Carbon – Science and Technology

ISSN 0974 – 0546

http://www.applied-science-innovations.com

ARTICLE Received: 16/12/2014, Accepted: 31/12/2014

Implementation of decentralized power generation by biogas digester: Policy and perspective

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Abstract: This paper aims to evolve innovative system for fast track implementation of decentralized power generation by biogas digester across the country commensurate with estimated potential of this energy resource. The methodology is based on the principle that necessity of a process or facility for human liveli hood generates demand of a new system if that is competitive enough to impress society by its value to meet the standard of usability economically and technically in all respect. Firstly, the study described a network of communication to propagate knowledge about the benefit, cost and operation of biogas digester to serve multiple purposes among policy makers and other stakeholders all over the country through distance mode programme and training of the human resources by simulating the process for training programme. Secondly, analysis by cause and effect method focused on major issues related to implementation of power generation by biogas that identified factors corresponding to the problems. Next the study attempt to focus on supply chain management for controlling those factors supported by administration with financial, technical facilities ensuring trouble free dynamic process from procurement of substrate through input to digester till delivery of electricity to the consumers. The study identified driving variables between resource centre and delivery stage of the supply chain that has influence on methane production related to power generation. The mathematical analysis reveal that optimum yield of biogas is independent of daily feed stock and improving methane fraction of biogas is possible by monitoring temperature and pH value within limited span of Hydraulic Retention period (HRT).The study observed by mathematical analysis that cost of power generation from biogas digester is dependent on the cost of substrate for biogas generation and the other fixed cost of the process. Bio gas digester cum power generation policy has been analyzed for rural and urban area focusing on the constraint at different stages.

Keywords: Decentralized power generation, Biogas, supply chain management

1 Introduction: Energy is the prime requirement for overall improvement of economy, but most of the population in remote rural area where population density is low, has no access to electricity. Besides 400 million populations in India including 47.5 % inhabitant is deprived of quality electricity even though the areas are located within the zone of the transmission grid **[1 - 8].** Especially millions of Low income group people in backwards area across the country have no access to electricity because of their poor economic condition and absence of communication and road connectivity with rest of the country. Moreover, construction of distribution line in sparsely populated area is uneconomic, besides inaccessibility to the locality due to geographical constraints. So far biogas digester implementation is underway across the country by National biogas and manure management programme that adopted policy on different issues in respect of implementation of family type biogas digester for cooking, heating and lighting purpose only at national level. But till now, there exist large scale gap between

potential resource and actual achievement in different states; the gap range vary in between 54 % and 95 %, indicating very poor performance in Bihar, Jharkhand and MP followed by poor to moderate performance in UP, Orissa, Assam, Tamilnadu. Similar programme can be instituted for power generation from biogas by biogas digester but adopting strategies to overcome problems in maintenance, implementation, training and monitoring in addition to application of information and communication technology for knowledge dissemination among stake holders about its cost, benefit and operation for multiple purposes. The aim of this paper is to justify that programme will achieve its goal if policy issues are developed by evolving strategies within a frame work of disseminating knowledge among stakeholders, training of manpower in distance mode and applying corrective measures to factors that are barrier to the implementation; this is effected in supply chain management. The methodology adopted in this paper is to highlight benefits and advantage of this renewable energy technology that is competitive with other conventional and renewable energy resource to policy makers, other stakeholders and to impress society by its value to meet the standard of usability economically and technically in all respect. This issue is perceptible to all in view of certain operational constraints at different stages of power generation from biogas; as for example, difficulties in availability of cow dung due to declining trend of cattle population. The application of technology in agricultural work is gradually replacing the cattle; there is decline of 18 lakh cattle population between 2002 -03 to 1971-72 across India .The percentage share of livestock to growth of GDP has declined from 4.02% in 2004-05 to 3.92% in 2011-2012 **[6]**. So, the methodology adopted cause and effect analysis to fix up such different factors that corresponds to causes affecting progress of implementation of programme then evolving strategies of supply chain management to control those factors. The study revealed that energy poverty in these areas can be resolved by implementation of off grid decentralized or grid interactive power generation by bio gas at tail end of grid. The strategy is to impress the policy maker and the other stakeholders about cost and benefit of the programme in comparison with other option of renewable energy resources. Therefore, the discussion in the paper first of all make a framework of input, output, outcome and impact of the installation of biogas digester cum power generation programme in the villages that is transformed into programme of creating awareness by distance mode to disseminate knowledge about benefit of this technology among policy maker and other stakeholders. The strategy attempt to add value to the digester implementation process by supporting collaborative training venture with dairy, food processing, agricultural farms and poultry industries .The idea is to maintain uninterrupted feedstock supply to biogas digester with minimum transportation and transaction cost. The electricity generation from biogas is simple; the cost of power generation is dependent on the substrates for biogas production. The cost of biogas production is depended on best monitoring of the parameters variation that has been identified by mathematical analysis. Another issue is installed capacity of power generation from Biogas is very low across the country, In addition to constraint of feed stock availability, even in plants operated cooking and lighting at individual level, there are problem of digester failure due to quality control in plant operation and more retention period of biomethanation during start up **[12].** There is necessity of new policy for implementation of power generation from biogas digester in view of those operational problems keeping in view of easy accessibility and operation process of wind power and solar power resources. Though power generation from biomass deserves merits because of the competitive cost of installation and uninterrupted supply, if feedstock supply is maintained continuously, but easy installation and operation process of solar and wind power has become more attractive to all, therefore, complexity in operational matters is major hinderers in popularizing this technology. So, this study look into factors affecting optimum biogas generation, cause of the operational problems and then suggest policy issues for fast track implementation of power generation from biogas. The study begin with discussion on context of study, then mathematical analysis to know the relationship between variable parameters that is responsible for optimum power generation, then analyze the causes of the problem by cause and effect analysis in section 3,section 4 focused on supply chain management strategy based on the factors identified followed by discussion on the training and knowledge dissemination for promoting

the implementation programme in rural and semi-urban area in section 5.Finally summarizing the discussion in concluding section 6.

2 Context of study: Decentralized electricity generation from renewable resources is now the major issue of policy development in power sector. In India, total IC of interactive grid power is 24194 MW as on 31.03.12 from all renewable energy resources ,out of this IC of biomass power share(including all types of biomass) is only 12.58% which include share of biomass gasifier. Considering the progress of biogas production, it has been ascertained that total nos. of biogas digesters installed for cooking, heating and lighting purposes is 45 lakh. But progress of power generation from biogas is not perceptible except in a few states. There are many benefit of decentralized power generation from Bio gas, one of this is T&D loss reduction due to proximity of plants near load centre which is now around 24.10 % as on 31,3,12 in India .IC of biomass power(including share of biogas) is 3135 MW while 199.96 GW is total IC from all resources. A comparative figure of installed capacity of power generation from biogas and share in total IC of all types of renewable has been mentioned in table 1.So far Solar and wind power has been accepted as popular technology to generate electricity because of its simplicity in availing of resource, constructional and operational procedures , but the power generation from biogas technology has not achieved much progress except in a few states in India as observed in Table 1 in spite of its many benefits and advantages in comparison with other renewable resources that need be presented to all stakeholders in power sector.

Information in Table 1 indicate that installation of off grid and grid interactive power generation from all types of renewable resources have achieved substantial progress in AP, Gujarat, Karnataka, Maharashtra, Punjab and Tamilnadu, while AP is only the state where considerable progress in power generation from biogas has been achieved. It has been revealed that share of off grid and grid interactive capacity of electricity generation from renewable energy resources in generation mix of total electricity supply out of all resources has reached 4.13 % only during last 8years according to a report [8]. The observation also indicate progress of electricity generation from biogas is insignificant in comparison with progress of electricity generation from other renewable resources and available potential of electricity generation from waste is 3836 MW in India **[9].**Though there are many schemes in operation by central and state institutions supporting financially and administratively to encourage installation of biogas plants for power generation, the status of progress is not satisfactory. Therefore, it appears that some policy issue need be revisited for introducing innovative idea to achieve progress in implementation of electricity generation from Biogas plants looking into following issues:

- Lack of awareness
- High upfront cost
- Complexity in construction & operation procedure
- Lack of planning process [data base, locality culture, maintenance support]
- Legal framework [selling electricity]

Therefore, the study needs logical analysis of the power generation system from biogas plants in order to identify the causes of the deficiency in progress. First of all, mathematical analysis has been performed to know Interrelationship between variables. The findings of mathematical analysis support to operate the process ithin known limiting value of parameters.

Table (1) Comparative statement of Installed capacity (MW) of renewable energy resources **[9].**

States	Installed capacity from all types of Renewable (MW)	Installed capacity Of generation from biogas (MW)	IC of Electricity generation from biogas out of total renewable (%)
AP	885	49.71	5.61
Gujarat	3498	10.79	0.31
Haryana	122	4	3.28
Karnataka	3183	4	0.12
MP	477	4.01	0.84
Maharashtra	3630	12.53	0.345
Orissa	97	0.02	0.021
Punjab	353	12.25	3.47
Tamilnadu	7219	11.79	0.163
UP	696	29.91	4.36
Uttaranchal	185	3.07	1.66
Total	20335	132.28	0.65

2 Mathematical analyses

Let Y = biogas production from substrate X kg,
∂ y/∂ X = the biogas yield per kg of substrate, μ = percentage of methane in the biogas,
pH/pH ref = the ratio of pH actual and pH reference,
T = the specific temperature in the digester for biogas production, t is ambient temperature in degree-centigrade HRT = hydraulic retention time,
η = efficiency of engine σ * efficiency of generator τ , γ =heat value of biogas equivalent to 6 Kw/m3,

Y = [{pH/pHre*(T/t)] / HRT}*X}
Where, percentage of methane in Y

$$Y = \{[pH/pHref*(T/t)] *HRT\}*X \quad \ldots \quad (1)$$

Since pH value remain within limit of 6.8 – 7.2 and HRT observed to be related to T, Differentiating Y w. r. t major variables HRT, T and pH the eq (1) become

$$\partial Y/\partial T.\ \partial pH\ \partial HRT = [(pH/pHref.] * HRT *X +pH/pHref*(T/t) X. +T/t *HRT \quad (2)$$

In case of maximum bio gas yield ∂ y/∂ X ∂ T ∂ pH/pHr = 0
Then, simplifying eq. (2),

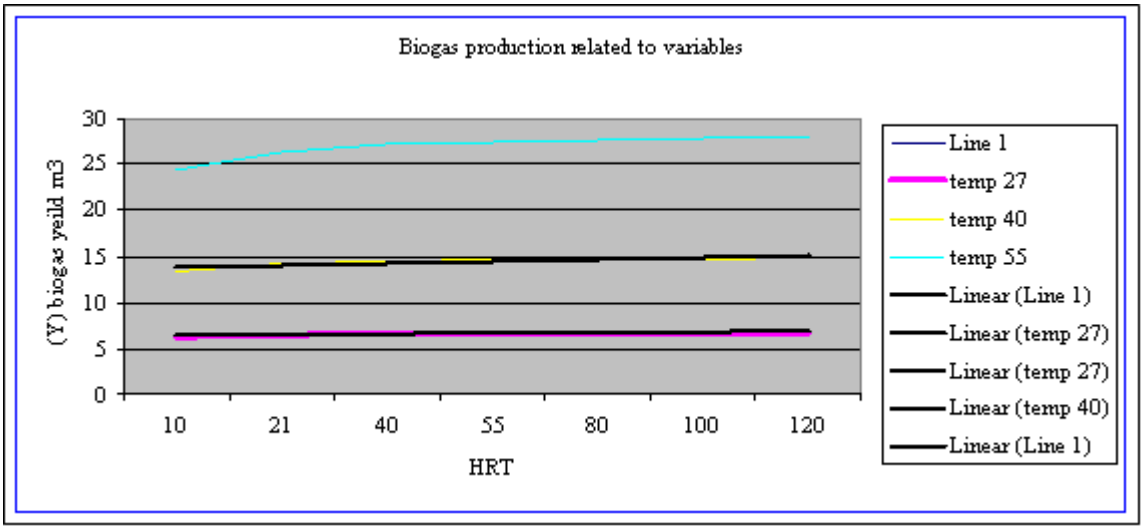


Figure (1): Pattern of biogas production, HRT and temperature

PH/pHr= - [(T/t)/ (HRT+T/t)]*HRT Substituting value of pH/pHr in equation (1)

Maximum Biogas yield

$$Ybio = X*HRT*[(T/t)\ ^2/\ (HRT+T/t)] \ldots\ldots \quad (3)$$

Percentage of methane in biogas yield,

$$Ymeth= \mu *(HRT+T/t)/\ X*HRT$$

Then power generation is

$$P = \eta *Ymeth* \gamma\ bio\ldots \quad \ldots \quad \ldots \quad (4)$$

In case of power generation, input of methane, efficiency of engine and generator and heat value of biogas is prime factor to optimize output, Heat value of biogas is normally 23.5 MJ/m^3 or 6 kW per cu.m. Efficiency of engine and generator normally available in the market is of value 25 % and 80 % respectively, so the only key driving variable for maximum generation is to maximize input, i.e., methane in biogas yield. The mathematical model suggest the pattern of optimum variation of biogas yield varies with variation of HRT, digester temperature T and ambient temperature t as displayed in Figure 1. However, pH/pHr never be exceeded beyond limit of 6.8 - 7.2 even the temperature rise increases biogas yield ,because pH/pHr ratio directly varies with temperature but receded with increase of HRT.Besides,the effect of ratio of temperature change and HRT on biogas production has been observed by trial and error method in excel worksheet , the result has been indicated in table 2 The biogas yield is increasing with rise of temperature and keeping pH value within a specific limit, the biogas yield show rising trend with increasing HRT till pH is balanced within limit of 6.8 – 7.2, the yield is maximum when temperature is maintained at 55 degree-centigrade. Therefore it transpires that biogas yield from fixed quantity of substrate is temperature dependent. The yield increases with increasing temperature of digester, but there is limit of biogas yield by increasing temperature with increasing HRT. It is necessary to keep HRT within 55 – 80 days for maximum yield. The observation of mathematical analysis suggest that pH value of the content need be constantly monitored during this period to remain within 6.8 – 7.2 with continuous feeding of the substrate for optimum biogas yield to achieve optimum power generation from this quantity of substrate. There will not be appreciable increase in biogas yield after crossing this limit. The mathematical analysis has not taken into consideration rate of growth or decay of the other elements during the digestion process. Thus this

analysis provide a direction to operating plant keeping the parameter within known value after computing with target production quantity by this method thus reducing procedural complexity in the system.

If those factors are considered then the analysis will be more complex but fine tuned to result.The result of trial error method of finding the relation between temperature HRT and pH in Table 2 indicate that power generation is increasing when the biogas availability is increasing with rising temperature. It is observed that power output decreases with decrease of biogas when the HRT period is high though temperature is high. Therefore, this observation suggests that Bio gas generation attained optimum value after a limiting period of HRT. Thus the findings of mathematical analysis support to operate the process within known limiting value of parameters.

Table (2) Optimum production of bio gas and corresponding electricity generation due to variation of parameters-trial and error method in excel worksheet.

substrate(x) kg dry weight	pH	Temperature of Digester (T) 0C	Ambient temperature (t) 0 C	Hydraulic Retention Time (HRT) days	Y biogas per (m3)	Y power (kW)
11.43	6.8 -7.2	27	35	10	0.552	0.76
11.43	6.8 -7.2	40	35	40	1.27	0.23
11.43	6.8 – 7.2	55	35	40	2.83	3.27
11.43	6.8 – 7.2	27	35	55	0.70	0.96
11.43	6.8 – 7.2	40	35	55	1.53	2.10
11.43	6.8 – 7.2	55	35	21	2.73	3.76
11.43	6.8 – 7.2	40	35	21	1.47	2.03
11.43	6.8 – 7.2	40	30	21	1.67	2.3
11.43	6.8 – 7.2	55	40	21	1.77	2.44
11.43	6.8 – 7.2	40	40	21	3.32	4.58
11.43	6.8 – 7.2	40	40	120	0.99	1.36

2 .1 Economic benefit:

Let y1 is cost of biogas generation (Rs/m^3)
X1 = Cost of Raw materials for biogas generation (Rs/m^3)
C1 =fixed cost for biogas plant and OH cost
and y2 = cost power generation (Rs/kwh),
X2 = cost of input for power generation
C2 = fixed cost for power generation;
Then,

$$Y1 = m1x1 + c1 \ldots \quad (5)$$

$$y2 = m2\ x2 - c2 \quad (6)$$

C2 in eq (2) is negative because at x2 = 0 or no input to power plant, the power plant has negative fixed coat which will account for losses.

Since x2 = y1, substituting y1 for x2 in equation (2)-

Eq. (2) transformed to

$$Y2 = m2*(m1x1 + c1) - c2$$
$$= m2m1x1 + m2c1 - c2 \ldots \quad (7)$$

Now differentiating y2 w.r.t x1,

$$Dy2/dx1 = m2m1; \text{ when } c2 = m2c1$$

For optimum power generation dy2/dx1 =0 or m2m1 =0; then

Substituting value of m2, m1 in equation (3), Y2 = m2c1 –c2 when there is no change in marginal cost of power generation and marginal cost of raw material for bio gas generation, then, fixed cost of power generation

Now comparing with equation (2): Y2 = m2x2 –c2

X2 is synonymous with c1, i.e.

Cost of biogas power generation is equal to fixed cost of bio gas generation

Therefore, the observation is fixed cost of biogas generation need be reduced to achieve optimum power generation cost.

The fixed cost in biogas generation is as follow: 1) land cost, 2) transaction cost, 3) Over head cost, 4) Water cost and 5) Maintenance cost

Another solution: Differentiating w.r.t time: Dy2 /dt = m2m1x1 + m2c1 - c2 = m2.m1.dx1/dt

Cost of power generation change is equal to cost of raw material for biogas generation.

Therefore supply chain management strategy will be to reduce cost of raw material in bio gas generation and fixed cost reduction

The interrelation between sources of input to generation of power need be managed by strategy 1 source of input to biogas generation and its methane gas production capacity is tabulated below.

3 Cause and effect analysis: After fixing up the objective of the study, it is necessary to find out the cause of deficiency in rapid progress of implementation of power generation from decentralized biogas resources. The logical analysis suggests that the process involved two parts of operation management; first part is biogas generation that is fuel resource to engine of generator. The proper procurement of resources at the initial stage of biogas generation is major critical issue to control that need be managed by co digestion method of feeding plant with mix of other waste products.. The manure procurement has now become scarce because of low cattle population because of the emerging technology in agricultural work. Therefore, the development of biogas digester at community level is more economical and feasible approach rather than individual level. When we decide to build community level biogas digester plant at large scale capacity, then the problem of transporting feedstock will arise .One of the cause of substrate procurement is the distance of the plant from resource centre, The problem has been

resolved by planning resource centric location of the plant as shown in Figure 3. Next cause of complexity is available substrate quality and pretreatment process that involve cost of labor and maitenance which rural people cannot afford to spend individually .Therefore, progress of biogas generation programme will not achieve success unless co-operative basis decentralized biogas power plants implementation policy is adopted. The mathematical analysis indicates maintaining proper temperature within limiting HRT period is an essential requirement. Also, balancing of alkalinity and acidity need be done by proper monitoring of pH value. All these activities is a strenuous work to an individual villagers The major problem is to maintain temperature during winter season when the biogas generation may be low unless proper temperature is maintained. All these causes suggest that community level biogas production is best option to achieve fast track implementation of the programme. The cost of biogas generation is major issue for keeping the power generation cost competitive with conventional and other non-conventional power resources that has been determined by the mathematical analysis. Efficiency of power generation need be maintained at higher level that is possible when the load factor is high. Therefore, this is the barrier to power generation from bio gas. People are more interested to avail of power from grid as they are quite ignorant of the ultimate benefit of electricity from biogas resources. So there is requirement of awareness creation among villagers. Another cause of lack of implementation is tariff for selling of bio gas to consumers when constructed at community level, because as discussed earlier, the power generation at individual level is too complex to operate. The programme of interconnecting plants of surrounding villages is possible to achieve progress of biogas power implementation. Feeding power to the tail end of grid is another problem in implementation of the power generation, because of the possible problem of synchronization. The cost of biogas production is another issue that is defined by the cost of the input for the biogas generation. Current situation of household energy perception and preference need be investigated. Unless energy option is accepted by the society, it has little chance of successful implementation regardless of its technical and economic merits.

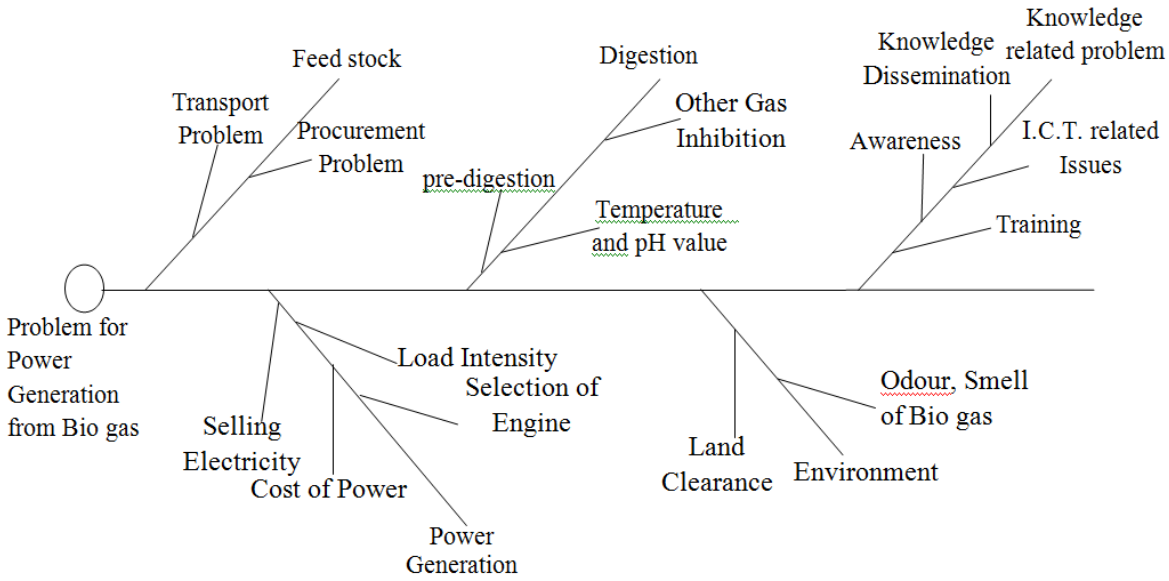


Figure (2): Cause and Effect analysis.

4 Supply chain management: Now the observation in cause and effect analysis supported with mathematical modeling has identified the factors that are considered in developing the supply chain management for supporting accelerated implementation of power generation from biogas digester. So far the observation revealed the major issues in the supply chain are as follows

- Maximizing biogas production

- Raw materials procurement
- Substrate transportation ,processing and monitoring digestion
- Management of power tariff and injecting power generated from biogas to grid.

The supply chain management will be effective if the programmed is planned properly. The planning of the programme is depended on statistical evaluation of the data collected from the proposed location well ahead of the starting date of project , the plan will solve the problem initially about the possible demand of electricity and the revenue return from exporting power to grid, The proposed feed in tariff need be settled with regulatory authority .The programme will look into the capital cost and solve the problem of financing the programme.The decision need be taken to approve the capacity of plant installation after considering different options of resource, operational methods and consumption of output. **[5]** The small scale biogas generation at individual level appears to be more complex operating process in view of the required effort for monitoring the parameters by chemical test and regular maintenance with procurement of feed stock to achieve economical power generation. Therefore, large scale power generation project in collaboration with specialized institutions need be undertaken. Inventory: The resource centre for feed stock need be located around the plant at minimum distance to reduce transportation cost. The quality of the feedstock need be monitored to ensure optimum methane production. The resource centers will be dairies, piggeries and poultry which can provide uninterrupted feedstock to biogas plant. Essential parts of equipment need be stored by the management.Process: the problem of maintaining required level of measurement regarding temperature; pH is solved by providing a basic infrastructure of chemical laboratory near the plant. The daily test of the biogas yield, pH, other content of gas and temperature will maximize efficiency of digester performance. Power generation will not add any problem in the operation, Power generator of 10 Kw to 100 Kw are commonly utilized for generating electricity, The conversion of diesel engine by modification of some component will be operated by biogas but debated to 50-55 % of diesel mode **[6].** The power output evacuation will be a problem in case of grid interactive plant at tail end of a grid due to frequency mismatch technicalities. The success of the fast track implementation of power generation from biogas depend upon the optimum availability as well as minimum cost of methane gas generation to keep the cost of electricity within limit as well as maximizing biogas input into engine according to observation in the mathematical analysis.Therefore,the management principle will be to consider integrate management activity at the resource end, digestion process in digester and easy access to grid for evacuation of power at optimum selling cost.**[2]** The chain of biogas generation and consequent power generation need be synchronized to avoid interruption at any stage of distribution of power.The performance of the biogas plant will be satisfactory if it share knowledge and information from other biogas plants successfully operating in India. This is possible if there is good communication network for information sharing in the villages. This is explained in the following activity flow chart.

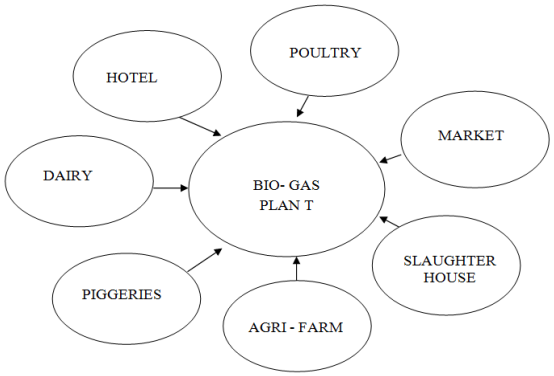
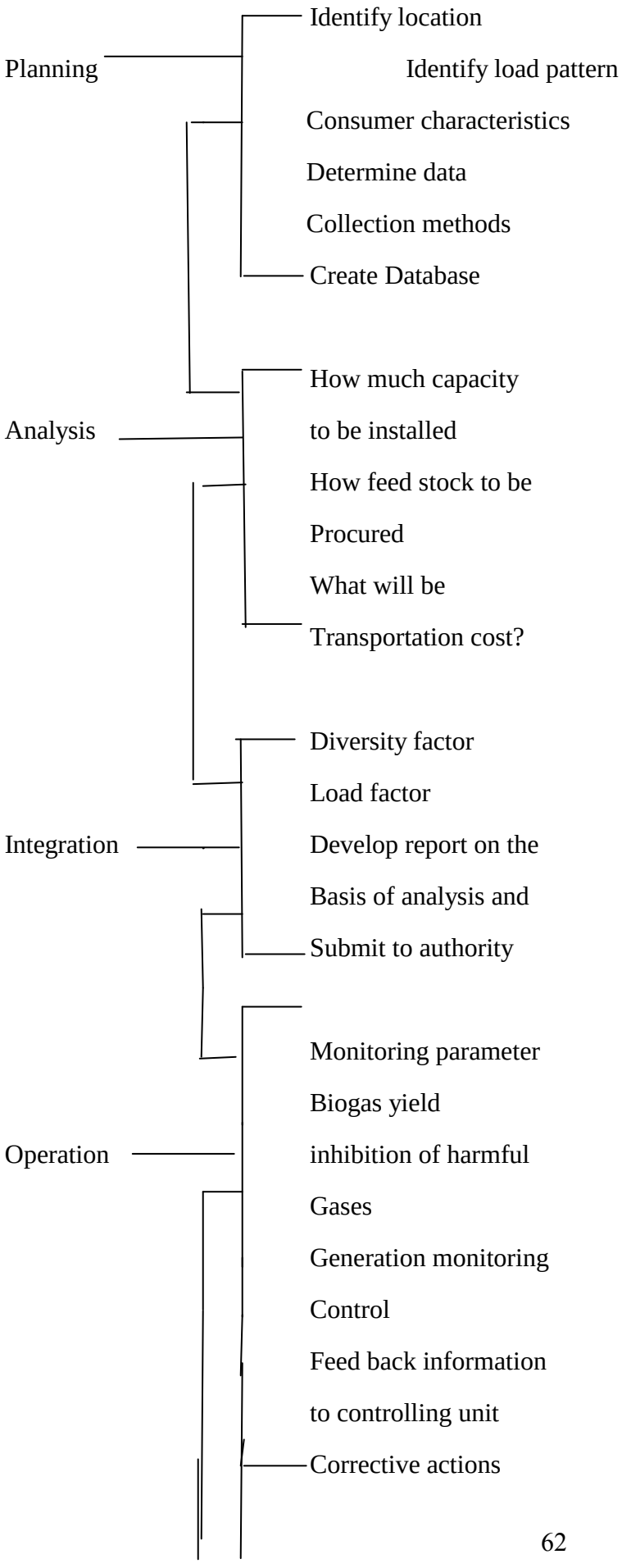


Figure (3): Model resource centre and biogas plant location.


Identify location
Planning
Identify load pattern
Consumer characteristics
Determine data
Collection methods
Create Database
How much capacity
Analysis
to be installed
How feed stock to be
Procured
What will be
Transportation cost?
Diversity factor
Load factor
Integration
Develop report on the
Basis of analysis and
Submit to authority
Monitoring parameter
Biogas yield
Operation
inhibition of harmful
Gases
Generation monitoring
Control
Feed back information
to controlling unit
Corrective actions

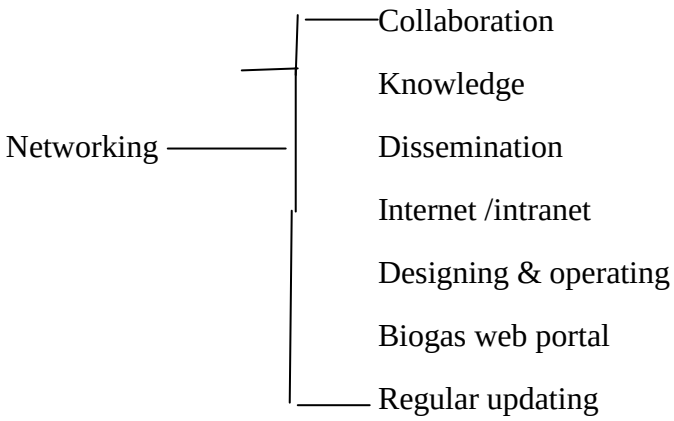


Figure (4):: Activity flow chart.

5 Knowledge dissemination: Information about cost of power generation, fuel procurement and processing, operation methods and utilization of output power need be disseminated among all stakeholders to popularize this renewable energy technology. The statistical data in respect of the power generation from biogas supported with block diagram of the process starting from procurement of raw material to delivery need presentation through audio visual method. The programme of presentation to NGO and administrators need be organized at district level periodically to update latest status of this technology. It is essential that collaboration between administrators at state level with NGOs' and other interested public institutions is primary steps to begin with the task of widespread installation of power generation from bio gas. The next step of popularizing the programme is selecting villages across the country on the basis of resources covering available cattle population, agricultural wastage, dairies, poultry farms, and piggeries, slaughter houses in rural area, restaurant, hotel and food processing industry in semi urban area. The common database of these resources need be compiled and stored in server of the web site specially created for the purpose of power generation from biogas in India. This web portal need be designed to include state wise database of resources, list of NGO's who are authorized by MNRE and state renewable energy department, the list of dealers supplying ancillary equipments, detail information about operational cost, fuel and transport cost and labor cost along with return of investment .The web portal must also cover expert's advise for troubleshooting with detail instruction about maintenance of the plant. There is necessity of informing all stakeholders through advertisement in public domain about information availability in web portal periodically. The next step of popularizing this technology is to set up model village with decentralized power generation from biogas digester at each district across the country based on available resources and electricity accessibility, then arranging workshop under supervision of district nodal officer for interactive discussion of the participant selected from dairies, poultry farm owners, farmers, food processing industries and other experts from departments associated with production of biogas from digester. The objective of the workshop will be to deliberate the idea that decentralized power generation from biogas is sustainable development of energy for future survival of the rural and semi-urban population. The energy availability from conventional resources need be substituted by biogas in a time bound programme by adopting suitable policy keeping in view above popularizing steps. The interactive discussion among the expert or field worker or the actual consumers of village will develop a road map of policy directive and action plan. The organizer will disseminate knowledge to the participants of the workshop at the model village highlighting present emerging technology of power generation from biogas in the world, encouraging reports about the achievement of power generation from bio gas in MW scale in the developed countries, clarifying all about the installation, operation and financial support from central and state renewable resources department to motivate them implementing the programme.The consensus of all stakeholders is desired for revising the present limit of 10% share of renewable energy out of total energy generation enhancing to 20% for implementation of this programme beside allowing tax waive on revenue and purchase of equipments. All the decentralized

plants are to be linked by intranet facility to facilitate exchange of view among the staffs about operational and financial data of every plant in the states .This action by the administrator will enable the plant operator to gain knowledge about controlling different parameter to generate optimum biogas for supply to engine of the generator.

5.1 Training : Training of the operating personnel is essential for any manufacturing process; the power generation from biogas similarly needs trained supervisory and operating staff at the plant. The training module will contain preliminary knowledge about the energy availability from different resources and comparison of cost. The different type and characteristics of the substrate to produce biogas ,methods of optimizing methane from biogas, the complex digestion process in the digester and the component of Engine and generator in power generation. This training module also need be incorporated in the internet activity. The staff will have easy access to the module at their convenient time for self learning. Therefore the module must be prepared for self learning according to the methods of distance learning programmed

Training modules in distance mode will include discussion on the following topic.

- Biogas installation in different parts of world,
- Capital cost and method of installation,
- The advantage of decentralized biogas digester over other renewable resources,
- Different technology developed-purification, bottling, digestion process,
- Economic analysis-flow of fund, subsidy, supporting finance
- Quality control,
- After installation service and support,
- Database and information network availability
- Common problem in plant operation and rectification,
- Radio and TV programme
- Centralized lecture by experts covering emerging technology, operation and monitoring procedure transmitted all over the country, the time schedule communicated in advance to the participants.

Training programme will be in 3 levels by utilizing internet, intranet, biogas web portal and video conferencing at remote location to include all.

1 junior level –for mason, rural people,technicial staff
2 middle level –for supervisory staff, local or regional authority
3 higher level - for policy makers, financial executives,politicians,researchers,decision makers

the distance mode of training will emphasis the improvement of general interest in decentralized digester implementation programme by focusing on advantage over conventional energy usage, Initiating debate to create enthusiasm among trainees on the selected topics of planning, operation, financial matters, The training on this technology with the aid of simulation of the real operation will add value to this programme,because the trainees at distance from plant area will have opportunity to learn in virtual mode the detail operating process.

6 Conclusions: The study begins with objective to innovate a system for fast track implementation of decentralized power generation by producing biogas from digester. The analysis on this topic has achieved the goal by identifying the relationship between key variables that need be controlled for optimum biogas production. This optimum condition is necessary for optimum power generation, because power generation is dependent upon production of biogas and the cost of generation also. The mathematical relationship reveals that pH, temperature within limit of Hydraulic Retention period (HRT) need be monitored to produce maximum quantity of biogas using fixed quantity of feedstock.

The biogas yield will attain maximum level at pH value within 6.8 – 7.2 during limiting time period and at temperature index (T/t) >1 and then decline with increasing HRT.The mathematical relation also stated the economical power generation condition. The cause and effect analysis of the system is useful to find out relevant factors which are known to be cause of the complex problem that need to be addressed for simplicity in operational procedures. The substrate procurement and feeding to digester is one of the problem that has been addressed by suggesting co-digestion and integrating biogas production with resource centers or else, the biogas plant should be located at the central location surrounded by resource centres.The complexity of the system operational problem is not suitable for implementation at individual level, therefore, cooperative basis implementation programme is effective .The study suggested to impress the society and the stakeholders by knowledge dissemination and information sharing in distance mode of learning method. That knowledge dissemination activity need communication network for two way communication between stakeholders and the implementing authority for interaction on the subject. It has been suggested that collaboration with financial institutions, different interested organization will pave the way for fast track implementation of the programme.The training needs for achieving the desired objective has also been discussed that necessitate training programme by simulation technique of real operation at plant, internet, intranet and video conferencing to reach the interested persons for their training off their daily work at any convenient period.

References:

[1] Bhavnagar Ashes, Text book of supply chain management, World – press, Lucknow (2009).
[2] Blanachard David, Supply Chain Management: Best Practices, John Wiley &sons (2010).
[3] Bendapuri ramkumar,SA PPLPP, BDGPO4,lighting up lives biogas from poultry litter as sustainable energy resource, good practices brief, new Delhi (2010).
[4] Department of science and technology National Resources Data Management system, http://nrdms.gov.in/
[5] S. U. Ferooqui, Encyclopedia of Supply Chain Management ,Vol 1,Himlaya Publishing House
[6] Govil G P Small gas engine Conversion Kit Ed.Vijay V K, Biogas Production, Up gradation and Slurry Management, Narosa , (2012) 65-70
[7] Khandelwal K. C., Technoeconomic Feasibility of Municipal Solid Waste based Bi omethanation and land fill gas power projects, Ed. Vijay V. K.,(2012), Biogas Production,Upgradation and Slurry Management, Narosa pp25 -48
[8] Ministry of new and renewable energy, www.mnre.gov.in/file-manager/dec-biogas/biogasscheme.pdf
[9] Ministry of Statistics and Programme Implementation,Govt. of India, www.mospi.gov.in
[10] Mudhoo Ackmz(2012),Biogas Production – Pretreatment methods in Anaerobic Digestion, John Wiley & sons.
[11] Nicholson Martin, "Energy in changing climate," Rosenberg publishing, Australia, (2009).
[12] National Research Council, Electricity from Renewable Energy Resources, National Academic Press (2010).

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