation Among Developing Countries on Large-Scale Biogas Technology, Beijing.

A. YEMEN: USING BIOGAS TECHNOLOGY

53. In 1987, ESCWA initiated many projects in Yemen to introduce the biogas technology within a social guidance intensive programme to improve the living, social, and economic conditions in the villages of Yemen.[8] The third of those projects was considered then a successful pioneer one at the international level. They resulted in the creation of a new administration called the General Administration of New and Renewable Energy in the Ministry of Electricity and Energy to develop renewable energy technologies with a focus on the biogas technology in rural areas; and the establishment of renewable energy research groups in the universities of Aden and Sana'a. The General Administration for the Development of Rural Women in the Ministry of Agriculture and Irrigation is following up biogas uses in the villages of Yemen through financially supported civil society associations, and subsidizing 50 per cent of the cost of equipment purchased by the villagers. Many pieces of that equipment are currently used in the villages of Raymah and Al-Hudaydah Governorates, and the municipal authorities are currently considering the implementation of a project in Sana'a Governorate to generate 2 MW of electrical power from sewage treatment.

B. LEBANON: FEASIBILITY STUDY OF EXTRACTING GAS FROM LANDFILLS

54. When the economic feasibility study was being conducted, the landfill of Bourj Hammoud on the Mediterranean coast in the northern suburb of Beirut contained 3.5 million cubic metres of solid municipal waste which comprised organic materials estimated at 65 per cent. According to that study which was undertaken by the Swedish consulting company SWECO, it was possible to extract 170 million standard cubic metres of gas during the first 15 years (2001-2015), with a decrease in the annual extracted volume from 27 million cubic metres in 2001 to 5 million cubic metres in 2015 and a remaining reserve of 25 million cubic metres to be extracted later on. The percentage of methane contained in that gas shall range between 45 and 55 per cent with a thermal value estimated at 5 kW-hour per standard cubic metres. Consequently, the total quantity of energy was estimated at 850 thermal GW-hour, given that the gas is extracted from 70 wells that shall be dug in different areas of the landfill. The possibility of generating power from the combustion of that gas in internal combustion engines with an individual capacity of 1.2 MW was also studied and the power that may be produced was estimated at 5 MW at the beginning, to decrease then to 1 MW in 2015. The total emissions to be avoided if the project was carried out were estimated at 1.6 million tons of equivalent carbon dioxide. Nevertheless, the economic feasibility of the project could not be assumed, because the price of those emissions was not taken into consideration and it was not possible at that time to take advantage of the clean development mechanism. Certainly, had the environmental factor been taken into consideration, the project would have been economically feasible. The only factor taken into consideration was the price of the electrical power that could be produced. Besides, the project was not carried out because "Electricité du Liban", the company that has the exclusive right to generate electricity in Lebanon does not accept to undertake small projects such as using landfill gases to generate electricity.

C. THE SUDAN: COMPRESS INDUSTRIES AND OTHER PRODUCTIONS

55. Many industries for the production of compressed items to be used as solid fuel have emerged in the Sudan. The working paper "Recycling Agricultural Waste in the Arab States" that was prepared by the Arab Organization for Agricultural Development and presented at the expert group meeting on "Transport for Sustainable Development in the Arab Region and its Relation with Climate Change" (Cairo, 29 September - 1 October 2009) organized by ESCWA with the cooperation of the League of Arab States and the United Nations Environment Programme (UNEP) contained a review of the main compress industries such as: the project of the compressed peanut peel in the west of the Sudan and the projects of producing compressed cotton stalks and bagasse cubes. The national plan for climate change mitigation in the Sudan also included the development of bio-energy production from biomass. The production of ethanol has already started at the Kenana Sugar Company with a capacity of 60 million liters per year that will reach 200 million liters per

---

[8] ESCWA, *Biogas technology and the Development of Rural Women in Yemen*, E/ESCWA/NR/1993/11-E/ESCWA/SD/1993/1 (English and Arabic).

year soon; at a factory belonging to the White Nile Sugar Company with a capacity reaching 30 million litres; at the Sudanese Sugar Company with a capacity of 25 million litres per year; and under a joint project between the Sudan and some Arab Gulf countries in the framework of the Agricultural Revival Program in the Sudan 2008-2011 with an estimated production capacity of 30 million litres of ethanol per year and 45 MW of electricity. Plans are also being prepared for the development of a joint Sudanese-Egyptian project named "Sabita Sugar" for both the production of sugar and the generation of 90 million litres of ethanol yearly.

D. EGYPT: AN INTEGRATED SYSTEM FOR MOLDING VEGETABLE WASTE

56. The New and Renewable Energy Authority in Egypt carried out a research project for the development of an integrated mobile system for molding vegetable waste in the fields (cotton stalks and rice straw). The system was manufactured and tested. It consists of a machine for mincing agricultural waste, a dryer for drying the resulting minced waste, a compressor for molding 300 to 400 tons per hour, a stove and an oven for the domestic use of molds instead of the butane gas cookers widely used currently. The Authority also carried out a research project for the design and production of a small clean system for wood charring to replace the anti-environment systems used currently. The experimental model was manufactured and set in operation.

E. JORDAN: SOLID WASTE DISPOSAL SYSTEM

57. In September 2008, the World Bank granted Jordan a loan in the amount of 25 million United States dollars to help the Government improve the operational, financial and environmental performance of the solid waste disposal system which consists also of generating electricity and reducing greenhouse gas emissions that cause global warming.

F. COMPARISON WITH THE DEVELOPED COUNTRIES

58. Those projects remain insufficient if compared with the achievements of the developed countries. In France for example, since the 1990s and in order to fulfill the needs in energy of the cement industry, a part of the fossil materials (coal, heavy fuel, etc.) has been replaced with other combustible materials. Burning waste provides currently more than third of the thermal energy used in the cement industry in France, saving thus 500,000 tons of oil equivalent per year.[9]

59. According to the International Energy Agency statistical data, the countries of the ESCWA region should deploy more efforts to take advantage of the numerous opportunities available for producing energy from waste, as the energy production in those countries was as shown in table 2.

TABLE 2. ENERGY PRODUCTION IN THE COUNTRIES OF THE ESCWA REGION

	Primary Solid Biomass (Terajoule)	Biogas (Terajoule)
Egypt	62 056	-
Iraq	1 100	-
Jordan	117	120
Kuwait	-	-
Lebanon	5 837	-
Oman	-	-
Qatar	14	-
Saudi Arabia	3	-

[9] Available at: http://www.infociments.fr.

TABLE 2 (*continued*)

	Primary Solid Biomass (Terajoule)	Biogas (Terajoule)
The Sudan	447 541	-
Syrian Arab Republic	258	-
United Arab Emirates	-	-
Yemen	3 240	-
Total	520 166	120
Percentage of world figure	1.1 per cent	1.76 per 10 000

Source: International Energy Agency, 2007 data recently issued.

V. CONSTRAINTS AND CHALLENGES

60. Many constraints and challenges prevent the use of waste treatment to generate energy, for various reasons including the type, nature and high expenses of waste/residues. Those constraints and challenges can be classified as follows:

(a) *Economic constraints*: The energy generated from waste and residues is deemed a by-product of the treatment process known to be highly expensive if many factors were not taken into consideration at the same time such as the financial factor or price of the generated energy, the environmental one or emissions and pollution reduction and the health one or limiting the spread of epidemics. The expenses of transporting and collecting waste/residues should also be added to the cost, especially in rural areas with a lower population. However, in the cities, where municipalities and local councils are responsible for the disposal of waste, the cost of transport and collection is evident and should not be counted within the expenses of treating waste and generating energy when preparing the economic feasibility study;

(b) *Technical constraints*: On the one hand, the lack of trained human resources in conducting statistics and collecting information on the quantity and quality of waste/residues prevents the different sectors from acquiring accurate statistical data and leads to a lack of knowledge of the recent available techniques and best treatment mechanisms in addition to the fragility of the necessary infrastructure. On the other hand, the variety of the waste/residues, such as dry solid waste or wet waste that should be dried, and organic or inorganic liquid waste and their different characteristics, makes the consolidation of waste treatment and energy production a very complicated process;

(c) *Social constraints*: Low level of social environmental awareness, bad behaviors and lack of community response to help reducing the volume of waste/residues through pre-screening and recycling and then utilizing waste for generating energy and reducing emissions;

(d) *Institutional constraints*: Absence of an institutional unit acting as a competent authority, weak coordination between institutions and ministries responsible of waste/residues and those responsible of energy, and absence of an integrated vision for environment-friendly waste treatment, pollution and emissions reduction and energy production at the same time. The lack of such a unit constitutes an obstacle to the consolidation of statistics and collection of information and diminishes interest, follow-up and applied scientific research.

VI. PROPOSED POLICIES AND PROCEDURES

61. Treating waste with the possibility of using it in generating energy is required to reduce pollution, protect the environment and mitigate climate change. This cannot be realized without taking into consideration the nature and conditions of each country, area or governorate. Because of the differences in infrastructure, living styles and resources, what can be useful in big cities might not be so in villages.

62. Therefore, policies and procedures should take into consideration all the facts and cover all levels. The proposed policies and procedures are as follows:

(a) Building capacities through workshops and training sessions for specialized persons to enhance their technical knowledge;

(b) Organizing raising awareness campaigns on the importance of treating waste in reducing pollution and generating energy;

(c) Giving special attention to scientific, practical, applied and statistical research and development to maximize the possibilities of using the energy present in waste/residues;

(d) Encouraging the adoption of the sustainable integrated waste management and defining a political, legal and institutional framework in support of that management;

(e) Establishing a national central cell composed of the various State institutions responsible of the issues of waste, environment and energy, to be in charge of finding the best ways to solve the problems of waste/residues and use them to generate energy;

(f) Finding sustainable means of reducing pollution, using energy generated from waste to fulfill the citizens' needs at low cost. One of those means is the use of anaerobic digesters of human and animal waste in rural areas to produce methane for cooking purposes and use the remaining residues as fertilizers;

(g) Improving waste management methods and promoting waste sorting and recycling and generating energy whenever possible;

(h) Including the environmental cost in the feasibility studies;

(i) Promoting regional and international cooperation in the fields of research, training, development, awareness raising, expertise sharing, technology transfer and financing; and expediting the launching of the works of the Arab Environment Facility and encouraging the States that have not yet done so to ratify it;

(j) Defining sustainable development indicators in that field and following up on their application;

(k) Supporting the efforts exerted by States in that field through securing the necessary financing from regional and international organizations and involving the private sector in investing and sharing information and expertise.
