Research Journal of Applied Sciences, Engineering and Technology 10(11): 1322-1329, 2015
DOI: 10.19026/rjaset.10.1829
ISSN: 2040-7459; e-ISSN: 2040-7467

Submitted: April 2, 2015 Accepted: April 22, 2015 Published: August 15, 2015

Research Article

Biomass Energy Utilization in Northeast Badia of Jordan

[1]Mohammad Al-Smairan, [2]Sura Al-Harahsheh and [3]Hassan Al-Khazaleh
[1]Department of Renewable and Sustainable Energy, Faculty of Engineering,
[2]Institute of Earth and Environmental Science,
[3]Water Environment and Arid Region Research Centre, Al al-Bayt University, Jordan

Abstract: Biogas systems can contribute to rural development, utilization of renewable energy, climate change mitigation, as well as environmental protection. Due to its multiple benefits, the Jordan Government must made great efforts to promote the development of biogas systems in rural areas, especially household biogas plants and medium scale biogas plants for intensive livestock and poultry farms. In order to better promote and improve biogas systems in rural Jordan, a comprehensive literature review of the various sources was undertaken for this research. This study aimed at exploring weaknesses in the biogas value chain that hinder wider dissemination of the technology in Jordan. The methodology used is holistic, combing literature review with interviews with farmers and observations of processes across the value chain in Jordan Badia regions, where biogas technology has no any history in Badia. It was revealed that wider dissemination of biogas is hampered by weaknesses in the processes and linkages among the actors. Many potential users are not aware of the technology and therefore the market remains slim. All these, coupled with inadequate policy environment, lack of stakeholder development, missing linkage to finance and few technicians, render the market unattractive to entrepreneurs who would have invested in the dissemination of the technology. The government should conduct awareness campaigns through media, translate current policies into actions to development key stakeholders, set the required institutional framework and programmes to support biogas dissemination activities. It should also train more technicians and concentrate on research and development.

Keywords: Biogas, biomass, digester, Jordan, northeast Badia, utilization

INTRODUCTION

In many developing countries, traditional fuels are normally available locally at low cost. The problem associated with these traditional fuels is their characteristic of low combustion efficiency. Poor combustion efficiency leads to emission of Carbon dioxide (CO_2), methane (CH_4) and Nitrous Oxide (N_2O) which leads to increase of greenhouse gases and global warming. On the other hand, modern fuels are expensive and are characterized by high combustion efficiency. These fuels are usually more expensive in rural areas due to high import and distribution costs. In most cases, the rural areas do not enjoy the availability of such energy source (Nyagabona and Olomi, 2009; Egeskog *et al*., 2011).

Energy is of vital importance for the processes of production and manufacturing and, as such, a key element of sustainable development. During the last two decades, the rising cost of energy has posed a difficult challenge for Jordan due to country's meager local resources of economic energy and its reliance on imports (Yadava and Hesse 1981; Kavali *et al*., 2013).

Jordan has no significant fossil fuel energy resources of its own and must rely on neighboring Arab oil producing countries. One of the most important energy sources in our economy is still oil, which is not renewable considering our lifetime. Jordan is an energy importing country; it imports almost 95-97% of its energy needs in the form of oil and petroleum products (Yadava and Hesse, 1981; EU, 1999). Electricity demand, which reached 2,900 mw in 2012, is expected to increase to 5,770 megawatts by 2020. The demand for oil, presently at 7.98 million tons, is predicted to double to reach 15 million tones, by 2020 UK (2008). Foresti (2001) indicated that minimizing reliance on imported energy to meet its current and future energy demands is being given policy priority. A major programmed of exploration for oil and gas is underway in partnership with international companies and natural gas is already being produced for power generation. It is thought possible that eventually natural gas from domestic reserves could generate all Jordan's electricity, thus reducing fuel imports by up to 40%. Currently, energy produced by natural gas represents 5.5% of the total energy demand (Yadava and Hesse,

Corresponding Author: Mohammad Al-Smairan, Department of Renewable and Sustainable Energy, Faculty of Engineering, Al al-Bayt University, Jordan, Tel.: +962 2 6297000, ext. (2819); Fax: +962 2 6297089

1981). Notwithstanding these challenges, Jordan has been actively seeking to reduce its reliance on fossil fuels from current 96% to approximately 61% of energy usage by 2020.

The expectations show that the demand for energy will increase at a faster rate than the growth in the Jordanian economy. Major concern is to reduce dependence on oil imports and diversify energy sources. Therefore, renewable energy resources in Jordan are needed in order to help in meeting the increase in demand for energy. The National Energy Strategy 2008-2020 aims to supply 29% of energy needs from natural gas, 14% from oil shale, 10% from renewable energy resources and 6% from nuclear energy by 2020 (UK, 2008; Dodic *et al*., 2010).

Recently, concern and even alarm about the excessive rates of fuel consumption in Jordan have been expressed, especially in the commercial and public service sector, which has experienced significant economic and technological changes during the past three decades.

In comparison with other countries, Jordan has great potential and abundant supplies of new and renewable energies, such as oil shale and solar energy, respectively. The current tendency in Jordan is to use in future various solar energy, wind energy and bio-energy applications in the overall mix of energy in Jordan, as well as identifying potential areas for utilizing future technologies and recommending future courses of action to encourage the commercial utilization of renewable energy technologies (Yadava and Hesse, 1981; EU, 1999; McCarty, 2001).

Badia is one of the poorest regions in Jordan and constitutes 75% of the total area of the country. The most of the country's low income families live in Badia areas and mainly depend on agricultural and/or livestock production for their livelihood. However the highest rate of the livestock is deployed at Northern Badia (Mafraq and Zarqa regions) of 27% of the total in Jordan (Department of Statistics (DOS), 2010).

The Bedouin are scattered across the huge desert area of the Jordanian Badia and are known for their nomadic, tent dwelling lifestyles. Although able to survive the hostile environment of the desert interior, most occupy the less fierce coastal plains. They have learned to cope with extreme temperatures. Bedouins move either constantly or seasonally, earning a living as stockbreeders or transporters.

Growth in the livestock sub sector is therefore important for poverty reduction and overall growth of the economy. Nearly 31.9% of the population of the Northern Badia (Mafraq) region living below the poverty line; then the Southern Badia (Maa'n) 24.2%, so use little modern energy sources insufficient to meet their various domestic and productivity needs (Department of Statistics (DOS), 2008).

Among many biogas feedstock sources, animal manure, food processing industry and energy dedicated crops are widely promoted in order to drive rural development (Beata and Joachim, 2012; Yao, 2010). Today, Biogas technology is well established in many countries of the world. A renewed interest is taking place in biogas because of its potential to poverty reduction and positive effect on the environment, as well as the high prices of fossil energy. Recent new developments include integrated biogas systems for household farm level, commercial digesters for large livestock farms and digesters for urban waste, wastewater and agro industry. These technologies reduce Greenhouse Gas (GHG) emissions and address other environmental concerns (air pollution and deforestation), sanitation and health considerations and urban and agro-industrial waste (water) management. Providing affordable energy to the rural population will contribute to poverty reduction and better quality of life. In fact Biogas technology applications are virtually unknown in the Badia region (Zhao and Yan, 2012; Oscar *et al*., 2012; Yao, 2010; Chen *et al*., 2010; Seghezzo *et al*. 1998).

Lettinga *et al*. (1993), Electrigas (2009), Seadi *et al*. (2008) and Swedish Biogas Association, Swedish Gas Centre and the Swedish Gas Association (SBGF, SGC and SGA), (2008) showed that, in order to deal with energy security, climate change, energy shortages and environmental pollution in rural areas, Jordan has must be made great efforts to promote the use of modern and clean renewable energy carriers in rural areas. Biogas is a kind of clean and renewable energy. Moreover, biogas system can treat organic wastes and turn them into organic fertilizer.

The Kyoto Protocol has created an additional stimulant for the development of new technology and applications for biogas. The Protocol's Clean Development Mechanism (CDM) presents financial incentives for investment in biogas technology through sale of Certified Emission Reductions (CERs). Wider application of biogas technology will contribute to sustainable development.

The present investigation main aim is to develop a new energy saving system, which in turn lead to a reduction of carbon dioxide emissions and to assess the social, economic and environmental impact of the biogas technology on Bedouin life.

Energy consumption in Jordan: The year 2003 witnessed the termination of Jordan's supply of crude oil from Iraq, as a result of the war. This prompted the government to research the alternative sources. Imports of crude oil and oil products in 2003 amounted to about $1091 million, which represented about 10.9% of the gross domestic product, 19.3% of the value of imports and 35.9% of the value of exports for the same year.

The primary energy demand reached about 8.157 mtoe in 2013, compared with 8.206 mtoe in 2012 reflecting a negative growth rate of (0.6%) (Yadava and Hesse, 1981; UK, 2008). Table 1 shows the final energy consumption in Jordan during the period 2008-2013.

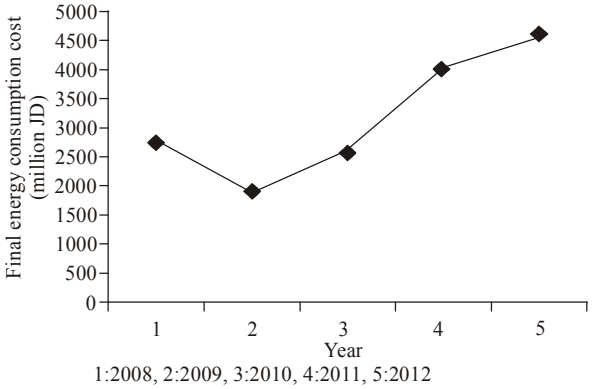

Fig. 1: Final energy consumption cost in Jordan during the period 2009-2013

Table 1: Final energy consumption (mtoe) in Jordan during the period 2008-2013

Year	Primary energy demand (mtoe)
2008	7.335
2009	7.739
2010	7.357
2011	7.457
2012	8.206
2013	8.157

The final energy consumption cost increase rapidly since 2009 due to the increase of oil prices, reaches its maximum in 2012. Heavy dependence on imported gas from Egypt increase the cost of electricity generation, where, Jordan imports about 80% of gas required for generating electricity from Egypt. During the last three years, Jordan faces a lot of problems with importing the gas from Egypt, which cause the sharply increase in the energy cost as shown in Fig. 1.

Study area and socio-economic data: Jordan lies in the Middle East within latitude 29° 11 to 36° north and longitude 34° 59 to 39° east. It is a small country with a total area of 89,206 km^2 including 329 km^2 of water. Jordan is comprised of several different geographical areas with special features. It provides a diverse landscape, from hills and mountains, like the al-Sharah mountains and Jabal Ram 1734 m height in the south and in some areas, like the area surrounding the Dead sea that are 400 m below sea level (bsl). There are steep valleys like the Jordan valley to the fertile areas near Irbid in the north of the country and there is the desert, which is called the Badia plains that extend in an eastward direction into Saudi Arabia.

The wider study area extends along the Syria/Jordan border eastwards from Mafraq for approximately 80 km (Fig. 2), more or less bounded to the south by the villages along the Mafraq-Safawi road, which joins the Amman- Baghdad highway to the east. Since settlement, the agricultural base of many of the region's villages has been a mix of cultivation and grazing. The climate ranges from semi-arid in the west to arid in the east, with mean annual precipitation

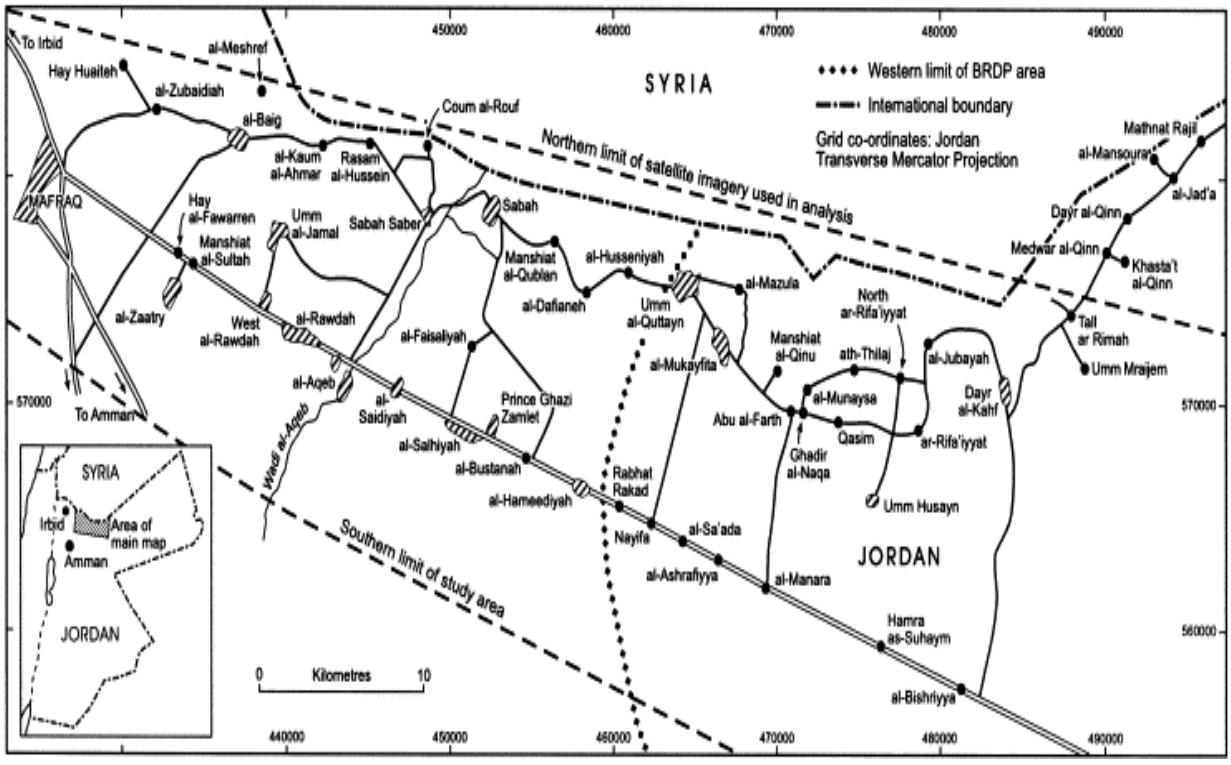

Fig. 2: The study area (northern Badia)

ranging from approximately 170 mm at Mafraq to about 100 mm at al-Aritein. The wet season can extend from October until May, but is often much shorter and the mean annual rainfall has a high variability. There is a marked seasonal temperature range in the eastern part of the study area, with summer temperatures rarely exceeding 40°C and winter temperatures not often dipping below freezing (Kirk, 1998).

The survey was conducted between March and May 2012 in different villages and settlements which is located in the Northeast Badia of Jordan (Northeast of Mafraq city). Its inhabitants work mainly in agriculture, farming and herding the sheep and goats and government sector. Two hundred and seventy four family were surveyed. More than 50% of the respondents have 5-10 family member, whereas, the other percent have more than 10 a family members. Regarding the source of income, about 50% of the respondents were found to be engaged in some kind of agriculture activities and 42% of the respondents were involved in employment government, while, 4 and 4% of the respondents were involved in remit and government support, respectively. In this study we found that 78% of the respondents have more than 50 herds, while, 13% have less than 50 and 9% haven't any herd.

RESEARCH METHODOLOGY

A comprehensive literature review of various sources was undertaken, including academic, government, NGOs and International organizations, so as to understand the research question in a comprehensive way.

A number of research methods have been applied in the study, including: case analysis, a number of articles with regard to the current development of household biogas plants, which were mainly written, also, a comparative study: the biogas development in a round the world are studied in order to learn the successful experiences for promoting biogas development; in addition, interviews: personal interviews as well as emails consultation have been done with experts on biogas both in Jordan in order to better understand the policies, economic measures, technologies and social factors for promoting biogas development.

The research adopted a holistic approach, combing literature review, interviews with local communities, farmers and others. A sample of 274 respondents was picked from Northeast Badia of Jordan during data collection.

The methodology of this study will compose of four steps as follow:

Step 1: We were distributed the designed questionnaires to 274 families in Northern Badia of the most villages. There are some questions about family economic conditions, energy, the perceptions, attitudes towards "waste," and biogas digesters in this questionnaire. The respondents are usually the householders or housewives; we were used SPSS 10.0 (Software for Statistical analysis) to process and analyze the data.

Step 2: The construction and adaptation of small bio-digesters, particularly by small livestock farm households for using it in heating and cooking and utilization of compost products. In addition, the social interest of energy conversion of livestock manure is not determined only by specific cost of the energy generated; for instance, the appropriate management of waste can contribute to considerable reductions in GHG emissions.

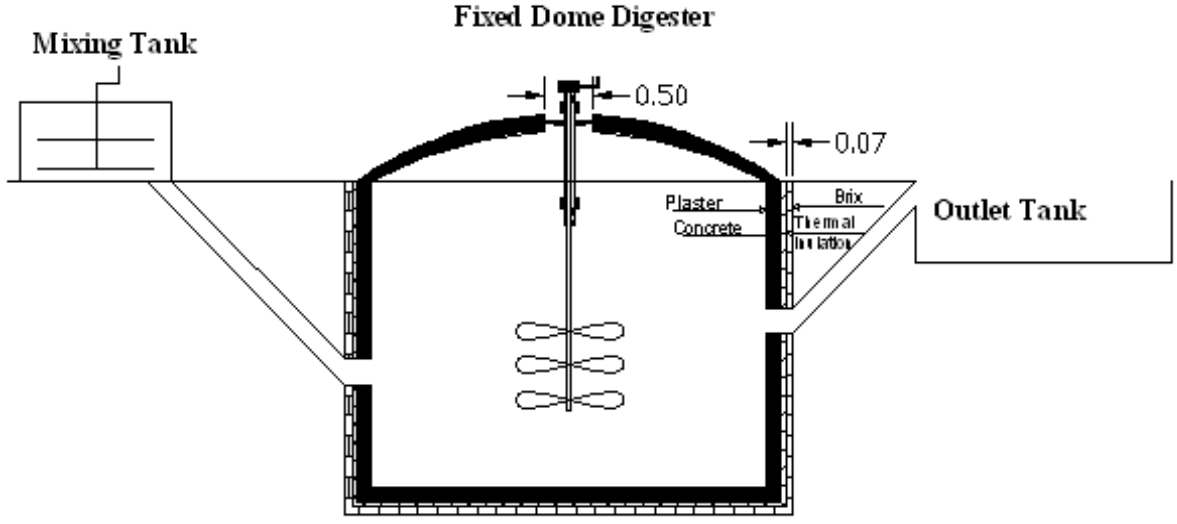

Fig. 3: Biogas digester

Step 3: The dissemination of information on bio-gas technology from animal waste; through broad-based public education and training, aimed at changing people's perceptions and attitudes towards "waste," especially derived from goat, sheep and cattle farming.

Step 4: Develop recommendations on promoting of biogas utilization, including access to energy investment financing through Clean Development Mechanisms (CDM) or public and private partnerships.

Design of the biogas digester: A fixed-dome digester was chosen to design for the many reason. The costs of a fixed-dome biogas plant are relatively low. It is simple as no moving parts exist. There are also no rusting steel parts and hence a long life of the plant (20 years or more) can be expected. The plant is constructed underground, protecting it from physical damage and saving space. While the underground digester is protected from low temperatures at night and during cold seasons, sunshine and warm seasons take longer to heat up the digester. No day/night fluctuations of temperature in the digester positively influence the bacteriological processes. The designed biogas digester with 5 m^3 volume and its components are shown in Fig. 3. The gas holder with 3 m^3 volume was determined.

RESULTS AND DISCUSSION

The development of biogas plants in rural areas of Jordan has a multiple of policy objectives and undertakings with regard to rural development, renewable energy, climate change and environmental protection. Due to its multiple benefits of biogas systems, the development of household biogas plants as well as medium scale biogas plants must be actively promoted in rural area in Jordan by Jordanian government.

Determined the potential of biomass energy in Northeast Badia of Jordan and design a biogas digester system, aimed at providing gas was presented in this project. The data obtained from recent nation-wide project on biomass utilization was the basis for designing and sizing the mentioned above system.

The first part of this research project was designing a questionnaire about the situation of biogas potential and technology in the study area. The following are responses from 274 respondents representing household owners in rural areas in Northeast Badia of Jordan. They responded to a survey as follows.

Responding to different kinds of energy sources for lighting they know and use, the answers indicated that much was depend on national web (about 90.5%), while, 5.5, 3.3 and 0.7% were depend on fanous by kerosene, Luks work by gas and others, respectively.

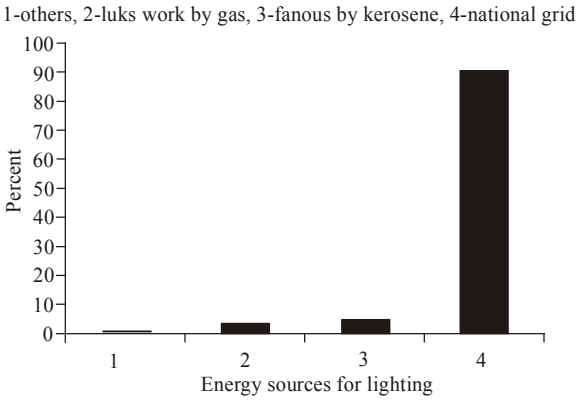

Fig. 4: Types of energy sources used for lighting

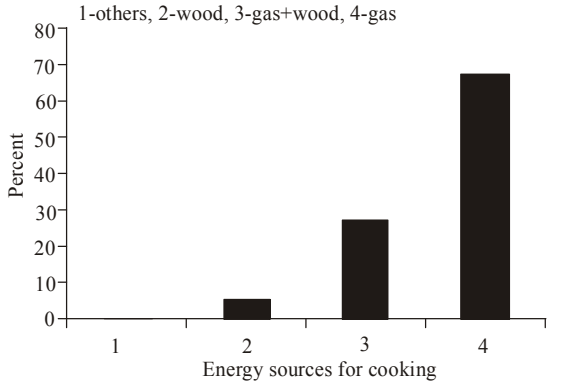

Fig. 5: Types of energy sources used for cooking

Figure 4 shows the types of energy sources used in lighting.

Responding to different kinds of energy sources for cocking they know and use, the answers indicated that much was depend on gas (about 67.2%), 5.1% of the respondents were depend on wood, while, 27.4 and 0.4% were depend on gas + wood and others, respectively. Figure 5 shows the types of energy sources used in cooking.

Responding to different kinds of energy sources for heating they know and use, the answers indicated that much was used gas (about 50.7%), 35% of the interviewed were used agriculture remain, while, 12.4, 1.1 and 0.7%, respectively were used heating machine, central heating and air conditioning unit, respectively. Figure 6 shows the types of energy sources used in heating.

Responding to different kinds of energy sources for cooling they know and use, the answers indicated that much was used fans (about 80.7%), 14.6% of the interviewed were nothing mentioned, while, 4 and 0.7% were used others and air conditioning unit, respectively. Figure 7 shows the types of energy sources used in cooling.

When asked of the reasons that make them not using biogas, the respondents showed that they lack

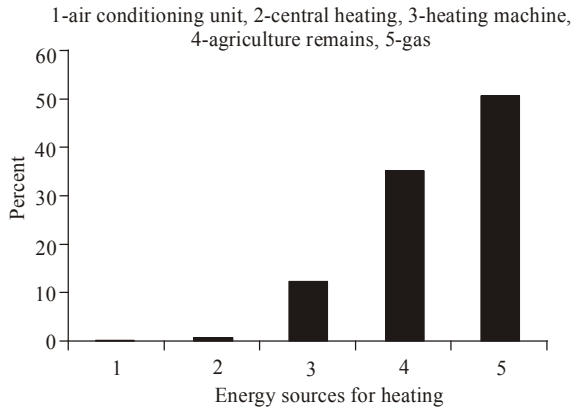

Fig. 6: Types of energy sources used for heating

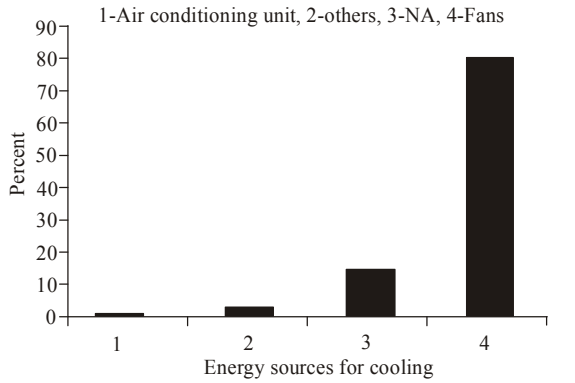

Fig. 7: Types of energy sources used for cooling

knowledge on this type of energy source by 40.5% and that the 20% they know about the biogas technology.

Responses showed that 36.1% of the interviewees did not respond to this question their reason was that, they didn't know what to say on an unknown. The results suggest that potential users of this technology lack enough knowledge of the technology.

Responding to importance of promoting biogas, responses showed that the endeavor is important as it will create awareness to more people and many respondents' shows, they do not know that using biogas technology will decrease the pollution result from agriculture activities, about 70%. While, 22% they know the benefits of promoting biogas technology. Regarding the question, are you read to applicable and use the biogas technology if it is feasible economically, 91.6% they said yes.

The second part of the project was designing a biogas digester with 5 m^3 digester volume and 3 m^3 gas holders. The pilot project was designed according to Fig. 3 and the research was carried out during the last six months using cow manure as the input material for the biogas digester. The percentage of the output from the gas holders was as follows: Methane (CH_4): 61.2%, CO_2: 29.3%, O_2: 0.4% and BAL 9.1%. These results show that the percent of the methane produced was reached the maximum limit which about 65% for the cow manure. This means that the pilot project was highly successful.

The dissemination of information on bio-gas technology from animal waste; and questionnaire through broad-based public education and training, aimed at changing people's perceptions and attitudes towards "waste," especially derived from goat, sheep and cattle farming, had been carried out during one day workshop for the targeted people. Twenty three people from the study area had been attended the workshop. The researchers had been disseminated the results from this project, including the outcomes, the barriers, the benefits, the incentives and how to use this resource as one of the renewable energy resources in the Jordan Badia.

Most of the people have one major question, which is, how to help us in this issue and what are the incentives that the government, the private sector may be offered for those people.

Nomadic Bedouin man 1 said "we are nomadic people, we do not know before about biomass energy, this is very new for us".

Nomadic Bedouin man 2 said "we are very poor people, we cannot install these systems, who will could help us".

"Who will follow these projects, how to deal with the gas product, what about the saftey" (Nomadic Bedouin man 3).

The results of this research project had been submitted to the policy-makers in all departments that dealing with energy issues in Jordan as one of the objectives of this project, in order to takes the recommendations into consideration for the future.

Therefore, in order to improve the biogas systems in Jordan Badia, it is necessary to strengthen the incentives and weaken the barriers. It is of great importance to recognize that the incentives and barriers for the development of household biogas plants and medium scale biogas plants are different though connected.

CONCLUSION

Biogas plants can treat organic wastes and produce biogas and digested residue, which are clean renewable energy and organic fertilizer respectively. Due to its multi-benefits for rural development, renewable energy, climate change mitigation and environmental protection, Jordan government must be made great efforts to promote the construction of household biogas plants and medium scale biogas plants in rural areas in the coming years.

Due to the high cost of energy prices and unavailable indigenous conventional energy sources in Jordan, this project discusses the renewable energy system (biomass) which helps in overcoming some of

these problems in the study area. It can be concluded that biomass energy source is a viable green technology source, cost-effective fuel option and has tremendous potential for application and rural development in Northeast Badia of Jordan.

The evidence on how biogas sub sector operate in Northeast Badia of Jordan, presented in this research, is enough to conclude that, biogas value chain has prospects to be upgraded to foster energy access for the poor. The weaknesses or gaps brought forward can be addressed using opportunities available and hence sustainable biogas access to the poor will be attained whilst creating jobs and increasing standard of living of many people in the study area. The research concludes that a critical factor that hampers the dissemination of the biogas technology is lack of awareness. As users remain unaware of the technology, the market remains slim as revealed in the research. We believe when awareness is addressed adequately, without ignoring other issues revealed here, the market will be stimulated. When biogas becomes a technology of choice to many users, many other problems will be solved through the rules of the market.

In order to improve the biogas system in Jordan, a series of measures have been suggested to strengthen the incentives and weaken the barriers. The policy advice for the development of household biogas plants in Jordan is to slow down the development step, strengthen the education and training of farmers on the proper utilization of biogas plants, improve the rural biogas service network and ensure the quality of biogas plants as well as the associated facilities and provide more funding for the research and development of household biogas plants.

ACKNOWLEDGMENT

This research cannot be finished without the help from many friends. First of all, I would like to give my thanks to Abed Al Hameed Shoman Foundation/Scientific Research Fund for funding this project. Special thanks to Mr Nabeel Abu Haneih for grateful help and his support.

REFERENCES

Beata, S. and V. Joachim, 2012. A GIS-based approach for evaluating the potential of biogas production from livestock manure and crops at a regional scale: A case study for the Kujawsko-Pomoriskie Voivodeship. Renew. Sust. Energ. Rev., 16: 752-763.

Chen, Y., G.H. Yang, S. Sweeney and Y.Z. Feng, 2010. Household biogas use in rural China: A study of opportunities and constraints. Renew. Sust. Energ. Rev., 14: 545-549.

Department of Statistics (DOS), 2008. Livestock Report in Jordan. Amman, Jordan.

Department of Statistics (DOS), 2010. Assessment of Poverty in Jordan: 3-4. Amman, Jordan.

Dodic, S.N., S.D. Popov, J.M. Dodic, J.A. Rankovic, Z.Z. Zavargo and M.T. Golusin, 2010. An overview of biomass energy utilization in Vojvodina. Renew. Sust. Energ. Rev., 14: 550-553.

Egeskog, A., G. Berndes, F. Freitas, S. Gustafsson and G. Sparovek, 2011. Integrating bioenergy and food production-A case study of combined ethanol and dairy production in Pontal, Brazil. Energ. Sust. Dev., 15(1): 8-16.

Electrigas, 2009. Anaerobic digestion of beef manure for electricity generation, agricultural. Preliminary Engineering Report, New Brunswick, Canada.

EU, 1999. Biomass Conversion Technologies. EUR 18029 EN ISBN 92-828-5368-3.

Foresti, E., 2001. Perspectives on anaerobic treatment in developing countries. Water Sci. Technol., 44: 141.

Kavali, J., S. Tulika, S. Guddy and K. Sudhakar, 2013. Hybrid solar PV and biomass system for rural electrification. Int. J. Chem. Tech. Res., 5: 802-810.

Kirk, A., 1998. A Synthesis of Climatic Data with Specific Interest in the Precipitation Record. In: Dutton, R.W., J.I. Clarke and A.M. Battikhi, (Eds.): Arid Land Resources and their Management: Jordan's Desert Margin. Kegan Paul International, London, pp: 47-66.

Lettinga, G., A. de Man, A.R.M. van der Last, W. Wiegant, K. van Knippenberg, J. Frijns and J.C.L. van Buuren, 1993. Anaerobic treatment of domestic sewage and wastewater. Water Sci. Technol., 27: 67.

McCarty, P.L., 2001. The development of anaerobic treatment and its future. Water Sci. Technol., 44: 149.

Nyagabona, N.T. and D.R. Olomi, 2009. Analysis of the value chain for biogas in Tanzania Northern Zone. University of Dar es Salaam, Tanzania.

Oscar, J., C. Alfredo and S. Yoel, 2012. Biomass based gasifier for providing electricity and thermal energy to off-grid locations in Cuba, Conceptual design. Energ. Sust. Dev., 16: 98-102.

Seadi, T.A., D. Rutz, H. Prassl, M. Köttner, T. Finsterwalder, S. Volk *et al*., 2008. Biogas Handbook. University of Southern Denmark, Denmark.

Seghezzo, L., G. Zeeman, J.B. van Lier, H.V.M. Hamelers and G. Lettinga, 1998. A review: The anaerobic treatment of sewage in UASB and EGSB reactors [Electronic version]. Bioresource Technol., 65: 175-190.

Swedish Biogas Association, Swedish Gas Centre and the Swedish Gas Association (SBGF, SGC and SGA), 2008. Biogas from Manure and Waste Products-Swedish Case Studies.

UK, 2008. Biomethane fueled vehicles the carbon neutral option. Proceeding of Calverton Energy Conference. Bath, October 24th, 2008.

Yadava, L.S. and P.R. Hesse, 1981. The development and use of biogas technology in rural areas of Asia (A status report 1981). Improving Soil Fertility through Organic Recycling, FAO/UNDP Regional Project RAS/75/004, Project Field Document No. 10.

Yao, C., 2010. The prospects for biogas systems in rural China-incentives, barriers and potentials. M.Sc. Thesis, Lund, Sweden.

Zhao, Z. and H. Yan, 2012. Assessment of the biomass power generation industry in China. Renew. Energ., 37: 53-60.