Rural Electrification Cooperative Model (Solar-PV) in Madhya Pradesh

NAJIB ALTAWELL[1], TARIQ MUNEER[2]
[1]Centre for Energy, Petroleum and Mineral Law and Policy (CEPMLP)
The University of Dundee, Carnegie Building , Dundee DD1 4HN,
SCOTLAND, UK
E-Mail: n.altawell@dundee.ac.uk
[2]School of Engineering
Edinburgh Napier University, 10 Colinton Road, Edinburgh EH10 5DT
SCOTLAND, UK
E-Mail: T.Muneer@napier.ac.uk

Abstract— In order to speed up the development of energy supply, involving the local population can be one of the main drivers for the success story of rural electrification. The local community involvement could be crystallised in the form of a cooperative model, i.e. in providing the power needed for a particular village or town. In this paper, details related to the supply of electricity, using renewable energy sources, has been examined and discussed. The electricity generated, such as from a solar energy, has been presented in the form of a cooperative model for a town in the Indian state of Madhya Pardesh, backed up with a methodology scoring value factors approach for the purpose of establishing a suitable power system for the proposed town.

Key-Words: - Rural, Cooperative, Electrification, Solar-PV, Renewable Energy Sources, Model, Town

1 Introduction

To provide a basic approach which may help in solving some of the issues related to rural electrification, a novel local community action would be needed and could provide an ideal solution. This could mean that the electricity supply can be provided via a cooperative enterprise village/town model, where the local population can participate in running a solar PV power station, as a first step in solving some of the basic domestic energy needs. In order to start the process for the above model, accurate data will be needed for a sample of villages/towns in Madhya Pradesh state. These samples should be able to provide a list of the number of households, in particular within a village or a town where electricity supply is still lacking for a large number of households within the local community. When it comes to an official statement, the claim is that 44% of the rural areas of India have access to electricity [1]; however, other statements from other sources concerning the same topic pertain to 30%, or close to this figure [2]. Whatever the actual figure is, the reality on the ground remains the same, i.e. there is still large number of people living without access to electricity. The problem of estimating the percentage of people who have access to electricity stems from the way in which a village provided with an electricity supply is defined. The Census of India define it as *'A village will be deemed to be electrified if electricity is used in the inhab-ited locality within the revenue boundary of the village for any purpose, whatsoever'* However, changes have been made to the above definition by clarifying the basic infrastructure of the supply distribution, the supply to public places and the number of households with electricity supply which should be a minimum of 10% of the total number of households in a in a village/town [2].

Table 1 Source of lighting for Households in Madhya Pradesh state [1]

Source of lighting	Total	%	Rural	%
Total	10,919,653	100	8,124,795	100
Electricity	7,641,993	70	5,063,424	62.3
Kerosene	3,224,055	29.5	3,024,423	37.2
Solar energy	15,130	0.1	10,535	0.1
Other oil	8,715	0.1	6,762	0.1
Any other	9,638	0.1	6,510	0.1

Whatever the result of 2001 'Census of India' has shown, concerning electricity supply to towns and villages (Table 1) , the idea of locating a village in

ISBN: 978-1-61804-055-8

the state of Madhya Pradesh where a program of electrification is urgently needed, a model of local community cooperative enterprise can be one of the solutions. A cooperative locally based model, the model itself should be able to provide all the energy needs, as well as it should be possible to apply the same principles later on elsewhere in other parts of rural India, for similar purpose. The question may arise of why choose the state of Madhya Pradesh, rather than any other state within the national boundary of India? Apart from the abundant of natural resources within the state of Madhya Pradesh, which make it an ideal place to start a natural sustainable energy system, there are a number of reasons why an electrification project, such as this one, should be allocated there, to start with [3]:

1. There are 52,074 villages in the state of MP, however, 4,949 of them do not have access to electricity
2. There are around 3,036 villages which have less than 10% of access to electricity
3. According to the Indian Census 2001 definition for electrified village, this means that there are 7985 villages in the state without electricity, i.e. 15.33% of the total villages in PM. The highest number of un-electrified villages is located in the Vindhya Region, accounting for 33.46% of the overall un-electrified villages in MP.
4. None of the districts of the PM is fully electrified

2 Rural Electricity Consumption & Tariff

According to Bharadwaj A. et. al, 2004 [4], the consumed electricity in rural India are connected to four categories of end users. These are: domestic, commercial, industrial and agricultural use, such as for the usage of irrigation pumps. The cost for consumption of electricity is usually measured by the supplied meter per kWh usage, however, the agricultural usage do not have meter measurement for the amount of electricity that has been used, instead, there is a flat payment rate [5]. As an example of rural India electricity distribution and consumption, metered end users are small for the overall consumption, the rest, i.e. technical, agricultural, electricity distribution losses, plus electricity theft, will make up the overall final balance [4]. The tariff charges also differ in that domestic usage has been allocated lower charges than the rest of the consumers (Table 2).

As illustrated in Table 2, the annual energy cost for the irrigation pumps has been left without a figure. This is simply because there is no available data for their usage, as they are not metered. The question is how the power supply utility calculates the electricity cost which they should charge? According to Bharadwaj A. et. al., 2004 [4], the cost has been estimated using the following simple equation: Total kWh (sub-station) = kWh (metered consumers) + kWh (unmetered consumers) + Technical Distribution Losses + Theft

Table 2 Examples of consumer, annual kWh consumption and tariff for rural India (Redrawn from the source: Bharadwaj A. et. al., 2004 [4])

Consumer	Sanctioned Connection	Annua l kWh	Annual kWh/ connection	Tariff
Domestic	1166	183,94	157	1.20 Rs//kWh
Commercial	12	1,30	108	4.75 Rs/kWh
Industrial	25	13,32	533	5.00 Rs/kWh
Irrigation Pumps	560	?	=	500 Rs//HP

There are two known values in the equation, i.e. 1 and 2, however, there are other three variables with unknown values, and these are 3, 4 and 5. To find out an estimated value of one of the above variables, then estimated figures for the other two variables should be known. The authors cite an example of how the utility normally estimate the overall cost of the power used in employing these agriculture pumps. They estimate the annual cost (kWh) by checking '*a few predominantly agricultural feeders'*. At the same time, the power utilities estimate the technical losses based on data obtained from a number of feeders. The above method cannot provide actual figures, and therefore it is prone to over/under estimate the overall cost, in regard to the substation and consumers.

3 Energy Cooperative

It has been reported that more than 70% of the population of India is located in villages, where lack of electricity and other essential services hinder the economic and social development [6]. A village cooperative model, therefore, to provide basic and essential services could be one of the solutions for the local community. The majority of the cooperatives around the world have a common principle in that the electricity supply should be provided on the basis of 'universal coverage', i.e. it should be provided for all the local people, with no exception, where the cooperative power enterprise operate. This kind of cooperative approach usually adhered to in the Western world have been noticed (to a certain level) in some parts of India, i.e. a number of households connected via a cooperative enterprise have much higher rate of connection, i.e. four time more than the connection provided via SEB [7]. A cooperative model can be in the form of direct benefits to the members or simply to function on a non-profit basis, i.e. for the sake of providing energy services. The second approach can focus on the quality and re-investment as part of the main objective of the model, while the first one usually concentrates on the maximisation of the profit to be distributed to their members, similar to the function of a company with shareholders [8]. Regardless of the choice, a number of factors should be discussed and agreed upon during the initial stages of consultation. These may involve the following points [9]: A. The type of ownership; B. Membership concept; C. The control mechanism of the community business; D. The size of the business; E. Internal and external relations; F. The social activities. An agreement concerning the above points should provide the platform for the next step in forming a 'cooperative power generation' enterprise. The project proposed the building of a solar plant in a village/town where there is no other power supply presently available. However, the village/town model should have the basic infrastructure for present and future economic development, e.g. a positive outlook for agricultural and/or local industries, as well as it should have an easy access to main roads.

3.1 Memberships

The first question will be raised is the population size of the village/town, i.e. the maximum and minimum range of the inhabitants within the proposed model location. According to Boyd, 2003 [9], in order to have genuine participation and cooperation for the purpose of achieving the aims and objectives of a community enterprise, i.e. fully active memberships, then the number of the memberships should be limited. In other words, the enterprise should not be structured as an organisation open for unlimited members. This may suggest that a village or a town of around 5,000 inhabitants can be an ideal for the proposed energy cooperative model. However, this kind of approach should not restrict or limit the considerations for other types of villages or towns, regardless of the population size, in that an experimental model should focus on the final possible positive outcome which can be achieved successfully with limited resources. At the same time, the whole focus should be for the benefit of the whole local population, rather than on certain section of the community.

3.2 Statistics

According to Census programme results for India during the year 2001, the following locations from class I to class VI, in the state of Madhya Pardesh, can be presented as an example, i.e. before deciding on the size of the town/village for the cooperative model [1]. A. Bhind (M) [Population: 153,752, Class - I]; B. Ashoknagar (M) [Population: 57,705, Class - II]; C. Chitrakoot (NP) [Population: 22,279, Class - III]; D. Gurh (NP) [Population: 12,450, Class - IV]; E. Hatod (NP) [Population: 9,028, Class - V]; F. Sethia (or Sethiya) (CT) [Population: 4,559, Class - VI]. According to the above source, the population size-class has been arranged as follows: Class I: 100,000 and above; Class II: 50,000 to 99,999; Class III: 20,000 to 49,999; Class IV: 10,000 to 19,999; Class V: 5,000 to 9,999 and Class VI: Less than 5,000 persons. Abbreviations used above: M – Municipality, N.P. - Nagar Panchayat (a form of an urban body in India comparable to a municipality), C.T.- Census Town (In India, a Census Town is one which has: 1. A minimum population of 5,000 2. At least 75% of male working population engaged in non-agricultural pursuits 3. A density of population of at least 400 persons per km^2.

3.3 The Model

The village/town model will be chosen on the basis related to the following points: 1. Lack of electricity supply; 2. The population size; 3. The willingness of the local population to get involved in the management, operation and maintenance aspects; 4. The town/village is located within the administered part of Madhya Pardesh state; 5. Recent data concerning the village/town are presently available for the project. However, as this will be the first cooperative developed model for the project, the preference will be given to a location in the form of a village, rather than a town.

ISBN: 978-1-61804-055-8

This is due to the cost, timescale and the final results needed within the lifespan of the project. As mentioned previously, the proposed cooperative model main objective is the provision of energy to the local community. In order to achieve the above structure successfully, a number of criteria and conditions need to be fulfilled [10], these conditions have been summarised below: 1. The size of the village; 2. Access to good roads; 3. Distant to distribution network and/or villages nearby already being supplied with electricity; 4. Number of consumers; 5. Number of established businesses; 6. Number of rural industries; 7. Comparison of other similar work done in other countries to the new location; 8. Availability of public facilities

The project will be established and will function under the following summarised guidelines: Local ownership; 2. Community participations; 3. Finding the most suitable solar model related to the geographical location, operation and maintenance; 4. Training those who are able to run successfully day-to-day operation and maintenance of the power generator; 5. Devising method(s) for revenue collection; 6. Tariff agreement (if possible) with the local/national authority – possibly the rate is in conjunction/proportionate to the motor/generator ratings; 7. Establishing town/village committee to deal with important aspects of present and future development and for major problems and final decisions. It is not difficult to locate a local community within the Madhya Pardesh state with the above requirements [1]. However, the fulfillment of all the above requirements mentioned above depend mostly on the timescale given during the initial stage of implementation. There are other aspects for village electrification, i.e. the village model will be considered under the following additional criteria [11]: 1. The possible influence of the geographic endowment on the electrification; 2. The possible influence of the State Electricity Boards (SEB); 3. The influence of the state's general development and structure; 4. Possible influence of the main grid, i.e. T&D losses, condition of grid infrastructure and future development; 5. A rural village could have a higher priority in states that depend on the agriculture sector; 6. There could be a negative effect in the form of higher cost for areas with a large number of villages, i.e. higher cost will be born out of longer transmission lines and interconnection; 7. There could be a positive effect on rural electrification from a large agricultural area, i.e. where irrigation, crop processing and storage are part of the working village environment where electricity demand will be high; 8. It is possible that because of the existence of electrification within regions adjacent to a village, electrification of the village would be part of the future electrification by the state and/or SEB plan, if electricity is not connected yet.

3.4 Town Profile

The town of Hatod, in the district of Mandla of Madhya Pradesh state, has been chosen for the purpose of solar-PV project implementation. Data regarding this town (Table 3) has been sourced from India Census, 2001 [1]. The geographical location of the town is within 22° 48' 0" North, 75° 44' 0" East (Google Map). The last census, i.e. India census, 2001, indicated that there are around 9030 inhabitants. The population of the town comprise of 51% male (4,648) and 49% female (4,382). The census also indicated that 16% of the total populations are under the age of 6 (Table 3). Even though electricity supply has been indicated to be available, reportedly, not all households have access to it. From the information provided regarding the town, access roads, drinking water facilities, population size and basic town income, all has fulfilled the specification outlined in the Model section provided above, i.e. it can be a suitable community example for the supply of electricity, e.g. via solar-PV system.

Table 3 Hatod town data [1]

Town	Hatod	Total population	9,030 persons
District	Indoore	Males (4,648)	3,116 (literates)
State	Madhya Pradesh	Females (4,382)	1,727 (literates)
Country	India	Drinking water facilities	Available
Approach paved roads	Available	Electricity for domestic use	Available
Approach mud roads	Available	Electricity for agricultural use	Available

3.5 Hatod's Energy Data

For the purpose of asserting the type of solar power system for Hatod, some basic initial statistic data will be needed. These data can range from the overall average power that will be needed per household and the overall power the system will be able to generate per day. In addition to the above, businesses, industrial and agricultural will be

ISBN: 978-1-61804-055-8

counted within the supply of the electricity generated from the proposed PV system. These have been included in the calculation. The usage of power calculation also included street lights, schools and places of worships. Below are estimated figures based on the Gollaprolu village proposal of hybrid solar energy power plant (2007) initiated by India Rural Community Projects Initiative (IRCPI). All the figures have been estimated in accordance to the size of the population, considering that there are 5 (or for calculation purpose 5.5, in order to get closer to the actual figures) persons living in an average household. According to the figures of India Census of 2001, there are 9028 persons live in Hatod, i.e. 9028/5.5 ~ 1640 approximate number of houses in the above town. Considering the population of the Gollaprolly village during 2007, there were 26,000 persons (present population figure is over 65,000), if divided by 5.5, we obtain the figure of 4727 which is roughly close to the actual number of households in Gollaproly (4487) during 2007. The following estimated figures have been worked out in a similar way (if compared to Gollaprolu village) (Figure 1):

Estimated power to be consumed…..........…1.1 MW
Peak load………….............…………………..8 KV
Number of household power connections…......1640
Number of commercial power connections….......40
Number of Industrial power connection…........…14
Number of agricultural connection…....……....…12
Number of street lights…..………...….………….28
Schools and places of worships…...…….……….14

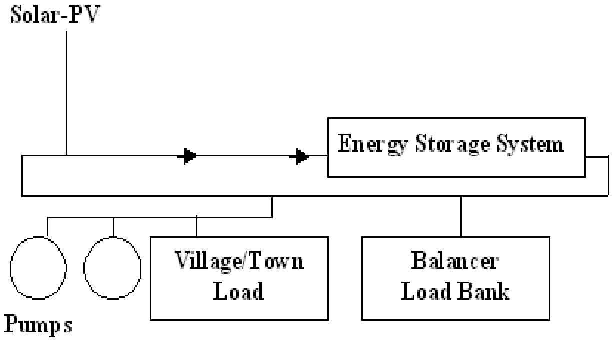

Figure 1 Basic illustration of the Solar-PV system

4 Financing Renewable Energy Project

The question is how to finance a rural electrification project, in particular a project such as a solar-PV system - in India? Rural electrification main funding in India can be sourced from: A. Corporation specialised in rural electrification projects; B. Plan allocation to the states; C. Direct Funding from government (e.g. in the form of loans or grants); D. Commercial banks; E. International finance institutes. In regard to point C above, steps has been introduced by the Indian government for a host of financial incentives. Some of these incentives have been summrised in the following points:

1. During the first year of system installation there will be 100% accelerated depreciation for tax purposes; 2. Lower import tariffs for Remain hardware and parts; 3. There is a five-year tax holiday for power generation projects; 4. Power generated via RE system and fed to the grid, the government will provide 'remunerative price' under alternate power purchase policy; 5. Banking facility plus wheeling of power; 6. Subsidies and/or financial incentives for expensive renewable energy devices.

5 Methodology

The starting point for this work has been based on the review of literature for a variety of rural electrification in different parts of the world, including those specifically designed with the cooperative model in mind.

Examples related to cooperative models where India's rural areas are concerned have been examined, as well as from those cooperative examples located in different parts of the world, i.e. in relation to the actual suitability and social/cultural aspects. The above study should complement the field work which will take place at a later stage of this project.

5.1 Methodology Approach

A methodology has been designed where the adapted approach is based on what is commonly known as *bottom-up-approach*, i.e. in the form of building a pyramid [12]. This may mean that all the starting basic factors are mostly known, and therefore, the process starts in recognizing the level of importance and functionality of these individual factors. The building and activation of these factors, in one form or another, will take the methodology to the next level of operation and/or construction.

The methodology, therefore, will consider a construction of, symbolically speaking, a pyramid where the aim and objectives of the methodology will be fulfilled at the top of the completed construction. This may mean that the following steps should be taken in the correct sequence, i.e. as

ISBN: 978-1-61804-055-8

and when each step has been completed separately and/or in relation to other steps. 1. Listing of all known factors on the ground where the proposed cooperative model will be located and function. This will include a number of areas which many of them have been mentioned and discussed in the previous section of this report.; 2. Analysing individual factors on their own merit and the level of importance of each factor in relation to the project. The viability/cost to present and future activity of those local communities involved in the running and maintaining the solar energy cooperative enterprise; 3. Compiling all the factors, i.e. hardware, labour/workforce, experts and energy sources under agreed guidelines, as well as under the principles of a ‘cooperative model’ for the purpose of generating electricity. The overall cost will be examined in the light of the project business viability, present and future operational aspects and predicted efficiency of the service for the local community; 4. A committee of the local entrepreneurs and engineers and other cooperative members will report and comments on the first operational test of the solar-PV system. The report will be in the form of a guidelines and a proposed solution(s) on how to overcome any shortages/negative aspects of the project, as well as on how to improve/speed up the process, as a whole; 5. The report received by those overseeing the project as a whole, in particular where financing, engineering and governmental aspects are concerned, will make the final decision on the viability of the work completed so far, and whether to proceed for the next stage or to reconsider again the previous one. The results shown at this stage will provide some data required for modification and changes - which should lead to an actual improvement during the following stage; 6. The modifications/improvement needed, whether in the form of technical aspects or human resources/local community engagement will be carried out over a period of time, which should lead to an improvised final operational test, i.e. during the second test; 7. The second operational test will be the actual final test, even if the test did not match the expected improvement and/or the service expected. This approach is simply to confirm whether or not at this stage further changes will be needed before the final operational mode has been finally reached, i.e. the starting of commercial service for the cooperative power supply model; 8. If the decision is made to proceed with the supplying of electricity to the local community and no further steps need to be taking for the time being, then this stage will, therefore, lead to the conclusion of the work. If further work will be still needed, then stage 7 will be repeated; 9. The final stage (where the overall activity of the project and the form of a cooperative model) will be part of the daily business activity of the local community. Feedback on the progress of the project will be part of the quarterly report produced by the management responsible for the daily operation of the solar-PV station to the cooperative executive committee.

5.2 Methodology Structure

The methodology will consider the importance of loads, cost/prices, human resources, taxations, grants and other relevant factors under the following three main headlines. These headlines are the make up of the three parts of the Pyramid. Starting from the base of the pyramid [12] the main factors are: 1. Regulations/laws and environmental/social; 2. Aspects; 3. Technical aspects; 4. Commercial aspects. The following methodology factors details have been summarised from two different sources [12], [13]: The first step is the regulations/laws and environmental/social aspects, which can be subdivided into the following headlines: Land and water issues, possible interference with other utility infrastructure, pollution and health issues, public and political acceptance, hazard rating, local and national government regulations, weather conditions, tax incentives, regulations related to the usage of local resources, incentive and opportunities for private investment. The second step is the technical aspects of the project, whether in the form of a hardware and/or software issues, as well as factors related to energy source and energy supply. This can be subdivided into the following headlines: Ratio for dependency on fossil fuels and/or other sources of energy, loads demand, electricity output, system life span, electricity payback ratio, quality of service, local skills needed, incremental capacity and other related infrastructure requirements and development. The commercial viability of the project, i.e. from operational point view, as well as from the influence of the previous factors mentioned above will be forming the final step in completing the pyramid approach. These commercial factors have been summarised in the following points: Number of customers, affordability for the end users, prices policy, prices for domestic usage and for local industries, seasonal and daily supply policy, profit/losses and share holders approach and policy, operational and maintenance cost, staff wages, marketing and present/future development approach. Using the above methodology structure, a percentage weighing of value to each factor, the level of factor and cost approach will be all considered during each stage of the project structure and valuation, i.e. it will be decided from the data obtained during the implementing process of the project itself. The work of the methodology is simply to provide a scale of measurement which will be converted into scoring values for each relevant factor, according to the fact on the ground during and after each field work observation and testing.

6 Conclusion

The rural community should be encouraged to work together by forming cooperative organisations as a way of establishing enterprises focusing mainly on the generation of electricity. Cooperative model will work as a symbol for other villages to implement similar procedures to provide access to electricity and consequently improving their daily conditions in their own community.

An outlined summary of a methodology related to the above has been presented as a mean for listing all the factors related to a Solar-PV project in the form of a cooperative model. The weighing of these factors, in accordance to their scoring of value and level of access, has made it possible to have a clearer picture for all the aspects connected to regulations, environment, technical and commercial level/values of the proposed solar-PV system.

References:

[1] Census of India 2001 (2001) *Housing Profile. Madhya Pradesh State.* http://censusindia.gov.in/Census_Data_2001/States_at_glance/State_Links/23_mpd.pdf 22.10.2010

[2] Coninck H. C. de, K.J. Dinesh K.J., Kets A., Maithel s., Mohanty P., Vries H.J. de (2005) *Providing electricity to remote villages: Implementation models for sustainable electrification of India's rural poor* http://www.ecn.nl/docs/library/report/2005/c05037.pdf 4.10.2010

[3] Bhawan V. (2009) *Status of Rural Electrification in Madhya Pradesh.* Working Paper II, Poverty Monitoring and Policy Support Unit State Planning Commission. http://www.mp.gov.in/spb/international-aided-projects/pmpsu/report.pdf 28.11.2010

[4] Bharadwaj A. and Tongia R. (2004) *Distributed Power Generation: Rural India – A Case Study* http://wpweb2.tepper.cmu.edu/ceic/pdfs/CEIC_03_07.pdf 1.11.2010

[5] National Rural Electric Cooperative Association (2000) *White Paper on Distributed Generation* http://www.nreca.org/Documents/PublicPolicy/DGWhitepaper.pdf 2.11.2010

[6] MNES 'Ministry of non-conventional energy sources' (2010) *Renewable Energy Scenario in India* http://www.indiasolar.com/ren-india.htm 22.10.2010

[7] NRECA (International, Ltd.) (2002) *Experiences in Cooperative Rural Electrification and Implications for India* - Background Paper. Submitted to: Samuel Tumiwa, Asian Development Bank Manila, Philippines. http://www.ocdc.coop/Sector/Energy%20and%20Rural%20Electrification/ExperiencesinCooperativeRuralElecADBRevisedFinal.pdf 21.12.2010

[8] DTI (2004) *Co-operative energy: lessons from Denmark and Sweden*. Global Watch Mission Report. http://www.urbed.com/cgi-bin/get_binary_doc_object.cgi?doc_id=232&fname=extra_pdf_2.pdf 28.9.2010

[9] Boyd G. (2003) *Community Enterprise Companies* http://www.caledonia.org.uk/papers/Community%20Enterprise%20Companies.doc 26.9.2010

[10] Holland R., Perera L., Sanchez T., Wilkinson R. (undated) *Decentralised Rural Electrification: The critical success factors* http://practicalaction.org/docs/energy/Rural%20Electrification.PDF 29.06.2010

[11] Andreas K. (2006) *Regional disparities in electrification of India – do geographic factors matter?* Swiss Federal Institutes of Technology, Centre for Energy Policy and Economic (CEPE). Working Paper No. 51. http://www.cepe.ethz.ch/publications/workingPapers/CEPE_WP51.pdf 4.11.2010

[12] Altawell N. (2009) *A systematic approach to biomass and energy crops streams for co-firing.* PhD Thesis. School of Environmental and Chemical Engineering, University of Nottingham.

[13] Lhendup T. (2008) *Rural electrification in Bhutan and a methodology for evaluation of distributed generation system as an alternative option for rural electrification.* Energy for Sustainable Development, Volume XII No. 3, September 2008. http://www.sciencedirect.com/science?_ob=MImg&_imagekey=B94T4-4V9PDGX-3-1&_cdi=56456&_user=9519913&_pii=S0973082608604342&_origin=search&_coverDate=09%2F30%2F2008&_sk=999879996&view=c&wchp=dGLzVz-kWA&md5=f1152d095ed69570f26a629cb41ebc3a&ie=/sdarticle.pdf 31.10.2010