THE INTERNATIONAL JOURNAL OF HUMANITIES & SOCIAL STUDIES

Examining Biogas Technology Adoption Process by Using Rogers Innovation Adoption Model: a Case of District Dera Ismail Khan

Syed Muhammad Amir
Ph.D. Student, College of Humanities & Development Studies,
China Agricultural University, Beijing, China
Liu Yonggong
Professor, College of Humanities & Development Studies, China Agricultural University, Beijing, China
Syed Umair Ali Shah
Master Student, Allama Iqbal Open University, Islamabad, Pakistan

Abstract:
The main purpose of this paper is to present results of a research based on examining biogas technology (BGT) adoption process in one randomly selected district in Khyber Pakhthunkhwa by applying Rogers' innovation adoption model. Data were collected through individual interviews by using a questionnaire from all 150 rural biogas households in randomly selected villages. Results revealed that among adoption process stages, persuasion stage was more shocking for beneficiaries in a sense that the provision of number of bio digesters both village-wise and household-wise, were made with bias, not uniformly distributed among villages, whereby the potential households lost their interest. The stakeholders promoted BGT with carelessness and emphasized on quantity rather than quality. However, interpersonal communication was noted as a major contributor of building social reinforcement towards BGT adoption. The implementation stage was also found very poor and relevant factors included were inexperienced and careless masons and poor monitoring by the project staff as well as lack of check and balance on building materials. Furthermore, after implementation stage, 47 bio digesters out of 150 were noted as not producing biogas at all. The main reason behind such case was promotion of BGT on 100% subsidization rate without conducting proper need assessment. The main recommendations for future improvements are included too.

Keywords: *Rogers' innovation adoption model, Bio gas technology (BGT) adoption process*

1. Introduction

Exclusive use of various energy sources such as wood, coal, oil, petroleum and nuclear power has resulted in public and political awareness to environmental problems and promotion of renewable energy resources has been focused to bring energy security. Biomass could be considered to play an important role in a more diverse and sustainable energy mix. In fact, energy is regarded very important in socio-economic development by raising standard of living. Humankind has used biomass as an energy source for thousands of years. Among the main energy resources, oil is the most important one followed by coal and gas. However, developed countries use modern renewable energy like geothermal, hydro, wind power and solar while developing countries consume 80% of the total renewable energy in traditional way (IEA, 2007).

Pakistan is an agricultural country. About sixty-two percent of its population living in rural areas, and is directly or indirectly dependent on agriculture as occupation. The country has only 5.17% of total land area covered by forests and only 5% of that area is protected. The pressure on natural forests is increasing and in order to reduce it, national forest policy call for diffusion of alternate energy resources composing micro-hydropower, bio-gas, solar and wind energy; and natural gas and liquid petroleum gas (LPG) shall be provided in mountainous regions. In addition, energy efficient houses and fuel efficient cooking stoves shall be diffused inside the country.

The economic progress of Pakistan has been deeply hindered by increased scarcity of energy since five years (GOP, Pakistan Economic Survey, 2009-10). In this context, Pakistan needs to adopt renewable and clean energy mix. Renewable resources may fulfill the long-term energy needs of Pakistan to a considerable level especially in rural areas, where access to commercial energy sources is limited and people fulfill their domestic fuel needs by using wood, animal waste and crop waste based on traditional methods.

Therefore, efficiencies of fuel use are poor and most of the potential is wasted because of non-scientific conventional technologies (Sahir M. H. and Qureshi A.H. 2008)

The renewable energy sources like biomass energy and others can be used to overcome energy crises in Pakistan by providing solutions to the long term energy issues being happened to the developing countries. The contribution of bio-resource to useful energy is relatively low even though its resource base of Pakistan is substantial. The carbon emissions would be high as an indirect result of low efficiency of energy use. There is lack of sufficient maturity of present biomass energy technologies which is considered among major obstacles for using the available bio-resources in an efficient and sustainable way (Chaudhry M. A. et. al, 2009). Therefore, it is necessary to utilize a variety of energy technologies to provide energy and economic services to rural households (Kishore et. al, 2004). as delivering clean and affordable energy reliably for poor households in developing countries is necessary for poverty alleviation (Ekholm et.al 2010).

There are many studies on adoption of different types of innovations. However, in relevance to biogas technology, such studies are limited as mentioned in above literature. In context of Pakistan, and specifically in Khyber Pakhthunkhwa, such studies have not been conducted. On the other hand, efforts have been done by various government and non-government organizations regarding implementation of BGT in KPK. But still the process of BGT adoption is low and it needs more focus as rural households have different characteristics regarding adoption behavior toward the bio energy innovations. In Pakistan, NGOs are working on dissemination of BGT more than the government. Pakistan council of renewable energies and technologies works for dissemination of renewable energies with some level of subsidization but their projects are not always open. However, the growing concern of the public is that their iron-made bio digester design led to corrosion and finally lots of bio digesters are closed now, thereby showing that their design was not proved sustainable in the long run. On the other hand, NGOs are providing BGT either based on some incentive to farmers or without incentive but there is lack of proper trainings and lack of building bio digesters on pilot basis so that farmers became fully aware and trained regarding BGT. Such mechanism has resulted in slowed adoption of BGT. In this context, this research was expected to fill such gaps by focusing on different stages involved in process of BGT adoption in order to explore which stages have more hurdles and which factors affect the final adoption results.

2. Materials and Methods

This study was carried out in rural areas of KPK well known to be typical farming area with low energy consumption. Multistage sampling technique was used for selection of district, tehsil and union council. One district, D I Khan was selected through simple random sampling technique. one tehsil was selected from the said district through random sampling technique. From each tehsil, one union council was selected and finally, five villages out of seven villages were selected randomly for the study. In this study, all 150 biogas users were intended to be considered for data collection. The head of the household was the respondent. The list of successful biogas users were obtained from the NGO named as FIDA (Foreign Integrated Development Action).

A questionnaire was designed by studying the related literature before getting primary data through face to face interview from 150 households during February to April 2015. An attempt was made to develop a complete picture of the major activities and processes involved in bio gas technology adoption. The data collection was ended when no more new relevant information on activities and processes became apparent. Finally, the collected data were processed and analyzed with the aid of SPSS and used for drawing the conclusions.

2.1. Rogers' Innovation Adoption Model

This research adopted a part of Roger's innovation adoption model to examine the process of adoption of BGT. According to Roger's innovation adaptation model, the adoption of an innovation is a dynamic process entailing the whole sequence of events occurring to an individual from the time one becomes aware of an innovation until the adoption stage. In the whole process, an adopter goes through different stages whereby awareness is the first stage and adoption the last stage (figure 1).

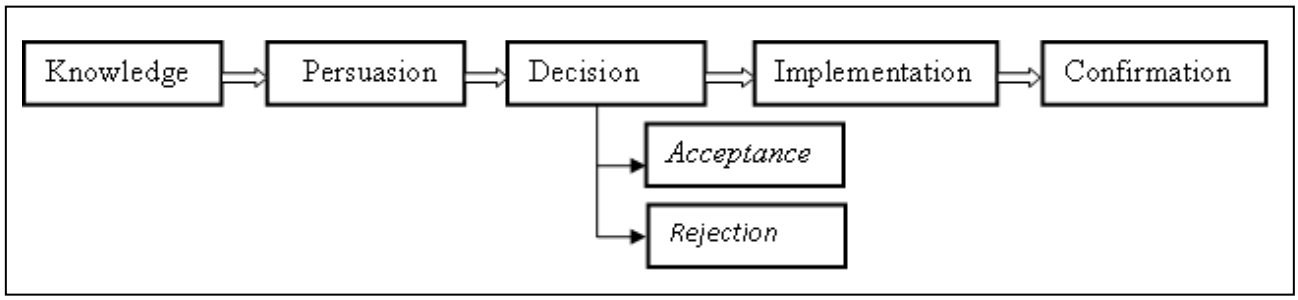

Figure 1: A Model of Five Stages in the Innovation-Decision Process
Source: Diffusion of Innovations, Fifth Edition by Everett M. Rogers, 2003

3. Results and Discussion

Five stages process was the mechanism followed in the study. The knowledge stage was the first followed by persuasion stage, decision stage, implementation stage and finally confirmation stage.

3.1. The Knowledge Stage

Results revealed that stakeholders who involved in this stage included FIDA (concerned NGO), local government officials and households themselves. The role of FIDA was to provide bio digesters on fully subsidized rate except expenses on labor activities with mason. The village and community organizations (voluntary organizations) worked under FIDA regarding awareness and knowledge building regarding BGT. The local government officials were expected to provide logistic support to FIDA.

Survey results showed that majority of respondents (76%) mentioned that they were informed about BGT project by FIDA organization themselves, followed by 16% through other friends or relatives having bio digesters and only 8% got information through media (figure 2).

According to (table 1), 64% of the respondents considered that knowledge regarding construction of bio digester was provided to them; and knowledge regarding proper operation & maintenance of bio digester and precautions of using bio digester was shared with a big majority (87% of them).

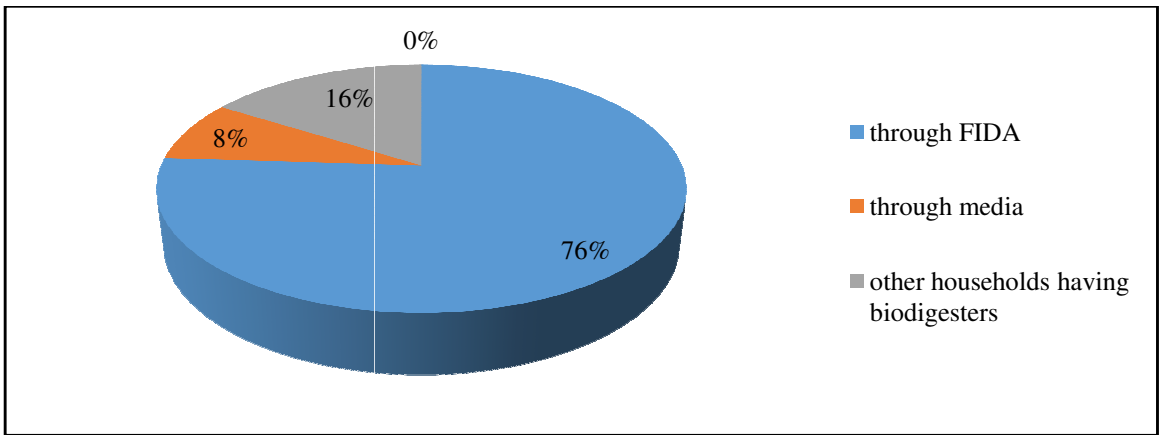

Figure 2: Source of awareness about bio gas technology

3.2. The Persuasion Stage

According to table 1, very few of the respondents (about 3 %) accessed BGT demonstration trials. Hence, those were not arranged by FIDA but they rather looked for other sources; all of the respondents mentioned that there was no demonstration trial or installation of a pilot bio digester before implementation; a big majority (94%) of the respondents got social reinforcement from others (neighbors and friends) compared to other sources.

According to figure 3, about 66% of them mentioned that their opinions and beliefs about bio gas technology were positively affected through that social reinforcement. It is clear from figure 4, that 76% of the respondents mentioned that their degree of uncertainty about outcomes of bio gas technology during implementation was high, followed by 16% who considered it was low while 8% considered it was not affected at all.

In addition, there was no advertisement in the study site showing that the bio digester installation project had been initiated. According to results from table 1, the degree of uncertainty about trust & confidence in BGT of majority of the respondents (i.e. 53%) gradually reduced through social reinforcement. Only few respondents (i.e. 12% of them) personally visited to other functional bio digesters in other areas. On the other hand, only 3% of them got outside experts' opinions regarding reduction of uncertainties of BGT outcomes and none of them got any information of scientific evaluations regarding reduction of uncertainties of BGT outcomes. A big majority (93 percent of them) reported that they had matched the costs and benefits of BGT against the other fuel energy sources while about 90 percent of them mentioned that they had proper pre-requisite raw materials for building bio digester. This stage was a little hard for households. At least the households should had given an opportunity to evaluate BGT against their available resources and skills.

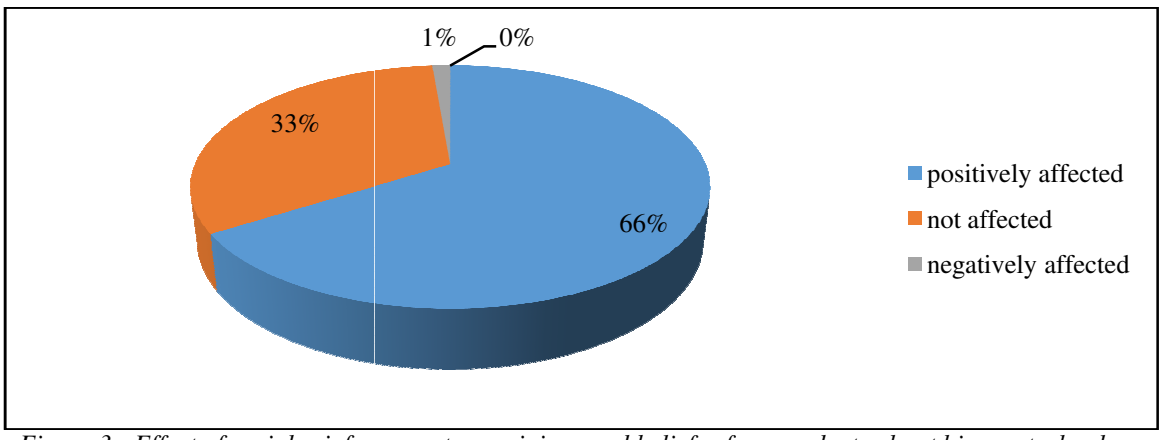

Figure 3: Effect of social reinforcement on opinions and beliefs of respondents about bio gas technology

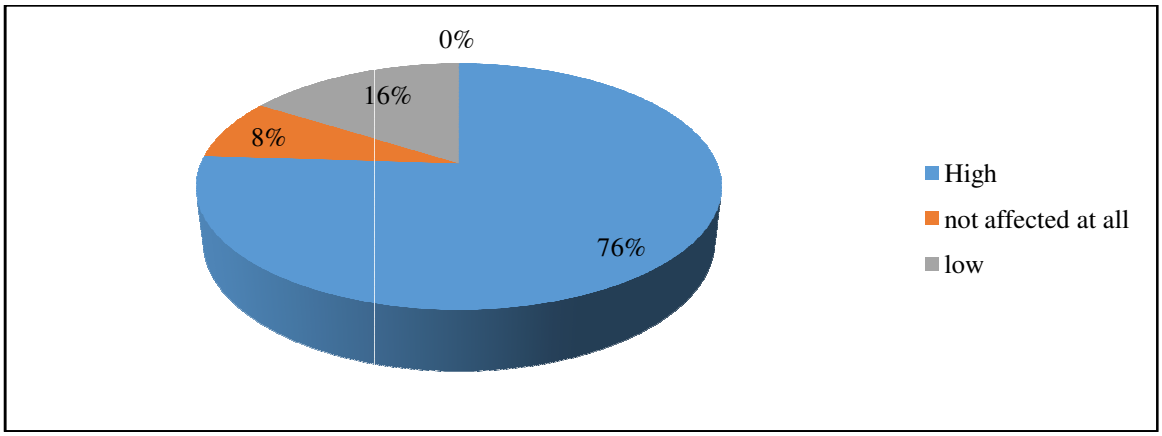

Figure 4: Degree of uncertainty about outcomes of bio gas technology during implementation

Statements	Yes	No	Not Applicable
About participation in any BGT trial	**3**(2)	**147**(98)	–
About building any pilot BD by FIDA for showing functionality and effectiveness of BGT	–	**150**(10)	–
Getting social reinforcement by respondents from others (neighbors or friends)	**142**(94.7)	**8**(5.3)	–
About reduction of degree of uncertainty about trust & confidence in BGT through social reinforcement	**80**(53.3)	**70**(46.7)	–
About personal visit to any other functional BD	**18**(12)	**132**(88)	–
About getting outside experts' opinions regarding reduction of uncertainties of BGT outcomes	**5**(3.3)	**145**(96.7)	–
About getting any information of scientific evaluations regarding reduction of uncertainties of BGT outcomes	–	**150**(100)	–
Matching the costs and benefits of BGT against the other fuel energy sources	**139**(92.7)	**11**(7.3)	–
About facing any problem regarding bio gas production	**33**(22)	**117**(78)	–
Regarding looking for any supportive information to fix bio gas production problem	**33**(22)	–	**117**(78)
Provision of help from the FIDA in order to fix bio gas production problem	–	**33**(22)	**117**(78)
Availability of pre-requisite raw materials	**135**(90)	**15**(10)	–
Availability of technical support for building bio digester	**96**(64)	**54**(36)	–
Provision of proper monitoring during bio digester installation	**124**(82.7)	**26**(17.3)	–
Provision of follow up visits after bio digester installation	**86**(57.3)	**64**(42.7)	–
Provision of (or access to) knowledge regarding construction of bio digester	**96**(64)	**54**(36)	–
Provision of (or access to) knowledge regarding proper operation & maintenance of bio digester	**131**(87.3)	**19**(12.7)	–
Provision of (or access to) knowledge regarding precautions of using bio digester	**131**(87.3)	**19**(12.7)	–

Table 1: Summary of responses based on different stages of BGT adoption

Source: field survey, 2015 Bolded figures are the number of respondents involved and those in brackets are the percentage

3.3. The Decision Stage

According to the resources of the project, the number of bio digesters could be more than 150. But only 150 households, out of 5750, adopted BGT and the rest of them decided not to adopt it.

3.4. The Implementation Stage

This stage started with bio digesters construction process. However, the decision stage was immediately followed by the construction process of bio digesters. Regarding this stage, about 64 percent of respondents mentioned that there was proper availability of technical support services for building bio digester and 83% mentioned that there was provision of proper monitoring during bio digester installation (table 1).

According to figure 5, 50% of the respondents mentioned that the masons for building bio digesters had proper expertise, while only 36% considered they were not of that level and 14% had no opinion.

Further, a minority (22%) of respondents faced problems regarding bio gas production since the first day of operating bio digesters (i.e. 30 bio digesters, some were either producing no bio gas and some were producing very little amount of gas) and then they looked for supportive information from FIDA to fix bio gas production problem (table 1). As a result, none of the respondents were helped by FIDA and they were regarded as not fixable by FIDA though about 57% of the respondents mentioned that there was proper provision of follow up visits after bio digester installation. The overall result was not good and other non-users lost their interest too. This has created a negative concept about BGT.

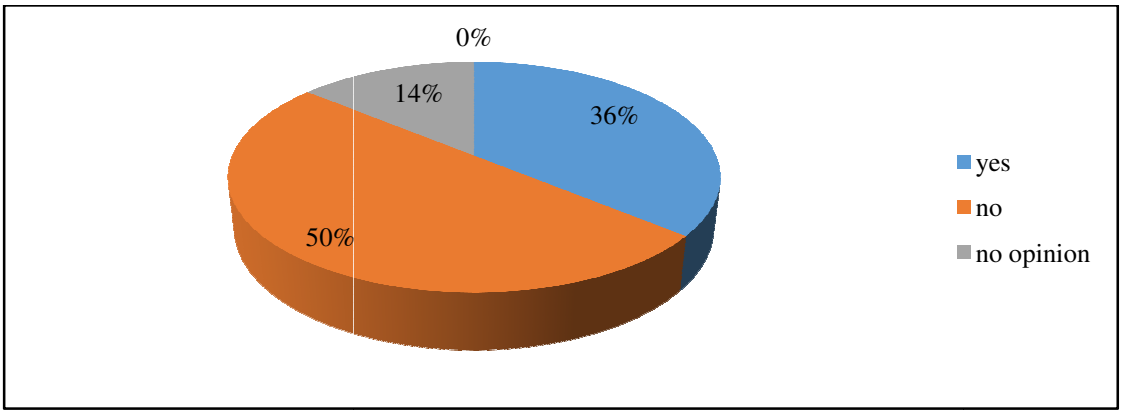

Figure 5: Availability of expert masons for building bio digester

3.5. The Confirmation Stage

According to figure 6, majority (about 69%) i.e. 103 adopters were found as still using their bio digesters successfully. However, 31% of them (47 adopters) were found as a case of failure; of which, 30 bio digesters did not start functioning since the first day of operation (immediately after installation), while, 17 bio digesters were gradually going towards low biogas production and eventually the households decided to stop using those any more. Actually, this stage, according to Rogers showed the confirmation of adoption decision. But biogas innovations are different compared to others. For example, we talk about mobile as a new innovation and people adopt it (buy it), use it for some time and later on confirm their initial decision of adoption or decide to reject it and replace it with another alternative. In case of bio gas innovation, once the adoption decision is taken then in the confirmation stage we can only see the confirmation of households' initial decision after operating bio digester for some time. In comparison to other innovations, it is hard to replace biogas technology as it can't be sold again.

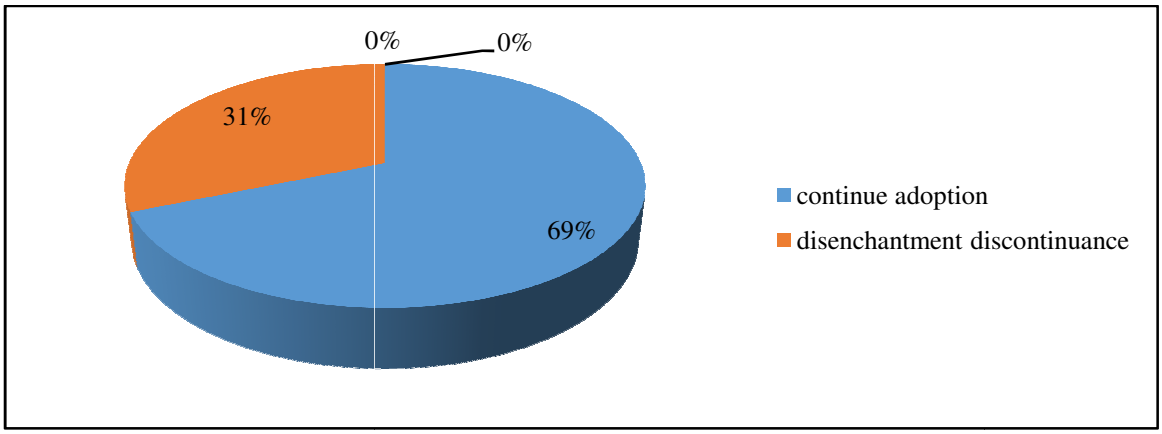

Figure 6: About status of bio gas technology adoption decision after implementation

4. Conclusions and Recommendations

The main purpose of this study was to examine different stages involved in process of adoption of BGT in five randomly selected villages in district D. I. Khan. A part of Rogers' innovation decision process model was used for achieving main purpose of the study. Among adoption process stages, persuasion stage was found poor for beneficiaries in the sense that the distribution of bio digesters both village-wise and household-wise, was made with bias, rather than uniform distribution due to dominancy in decision making by influential members in village councils which lost the interest of households. As a result, some villages got greater number of bio digesters and some got less and at the same time, the most deserved and potential households could not included among beneficiaries. The stakeholders (i.e. NGO named as Foreign Integrated Development Action and Village organizations) promoted BGT with carelessness and emphasized on quantity rather than quality. However, interpersonal communication was noted as major contributing element in building social reinforcement towards BGT adoption. The implementation stage was also found poor and relevant factors included inexperienced masons and poor monitoring by the project staff as well as lack of check and balance on building materials bought by beneficiaries though beneficiaries' uncertainty regarding BGT outcomes decreased during this stage. Furthermore, a considerable number of the bio digesters (30) did not produce any gas at all since the first day of bio digester operation, while the rest of bio digesters (120) started working well with better production of bio gas of which, 17 bio digesters reduced bio gas production gradually and eventually stopped working due to poor handling techniques of beneficiaries. It is clear that hundred percent subsidization rate without doing any needs assessment is among the major reasons behind such failure case. It is recommended for future projects in KPK that proper need based assessment is obligatory for beneficiaries' selection rather than providing BGT with biasness. The technical concerns are also important regarding selection of well trained and experienced masons as well as close check

and balance which will result in successful implementation of BGT projects. The bio digesters first needed to be built on pilot basis before starting a project in order to raise motivation of rural people as well as to monitor technicalities. The government should take proper steps for training rural dwellers regarding awareness, knowledge, operation and benefits of BGT.

5. Acknowledgements

The authors are grateful to the anonymous reviewers for valuable comments on this paper. The authors are also obliged to China Scholarship Council (CSC), China, for providing stipend in order to accomplish this study. The principal author especially is grateful to Professor Liu Yonggong regarding his continuous help and support in the completion of this research endeavor.

6. References

i. Amjid, S.S., Bilal, M.Q., Nazir, M.S., & Hussain, A., 2011., Biogas, renewable energy resource for Pakistan., Renewable and Sustainable Energy Reviews, 15(6), 2833–2837.
ii. Asif, M., 2011., Energy Crises in Pakistan., Pakistan, Oxford University Press.
iii. Bensah, E.C., Mensah, M., & Antwi, E. (2011). Status and prospects for household biogas household bio-digesters in Ghana - lessons, barriers, potential, and way forward. International Journal of Energy and Environment, 2(5), 887–898.
iv. Deacon D., Bryman, A., & Fenton, N., (1998)., Collision or Collusion? A Discussion of the Unplanned Triangulation of Quantitative and Qualitative Research Methods, International Journal of Social Research Methodology, 1: 47-63.
v. Harijan, K., Memon, M., Uqaili, M.A., & Mirza,U.M., 2009., Potential contribution of ethanol fuel to the transport sector in Pakistan., Renewable and Sustainable Energy Reviews. 13(1) ,291-295
vi. HDIP., 2011., Pakistan Energy Yearbook, Islamabad, Ministry of Petroleum and Natural Resources Government of Pakistan.
vii. Ilyas, S.Z. (2006). Biogas Support Program Is a Reason for its success in Pakistan. American-Eurasian Journal of Scientific Research, 1(1), 42-45.
viii. Ibrahim, S., 2009., Renewable Energy Resources of Pakistan., Economic Review (053189955), 40(12).
ix. Jing ming, L., 2007., Rural Biogas Development in China. Paper Presented at the Workshop on Challenges and Strategies to Implement Anaerobic Digestion in Agri. systems. Buenos Aires, Argentina. May, 2007.
x. Prasertsan S., Sajjakulnukit B., 2005., Biomass and biogas energy in Thailand: Potential, opportunity and barriers., Renewable Energy, 1–12.
xi. Quin Ni Ji & E. Nyns, (1996). New concept for evaluation of Biogas Management in developing countries. Energy Conversion and Management 37, 1525-1534.
xii. Raven R. P. J. M., Gregersen K. H., 2005., Biogas plants in Denmark: successes and setbacks., Renewable & Sustainable Energy Reviews.
xiii. Remais, J., Chen, L., & Seto, E. (2009). Leveraging Rural Energy Investment for Parasitic Disease Contol: Schistome Ova Inactivation and Energy Co-Benefits for Anarobic Household bio-digesters Rural China. PLOSONE; 4(3).
xiv. Rogers, E.M. (2003). Diffusion of innovations (5th ed.). New York: Free Press.
xv. Shah, S., Rashid, A., Bhatti, M.K.L., Khattak, S., & Khan, L., 2010., Crisis of electrical energy in Pakistan and future guidelines for policymakers., Canadian Journal on Electrical and Electronics Engineering, 1(3).
xvi. Sheikh, M.A., 2010,. Energy and renewable energy scenario of Pakistan. Renewable and Sustainable Energy Reviews, 14, 354-363.
xvii. Sherry, L. (1997). The boulder valley internet project: Lessons learned. THE (Technological Horizons in Education) Journal, 25(2), 68-73.
xviii. Squazzoni, F., 2008., Local Economic Development Initiatives from the Bottom-up Approach: the Role of Community Development Corporations., Community Development Journal, 2008. Oxford University Press, UK
xix. Talukder, M.F.S.I. (2010). Impact assessment of biogas household bio-digesters: A case study of Bangladesh. M.Eng dissertation, University of Flensburg, Germany.
xx. Wargert, D. (2009). Biogas in developing rural areas. Lund, Sweden: Lund University. Retrieved April 5, 2015, from http://www.davidwargert.net/docs/Biogas.pdf.