India: Biomass for Sustainable Development

Lessons for Decentralized Energy Delivery

Village Energy Security Programme

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South Asia Region
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Abbreviations and Acronyms

BPL	Below Poverty Line
CCIG	Japan Climate Change Initiative Grant
CFA	Central Financial Assistance
CREDA	Chhattisgarh Renewable Development Agency
CUF	Capacity Utilization Factor
DDG	Decentralized Distributed Generation
DPR	Detailed Project Report
GoI	Government of India
IEP	Integrated Energy Policy
IREP	Integrated Rural Energy Programme
MNRE	Ministry of New and Renewable Energy
MoP	Ministry of Power
NEP	National Electrification Policy
NIC	National Consultant
NPBD	National Program of Biogas Development
NPIC	National Program on Improved Cookstoves
NSSO	National Sample Survey
O&M	Operation and maintenance
OEM	Original Equipment Manufacturer
OREDA	Orissa Renewable Development Agency
PHRD	Japan Policy and Human Resource Development
PIA	Project Implementing agency
REP	Rural Electrification Policy
RGGVY	Rajiv Gandhi Grameen Vidyutikaran Yojana
SNA	State Nodal Agency
VEC	Village Energy Committee
VESP	Village Energy Security Programme

Conversions

Units of measurement

1 lakh	100,000
1 crore (100 lakh)	10 million
1 hectare (ha)	2.47 acres or 10,000 m^2
1 km^2	0.4 sq. mile
1 cumec	1 m^3/second
°C to °F or °F to °C	(F-32)/9 = C/5

Effective exchange rate (May 20, 2007)

US$1	Rs (rupees) 40.76
Re (rupee) 1	US$ 0.0245

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Executive Summary

A. Background

1. Energy is vital to fostering development, while the lack of it has potential to perpetuate poverty and jeopardize the growth of a nation. Today, absence of electricity severely curtails working hours and opportunities for the socio-economic betterment of 400 million households in India. Nearly 700 million Indians still burn biomass as the primary source of energy for cooking in inefficient cookstoves. The presence of reliable energy services in the lives of these rural populations can significantly improve their prospects by offering a range of benefits, such as poverty reduction, health improvements and opportunities for a better livelihood.

2. The Government of India (GoI) recognizes the importance of bringing rural populations into the ambit of development and economic growth through the provision of energy services. India's Eleventh Five Year Plan 2007–2012 and the Integrated Energy Policy 2005 seek to eradicate poverty, and have created new opportunities to address India's rural energy problems through the use of biomass. As part of this policy environment, electricity will be supplied to all by 2012. In areas where electrification is not possible, such as in remote villages, the Government is exploring the development of community-driven biomass-based resources programs to meet the basic energy needs of the population. As a climate change co-benefit, a large-scale conversion to biomass-energy can decrease India's greenhouse gas emissions.

3. To address this developmental challenge, the Ministry of New and Renewable Energy (MNRE) developed a Village Energy Security Programme (VESP) in 2005 to go beyond electrification alone, and address the total energy needs (i.e. cooking, lighting, and productive use) of remote villages by using local biomass resources. The project sought to benefit remote village communities, often from poor and tribal villages, with no access to modern energy services and opportunities for productive activities. The Ministry selected villages that would not be connected to the national grid in the near future for VESP implementation from a list of villages in consultation with the Ministry of Power (MoP), and laid down detailed guidelines for program implementation.

4. The VESP installed an energy production system for the (i) generation of electricity through renewable energy technology systems, such as biomass gasifiers, biofuel, biogas and/or hybrid systems[1], and (ii) utilization of electricity for domestic and productive use, while providing energy for cooking through community and/or domestic biogas plants (based on animal or leafy waste) and energy efficient cookstoves (such as gasifiers, turbo or fixed cement concrete stoves).

5. At the time of its conception, the VESP was considered as highly innovative, unique and the first of its kind in India. The country had limited experience in

[1] Depending upon specific requirements and availability of resources, solar photovoltaic devices, such as solar lanterns or an appropriate battery backup arrangement or micro hydro systems, could also be considered.

implementing a program involving rural communities in such remote locations that would be generating and distributing power themselves. The MNRE recognized that while the risks in implementation could be significant, the lessons learned from the program experience would be valuable. Appropriately, for such a pioneering and unprecedented program, the first phase was rolled out as a pilot phase to test the concept and preparedness of the various institutions to deliver the VESP to remote and inaccessible communities.

B. Objectives and Scope of the Technical Assistance

6. In 2006, at the request of the GoI, the World Bank initiated a recipient-executed technical assistance titled "Biomass for Sustainable Development" to support the MNRE's promising Village Energy Security Programme. For the technical assistance the Bank drew from the lessons of previous analytical work in India on household energy and practical experiences from a range of state-level, community-driven rural development and rural infrastructure projects. The Japan Policy and Human Resource Development (PHRD) Climate Change Initiative Trust Fund, was responsible in funding the technical assistance of US$ 998,700[2]. It is pertinent to note that the VESP was entirely funded by the MNRE, while the Trust Fund provided an opportunity to support the Government in learning lessons from the pilot phase and developing a larger program, pending successful results from this phase.

7. The objectives of the technical assistance were to:

- design, test and evaluate test projects being implemented under the VESP, forassessing the sustainability of institutional arrangements and business models. The focus of the support was on participatory village energy planning, financing arrangements, packaging with income generation, and monitoring and evaluation; and
- promote knowledge sharing and dissemination with the aim of propagating sustainable models of energy service delivery in remote villages and learning of lessons.

8. The technical assistance was designed to cover 95 test projects in eight states that were under the VESP: Assam and West Bengal (eastern region); Gujarat and Maharashtra (western region); Chhattisgarh and Madhya Pradesh (central region); and Andhra Pradesh and Orissa (southern region). These states were chosen on the basis of geographical coverage, presence of state nodal agencies (SNAs) and a rapid assessment of the state's potential to take up at least 15–20 new test projects in a couple of years. Of the 95 test projects, 8 had been commissioned even before the commencement of the technical assistance but needed ing on institutional and capacity building aspects.

9. The Bank's recipient-executed technical assistance sought to enhance the effectiveness of the VESP through the following aspects.

- *ing the project implementation structure at the MNRE*: The support ed the dedicated project implementation structure at the MNRE, by supporting the

[2] Of the Bank support of US$ 998,700, total disbursement stood at 52% at the close of the technical assistance.

appointment of qualified support staff. This arrangement helped to the regular implementation structure at the central, state and district levels.

- *Providing expert technical and managerial support through a consortium of consultants*: The support ed implementation of the ongoing test projects and helped develop new projects by contracting experienced non-governmental organizations (NGOs), with greater potential to bolster community mobilization and build grassroots capabilities. These consultants supported the agencies working at the state and district levels.
- *Providing knowledge products to help make the design, implementation and monitoring a systematic process*: The support focused on developing a systematic process for the design of participatory village energy plans, performance monitoring and learning of lessons.

C. Findings and Recommendations

10. Of the 67 sanctioned projects, 67 percent were commissioned and 51 percent were operational. There was mixed project performance among the eight states. The performance in Assam, Chhattisgarh, Maharashtra and Orissa was encouraging and these states accounted for 85 percent of the operational projects across the eight states. Overall, about 2500 households in 34 remote and inaccessible villages received direct lighting benefits. About 700 kW of electricity generation equipment was installed of which nearly 90% was biomass-based gasifier technology. A total of 4079 households were given improved cookstoves and 1330 cubic meters of biogas capacity was created during the pilot phase.

11. Notwithstanding the above achievements, the pilot phase highlighted several institutional shortcomings in delivering the VESP to remote locations and the need for ing the institutional mechanism between the MNRE and state level stakeholders. Given the small-scale and complex community-driven nature of the Programme, the SNAs had little interest in its implementation. Thus, by-and-large decision-making remained centralized at the MNRE leading to delays in sanctioning of projects and limited ownership from the states. The pilot phase highlighted the need for 2–3 year action plans developed by dedicated state program management units that should form the basis for the MNRE to engage with the states. While MNRE should focus on setting guidelines and monitoring progress and performance, the state units should focus on activities, such as identifying the principal implementing agencies, approving “detailed project reports”(DPRs), sanctioning projects and ensuring the presence of trained and accredited local service providers in the vicinity of the projects.

12. The performance of the VESP was largely mixed at the project level due to the following key reasons: the failure of the technology suppliers to provide prompt and reliable aftersales services; inadequate training of local operators and non-payment of their salaries; lack of organized supply of fuelwood; and the lack of capacities and interest among the village communities to manage the day-to-day affairs of the power plant. To overcome these issues, the VESP should consider phasing the management of the power plants from the VECs to dedicated and skilled entrepreneurs whose capacities could be developed over time. These entrepreneurs would be responsible for operating and maintaining the plant, ensuring the supply of biomass, collecting payments from the users and

ultimately delivering the electricity services. In addition, the report suggests measures to establish local service providers duly certified by equipment manufacturers to provide prompt aftersales service.

13. An ineffective system for ***biomass supply*** has seriously affected the uptime in many VESP projects. Being located in the midst of forests, the supply of biomass was not recognized as a limiting factor and responsibility to ensure that biomass was delivered at the power plant was not taken seriously. The current arrangement of every household supplying a certain quantity of biomass regularly was unsuccessful in most test projects. It may be better to monetize the biomass supplied and thereby provide an incentive to those households that do supply biomass to the power plant. For large scale biomass based programs in which unsustainable extraction of biomass could pose a serious risk, it will be important to assess the feasibility of supporting plantations through appropriate biomass policy options. These would include provision of incentives for production, buy-back arrangements, extension services and systematic convergence with programs of the forest institutions.

14. As a result of irregular and inconsistent delivery of energy services, communities' willingness to pay for services could not be adequately established except in a few test projects. However, an analysis of the financial parameters of a typical VESP project shows that revenues that are based solely on what domestic users pay would not be sufficient to cover the costs of operation and maintenance. It is recommended that a budgetary provision is made available to the entrepreneur to cover this viability gap to help cover costs and leave a regulated amount of profit. However, to ensure that the entrepreneur is interested to constantly improve technical performance and economic efficiency the viability gap funding should be provided on a decreasing scale over time.

15. Further, analyses shows that if the playing field were level for grid and off-grid villages in terms of equal subsidies, then current levels of ability to pay in these remote communities (which is equivalent to kerosene replacements costs) are adequate to cover the operation and maintenance costs of the power plant. Given that VESP villages are likely to be more remote, inaccessible, scattered and tiny compared to those served by conventional grid-based programs, there is a need to reconsider the policy framework for subsidizing off-grid power generation and distribution to remote communities.

16. Finally, a technology-neutral approach that guides the selection of technology based on cost, reliability, and ease of operation, and focuses on delivering grid-like power, rather than insisting on biomass technologies alone would be a way forward. A separate and dedicated program for cooking energy is also recommended to increase the importance of delivering robust cooking energy services that can reduce indoor air pollution.

17. The following table presents a summary of recommendations for enhancing the effectiveness of energy service delivery through a decentralized program, which currently finds a critical place in the Government's energy policies and electrification targets.

Table E.1: Summary of Recommendations for Enhancing Effectiveness of Decentralized Energy Programs

Improving institutional performance	
Decentralize and devolve powers and responsibilities	• State nodal agencies (SNAs) should have the power and responsibility to sanction and implement projects through dedicated program management units (PMUs). • MNRE's engagement with the SNAs should be based on a two-three year plan to be submitted by the SNA. • The state PMUs could seek external experts with multiple skills to complement their resources.
Phase the management of power plants from village energy committees (VECs) to entrepreneurs	• Power plant management should be with the entrepreneurs who will be responsible for the entire operation and collection of dues. • The basis for engagement will be an agreement drawn up between the entrepreneur and Gram Panchayat/VEC.
Change the focus from output reporting to performance monitoring	• State and central PMUs should develop and maintain a performance database over the lifetime of the equipment. • Integrate the performance monitoring system into the contractual obligation of the project implementing agencies and institute third party performance audits.
Improving technical performance	
Build a robust aftersales services network of third party local service providers	• Every state must identify and train local service providers, such as diesel mechanics and electricians before project implementation. • Develop contractual obligations between the project and trained local service providers.
Impart modular and graded training to develop specific skills and knowledge	• Provide innovative and hands-on training to entrepreneurs, operators and selected village community representatives.
Improving financial performance	
Make viability gap funding an incentive for better performance	• Viability gap funding should be used to attract entrepreneurs. • However, this support should be gradually phased out so that entrepreneurs are encouraged to secure other revenue streams for commercial viability.
Secure convergence and revenue streams of VESP at a policy level	• Convergence is necessary to enhance loads and secure additional revenue streams. • A system should be instituted to secure the cooperation of state and district officials from the relevant departments to the VESP.
Sustainable plantations and improving biomass supply	
Monetize biomass supply	• Voluntary contributions of biomass on a non-payment basis have not worked. • Village level systems should be in place to provide a cash incentive to villagers who deliver biomass to the power plant.
Emphasize sustainable biomass plantations	• Every project should secure biomass supply by dedicated plantations on private and public lands, contracting with village forest committees and forest departments. • At a policy level, central and state governments should promote incentives for biomass plantations in individual and community lands with assured buy-back and forge systematic and large-scale convergence with forest department programs.
Improving the policy framework for VESP	
Ensure a level playing field for VESP vis-à-vis the decentralized distributed	• Reconsider the policy framework for subsidizing off-grid power generation and distribution to remote communities.

generation program of the MoP	
Adopt a technology-neutral and scale-neutral approach	• Decentralized energy programs should take a technology- and scale-neutral approach. • The technology and its size should be based on the needs and resources available at the project site rather than on prior guidelines.
Focus on delivering grid-quality electricity	• Given the complex nature of delivering grid quality electricity decentralized energy programs should focus on delivering electricity alone. • Cooking energy interventions may be taken up through other dedicated programs.

D. Conclusions

18. The pilot phase of the VESP has shown several lessons and the need for improvements. Two very important issues were highlighted: first, that the VESP is important and relevant in the absence of any other Government initiative for bringing grid quality power to the poor, undeveloped and underserved communities residing in the remotest corners of the country; second, the mixed performance of the VESP during the pilot phase was due to reasons that are not entirely intractable and insurmountable. Thus, a decentralized energy program that is focused on performance, backed by greater policy support and a vastly ed institutional mechanism for implementation is the way forward.

1. Rural Energy Scenario in India

1. India is blessed with an abundance of human capital whose potential is not fully realized especially in rural areas. Among other things, access to reliable energy is vital to ensuring that these communities move beyond subsistence and contribute to the country’s economy. Thus, energy is the key driver to lift people out of poverty and provide them with a better quality of life. Consequently, to address the twin objectives of eradicating poverty and fully harnessing the abundant human capital, provisioning of energy services in the rural areas is a priority for the Government of India (GoI).

2. About 70 percent of India’s population currently lives in rural areas but access to and availability of reliable and assured energy to them is far from satisfactory. For example, in the electricity sector, over 44.2 percent (84 million households) still have no access to electricity. Even those end-users in the rural areas who have access to electricity, cannot use it either due to shortages and poor quality of supply resulting from inadequate infrastructure and services, or because of their poor paying capacity.

3. Similarly, in the household cooking sector an overwhelming proportion of the rural population continue to burn traditional biomass fuels in an inefficient manner. Fuelwood, chips and dung cakes, contribute around 30percent of the primary energy consumed[3]. Meanwhile, the penetration of petroleum fuels for lighting and cooking has been low in the rural areas. Despite large national level subsidies[4], only 5.4percent and 1.62percent of the rural households were using liquefied petroleum gas and kerosene, respectively, as fuel for cooking, though kerosene is used by 55percent of the rural households for lighting[5].

4. Provisioning of energy services in rural areas has remained a major challenge for the Ministry of New and Renewable Energy (MNRE), the Ministry of Power (MoP) and other agencies/authorities responsible for the production and distribution of electricity. However, realizing that rural communities must get access to assured and reliable energy, the MNRE conceived and designed the Village Energy Security Programme (VESP) for remote villages that are unlikely to be connected to the national grid in the near future. This Programme looks beyond mere electrification and aims at providing total energy solutions, including biogas and improved cookstoves for cooking, and electricity for stimulating economic activity and lighting.

5. The core principle of the VESP is community driven development. The Programme is based on the premise that targeted capacity building of rural communities coupled with ownership and management of the energy infrastructure would ensure the availability of reliable energy to these communities. It aims at delivering a completely decentralized power generation unit owned and governed by communities that use locally available biomass

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[3] According to the 61st round of the survey conducted by the National Sample Survey Organization.
[4] During 2004–2005 the total recoveries borne by the Government on liquefied petroleum gas and kerosene subsidies were Rs 10,000 crore mainly benefiting the urban areas.
[5] According to the 2001 census.

resources for long term and sustainable energy production. At the time of its conception, the Programme was unique and the first of its kind in India. The country had limited experience in implementing a program involving rural communities in such remote locations that would be generating and distributing power themselves.

6. Appropriately, for such a pioneering and unprecedented program, the first phase was rolled out as a pilot phase to test the concept and preparedness of the various institutions to deliver the VESP to remote and inaccessible communities. Therefore, the purpose of this phase was to learn lessons and improve the Programme at both the program and project levels before scaling it up. The test phase has provided important lessons for the development of a decentralized energy program in the future, which could lead to a better achievement of the rural energy policies and electrification targets.

1.1 Comprehensive Regulatory and Policy Environment for Rural Electrification yet Large Unmet Energy Demand

7. India needs to sustain an economic growth rate between 8 and 10percent over the next 25 years to eradicate poverty and meet its human development goals. To deliver a sustained growth rate of 8percent from now through to 2031–2032 and meet the basic energy needs of its citizens, India will need to increase its electricity capacity and supply to around six times that of 2003–2004 levels. By 2031–2032, the power generation capacity must increase to nearly 800,000 mega watts (MW) from the current capacity of around 160,000 MW, inclusive of all captive plants. With such large demands for electricity, it is natural that the GoI has been evolving and amending the legal, policy and regulatory environment to ensure that electricity generation and distribution keep pace with the growing demand.

8. Over the years, the learning from several programs of the GoI has helped in shaping the energy policies with positive implications and benefits for the rural poor. The Electricity Act, 2003 obligated the Government to supply electricity to the rural areas. In addition, the Rural Electrification Policy (2006), National Electricity Policy (2005) and the Integrated Energy Policy (2005) provided the required enabling environment for the promotion of electrification to the entire country. The Rural Electrification Policy envisaged the provision of access to electricity to all households by 2009 and a minimum lifeline consumption of one unit kilo Watt hour (kWh) per household per day by 2012. The National Electricity Policy and the Integrated Energy Policy support decentralized distributed generation (DDG) facilities (either conventional or non-conventional methods of electricity generation, whichever is more suitable and economical) together with a local distribution network, wherever grid-based electrification is not feasible.

9. Yet with such a robust policy and legal framework being in place and evolving, there remains a large unmet electricity demand in the rural areas. The Rural Electrification Policy target of electricity to all rural households by 2009 has been missed. Despite the increasing national trend in rural electrification since 2000, only 83percentof villages and 56percentof rural households in the country are electrified through the grid. More than 100,000 villages still remain to be electrified. Hamlets that are located far away from the inhabited villages are

often not connected to the grid, despite being part of the revenue of the village, resulting in their large populations being deprived of electricity. Even in the villages that are electrified, the supply remains unsatisfactory as power is usually not available in the evenings when it is needed the most. Thus households deprived of electricity, whether in the electrified or un-electrified villages continue to rely mostly on traditional biomass and kerosene for their energy needs.

1.2 Efforts and Initiatives on Rural Electrification and Cooking Energy

10. Several programs of the MoP and MNRE are in place to meet the rural energy demands and have, through their learnings, contributed to the making of the electricity policies discussed above. Many wide-coverage electrification schemes have been implemented by the state electricity utilities with central financial assistance from the MoP.

11. Among the many schemes for rural electrification in the country, the Kutir Jyoti program was perhaps the longest serving scheme. It was launched in 1988–1989 for extending single-point light connections to “below poverty line” households in the rural areas. A reported 7,129,370 single-point light connections were released across the country for these households until March 31, 2005. Other programs, such as the Urjagram program and Integrated Rural Energy Programme of the MNRE, have helped to make villages self-reliant in energy through an optimal mix of various renewable energy technologies (e.g., solar, picohydro, biomass). However, many of the above programs have proved to be self-limiting, either because the technologies were not mature or because of the inadequate service network that failed to show the desired impact. Furthermore, the programs were also mostly “target driven” rather than being “need driven” with limited involvement of the community during the planning and design stages, because of which their success rates were minimal.

12. Among the recent and ongoing programs of the GoI is the Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) launched in 2005, by merging all other existing schemes of rural electrification. This scheme receives a 90percentcapital subsidy and therefore imposes a huge fiscal burden. It aims to electrify 125,000 villages and connect the entire 23.4 million “below poverty line” households with free connections; the 54.6 million households “above the poverty line” are expected to get connections on their own. The Yojana is also expected to augment the existing network in 462,000 electrified villages by 2010. However, given the current constraints of electricity supply with a peaking shortage of 11.7percentand energy shortage of 7.3percent, program performance already seems to be heavily compromised. The RGGVY has not been able to satisfactorily address the common problems of poor networks, lack of maintenance, low load density with high “aggregate technical and commercial” losses, high cost of delivery, and poor quality of power supply. As a result, nearly 40percentof households remain without electricity even in the states that have been fully electrified through the RGGVY.

13. Similarly, in the rural cooking energy sector, efforts have been ongoing for over three decades. The National Biogas and Manure Management Programme and the National Programme on Improved Cookstoves, for example, disseminated

3.93 million family-type biogas plants and around 35.2 million improved cookstoves from the early 1980s until the early 2000s. However, the impact of these efforts is not known, because of a lack of comprehensive assessment of the outcomes as well as of information on how many of these cookstoves and biogas plants are currently operational.

14. Given this situation, the provision of energy security remains a principal challenge to, and an imperative for, India's economic growth aspirations and its efforts to improve human development. And while the various ministries and other agencies of the GoI are implementing a range of schemes and creating an enabling environment to meet rural energy needs, it is well accepted that biomass will remain the dominant source for meeting energy requirements. Therefore, a sustainable approach towards rural energy security requires the intensification of commercial initiatives as well as a diversification of the energy mix to include renewable energy sources that are capable of contributing to energy security, rural economic growth and environmental protection. In this regard, the efficient use of available biomass stocks, its potential to be grown and harvested sustainably, and available technologies make biomass a potential candidate for designing and delivering rural energy solutions.

1.3 Objectives and Scope of the World Bank Support to the Village Energy Security Programme

15. Recognizing the VESP of the MNRE as an innovative and futuristic initiative and based on the World Bank's previous analytical work on household energy, collaboration between the two organizations was initiated. As a result, in early 2005, following the recommendations of the World Bank's reconnaissance mission in India and discussions with the MNRE, an application for a grant of US$ 998,700 for providing recipient-executed technical assistance to the ongoing Programme's pilot phase was made to the Japan Trust Fund under the Policy and Human Resource Development Climate Change Initiative Window. The technical assistance grant titled "Biomass for Sustainable Development" became operational in May 2006 and ended in June 30, 2009, after being extended for 12 months at the request of the MNRE (see Annex 1 for details of the technical assistance grant performance). The technical assistance had the following development objective:

- To identify and test scalable models for designing and implementing community-driven programs for meeting comprehensive village energy needs, with a focus on business models for small-scale biomass-based renewable applications that can meet energy needs related to productive uses, cooking and lighting.

16. In addition, the climate change related objectives were to:

- remove barriers and reduce implementation costs for productive and household use of biomass-based renewable energy in support of sustainable rural development.
- reduce greenhouse gas emissions by substituting fossil-fuel–based energy and traditional greenhouse gas-intensive biomass energy with modern renewable energy technologies.

17. At the time of the launch of the Programme, the MNRE was aware of the range and extent of challenges that such an innovative program may face. The World Bank provided *soft support* through recipient-executed technical assistance (Box 1.1) to help the MNRE address the challenges. The scope of this support included:

- providing technical assistance to projects being implemented under the VESP, with the objective of testing the sustainability of institutional arrangements and business models for community driven initiatives to meet their total energy needs through biomass-based or other renewable energy sources;
- promoting knowledge sharing with the aim of propagating sustainable models of energy service delivery in remote villages; and
- identifying interventions that promote synergy between energy services and environment management, rural employment and incomes, and social service delivery.

Box 1.1: World Bank's Technical Assistance Support to the VESP

The "technical assistance" sought to enhance the effectiveness of the VESP through the following aspects.

- **ing the project implementation structure at the MNRE**: Implementing the projects through a dedicated and ed project implementation structure at the MNRE, by supporting the appointment of qualified staff with experience in the rural energy sector. This arrangement helped to implementation and was distinct from the regular implementation structure at the central, state and district levels.
- **Providing expert technical and managerial support through a consortium of consultants**: This support ed the implementation of ongoing test projects. It also helped develop new projects that complemented the MNRE-financed pilots by contracting a consortium of experienced non-governmental organizations, with greater potential to community mobilization and building of grassroots capabilities. These consultants closely supported the agencies working at the state and district levels.
- **Providing knowledge products to help make the design, implementation and monitoring a systematic process**: The support focused on developing a systematic process for design of participatory village energy plans, performance monitoring and evaluation, and learning of lessons.

1.4 Structure of the Report

18. This report is organized as follows: Chapter 1 provides a background of the rural energy scenario in India, describing the unmet energy needs, and the policies and regulatory environment as a rationale for the VESP. Chapter 2 discusses the program design, its key components, and a detailed analysis of its pilot phase performance on institutional, technical, financial, managerial and social aspects, ending with lessons learned. The report ends with a chapter on the important lessons with policy and program level recommendations as the way forward for improving the outcomes of decentralized rural energy initiatives in the future.

2. The Village Energy Security Programme

1. The introductory chapter described the situation in India in terms of electricity generation and distribution in rural areas. The policy and regulatory framework to promote rural electrification was also presented. This chapter deals with the rationale behind designing the VESP, its key components and performance at the project and program levels.

2. Despite the projected scale up to 800,000 MW by 2031–2032, the Integrated Energy Policy predicts that traditional biomass will still be used as a primary fuel, particularly in rural areas for a long time. In the absence of reliable grid power and continued dependence on traditional biomass fuels, the unmet demand for energy will only increase in the rural areas as well as in industry (its share is expected to go up from the present 153 mtoe to 185 mtoe). In the future, more villages and small industries are likely to opt for energy production units of their own. Special action is therefore needed so that communities help themselves instead of waiting for utility companies to supply electricity.

3. Given that woody biomass is locally available and rural communities are using it, though inefficiently, suitable handling and management of biomass resources can help meet the unmet demand leading to greater energy security for villages and small industries. Such a win–win strategy would significantly reduce the dependence on oil reserves and foreign exchange outflow, considerably enhance the tree and biomass cover through plantations on unproductive and degraded wastelands, provide decentralized energy solutions for villages and industry, and create new opportunities for employment and livelihoods.

2.1 Objective and Design

4. Keeping in view the above rationale, the MNRE conceived the VESP in 2005 as a consolidation of its electrification scheme and numerous vertical programs on cooking energy into a single decentralized energy program. The Programme is very important for rural India and goes beyond rural electrification to place additional emphasis on energy for productive use and cooking. The overall goal of the Programme is to provide energy to the villages through locally available biomass resources with full participation and ownership of the community and ensure enhanced livelihoods and improved quality of life. The emphasis of the VESP is on energy security at the village level with a further thrust on micro-enterprise development for enhancing employment opportunity and economic viability of the Programme projects.

5. Based on a community-centered approach, the Programme provides a one-time grant (up to 90 percent of the investment cost; see Box 2.1) to a village community (only in remote villages that are unlikely to be connected with grid electricity) for providing energy systems capable of meeting local energy demands. The villagers are expected to provide an equity contribution either in cash or kind. The Programme includes biomass gasifier systems, biogas systems, biofuel-based options and energy efficient stoves, based on the village's energy plan, which consists of a mandatory provision for raising and managing dedicated plantations as feedstock in biomass gasifiers and/or for harvesting

oilseeds for sustainability. The VESP pilot phase, therefore, had the following objectives:

- *Set up decentralized energy production and distribution systems in remote villages* by creating an appropriate institutional mechanism at the village and state levels through community facilitation and technical support.
- *Promote sustainable management of assets* bying the capacities of different stakeholders (such as communities, local institutions) through training, workshops, exposure visits and other activities.
- *Address the total energy requirements of a village* by including the provision of improved and efficient devices for lighting, cooking and options for productive use of the generated electricity within the village.
- *Establish a sustainable fuel supply chain* by supporting Village Energy Committees with technical know-how, in partnership with the state forest departments, for establishing and maintaining dedicated plantations and management of tree species to be used as feedstock in the energy production systems.

Box 2.1: Subsidy Flows in VESP

As per the VESP Guidelines 2008, a typical VESP project receives two types of financial support, viz.a one time capital subsidy of up to 90% of the project cost and an operation and maintenance (O&M) support fund to cover two years of operations. Accordingly, the Village Energy Committee (VEC) maintains two bank accounts; one each to receive the capital subsidy and the O&M subsidy. The VEC is formed as a sub-committee of the Gram Panchayat and therefore is subject to audit of accounts and is required to report periodically to the Gram Panchayat.

The VEC is expected to procure the power generating equipment through a process of competitive bidding and release payment to the supplier from the capital account fund. However, in reality, given that the VECs are inexperienced, the state nodal agency is allowed to carry out this function. The VECs are expected to pass a resolution authorizing the state nodal agency to act on its behalf.

The table below provides details of the capital support in a typical VESP project:

VESP capital subsidy for a 100 household VESP project

Components	Items	Budget support (Rs.)	% to total	Rs./ household
A	10kWe biomass gasifier based power plant, 5years AMC, distribution system, domestic wiring, 5Ha. Biomass plantation, biogas systems and improved chullahs.	2,272,500	74	22,725
B	Capacity building and social mobilization costs	200,000	7	2,000
C	Implementation, monitoring and 2 year operation and maintenance support	593,125	19	5,931
	Total	**3,065,625**	**100**	**30,656**

6. The VESP, therefore, installed an energy production system for the (i) generation of electricity through renewable energy technology systems, such as biomass gasifiers, biofuel, biogas and/or hybrid systems[6], and (ii) utilization of electricity for domestic and productive use, while providing energy for cooking through community and/or domestic biogas plants (based on animal or leafy waste) and energy efficient cookstoves (such as gasifiers, turbo or fixed cement concrete stoves) (see Annex 2 for a brief description of the VESP technologies).

7. Each project design was based on the respective village energy plans developed through a participatory approach and included appropriate provisions for capacity building of stakeholders for maintaining the energy production systems and managing the project. Community mobilization and institutional building for effective project management played a critical role in realizing the overall aim and objectives of the Programme.

8. The project service delivery model that was followed involved the formation of a village energy committee (VEC) by the project implementing agency (PIA) with representations from villagers and the local governance body (the *Panchayat*). The committee was constituted through the *Gram Sabha* and duly notified by the *Gram Panchayat* as a "sub-committee" or "standing committee" of the Gram Panchayat as per the relevant provisions of the State Panchayati Raj Act and rules in this regard. The VEC consisted of 9–13 members with 50 percent representation from women members and the elected Panchayat member from that village being the ex-officio members.

9. The implementing agency is responsible for setting up the energy production systems through the "original equipment manufacturer (OEM)" and hands over the hardware to the VEC for day-to-day operations and management. The committee acts as a custodian of the energy production system and is responsible for the operation and maintenance of the system. The electricity generated from the energy production system is distributed to the community through a local mini-grid. The VEC in consultation with the PIA sets the tariff to include the fuel and the operation and maintenance costs.

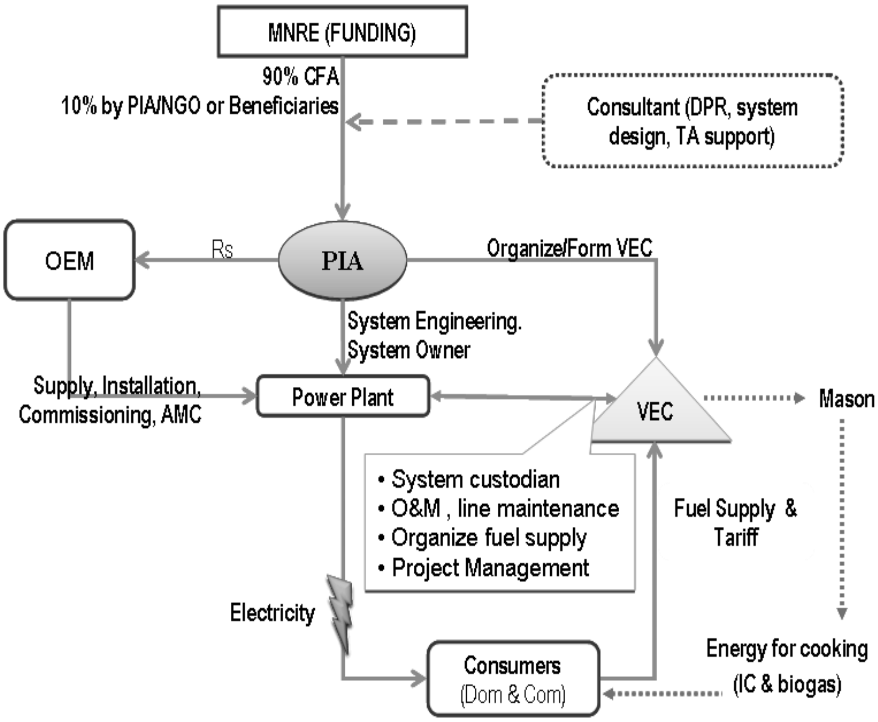
10. The VEC is also responsible for arranging the biomass, either as a contribution from the project beneficiaries on a rotation basis or through the purchase of biomass from biomass collection agents, such as self-help groups. The committee also creates energy plantations in the village forest land or community land to ensure a sustainable supply of biomass. The committee collects user charges to meet the operational expenses of the project and manages all the accounts in relation to the project.

11. For sustained operation and management of the project, a village energy fund is created by the VEC under the provisions of the State Panchayati Raj Act, initially with beneficiary contributions. The monthly user charges from the energy users are deposited in this account. The committee manages the fund with its two nominated signatories — the Gram Panchayat member and the president

[6] Depending upon specific requirements and availability of resources, solar photovoltaic devices, such as solar lanterns or an appropriate battery backup arrangement or micro hydro systems, could also be considered.

or secretary of the committee. Thus, the committee plays the role of a stand-alone power producer, distributor and supplier of electricity, which manages revenue collection from electricity users and disputes resolution in case of a power supply disruption (Figure 2.1).

Figure 2.1 The Village Energy Committee Model



MNRE=Ministry of New and Renewable Energy; OEM=original equipment manufacturer; DPR=detailed project report; TA=technical assistance; PIA=project implementing agency; VEC=village energy committee; O&M=operation and maintenance; IC=improved cookstoves.

2.2 Pilot Phase – A Learning Opportunity

12. At the time of its initial design in 2005 the VESP was expected to cover nearly 20,000 villages that would remain off-grid even by 2012 and a further 200,000 "forest-fringe" villages that were also expected to remain beyond grid coverage. However, with the launch of the Rajiv Gandhi Grameen Vidyuthikaran Yojana under the Ministry of Power (MoP), the scope of the Programme was considerably pared down and the remotest and the most inaccessible villages were left under its purview.

13. At the time of Programme design, the country had limited experience in implementing a program that involved rural communities in such remote locations to generate and distribute power themselves. Undoubtedly, the Programme was ambitious and had set itself a challenging mandate.

14. Appropriately, for such a pioneering and unprecedented program, the first phase was rolled out as a pilot phase to test the concept and preparedness of the various institutions to deliver the Programme to remote and inaccessible communities. Therefore, the purpose of this phase was to learn lessons and improve the

Programme at both program and project levels before scaling it up. It is from this viewpoint that an analysis of the VESP's performance is presented in this report.

15. In the absence of any real field-level experience, many assumptions were made while designing the VESP, which were tested against the benchmark of grassroots practicality and feasibility. Similarly, solutions for many problems identified during the design process were also tested. The extent of learning needed at institutional levels to implement this grassroots level program was an unknown factor. It was not certain how a technology that had hitherto run satisfactorily in a handful of projects in more accessible villages and more advanced communities, would perform in the remotest corners of the country with the poor and socially backward communities left to manage them. This aspect should be kept in mind while reading the subsequent sections that deal with performance of the Programme at the project level.

2.3 Status of Test Projects

16. A total of 95 VESP projects spread across eight states, were submitted[7] to the MNRE for approval and sanction. The following table gives details of the sanctioned, commissioned and operational[8] projects.

Table 2.1: Status of the Village Energy Security Programme

State	**Total projects submitted**	**Total projects sanctioned by MNRE**	**Projects commissioned**	**Projects operational**	**% operational vs. commissioned**	**% operational vs. total operational**
Chhattisgarh	15	15	15	12	80	35
Orissa	12	12	9	9	100	26
Maharashtra	10	10	5	4	80	12
Madhya Pradesh	15	10	8	2	29	6
West Bengal	10	4	2	2	100	6
Gujarat	10	2	2	1	50	3
Assam	20	14	4	4	0	12
Andhra Pradesh	3	0	0	0	0	0
Total	95	67	45	34	76	100

17. Seventy-one percent (67 projects) of the 95 projects were sanctioned, of which 67 percent (45 projects) were already commissioned. Of the 45 commissioned projects, 34 (76 percent of commissioned projects and 51 percent of sanctioned projects) were operational. However, the situation varied across the nine states. As shown below (Figure 2.2), of the total projects sanctioned, Chhattisgarh had the highest percentage of projects sanctioned followed by Assam, Madhya Pradesh and Orissa.

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[7] As of June 30, 2009.

[8] Sanctioned (Detailed Project Reports approved by MNRE for implementation); Commissioned (Power generating equipment is deemed commissioned if it has been run for a period of 30 hours over a period of 3 days in a VESP project site); Operational (a VESP project is deemed operational if it is generating and supplying power to users).

18. Chhattisgarh had the highest number and percentage of commissioned projects; and Chhattisgarh, Orissa, Madhya Pradesh, Maharashtra and Assam, together accounted for 91 percent of all commissioned projects (Figure 2.3). It must be noted here that the number of commissioned projects would have been higher but for the delays that the projects in Assam faced on account of inter-departmental processes and hurdles. Nevertheless, towards the end of the technical assistance grant, four projects were commissioned in Assam and more were lined up for commissioning.

Figure 2.2: State-wise Sanctioned Village Energy Security Programme Projects

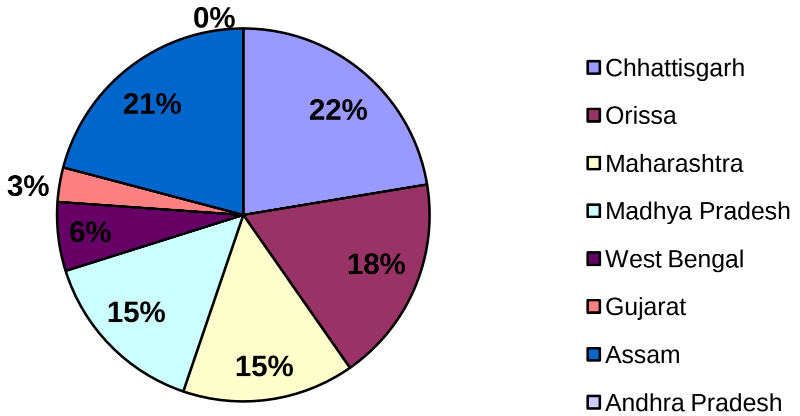
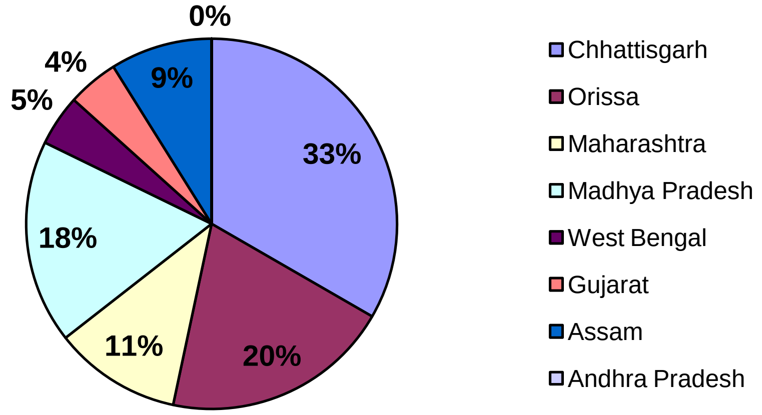
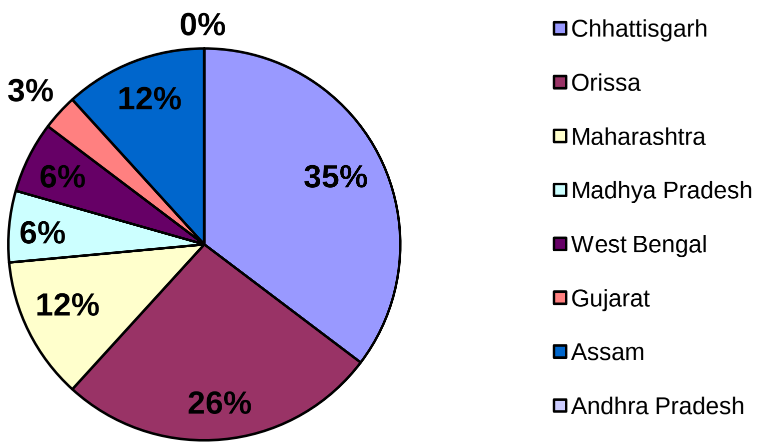


Figure 2.3: State-wise Commissioned Village Energy Security Programme Projects



19. In terms of operational projects, Chhattisgarh again accounted for the maximum (35%), followed by Orissa (26%), Maharashtra (12%) and Assam[9] (12%). Thus, these four states accounted for 85 percent of all operational projects (Figure 2.4).

Figure 2.4: State-wise Operational Village Energy Security Programme Projects



2.4. Delivery of Outputs in the Pilot Phase

20. As mentioned earlier, the VESP consisted of a package of three biomass-based technologies. Each village was to be electrified by either a diesel generating set run on straight vegetable oil[10] (non-edible oils such as pongamia or jatropha) or a biomass gasifier of 10–20 kW range powering a 100 percent producer gas engine. Improved cookstoves and biogas-based cooking solutions were also introduced to reduce indoor air pollution and provide a clean environment to women and children in the kitchen. More importantly, these devices were expected to reduce the use of fuelwood for cooking and the surplus was to be delivered to the biomass gasifier power plant.

21. In all, nearly 700 kW of electricity generation equipment were installed in this phase of the Programme, of which nearly 90 percent were biomass gasifier-based technology. In the performance analysis that follows, the high proportion of biomass gasifiers in the sample of projects is because of the relative preponderance of biomass gasifiers being chosen as the technology to generate electricity. About 4079 households were given improved cookstoves and 1330 m^3 of biogas capacity was created during the pilot phase of the Programme (see Table 2.2).

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[9] For purposes of further analysis projects from Assam are not being considered since most of them were commissioned towards the end of June, 2009 when the TA Grant had almost come to an end.
[10] Straight vegetable oil (SVO) is usually non-edible oil from plant sources that are used as a substitute for diesel as a fuel in diesel engines without any further chemical treatment such as transesterification. When SVO is transesterified then it is converted into biodiesel.

Table 2.2: Summary of State-wise Village Energy Security Programme—Pilot Phase

State	Electricity generation system in kW		Improved cook stoves (Numbers)	Biogas (m^3)
	SVO	Biomass gasifier		
Assam	0	50	1294	332
Andhra Pradesh	0	0	0	0
Chhattisgarh	13.5	195	716	340
Gujarat	0	40	162	40
Maharashtra	54	30	463	180
Madhya Pradesh	0	160	934	212
Orissa	0	120	215	102
West Bengal	0	40	295	124
Total	**67.5**	**635**	**4079**	**1330**

22. To put this achievement in perspective it may be useful to note that Biomass Energy for Rural India, a project being implemented by the Government of Karnataka with funding from the United Nations Development Program, has installed 1 MW of biomass gasifier based power plants in four years. The project is located 120 km north of Bangaluru and is easily accessible by road. The size of the smallest plant installed is 100 kW. In contrast, the VESP's project villages are located in hilly, forested areas that are remote and inaccessible and the size of a typical power plant n is 10 kW. In short, while the physical output could have been higher, it is not insignificant either. Further, considering the relative inexperience of the institutions implementing the VESP, and therefore, the learning lead-time involved, it is a satisfactory performance.

23. However, the outputs mentioned above provide a limited view of performance. How these technologies performed vis-à-vis the objectives of the Programme is more important. The measurement and assessment of outcomes at the project and program levels are presented and analysed in the following sections.

2.5 Framework for Assessing Performance

24. This section explains the framework that was adopted to assess the performance of the VESP projects at the grassroots level. As alluded to earlier, the Programme was conceived on the premise that biomass-based energy technologies are reliable and robust, that operations can be viable, and that communities (represented through the Panchayati Raj system) would be able to manage the entire energy package. Accordingly, the Programme performance was assessed on the following factors:

- Technological performance
- Financial performance
- Managerial performance
- Biomass plantation performance

25. Table 2.3 presents the key questions that were used to assess the performance with respect to the above-mentioned areas:

Table 2.3: Key Questions to Assess Performance of the Village Energy Security Programme

Area of performance	Key questions	Remarks
Technological	▪ Did the project meet the energy needs identified in the village energy plan? If yes,	Given the remote locations of most of the Programme projects, uptime is thus a

	to what extent (as measured by uptime)?	factor to measure reliability and regularity of service. Conventional factors used in measuring performance of power plants such as load, load factor and capacity utilization factors are also presented, and however, for reasons mentioned above, uptime is the key factor.
Financial	▪ What is the levelized unit cost of electricity (LUCE; taking into account subsidies available for the Programme) delivered to users in Programme projects? ▪ What is the amount of electricity being consumed by households/month? ▪ What is the cost of such service to households/month? ▪ What is their willingness to pay/month? ▪ What is the gap between LUCE and the willingness to pay/month? ▪ What is the cost of delivering the same service through extension of grid as is being done under the RGGVY?	▪ Assessing if there is a viability gap and if so to what extent is key factor being used to assess financial performance
Managerial	▪ Are local youth able to operate and maintain the power plant? ▪ How is the fuel supply managed? Is it organized? ▪ Does the village energy committee (VEC) meet regularly? Is it aware of its roles and responsibilities? ▪ Does the VEC feel accountable for providing power to the community? ▪ Are regular records of operations and financial transactions being kept? ▪ Is the operator's salary being paid regularly? ▪ Is there a system for collecting fees from electricity users? ▪ Is the VEC able to get the system repaired when it breaks down?	▪ The VEC is the owner and the manager of the power plant. Therefore, their performance as owner and managers is being assessed.
Biomass supply and plantations	▪ What is the status of the biomass plantation? ▪ What is the current status of fuel supply? Is it organized? Is it regular? Is it sufficient?	▪ Biomass has two aspects to it. One is the current supply system until the biomass plantations begin to yield. ▪ The other is biomass plantations and supply system once the plantations begin to yield.

2.5.1 Selection of sample test projects

26. Of the 34 projects that were reported as operational, 11 projects that had regular operations and a potential for improved performance were short-listed (Table 2.4). Based on the above mentioned framework, data on technical, financial and managerial performance for these projects were collected from various sources such as World Bank mission reports, monitoring and evaluation report of the

national consultant, reports generated by the regional consultants, among others (see Annexes3–6 for project-wise data).

27. The above projects covered the states of Chhattisgarh, Madhya Pradesh, Maharashtra and Orissa (which together accounted for nearly 80 percent of all operational projects). These projects also represented both sets of technologies employed in the Programme projects, namely biomass gasifier-based power plants and single vegetable oil based diesel power plants.

Table 2.4: Shortlisted Village Energy Security Programme Projects

Village	Location
Dicholi	GP-Dicholi, Block-Patan, District-Satara, State- Maharashtra
Bhalupani	GP-Dhalbani, Block-Joshipur,District-Mayurbhanj, State-Orissa
Rapta	GP-Nakia, Block and District-Korba, State-Chattisgarh
Mokhyachapada	GP-Kaulale, Jawahar Taluk,District-Thane, State-Maharashtra
Kanjala	Kanjala,Sahada,Nandurbar, Maharashtra
Mahisiakada	GP- Bandhamunda, Block-Ranpur, District-Khurda, State-Orissa
Mankidiatala	Block-Borigumma, District-Koraput, State-Orissa
Siunni	Block-Umerkote, District-Nabrangpur, State-Orissa
Kudrichigar	GP-Nakia, Block and District-Korba, State-Chhattisgarh
Jamunpani	GP-Jamunpani, Block and District-Burhanpur, State-Madhya Pradesh
Ranidehra	GP-Bairakh, Block-Bodla, District-Kabirdham, State-Chhattisgarh

2.5.2 Site characteristics of sample

28. Remoteness and inaccessibility are key site characteristics of a typical VESP project. Often, mo
th
e quality of their lives, if not, their economic status. The projects represented a wide range of terrain: from valleys (as in Rapta), to deep dense forests (as in Bhalupani), to an island (as in Dicholi) and to relatively more accessible hill tops (as in Mokhyachapada). Thus, these projects are fairly representative of what a typical VESP project is all about. A performance analysis of these projects would offer valuable lessons to both implementers of such projects as well as those that design such projects.

29. Dicholi is located in the backwaters of the Koyna dam. Ironically, while the dam produces electricity in thousands of mega watts, Dicholi does not receive any since it is an island and it is expensive to draw the grid across 10–15 km of water. Added to this, the village is situated on a hill, the way to which is through a dense forest and up a steep slope. Thus, the only way to reach the villages is by an hour-and-a-half motorboat ride followed by a steep climb of about 45–60 minutes. In Dicholi, when the gasifier engine arrived at Koyna town, the local community had to help the supplier to disassemble the engine and take it by boat to the boat jetty at Dicholi, from where each part was carried as a headload up

the hill or slung from bamboo poles and carried on the shoulders of teams of 10–20 persons.

30. Similarly, Bhalupani is located deep inside the dense Similipal Bioreserve, with mud tracks for roads. Rapta is deep inside a jungle that is connected only by a fair-weather road and is prone to attacks by Naxalites making it dangerous as well as difficult for outsiders (the project implementing agency or even the aftersales service person) to operate here freely. Of these four villages Mokhyachapada was the easiest to reach but still involves a difficult climb of about 2 km from the nearest road head.

31. All these villages become completely inaccessible during the monsoons when roads turn into slushy stretches and the only way to reach a village is on foot, that too when the weather permits. The degree of difficulty in installing, operating and servicing a biomass-based power plant in such locations can easily be understood. Therefore, it needs fierce commitment, great ingenuity and persistence to implement a VESP project.

2.5.3 Sample test projects: technology package, PIAs and status of working

32. "Biomass gasifier-based power plants" and "single vegetable oil based diesel generating sets" were the two main technologies deployed in the VESP to generate electricity with biomass gasifiers in nearly 90 percent of the projects. Non-governmental organizations (NGOs) and state departments (especially the forest department since many villages were located inside forests) were the PIAs contracted by the MNRE to implement the projects at the grassroots level. Table 2.5 presents project-wise details of implementing agencies, the technology used, status of installation and operation in the project villages.

33. In all locations, except Rapta and Mankidiatala, local NGOs with a long history of work in the area are the PIAs. "Sambandh" in Bhalupani was already implementing a livelihoods project in the same village. In Dicholi, the Founder Secretary of Shramjeevi Janta Sahayak Mandal, Mr. Balasaheb Kolekar, hails from the village and thus is very well acquainted with the problems of working in Dicholi.

34. In contrast in Rapta, the Chhattisgarh Renewable Development Agency (CREDA) is implementing the project. Earlier it was being implemented by the state's forest department, which managed to float tenders and procure biomass gasifier-based power plants from M/s Aruna Electrical Works based in Tamil Nadu. However, despite follow-up they could not get the systems installed by the vendor. In some cases, when the systems failed after installation, the vendor never repaired them despite repeated reminders. Thus, many projects just came to a halt and the equipment procured began gathering dust at various locations. At this stage, the Agency, which has a successful track record in using solar photovoltaic systems in electrifying and creating a service network to cover more than 800 villages stepped forward to implement and manage the Programme project. In Mankidiatala, the state forest department is the implementing agency.

Table 2.5: Technology Package, Project Implementing Agencies and Status of Working

Village	Implementing agency	Power generation technology and specs	Status of installation	Status of working
Dicholi	Shramjeevi Janta Sahayak Mandal	1x10 kW Ankur Gasifier	1x10 kW Gasifier is installed and commissioned.	Working, run by local youth.
Bhalupani	Sambandh	Biomass gasifier 1x10 kW	Installed and commissioned.	Working, run by local operator
Rapta	Earlier—State Forest Department; Now—Chhattisgarh Renewable Development Agency (CREDA)	2x10 kW Aruna Gasifier	1x10 kW installed	Working, run by local operator with support from CREDA supported mechanics and electricians
Mokhyachapada	Pragati Pratishthan	1x10 hP (7.5 kW) biofuel engine of Field Marshall make, 1000 rpm, alternator of Field Marshall make, 1500 rpm. One oil expeller with filter press, 50 kg/h, One shell decorticator and one baby boiler	Installed. Filter press and baby boiler is not being used	Working, run by local operator. Stopped at the time of visit due to non-technical reasons
Kanjala	BAIF	1x 7.5 kW FM Bio fuel Eng.	Implemented August 2008	Run by VEC President
Mahisiakada	READ Foundation	1x10 kW Ankur Gasifier 1x10 kW Biofuel Engine	1x10 kW gasifier is installed and commissioned. 1x10 kW biofuel engine is not commissioned.	Working.
Mankidiatala	State Forest Department	Biomass gasifier 2x10 kW	Installed and commissioned.	Working. Only 1x10 kW gasifier is in use, the other is on standby or under repairs
Siunni	Gramodaya	Biomass gasifier 2x10 kW	Installed and commissioned.	Working. Only 1x10 kW gasifier is in use, the other is on standby or under repairs
Kudrichigar	Earlier—Forest Department, Now CREDA	1x10 kW Aruna Gasifier	1x10 kW installed	Working, run by local operator
Jambupani	The Energy and Resources Institute (TERI)	2x10 kW TERI Gasifier	2x10kW Installed and commissioned. Only one is in use. Other one is kept as standby	Working, run by local operator
Ranidehra	Winrock India International	3*6 HP and 1*10 HP Biofuel Engine	Installed and commissioned	Working, run by local operator under the supervision of WII

35. Biomass gasifier-based power plants were installed in all locations except Ranidehra, Kanjala and Mokhyachapada, where single vegetable oil based diesel generating sets were installed. In most of the locations, M/s Ankur Scientific Technologies Ltd., Baroda, Gujarat was the supplier of biomass gasifiers-based power plants. In Rapta and Kudrichigar, the supplier was M/s Aruna Electrical Works, but the gasifier and the engine were overhauled and modified by CREDA with the help of M/s S.R. Biofuels, Raipur, before installation.

36. At all project locations trained local youth are operating the systems. The power generation technology was operational in all locations. In Mokhyachapada, the machine was in working condition but was not being run because users were not

willing to pay for the power consumed. Thus, the reason for the plant not being operational was non-technological.

2.5.4 Sample test projects: operating conditions

37. Load, load factor and capacity utilization factor are measures commonly used to describe the operating conditions of a power plant. Load is the summation of power rating (measured in terms of watts (W) or kilowatts (kW)) of all the equipments that are drawing power from a power plant and is expressed in terms of kW. Load factor is the load expressed as a percentage of the capacity of the power plant. The capacity utilization factor is expressed in percentage and is the number of units of power (kWh) actually generated by a power plant in a year compared to the number of units that can potentially be generated by the power plant in a year if it was running continuously.

38. Load factor has a significant impact on the performance of an engine, especially its specific fuel consumption, i.e. the quantity of fuel consumed / unit of power generated. In general, if an engine is loaded between 50 and 80 percent, its fuel consumption is lower, which translates into lower costs of operations. The capacity utilization factor also has a direct relation to the costs of operations. In general, a low capacity utilization factor means that the capital costs as well as the fixed operating costs are spread over fewer units of power produced, leading to a higher cost/unit of power produced.

39. Thus, these factors have a bearing on how the technology performs and a direct impact on the unit cost of power produced. Table 2.6 presents the operating conditions under which the technologies are working in VESP projects.

40. The connected load ranged from 3 kW in Ranidehra to 8 kW in Dicholi. This is at variance from the estimates made during the preparation of the village energy plan based on the Programme guidelines. As per the guidelines, each household is to be provided two light points of 11 W compact fluorescent lamps each and a power socket of 5 amperes. Thus, the total load/household was expected to be in the range of 30–40 W. For a 50-household village, the domestic load was expected to be in the range of 1.5–2.0 kW (30–40 W x 50 households). In addition, street lighting was expected to be around 1.5–2.0 kW. Thus, a typical VESP project village with 50 households was expected to have a lighting load of 3–4 kW.

41. During the pilot phase, however, almost all villages reported higher loads. This is because the respective village energy plans assumed that when a compact fluorescent lamp provided at the time of installation broke down another compact fluorescent lamp of similar capacity would replace it. However, in almost all places compact fluorescent lamps were replaced with 40–60 W incandescent lamps leading to the connected load increasing to nearly 80–120 W/household. Thus, overall, the connected load for a 50-household village increased to nearly 6–8 kW. Higher loads resulted in higher load factors ranging from 53 percent in Mokhyachapada to 80 percent in several other areas. As mentioned earlier this had a salutary effect on the operating conditions for engines which perform better when they are loaded in the range of 50 percent to 80 percent.

Table 2.6: Load, Load Factor, Capacity Utilization Factor

Village	Estimated connected load kW	Load factor in %	Capacity utilization factor in %
Dicholi	8	78	10
Bhalupani	2 kW domestic + 4 kW commercial	60	14
Rapta	7	70	12
Mokhyachapada	4	53	9
Kanjala	6	80	13
Mahisiakada	6	60	10
Mankidiatala	7	70	12
[illegible]	8	80	13
Kudrichigar	5	54	9
Jambupani	7	72	12
Ranidehra	3	54	7

42. Noting the low load factors based on the initial loads projected in the village energy plans, the P

along with charging the battery bank and thus increase the load factor leading to better operating conditions for the engine. In addition, it would not be necessary to operate the power plant during the night since domestic lighting was to be powered by the battery bank. Now, with the actual increased domestic loads, the battery bank is likely to be inadequate, while the load factor on the engine is adequate even if only the domestic load is met.

43. However, higher loads have also meant that each household is consuming more units of power/month. With the fixed tariff based on a flat rate of Rs 30–60/month/household, higher consumption/household means for the same tariff collected realization/unit supplied will be lower. More importantly, when the plant is already optimally loaded with just domestic loads, more loads, even if they are financially attractive (such as flour milling, irrigation) cannot be accommodated during the same period of operation because domestic loads cannot be rescheduled in terms of timing. Thus, the only option is to schedule the new loads if they are technically feasible and financially attractive and the plant is run exclusively for it.

44. The capacity utilization factor was very low and ranged from 7 percent to 14 percent. In contrast, commercial grid-connected biomass based power plants operated in excess of 80 percent capacity utilization factor. As explained earlier, a low capacity utilization factor has implications for the cost of power generated. The low capacity utilization factor is mainly due to the very short duration for which the plant is operated every day, usually 3–6 hours/day during 6–10 pm. The usual reason stated was that there was no demand for power during the rest of the time from households. However, in many villages other loads existed, such as flour milling in Dicholi and Rapta and oil expelling in Mokhyachapada. But due to the irregular nature of power supply from the biomass power plant, none of these commercial loads sought a connection.

2.6 Performance of Projects — Findings

2.6.1 Technological performance

45. Uptime is the key factor when measuring technological performance in the Programme projects (Box 2.2). As discussed earlier, load and load factors were not the problem in the Programme projects. The issue could be related to whether the plants operate reliably and the period for which demand for power services were estimated at the time of preparing the village energy plan with the community. Table 2.7 presents project-wise uptime data[11].

Box 2.2: What is Uptime?

Uptime for the electricity generating system: This is the number of units of power actually supplied during a period of operation compared to the number of units estimated to be supplied in the village energy plan. This ratio is expressed as a percentage and is called 'uptime.

$$\text{Uptime} = \frac{\text{No. of units of power actually supplied in a month}}{\text{No. of units of power that was supplied as per the VEP during that period}} \times 100$$

Thus, as per the village energy plan for a project village, if 50 kWh (units of electricity) was to be supplied per day to the community, then the number of units of power to be supplied in 100 days would be 5000 kWh. The energy meter reading at the end of 100 days of operations showed 2500 kWh as having been supplied. Therefore, the uptime for this case works out to 50%, which means that the power was supplied once in 2 days or for just 15 days out of 30.

46. All power plants, except those at Rapta and Kudrichigar, had been in operation for over a year at the time of collecting the above-mentioned data. Thus, the data presented here represents an uptime that has been averaged over a period of 12 months at least. Uptimes ranged from 80 percent for Mokhyachapda to just 22 percent for Siunni. This means that in Mokhaychapda, power is supplied to the households for about 24 days in a month, while in Siunni it is supplied just for 6–7 days in a month. This is a clear reflection of the degree of regularity and reliability of the power supplied.

47. The higher uptimes of Dicholi (49.58%), Rapta (36.61%) and Ranidehra (39.68%) are interesting for analysis. In Ranidehra the higher uptime was because they had three generator sets each of ~5 kW each, while the load was

Table 2.7: Uptime

[11] Uptime is calculated as: Columns C/(B-A in days) x D) x 100.

Village	Date of visit for collecting this data(A)	Power plant running since (B)	Energy meter reading (C)	Estimated power demand/day in kWh(D)	Uptime (E)
Dicholi	16-Apr-09	May-08	4235	23.4	**49.58%**
Bhalupani	20-Jun-09	14-Nov-07	4437	34	**24.17%**
Rapta	13-Apr-09	Dec-08	615	28	**36.61%**
Mokhyachapada	19-Mar-09	Mar-08	No energy meter installed	~4.0kW @ 80w/household for 50 households	**80% during the period Apr2008-Nov 2008**
Kanjala	15-Apr-09	Aug-08	No energy meter installed	24	**23.00%**
Mahisiakada	09-Apr-09	Apr-07	Meter reading not reported	24	**28.00%**
Mankidiatala	20-Jun-09	14-Nov-07	3801	28	**28.28%**
Siunni	09-Apr-09	14-Nov-07	3400	32	**22.14%**
Kudrichigar	14-Apr-09	Jan-09	552	21.6	**28.40%**
Jambupani	04-Apr-09	Oct-07	3959	28.8	**26.95%**
Ranidehra	31-Mar-09	Jul-07	2552	10.72	**39.68%**

just 2.68 kW. Thus, Ranidehra had two engines on standby in the event of an engine failure. Thus, the load was being catered to with higher reliability because of the sheer extent of redundancy built into the project. Dicholi, on the other hand, had no other alternative than having a higher uptime. Even the choice of using kerosene is expensive since it has be ferried across the backwaters from Koyna town and then hauled up the hill. Persistent efforts are being made to keep the plant up and running, despite the battery for starting the engine getting frequently discharged. When this occurs, the villagers tirelessly go to Koyna town, get the battery recharged and get the plant up and running again. However, in Rapta and Kudrichigar higher uptimes were due to the on-the-job training support as well as round-the-clock and on-the-spot repair and maintenance service being provided by a dedicated diesel mechanic and electrician posted to these villages by CREDA for three months after installation.

48. Needless to say, even these higher uptimes are not satisfactory in terms of service to the electricity consumers in these villages. Even in Dicholi, the uptime translates into supply of electricity only 50 percent of the time. The reasons for low uptimes generally get attributed to branding the gasification-based power generation technology as unreliable and not robust enough to run in such remote rural locations. Yet, others have quoted examples of Odunthurai[12] in Tamil Nadu and Gosaba[13] in West Bengal where the very same biomass gasifier-based power plants have been successfully generating and supplying electricity for local use. Many others have averred that the technology is too complicated for simple rural

[12] Odunthurai is a Gram Panchayath near Mettupalayam in Tamil Nadu. A 10 kW biomass gasifier-based power plant has been in use since January 2004 to pump drinking water over a 12 km pipeline network reaching out to more than 400 households. The gasifier based power plant is operated by local youth and runs for about 12–16 hours every day.

[13] Gosaba is an island in the Sunder Bans in West Bengal, where WBREDA has been running a gasifier based power plant since 1997 providing power to more than 1100 households.

people to run it. But as has been shown in the above-mentioned examples, it is the simple rural people who are actually running it and that too successfully. Analysis indicates the following reasons for low uptimes in the VESP projects:

- Faulty "direct current (DC)" motor of the cooling water pump.
- Battery discharging too soon or not getting charged adequately.
- Lack of dry biomass especially during the monsoons. The dryer provided with the power plant is too small to dry all the wood that is needed for regular operations.
- Poor or delayed response from the supplier to service requests from users.
- Lack of simple spares, such as filter cloth, at the site. Sourcing them from the manufacturer is time consuming and leads to reducing uptime performance.
- Overloading because of replacement of compact fluorescent lamps with incandescent lamps leads to burning out of the electrical systems.

49. None of the reasons cited for poor uptime are major technological problems as none are related to the core gasification or engine technology, but are instead accessory-related. Key non-technological reasons that emerge for the low uptimes mainly stem from two causes: (1) poor training to local operators, and (2) very poor and delayed aftersales service response. In a typical Village Energy Security Programme project in a remote location the usual chain of events that result in low uptimes include the following:

- Soon after the gasifier-based power plant has been installed and commissioned by the technician of the supplier, two or more local youth are provided a couple of days training on how to start and shut the gasifier power plant. The operators may also be sent to the factory of the supplier for a training program lasting 5–7 days, where all parts of a gasifier and engine are explained, including its operation and maintenance.
- Armed with this training, the local operators return to the village and start running the system. If the power plant breaks down, often for a simple reason like a battery discharge, the operators would be unable to start the engine. This is because the battery discharge occurred due to frequent and repeated cranking of the engine even before the gasifier started producing gas of the requisite quality. Thus, the training imparted was inadequate and the operators instead start learning by trial-and-error method to spot when it is ready for the gas to be fed into the engine.

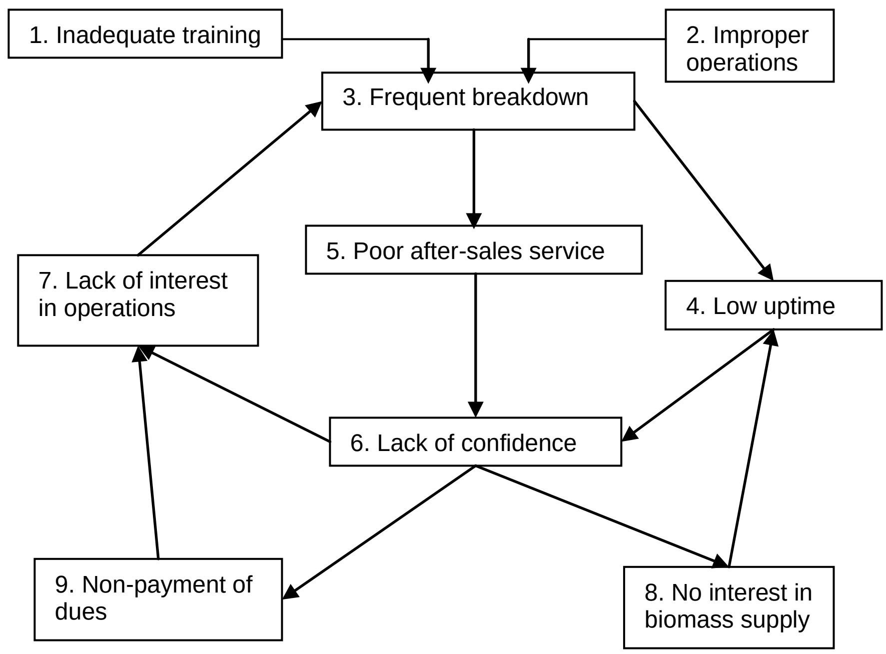
50. In a remote and inaccessible village with no other source of electricity, even a simple task, such as getting the battery charged, assumes a daunting proposition. In a place like Rapta it entails a journey of about 3–4 hours to the nearest charging point leaving the battery there overnight and returning with it the following evening. By then, the plant has not been operational for at least 36 hours, assuming that the battery was sent for recharging immediately after it broke down.

51. Thus, poor and inadequate training leads to poor operations that cause frequent breakdowns and low uptimes. Frequent breakdowns are further compounded by poor and delayed aftersales service responses from the supplier, often because of the cost and time associated with reaching remote locations. As a result, uptimes

plummet and villagers lose confidence in the operator and the system. The operator too loses interest in running the system leading to even lower uptimes. Once, the villagers find out that the plant is not being operated regularly; they lose interest in supplying biomass, and the commitment to pay the dues also decreases. With no biomass supply and no revenues to pay the salaries of the operators, the operation of the power plant is stopped. The following schematic diagram (Figure 2.5) depicts the typical cycle that leads to poor uptimes in a Village Energy Security Programme project.

52. Usually, this scenario plays out 3–6 months after installation. Villages that persisted managed to learn to operate the power plant successfully. For example, in Bhalupani, after repeated breakdowns and with poor or no response from the supplier, the VEC and the community decided to return the plant to the MNRE. However, Sambandh, the PIA, assured the community that they would support them in operating the plant and persuaded them against taking such a hasty decision. However, many villages have not been able to muster the effort, persistence, time and money to overcome the initial hiccups that ultimately resulted in a failed project.

Figure 2.5: The Poor Uptimes Cycle



53. The Orissa Renewable Development Agency (OREDA) and CREDA are two organizations that have successfully negotiated the initial learning period which show the way forward. Orissa has a large number and proportion of operational projects vis-à-vis commissioned ones. The OREDA played a pro-active role in tackling the problems of poor training and lack of aftersales service responses from the original equipment manufacturer and has contributed significantly to the learning of this initiative.

54. When reports of frequent breakdowns and complaints of poor aftersales service responses of the original equipment manufacturer started pouring in, OREDA

took charge of the situation and called upon the manufacturer to depute a person to Orissa exclusively for covering project installations. The organization even provided office space to the representative in its own premises. Initially, the manufacturer was unwilling, but succumbed to the relentless pressure by the OREDA. Simultaneously, OREDA also deputed its own staff to the original equipment manufacturers factory for training in operation and maintenance of the equipment. The idea was to have enough capacity within OREDA to tackle technology related issues so that the implementing agency and committees develop confidence in the equipment and the support system. Finally, the efforts paid off and performance improved. In Mankidiatala, the Secretary of the VEC, who was also the operator, gained so much proficiency in operating and maintaining the system that the manufacturer began to send the person to train and guide operators in other villages.

55. The CREDA followed a different approach for tackling the issues of poor training and poor aftersales service. The Agency has knowledge of the importance of organizing an aftersales service network with local vendors and experience in implementing SPV-based village lighting in more than 800 villages, including the poor response of a gasifier power plant supplier in providing training, service support and supply of spares. The Agency, however, decided to find and organize local technical support and rightly realized the importance of keeping the system operational during the initial months after installation and commissioning to bolster the confidence of the operators, the VEC and the community. The CREDA noticed that the gasifier engines were actually modified diesel engines and felt that local diesel and tractor engine mechanics should be equipped to provide technical support service. It also observed that the support of an electrician is required during the initial period. Thus, soon after installation, a diesel mechanic and an electrician were placed in the village to provide constant training and support to the local youth. In the second month, the Agency technicians were made available to the operators every alternate day or week. In the third month, the technicians were made available only for seven days. During this period, the local youth not only learnt how to operate and maintain the plant, but also to attend to repairs. If the operators were unable to set right any problems encountered after the first three months, then the technicians could be called up for support. They are often only a few villages away as opposed to the supplier’s serviceman who may be thousands of kilometers away.

56. Thus, CREDA not only found a way to break the vicious cycle of poor training and poor aftersales service that led to poor uptimes but also replaced it with a virtuous cycle of on-the-job and on-the-spot intensive training and technical support during the learning period leading to lesser breakdowns and consequently higher uptimes. Incidentally, CREDA did not seek extra funds to provide this support; and instead merely used the training funds for this purpose.

Summary of findings – Technological Performance

Technology

- Parts such as the cooling water pump, the battery, and the governing system were found to give trouble repeatedly. Their design needs to be reviewed and simplified / modified to make them trouble-free and more rugged.
- Capacity of the drier is not sufficient to dry wood during the monsoon season, when uptime dips sharply because of the wet wood.
- The electrical system needs more protection, especially for overload cutoff to prevent damage to the wiring and appliances.
- A 'spares' bank of parts that need frequent replacement should be maintained at site and should form a standard part of the equipment supply contract that is signed with the supplier.

Operations and maintenance

- Training provided by the supplier is not adequate and leads to improper handling of the power plant causing breakdowns and damage to the system.
- Close handholding (as opposed to mere training) as implemented by the CREDA during the first three months after commissioning is crucial to ensuring higher uptimes and continued operations.

Aftersales service

- As most of the producer gas engines are modified diesel engines, involving local mechanics (rather than waiting for the supplier, who is often far away) as CREDA has done for providing support and service is the way forward.

Overall

- Higher uptime (especially just after commissioning) leads to higher degree of confidence among the users and a higher degree of interest among the operators. This creates a virtuous cycle of higher uptime – higher confidence – higher interest to operate.

2.6.2 Financial performance

57. This section seeks to assess the financial performance of the VESP projects by trying to measure if the revenue[14](“willingness to pay” calculated as “levelized unit cost of electricity” or“LUCE”) is sufficient to cover the expenses of operations and maintenance. If it is not, an attempt has been made to quantify the extent of the gap and put it in perspective by comparing with viability gap funding support that other similar projects receive.

58. In almost all the Programme projects, the collection of electricity dues was very poor and inconsistent. This has largely been because of the stop-and-start nature of operations and low uptimes. Further, with the very poor record keeping with reference to operations, costs and revenues, very little information is available from the various Programme projects to carry out any meaningful analysis. Therefore, the analysis in this section is based on the estimates derived from the The Energy and Resources Institute report titled “Economic and Financial Analysis Report, April 2009”[15]. While preparing the report, the Institute carried

[14] Willingness to pay has been used as a proxy for revenue, while costs have been estimated based on TERI’s spreadsheet for calculating LUCE.

[15] Submitted to MNRE as a part of the National Contract for Economics & Financing, Monitoring & Evaluation Frameworks and Policy & Institutional Issues supported by the World Bank under its TA Grant to MNRE for VESP.

out a series of visits to various Programme project sites and collected information from various sources (operators, VEC members, project implementation agencies, regional consultants, state nodal agencies, among others) to arrive at estimates, such as LUCE and willingness to pay.

59. In addition, to compare the cost of serving such remote areas through extension of the grid (as is being done under RGGVY), the estimates of LUCE[16] derived for hilly terrains[17] were used. Electricity consumption has been estimated based on meter readings taken at the site for each of the projects. Where the meter was damaged or not installed (as in Mokhyachapada), electricity consumption was estimated based on the fuel consumption.

Levelized Unit Cost of Electricity for the projects

LUCE = [Levelized (O&M) + Levelized (capital)]/ Levelized (Electricity generation)

where, levelized (O&M) is the present value of annual maintenance costs (including interest payments, if applicable); levelized (Capital) is the present value of all capital expenditures; levelized (electricity generation) is the present value of electricity generation over the system's life time.

60. LUCE for various VESP projects was calculated using the spreadsheet developed by The Energy and Resources Institute as a part of its report to the MNRE under the technical assistance grant support of the World Bank for the Programme (see Annex 7for details of how TERI has calculated LUCE, and Annex 8for how it is sensitive to factors such as capacity utilization factor, load factor). Table 2.8 presents the LUCE by project[18].

61. As seen in Mokhyachapada, Kanjala and Ranidehra, power sourced from single vegetable oil-based generation was the costliest (also see Box 2.3). In contrast, LUCE for power from gasifier-based power generation ranged from Rs 6.49 to Rs 9.54. In general, LUCE varied inversely with the capacity utilization factor, e.g. capacity utilization factor in Dicholi was 10 percent compared to 14 percent in Bhalupani. Accordingly, the LUCE at Dicholi was higher at Rs 8.88 compared to Rs 6.49 in Bhalupani. However, despite similar loads and capacity utilization factors, the LUCE was different for Mankidiatala, Siunni and Rapta, with Rapta having the lowest LUCE. The reason for this was the lower salary paid to the operators in Rapta (Rs 2000/month) compared to Siunni and Mankidiatala (Rs 3000/month), which are more accessible and offer other employment opportunities as well for the local youth.

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[16] Nouni MR, et al. Providing electricity access to remote areas in India: An approach towards identifying potential areas for decentralized electricity supply. Renewable and Sustainable Energy Reviews (2008), doi:10.1016/j.rser.2007.01.008

[17] LUCE for hilly areas under 5 kW peak load, 80% load factor and 12 km of grid extension.

[18] LUCE for biomass gasifiers is calculated using TERI's spreadsheet for LUCE. For SVO systems, LUCE is taken from TERI's report titled "Economic & Financial Analysis Report", April 2009, Project No.2007BE07.

Table 2.8:Levelized Unit Cost of Electricity for the Projects

Village	No. of Households	Estimated connected load kW	Load factor in %	Capacity Utilization Factor in %	LUCE as per TERI report at existing operating conditions in Rs /kWh
Dicholi	85	7.8	78	10	**8.88**
Bhalupani	50	2 kW domestic + 4 kW commercial	60	14	**6.49**
Rapta	56	7	70	12	**7.59**
Mokhyachapada	52	4	53	9	**21.00**
Kanjala	90	6	80	13	**21.00**
Mahisiakada	85	6	60	10	**8.68**
Mankidiatala	84	7	70	12	**9.15**
Siunni	141	8	80	13	**8.13**
Kudrichigar	75	5.4	54	9	**9.54**
Jambupani	107	7.2	72	12	**7.40**
Ranidehra	128	2.68	54	7	**21.00**

Productive loads – A missed opportunity

62. A key contention that is made in most small-scale DDG projects, such as VESP, is that if the loads were increased the cost of service would come down. Based on loads projected in the village energy plans and also based on the World Bank mission's observations, LUCE for the four projects was also calculated if the extra loads also were catered to (Table 2.9).

63. The LUCE falls steeply if the capacity utilization factor is increased by catering to other potential loads that exist as indicated in the table above in all the locations. For example, in Dicholi the 3.75 kWcapacity flourmill that worked for 50–60 hours every month currently runs on diesel. If this mill were to run on the electricity produced from the gasifier power plant, the LUCE would decrease to just Rs 7.56. However, since the power plant is already fully loaded because of the use of incandescent lamps, the load from the flourmill would have to be scheduled separately. The LUCE calculated above is based on the power plant being run separately for domestic and commercial loads.

64. On the other hand, if all the households were to use compact fluorescent lamps, then the existing load would reduce to just 4.17 kW from the existing 7.8 kW. The total load would be 7.9 kW (4.17 kW for domestic + 3.75 kW for the flourmill) and the plant can safely cater to this entire load and thus, need not be operated separately for the two loads. The LUCE for this load factor and capacity utilization factor would be Rs 8.76, which is not different from the LUCE when only the domestic loads existed. However, as domestic consumers have a lower load, meaning that they are consuming less electricity, the total amount to be recovered from them would be based on the LUCE decreases.

Box 2.3: Why is Power from SVO Costlier than from Biomass Gasifiers?

The table below presents the share of various components that contribute to the levelized unit cost of electricity for biomass gasifiers and SVO based systems. The share of fuel cost as a proportion of total LUCE for SVO was very high (nearly 80%) compared to biomass gasifiers of 10 kWe capacity, which was just 48%. Further, the levelized fuel cost per unit generated was 3.5 times higher for SVO-based systems compared to biomass gasifiers.

Share of various parameters in LUCE	**Levelized Unit Cost of Electricity (Rs/kWh)**		
	Biomass gasifier		**SVO Engine**
	10kWe	20kWe	10kWe
Fuel	2.67	2.67	9.49
O&M	2.07	0.9	1.84
Capital (10% equity)	0.76	0.7	0.57
Total	5.5	4.27	11.9

Note: CUF taken at 33%

Source: TERI Report under TA Grant for VESP

The reason for the high fuel cost is the high cost of SVO compared to fuelwood that was used in biomass gasifiers. For example, the cost of oilseed assumed by TERI was Rs 6/kg. Thus, if the oil recovery rate is 25%, then every 4 kg of oilseed should yield 1 kg of oil. At a price of Rs 6/kg of oilseed, the cost of 4 kg of oilseed would be Rs 24, which would produce 1 liter of SVO. Therefore, the price of 1 liter of SVO would be Rs 24.

At optimal loads, the SFC for SVO was around 0.4 l/kWh. Thus, a liter of SVO would produce 2.5 units of power. At a cost of Rs 24/liter, the cost/unit of power works would be Rs 9.6. If the load were lower, the SFC would be higher as in Mokhyachapada where it was as high as 0.770 l/kWh. At this level, the fuel cost/kWh would be Rs 18.5.

Thus, the relatively higher cost of fuel and higher SFCs due to the low capacity utilization factors in SVO-based systems explain why the LUCE was consistently higher than for biomass gasifiers.

65. Thus, even connecting to existing productive loads could lead to better financial performance. Obviously, this has implications for the viability gap funding (i.e., subsidy needed to cover the gap between revenue and operating costs), which is explained in the following section.

Willingness to pay, amount to be charged and the viability gap

66. The recurring theme of discussions on the viability of a small-scale DDG project, such as VESP, is that communities in remote rural locations do not have the ability to pay, or the willingness, or both. The contention is that at best they can pay what they were hitherto spending on kerosene for lighting.

Table 2.9: Reducing Levelized Unit Cost of Electricity

Village	Dicholi	Bhalupani	Rapta	Mokhyachapada
Capacity utilization factor %	10	14	12	9
LUCE as per TERI report at existing operating conditions in Rs /kWh	8.38	6.40	7.52	21
LUCE as per TERI report if capacity utilization factor (CUF) is increased in Rs /kWh	4.94	4.29	4.26	15.6
CUF is increased %	19.5	23.3	29.17	13
Potential loads	**A flour mill of 3.75 kW working for about 50-60 hours per month**	**Existing loads are operated for longer durations**	**A flour mill of 3.75 kW working for about 70-80 hours per month**	**An oil expeller in the village is now running on diesel. If it is run on this system then the CUFwould increase**

67. A survey carried out by the national consultant,TERI, showed that the willingness to pay (Rs/month/household) for electricity consumed ranged from Rs 30 to Rs 133 (average of Rs 82). However, the actual tariff set and agreed upon usually ranged from Rs 30 to Rs 50, which is equivalent to kerosene replacement. The amount needed to recover the cost of supply is calculated according to the following formula: units consumed/household/month times the cost/unit of power as measured by LUCE. Given that loads were almost entirely domestic in most projects and the duration of supply of power was fixed (usually 3–6 hours/day) the amount to be charged/household/month would depend entirely on the load. If using compact fluorescence lamps lowered the load, then the amount to be charged per household would also decrease. Table 2.10 shows the willingness to pay and the viability gap for VESP projects.

68. The willingness to pay, as explained earlier, is based on the cost avoided by using kerosene and ranged from a low of Rs 25 in Mankidiatala to as high as Rs 60/household/month in Rapta and Kudrichigar. The CREDA secured a payment of Rs 25/household/month from the Government of Chhattisgarh for every connection provided through renewable energy, SPV or biomass power. The argument is that the state government heavily subsidizes the power to rural homes when supplied through the conventional grid; therefore it should also support plans like the VESP. A further amount of Rs 35 collected from the households represents the avoided cost of kerosene. Thus, the willingness to pay was higher in Chhattisgarh.

Table 2.10: Willingness to Pay and Viability Gap

Village	No. of House-holds	Units /month/ house-holds	LUCE Rs / kWh	Amount to be charged as perLUCE/ month/ household (a)	Willingness to pay Rs /month/ household (b)	Viability gap Rs / household /month (b-a)	Amount needed/year to bridge the viability gap for the project Rs

Dicholi	85	8.26	8.88	73.33	50.00	-23.33	**-23801**
Bhalupani	50	6.00	6.49	38.93	45.00	6.07	**3643**
Rapta	56	12.00	7.59	91.02	60.00	-31.02	**-20848**
Mokhyachapada	52	4.62	21.00	96.92	30.00	-66.92	**-41760**
Kanjala	90	8.00	21.00	168.00	50.00	-118.00	**-127440**
Mahisiakada	85	8.47	8.68	73.55	35.00	-38.55	**-39318**
Mankidiatala	84	10.00	9.15	91.54	25.00	-66.54	**-67072**
Siunni	141	6.81	8.13	55.39	50.00	-5.39	**-9115**
Kudrichigar	75	8.64	9.54	82.39	60.00	-22.39	**-20152**
Jambupani	107	8.07	7.40	59.77	50.00	-9.77	**-12549**
Ranidehra	128	2.51	21.00	52.76	60.00	7.24	**11117**

69. The units/household/month ranged from a low of just 2.51 units in Ranidehra to a high of 12 in Rapta. As explained earlier this is the direct result of the use of incandescent lamps in Rapta compared to the compact fluorescent lamps being used in Ranidehra. However, about 8 units/household/month are consumed in most of the villages. Therefore, the amount to be charged/household/month would be a product of the units consumed/month/household and the LUCE estimated for that village and ranged from Rs 40 to Rs 100.The willingness to pay ranged from Rs 30–60 leaving a viability gap in most of the projects that ranged from a mere Rs 6 to Rs 70/household/month. This translates to a viability gap of about Rs 9000/project/year to about Rs 50,000/project/year. For the entire lifetime of the power plant (10 years) the viability gap was just Rs 100,000 to Rs 500,000. The MNRE in its revised guidelines for VESP (2008) allocated an operation and maintenance expense of nearly 10 percent of the project cost for each of the first two years. This is in line with the above-mentioned sum needed to meet the viability gap over the entire lifetime of the project, even at current levels of capacity utilization factor.

70. If domestic users shift to compact fluorescent lamps, their connected load and units/consumed/month would decrease. As a consequence, the total amount to be charged would also decrease. For example, in Dicholi the domestic load could be brought down to just 4.17 kW from 7.8 kW by replacing all domestic lights with compact fluorescent lamps. This meant that the amount to be charged/month/household would also reduce to just Rs 39 from the existing Rs 73/month/household. Given the current willingness to pay of Rs 45, the project does not have a viability gap.

71. Further, if the capacity released as a result of reducing the domestic load is used to cater to the flourmill load, then the revenue from the operations would increase for the same quantum of power generated and supplied, thereby further increasing viability. A word of caution is that these projections are based on two assumptions: (1) that the power plant runs reliably and enthuses the commercial loads to seek connections, and (2) dues from users are collected with 100 percent efficiency.

VESP vs. RGGVY for electrifying rural areas

72. The Rajiv Gandhi Grameen Vidyuthikaran Yojana (RGGVY) is a scheme being implemented by the Ministry of Power, to extend the grid to hitherto unelectrified villages. Often, the RGGVY and VESP have been perceived to be competing to provide services to similar sets of consumers. The key question to be asked is how do the costs of delivering electricity to remote rural consumers compare? Table 2.11 provides a comparison.

Table 2.11: Village Energy Security Programme vs. Rajiv Gandhi Grameen Vidyuthikaran Yojana: Levelized Unit Cost of Electricity and the Viability Gap

Scheme	LUCE Rs/kWh	Operating conditions	Tariff Rs/kWh	Remarks
VESP (Based on TERI estimates)	14.91 (unsubsi-dized)	80% load factor, 10 hours of operation, SFC of 1.5kgkWh.	Rs6.25	Based on a willingness to pay of Rs 50/household/month for consuming about 90–100 W for 3 hours/day
RGGVY (Based on estimate made by Nouni et al)	16.8 (unsubsi-dized)	80% load factor, peak load of 5 kW, 12 km of grid extension	Rs 1–2	Local energy service company sets the tariff and collection efficiency is very low. Besides, the cost of collecting small sums from such remote locations is high.

73. On an unsubsidized basis, LUCE in both programs was comparable. However, in VESP the cos with increasing hours of operations at similar load factors, the LUCE decreased further, while in for RGGVY the LUCE increased with increase in distance from the grid as well as decrease in load factor.

74. However, in terms of the viability gap the comparison was more interesting. A typical VESP household connects a load of about 90–100 W and uses it for three hours every day (i.e. about 8 units/household/month), for which it pays Rs 50 per month. Thus, the tariff being charged to the household/unit consumed is Rs 6.25 (Rs 50 per 8 units). Further, if households use compact fluorescent lamps, then the connected load would reduce from 90 W to just about 40 W per household. At this level, for the same willingness to pay of Rs 50/household/month, the tariff would be Rs 14 per unit, which is almost equal to the LUCE of Rs 14.91. Thus, the subsidy for the VESP ranges from Rs 1 to Rs 8.66 per unit (Rs 14.91–6.25) depending on the units consumed/household/month.

75. Compared to this, the tariff being charged from RGGVY customers is usually just Rs 1–2 per unit of power consumed. Thus, the subsidy to just cover the LUCE for RGGVY ranges from Rs 14.8 to 15.8 per unit supplied, not taking the cost of collecting the Rs 1–2/unit into account.

76. Overall, an analysis of the financial data indicates that there is potential for improving Programme performance by adding already existing productive loads. Further, the viability gap funding required even at current levels of operations was not very large. Indeed, compared to subsidies provided under other programs serving communities in similar situations, these were far lower.

Summary of findings — Financial Performance

Loads, Loads factor and LUCE

- Load factor and hours of operations (together they determine the CUF) are key factors that influence the LUCE.
- For the same CUF, higher loads and shorter durations of operations lead to lower LUCE.
- Therefore, it is more economical to schedule loads so that the plant is loaded to capacity (80%).
- Further, the load is determined by the rating of the equipment being used. Because the load in VESP villages is largely domestic lighting, using CFLs would reduce the load considerably compared to using incandescent lamps.
- If the capacity available due to reduced domestic load is used to cater to other commercial loads, the total cost of electricity generated would remain the same, but the dues would be recovered over a larger number of users, thereby reducing the amount to be charged to domestic users
- Therefore, development of commercial loads and its scheduling is very crucial to ensuring the economical viability of VESP projects.

Willingness to pay and LUCE

- The willingness to pay averages around Rs82/household/month, but the tariff is at Rs 30–50/household/month based on the avoided cost of kerosene. This indicates that there is scope for increasing the tariff if reliability of service is ensured.
- Although LUCE is a very good indicator of how much to charge customers, rural users are more concerned about total monthly outgo rather than the tariff/kWh. For example, even at Rs 50/households/month, the tariff/kWh works out to nearly Rs 6.
- If the connected load of domestic users is reduced by ensuring the use of CFLs, then even the current tariff of Rs 50/households/month should be sufficient to cover costs, provided the released capacity is used up by other (commercial) users.

Viability gap and subsidy

- The viability gap at current levels of operations is Rs 10,000–Rs 50,000/annum/project, which is just 1% of the total project cost, and over the life of the equipment would be just 10% of the project cost.

VESP and RGGVY economics

- The LUCE under VESP and RGGVY compares well when measured without taking into account subsidies being provided to the two programs.
- For similar LUCEs, the subsidy demand on account of the viability gap under VESP is far lower than under RGGVY because of the higher tariff recovery of nearly Rs 6/kWh (under current load conditions) compared to the usual Rs 0.4/kWh to Rs 1.0/kWh charged to below poverty line customers by energy service company.

Overall

- VESP can be economically viable if the plants are loaded optimally, domestic loads are kept under check by ensuring use of CFLs and commercial loads are encouraged.
- Scope to increase tariff to domestic customers exists.
- Operation and maintenance support provided to Programme projects under the new guidelines help bridge the viability gap.

2.6.3 Managerial performance

Ownership and community participation

77. In general, the projects were characterized by a high degree of community participation during planning, installation and commissioning phases. For example, in Dicholi, but for the commitment shown by the villagers, the equipment consisting of heavy components, such as the engines and gasifiers, could not have been transported to the site. Similarly, in Naringipadar, in Koraput district of Orissa, the villagers carried the engine and other components as head loads across a stream and up a steep hill for 5 km.

78. However, a similar sense of participation was lacking in operating the system and serving the community by delivering power and collecting revenue. In Mokhyachapada, for example, the evident enthusiasm in the community for the project did not translate into any significant collection of revenue. Similarly, in Jamaganda, in Orissa only after much struggle could the PIA get the power plant to operate. Despite introducing a system for each household to enter into a MoU with the VEC for power supply and a commitment to pay for the same, the results were not very encouraging. The reasons for poor involvement of both the community and the VEC in owning and managing the power plant were:

- The long gap between planning (preparation of the village energy plans) and actual commissioning of the plant, which led to disillusionment in the community in general, but also among the opinion leaders in the village.
- Extended time taken from submitting the detailed project reports (DPRs) to the commissioning of a VESP project in Orissa (see Table 2.12).

79. The two main reasons for the lack of confidence and interest among the VEC members in managing the plant at the operator and community level were the frequent breakdowns of the plant, especially immediately after commissioning, and the long time taken for repairs due to poor supplier response. In Bhalupani, for example, the committee would have requested the OREDA to take the power plant back if it had not been for the persistent efforts of the Sambandh. A lack of technical knowledge for operating the system coupled with poor training inputs from the supplier meant that the committee and the community felt that it was too difficult for them to operate and manage. One of the reasons for the high number of operational projects in Orissa and Chattisgarh is the emphasis laid by the respective state nodal agencies (OREDA and CREDA) on training and ensuring quick and prompt aftersales services.

80. Following a spate of complaints about poor supplier response, the OREDA ensured that the supplier posted a trained technician in Orissa to address calls for assistance in a rapid manner. This move soon paid off when many of the projects started showing improved uptimes. In addition, adequate training and regular handholding meant that local youth felt confident to operate and maintain the system. In contrast, CREDA applied a different yet also successful strategy in hiring the services of local diesel mechanics and electricians to provide handholding support to local operators instead of relying on the supplier to respond to calls for assistance.

Table 2.12: Average Time to Commission Test Projects

Name of the project	Project implementing agency	District	DPR submitted date	Date of inauguration	Months from DPR to inauguration
Bhalupani	Sambandh	Mayurbanj	30-Mar-05	7-Nov-07	**32**
Mahisiakada	READ Foundation	Dhenkanal	23-Feb-05	25-July-07	**29**
Kandhal	OPMDC	Cuttack	26-Aug-06		**32**
Siuni	Gramodaya	Nabarangapur	19-Feb-05	14-Nov-07	**33**
Mankadiatala	DFO	Koraput	27-Jan-05	13-Nov-07	**34**
Champapadar	DFO	Koraput	27-Jan-05	13- Nov-07	**34**
Masipadar	DFO	Koraput	27-Jan-05	13-Nov-07	**34**
Lekidiguda	Arupa Mission Research Foundation	Koraput	3-Mar-06	11- Jan-08	**22**
Naringipadar	Arupa Mission Research Foundation	Koraput	3-Mar-06	24-April-08	**25**
Average time taken to commission a project from DPR submission date					**30.6**

81. In both cases, rapid problem solving ensured that the confidence of the operators as well as the community was restored leading to higher uptimes. The interest and commitment displayed by the project implementing agency was crucial to ensuring the interest and ownership of the project among the community. For example, projects implemented by non-governmental organizations usually stand apart from those implemented by state forest departments. In Mankidiatala in Orissa, the forest department had to hire a local non-governmental organization to address social issues and mobilize the community. Even in Chattisgarh, the services of SRCCL (regional consultant) were used to address social issues although CREDA was the implementing agency.

VEC – Leadership and team spirit

82. The VEC is the most important stakeholder in the institutional arrangement of the VESP. However, its role and performance was very weak and in most projects the committee did not display any leadership or team skills (Box 2.4). The VECs rarely realized their responsibility towards their community to provide electricity supply on a regular and reliable basis; and that they are the custodians, on behalf of the community, of the entire infrastructure created in their village under the VESP. The PIAs approach in building the VEC into a coherent team with good leadership skills was also unenthusiastic. Most of the PIAs were busy with getting the power plant up and running and interacting with the equipment supplier to provide training and aftersales service.

83. Team building requires frequent meetings, reiteration of roles, responsibilities and powers, and review of performance. However, most of the VECs met only once a month at the behest of the implementing agency. The community looked up to the implementing agency for help when power failure occurred rather than their own committee, which confirmed the marginal role that the committees were playing. Thus, even in places where the power plants were running, it may

take at least another 24 months before the implementing agency begins handing over the plant to the VEC, that too if it worked as a management team.

Box 2.4: Funds Flow and Empowering VECs – A missed opportunity

As described in the preceding chapter, capital subsidy in a VESP project was expected to flow through the VEC. However, in view of the inexperience and lack of capability of the VEC, it is currently routed through the SNA. It is the SNA that calls for tenders and pays the OEM on delivering as per contract. While this arrangement is convenient from the OEM point of view, it cuts off the VEC from decision making.

Instead, if the VEC is given the responsibility of verifying the work executed before authorizing the release of payment by the SNA, they would be more involved in the project implementation. Further, this would ensure that the OEM treats the VEC as his customer rather than the SNA.

Even, if the process of verification by the VEC is done as a matter of routine (the real verification is done by PIA and/or SNA) it results in empowerment of the VEC and helps enhance their stature and thereby, acceptance amongst the local community. This aspect of empowering communities has been implemented and found effective in other sectors such as community managed drinking water supply and rural sanitation.

This aspect of empowering and co-opting VECs in decision making has been overlooked by most PIAs in implementing the VESP.

Systems and procedures

84. Efficient systems and procedures are required for managing power plants need to be in place for a successful program. The projects lacked a good biomass supply mechanism and follow up by the VEC, leading to situations where fuel shortage caused the plants to shut down. The projects were found wanting in revenue collection mechanism and enforcement of payment. Despite a monitoring and evaluation system being developed by the national consultant (under the World Bank technical assistance grant), implementation was delayed. Even where it was implemented, a lack of literacy skills among the operators resulted in very poor recording of data. The key reasons for poor systems and procedures in the projects were:

- The attention and efforts of the implementation agency were focused entirely on installing and commissioning the power plant and not adequately on systems and procedures.
- The VEC members were not very clear about their role and quite often lacked leadership skills and the stature to ensure revenue collection from users.
- The project implementing agency did not paid attention to this aspect since the reporting requirement from MNRE did not specify issues, such as uptime and revenue collection.

Summary of findings – Managerial Performance

- Early success breeds confidence and fosters ownership. Therefore, it is important to ensure that the power plant operates well during the initial period.
- A key step to ensure this is to provide quick response to calls for assistance. The CREDA model of placing local diesel mechanics at the site for three months is promising.
- The approach and commitment of the PIA is crucial in ensuring that the community and the VEC are kept interested in the project despite the long time taken to commission the project and the frequent start-and-stop nature of power plant operations.
- Usually, NGOs that have been working with the community for sometime before the VESP project have been able to keep the community together and interested.
- State government departments as PIAs were less effective. There is a need to focus on building systems and procedures for running the plant and ensuring that they are adhered to.
- Record keeping is essential (especially in a pilot project to learn) for review of operations and decision-making by the VEC / PIA.
- The VECs' understanding of its roles and performance has been found wanting and needs urgent attention from PIAs.

Overall

- Community ownership and participation was weak in the VESP.
- The village energy committee needs more capacity building support from the project implementing agency to emerge as an institution to handle its responsibilities.
- The role of the project implementing agency and continued support to the village energy committee for at least two years after commissioning is essential to ensure that the project is on a sound footing.

2.6.4 Biomass plantations and supply

85. Biomass plantations and supply management were the two most neglected aspects of VESP project implementation. In most of the projects, biomass plantations were set up, but survival was very poor largely due to inappropriate time of planting, poor soils, species not being suited to local conditions, and most importantly, no after care. In many of the projects, while the power plant needed woody biomass, oilseed bearing plantations were raised, e.g. in Champapadar and Masipadar, nearly 10 percent to 30 percent of the area was planted with oilseed bearing trees. In many of the projects in Orissa, the low uptimes were largely due to a lack of organized supply of biomass.

86. The VESP guidelines state that every user family is expected to contribute a certain quantity of biomass regularly to operate the power plant until the biomass plantation set up under the project begins to yield enough biomass. However, with the supply of biomass being everybody's responsibility, it has ended up becoming nobody's responsibility. In the Siunni project in Nawarangapur district of Orissa, the operator, fed up with the poor response of the households in supplying biomass, offered to manage the supply of the biomass as well as operate the power plant if paid a salary of Rs 3000/month.

Summary of findings – Biomass Plantations and Supply
• Because most of the villages were located in the middle of forests, the biomass supply was taken for granted and the importance of securing a steady biomass supply to run the power plants was not realized in VESP projects. • The current supply of biomass is based on extraction from forests around the village, which is not likely to be sustainable during scale-up. • The current arrangement of every household supplying a certain quantity of biomass regularly was not successful. • It may be better to monetize the biomass supplied and thereby provide an incentive to those households that do supply biomass to the power plant

2.7 Village Energy Security Programme— Stakeholder Performance

87. This section presents the peformance of the various stakeholders of VESP and the key lessons to be learned from them. The schematic below (Figure 2.6) depicts the stakeholders and the roles expected of them. (VEC performance is not presented here as it was discussed in the preceding section.)

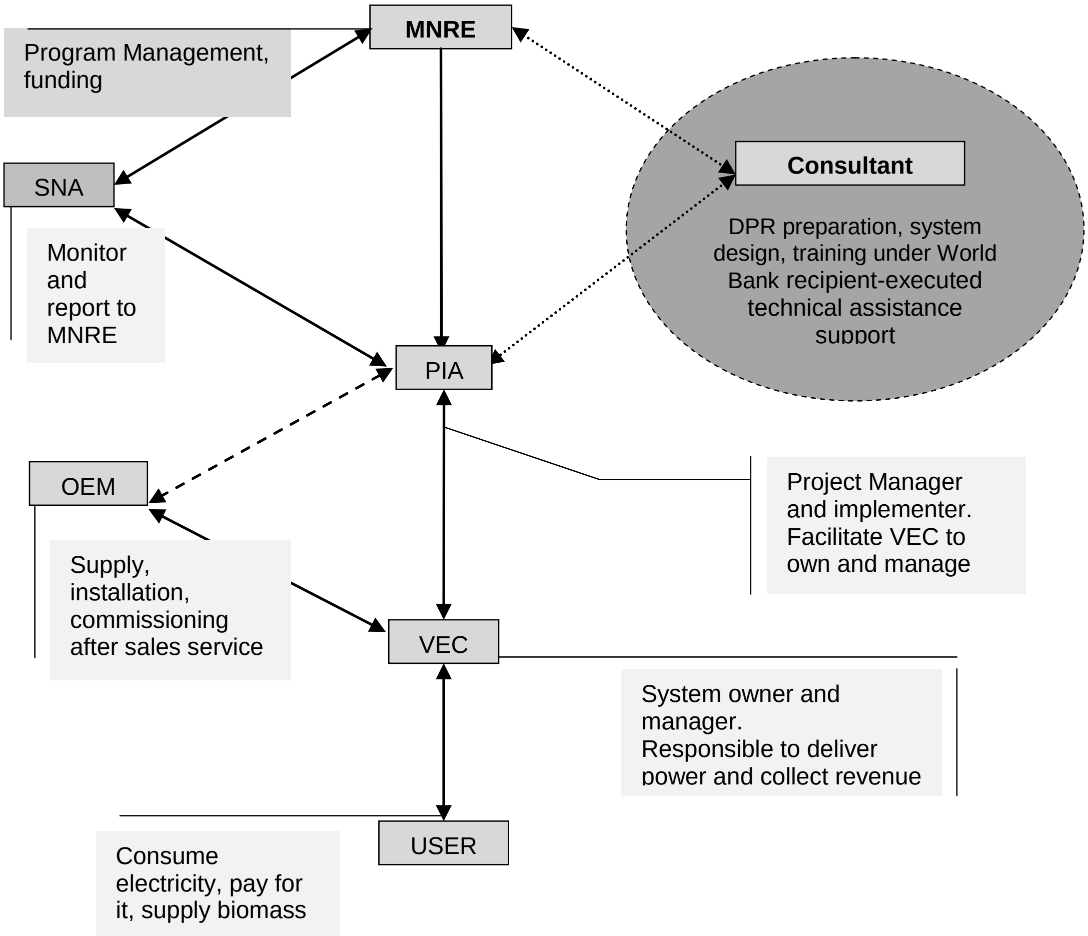
2.7.1 Project implementation agency

88. Despite the VESP being a community-driven project, it is the VEC that is de jure the project holder; while de facto it is the project implementing agency that acts as the project holder. The project implementing agency is responsible for most tasks, from identification of the project, formation of the VEC, preparation of the DPR, implementation of the project to helping the VEC manage the power plant. The PIA connects all other stakeholders to the project at the grassroots level. The key skills needed in a PIA for successfully executing a VESP project, is listed in the order of importance:

- Community mobilization skills
- Project management skills
- Technological skills
- Financial skills

89. Apart from these skills, dogged perseverance and commitment to the task at hand is essential. Finding an agency with such skills and commitment is very difficult. In general, NGOs have proved to be better than state departments (especially the forest departments) (Table 2.13). This is largely on account of the superior community mobilization skills of NGOs compared to state departments. Also, the NGOs are usually able to deploy dedicated manpower to the task, whereas for state department officials, it just another task to be completed.

Figure 2.6: Village Energy Security Programme: Stakeholder Roles



Note: MNRE = Ministry of New and Renewable Energy; OEM = Original Equipment Manufacturer; PIA = Project Implementing Agency; SNA = State Nodal Agencies VEC = Village Energy Committee

Table 2.13: Success Rates of Village Energy Security Programme Projects

State	Projects commissioned	Projects operational	% operational	Project implementation agency
Chhattisgarh	15	**12**	80	CREDA with support from SRCCL. Winrock, NGO was also a PIA
Orissa	9	**9**	100	NGOs and forest departments with NGOs
Maharashtra	5	**4**	80	NGOs
Madhya Pradesh	7	**2**	29	State forest department. In the only two projects that were operational, the PIA wasTERI an NGO
Total	36	**27**	75	

90. In Madhya Pradesh, of the seven projects commissioned, only two were operational. The state's forest department had implemented the non-operational projects. Similarly, in Chattisgarh, the projects were initially implemented by the

state's forest department and later abandoned after the technology supplier did not respond to calls for repair and maintenance. The projects were revived only after CREDA stepped in and used local diesel mechanics to repair the machines. However, even CREDA used the services of the SRCCL to carry out activities related to community mobilization and training.

91. In Orissa, where the state forest department acted as project implementing agency, it hired local NGOs to carry out the community mobilization tasks. However, in all project implementing agencies, there was a lack of sufficient technical skills that became the major reason for not succeeding in getting the power plant operational. However, over a period of time, most of the NGOs picked enough skills to manage this. Having a diesel mechanic on the PIA team is a big plus during installation, commissioning and operations of the power plant.

2.7.2 Original equipment manufacturer

92. This is the agency that supplies the power plant, installs and commissions it and is expected to provide training, aftersales service and honour the warranties and guarantees that come with the equipment. Thus, the performance of VESP, viz., generation of electricity and supply to the users is closely linked to the technology design, quality of the equipment, and the original equipment manufacturer's promptness and quality of response to problems encountered in the field during operations. Further, a trouble-free performance of the power plant is directly related to the quality of the training imparted to local operators for operation and maintenance. Also, logistical arrangements for repairs, service and spares support is crucial for a smooth operation of power plants in remote areas.

93. The common reasons cited for the start-and-stop nature of plant operations in the projects were:

- Recurring problems with certain components of the technology, such as battery and governor.
- Poor or no response from the manufacturer to requests for deputing repair personnel to the power plant.
- Long lead-time in despatching spares to the field.
- Inadequate operator training that led to improper handling of the equipment, which in turn caused breakdowns.

94. The manufacturer's faced the following problems:

- Having to deal with the villagers, especially in the early VESP projects that were implemented by state forest departments. The situation was better once NGOs were hired as PIAs.
- A lack of adequately trained and skilled manpower that could be deputed to various sites.
- The high cost of providing regular service to widely spread-out project sites.
- Having to deal with multiple agencies (such as VEC, PIA and SNA) to secure the release of payments due to them.

- Delayed payments on work already executed.

95. A matter for concern to the MNRE and those implementing the VESP during scale-up would be that only one original equipment manufacturer actively participated in supplying to biomass gasifier-based power plants.

2.7.3 State nodal agencies

96. State agencies are set up as nodal agencies to promote renewable energy at the state level. Their task is to monitor the progress of VESP, and help the PIA to float and finalize tenders. They are also the primary channel for funds to flow from MNRE to the PIA, VEC and the OEM. As the primary agency entrusted with the responsibility of monitoring the VESP project, very few of them, notably, CREDA (Chattisgarh) and OREDA (Orissa) actually deputed staff to the project site and gathered reports on the progress. Most other project relied on the information reported by the PIA or the regional consultant.

97. None of the SNAs monitored factors, such as uptime and revenue collection, on a regular basis. However, most of them played an active role in finalizing the tender documents, in selection of original equipment manufacturers and dealing with the manufacturer. The MEDA (Maharashtra), for example, advanced some funds to the PIA in Dicholi when the manufacturer sought additional sums to deliver the power plant. In Orissa, OREDA negotiated with the manufacturer and ensured that a trained and skilled person was made available exclusively for the VESP project in Orissa for attending to calls for repairs and training. Overall, SNAs played a good role in ensuring that administrative procedures were followed for the procurement of equipment. However, they were found wanting in terms of actually monitoring of the progress and performance of VESP projects. Given that many of the SNAs do not have adequate ground staff, it is a moot point if they can actually do any ground level monitoring, which is so vital for the Programme’s pilot phase.

2.7.4 Regional Consultant

98. These consultants were professional entities hired by the MNRE under the technical assistance grant support provided by the World Bank to the MNRE for the pilot phase of the VESP. These consultants were broadly responsible for:

- Identification of new projects
- Preparation of DPRs
- Helping the PIA float tenders and finalize suppliers
- Training to operators and VEC
- Help PIA prepare proper business plans for the VESP projects

99. Many regional consultants can be credited with the revival of many of the older projects that were lying neglected because of a lack of initiative or information on the part of the PIA and a lack of constructive support from the SNAs. The regional consultant also ensured commissioning of new projects in a vastly shorter time compared to the early VESP projects. In Chattisgarh, the regional consultant (SRCCL) along with CREDA (the SNA which is also the PIA) ensured that all the nine new projects sanctioned by the MNRE were commissioned in a record time of just 3-4 months. In Maharashtra, the regional

consultant (READ Foundation) coordinated between the PIA (Dicholi and Mokhyachapada), and the SNA and the OEM in ensuring that some additional funds were released to the OEM for power plant supply. In Orissa, the regional consultant (Winrock, along with their partners CEE) provided a series of trainings to the PIAs and the VECs apart from regular review of the projects. In Siunni and Mankidiatala the uptime improved from a mere 10–13 percent to nearly 30 percent. In a World Bank mission to Orissa in early 2008, Siunni was categorized as a project without much hope since the PIA had hardly any rapport with the community and the VEC was virtually non-existent.

100. Although, probably unintended, but regional consultants have ended up being held responsible for the progress and performance of VESP projects, even though the PIAs are directly in-charge and have all the authority and resources to act at the field level. Regional consultants were also the de facto source for monitoring information to MNRE and SNAs. Undoubtedly, the presence and support of regional consultants helped the MNRE receive better quality of DPRs;

- the PIAs in the preparation of DPRs, finalizing OEMs, training of VEC and operators; and
- the SNAs in monitoring the projects.

101. The regional consultants brought in skills that were lacking in some of the PIAs and thus complemented their strengths. For example, in Orissa, Winrock-CEE brought in professional training skills as well as technical skills and helped the forest department handle issues related to these areas. Similarly, in Maharashtra, the READ Foundation brought in process and technical skills in helping the PIAs select and source equipment while adhering to proper procedures. Thus, the regional consultants' contributions to improving the process and quality aspects of the VESP was commendable. Having regional teams with technical and social skills would be vital for managing the VESP even at current levels. If the VESP were scaled-up the role of regional consultants would be even more essential.

2.7.5 Ministry of New and Renewable Energy

102. The MNRE conceived the VESP in early 2004 and has since then funded and implemented it. Accordingly, the Ministry plays a major role in controlling the direction and pace of implementation of the VESP. The VESP posed a major challenge to the MNRE because this is the first project it has implemented directly at the grassroots level and in many locations. Moreover, the project was not about delivering hardware but about delivering electricity to remote unelectrified communities. Usually, the Ministry sanctions funds to the SNA, which in turn implements directly or works with other agencies to implement projects, mostly related only to delivering hardware such as solar lanterns to households.

103. In contrast, in VESP, the funds were sanctioned to the VEC, which implemented the project with the help of the PIA and the SNA. In addition, for the first time biomass-based technologies were installed in many remote and widespread locations. The challenge was further compounded with many of the less remote sites being taken up under the RGGVY (Ministry of Power) leaving only the remotest and most backward villages for VESP. The performance of the MNRE has to be viewed against this background. The MNRE has so far sanctioned 67 projects of which 45 were commissioned with 34 being operational. Though

commendable given the circumstances, the progress has not been as rapid because the MNRE set out to electrify 200 villages when it launched the VESP as a pilot programme.

104. The reasons for the slow progress are understandable. With many unelectrified villages being taken up under the RGGVY for electrification, the list of potential villages for VESP were considerably pared down and finding suitable sites with at least 50 households and capable PIAs has not been easy.

105. Monitoring of outcomes or results (uptime in the project) in addition to monitoring project outputs (power plant installed and commissioned or not) would have perhaps given more information and lessons. The thrust remained on projects being commissioned and declared operational, while the actual performance in terms of quality and quantity of power delivered were not systematically measured. This method of monitoring has implications for any pilot project because unless the effectiveness of the VESP is properly tested and data are gathered, learning will be limited.

106. Finally, during Programme scale-up, the human resources deployed would be insufficient to effectively manage all aspects. During the technical assistance grant period, the MNRE was supported by additional staff in the VESP Cell and by the regional consultants in the field. With the end of the technical assistance grant, the MNRE would need additional staff to go beyond merely monitoring physical and financial progress of VESP to monitoring the effectiveness and performance of the VESP. The VESP Cell needs to be ed with adequately skilled staff before the Programme is scaled-up.

2.8 Conclusion

107. As mentioned earlier, the VESP is a first of its kind in the area of decentralized electricity generation in remote and inaccessible locations. For the MNRE and some SNAs, it was a first foray into grassroots program management that involved working closely with the community as well as the manufacturers. The location of the villages, the backwardness of the community and the relative inexperience of the entire implementation machinery right from the PIA at the grassroots level to the SNA at the state level and the MNRE itself at the national level were factors that affected the outputs and outcomes of the VESP during the pilot phase.

108. Nevertheless, 45 out of 67 projects that were sanctioned by the MNRE were commissioned; of these 34 were functional when the technical assistance grant ended. Nearly 700 kW of electricity generation capacity were created in these remote locations, which is a significant achievement. In terms of outcomes, while the results have been wanting, there is great potential for improving performance.

109. In conclusion, it can be said that the purpose of rolling out a pilot phase for the VESP has been well served. An analysis of the projects has generated a lot of lessons at the project, program, and policy levels, which are discussed in the next chapter along with suggestions on the way forward.

3. Rural Energy Security — The Way Forward

3.1 Village Energy Security Programme — Continued Relevance

1. Even as the pilot phase of the Village Energy Security Programme (VESP) was nearing its end, the Ministry of Power (MoP) announced the roll out of the "Decentralized and Distributed Generation (DDG)" scheme. With villages of more than 100 households coming under this scheme, the scope of the VESP has been considerably reduced. The immediate impact would be that the Ministry of New and Renewable Energy (MNRE) would now have to cover even smaller and more remote villages with backward communities, than previously mandated. Obviously, the degree of difficulty in delivering energy services to these marginalized households has now increased manifold. However, this has only underscored the Programme's importance in reaching out to the remotest and most inaccessible communities in the country. The VESP is the only program that seeks to go beyond mere home lighting for such remote communities and offers hope for their economic and social development, and therefore continues to remain relevant in the context of the above-mentioned goal of the Eleventh Plan.

2. Overall, the pilot phase of Programme implementation has shown several lessons. The VESP as a program has continued relevance and the original mandate of providing electricity to those who continue to remain beyond the reach of the grid has become more pressing. The VESP has the potential to deliver better performance, however to do so lessons on various aspects need to be learned. This chapter discusses the key lessons learned and provides suggestions on the way forward for the MNRE to consider, if it intends to scale-up the VESP.

3.2 Village Energy Security Programme Performance — Summary of Findings

3. As discussed in the preceding chapters, the performance of the VESP has been largely mixed on the technical, financial and managerial aspects at the project level. The key reasons for such a performance at the project level were: the failure of the original equipment manufacturers (OEMs) to provide prompt and reliable aftersales services, the inadequate training of local operators and the lack of capacities and interest in the village energy committees (VECs) to manage the day-to-day affairs of the power plant. However, the reasons for poor performance are not entirely insurmountable and the pilot-testing phase showed immense potential for better performance in many of the test projects.

4. A performance analysis revealed organizational shortcomings at various levels in delivering the VESP to remote locations. Given the small-scale of the VESP during the pilot phase, interest at the state level in the state nodal agencies (SNAs) was at best halfhearted. Also, during the initial stage, the use of state forest departments to implement the VESP did not yield the desired results because they could not successfully mobilize the community or handle the technical issues. During the latter part of the VESP pilot phase, however, non-governmental organizations (NGOs) that were brought in as project implementing agencies (PIAs) performed better, but took time to understand that aftersales services and operator trainings were the crucial elements missing in the

delivery mechanism of the VESP. With the induction of the regional consultants under the technical assistance grant support from the World Bank, old projects got revived and the performance of many of them even improved, underscoring the importance of the role of the regional consultants and the need for ing the institutional mechanism between the MNRE and the state-level stakeholders. The following sections present suggestions on the way forward against this backdrop.

3.3 Improving Institutional Performance

5. The current institutional mechanism for implementing and monitoring the VESP comprising the MNRE – SNA – PIA –VEC alliance was found deficient in several aspects. Though, the VESP is demand-driven by nature and a grassroots-based intervention, most of the decision-making was concentrated at the MNRE, while the PIA was saddled with the onerous responsibility of making the VESP happen. While NGOs as PIAs showed more commitment and skills, the use of state departments as PIAs often ended in a non-operational project. The SNA had a marginal role to play as a monitoring agency, and could not undertake output monitoring given their limited human resources and logistical issues. 6. The performance of the VECs, as owners and managers of the power plant at the village level, was below par. However, it is important to know that for the most part the PIAs, which are the key agencies for facilitating the participation of the VECs, were more concerned with getting the power plant running than in ensuring the involvement of the VECs in owning and managing the plant. As a result, the capacity, motivation and incentive for VEC members to take on an active role in managing the day-to-day affairs of the power plant proved to be rather weak, more so because the members were working on an honorary basis. Furthermore, the manufacturers, who had the responsibility of providing the technology, did not provide adequate aftersales services and training. Given the scattered nature of the VESP projects, their utter remoteness and the stark inaccessibility, the idea of an OEM providing training and aftersales services from a pool of human resources based at a central (often the OEM's manufacturing plant) location was considered impractical.

7. The performance assessment also revealed that Programme monitoring should be carefully oriented towards outcomes rather than outputs and given significantly greater attention throughout the program duration. Despite a good monitoring and evaluation framework being established[19] as part of the technical assistance grant, the focus was on mere outputs (such as installing the power plant, constructing the gasifier shed, and preparing the statement of expenditure) rather than on outcomes (such as operationality of power plants, providing power supply to the households as per plan, ensuring that users paid for the power consumed, evaluating if the payment was sufficient to meet expenditures). Given the centralized information flow towards the MNRE, the institutional mechanism was inclined to reinforce output monitoring.

8. Thus, the institutional mechanism of the Programme needs to be ed, the roles and responsibilities of the agencies need to be better allocated, and the focus should

[19] However, it is only fair to mention that the M&E framework was never tested earnestly at the field level due to paucity of time.

be on monitoring performance (outcomes). The following section presents some concrete steps towards improving the institutional performance.

3.3.1 Decentralize and devolve powers and responsibilities

9. The VESP experience showed that decision-making is largely centralized in the MNRE. This has potential to lead to delays in vetting the detailed project reports (DPRs) and sanctioning of projects. If the VESP is scaled-up now, it would only get slower due lack of adequate human resources. Further, with SNAs having little role in decision-making, they would not have ownership of the project or the Programme. Therefore, the first step in ing the institutional mechanism is to decentralize decision-making and devolve powers to the SNA. The MNRE should continue to set the policy and design the VESP, but implementation should be in partnership with SNAs who would have powers to approve DPRs and sanction projects. The SNAs should submit a state level plan for undertaking the VESP for 2–3 years, which should form the basis for the MNRE to engage with them.

10. Dedicated central and state level program management units should be created to manage the VESP. These units should have members with multiple skills in technical, community development, economic analysis, and performance monitoring aspects. Since, both the MNRE and the SNAs may not have all these skills, external teams should be brought on board along the lines of the national and regional consultants that the technical assistance grant of the World Bank supported.

11. The central program management unit (i.e. the MNRE) should focus on setting guidelines, monitoring the progress and performance, while the state level program management units (state nodal agencies) should focus on activities, such as identifying PIAs, approving DPRs, sanctioning projects, and ensuring that adequate training is provided. The SNAs should be made central to implementing the VESP. However, recognizing their limitations in terms of numbers and quality of the workforce, NGOs with experience in VESP-like projects should be co-opted into the state level program management unit to provide support and guidance to PIAs and the SNAs. This step would greatly relieve the pressure on the MNRE while increasing the interest and incentive for the SNAs to be more involved. Further, with the formation of the program management units (central and state), the skills necessary to manage the VESP would become available.

3.3.2 Phase the management of power plants from VECs to entrepreneurs

12. Power plant management needs a dedicated and skilled workforce. Currently, the VECs are the owners and the managers of the power plant at the village level. However, the VEC members work in an honorary capacity and thus lack the interest and incentive to manage the power plant on a day-to-day basis. Quite often, this task is left to the local operators, who are also not interested since they are not paid regularly. Thus for better power plant performance the ownership should be separated from the management. One option is for the Gram Panchayats or VECs to own the power plant, while the operations and management could be handed over to the entrepreneurs since the energy production system has a public goods element whose benefits must reach the entire community. In such an institutional arrangement the Gram Panchayat

would, as the owner of the system, have a role in setting tariffs, helping the entrepreneur in recovering dues and ensuring that the community abides by the decisions of the Gram Panchayat. The entrepreneur would be responsible for operating and maintaining the plant, ensuring the supply of biomass, collecting payments from the users, and ultimately for delivering electricity services as per an agreement drawn up between the entrepreneur and the Gram Panchayat or VEC (as a representative of the users).

13. The entrepreneur could be an individual or groups of individuals, NGOs, or self-help groups, that were chosen based on an appropriate process of selection. Given the very tiny scale of operations in a typical VESP project, it is very unlikely that entrepreneurs from far off places would be attracted on purely commercial terms. Therefore, it is very likely that the entrepreneur would be from the project village itself or from neighboring villages. An entrepreneur who is already running a flourmill or an oil expeller in the village using diesel engines, for example, could be the first choice because the person would have the necessary technical and business skills to manage the power plant. This would help in adding the productive load of milling or oilseed crushing to the power plant, thus ensuring a better load factor for the power plant. It would also provide greater incentive to the entrepreneur by generating a cheaper power source for the milling operations leading to higher profits.

14. If an entrepreneur is not identified at the time of sanctioning the project, then a local youth may be selected to eventually run the plant as an entrepreneur. Initially, the entrepreneur or local youth may be paid a fixed salary to tide over problems during the learning period (for about six months of operations), but should be gradually replaced with a compensation scheme that is based on performance, such as the number of units supplied, percentage of billed amount collected, or uptime, rather than a fixed payment. This would lead to a more business-like approach to the VESP at the project level. The entrepreneur should execute an agreement with the VEC to provide a certain quality and quantity of service which will form the basis for measuring performance and accordingly the compensation. The VEC should assure to support the entrepreneur in recovering dues from the users.

15. Because the entrepreneur is the last and crucial link in delivering the VESP at the project level, it is vital to build entrepreneur capacity to successfully handle all tasks. Every entrepreneur should undergo the following steps before being handed over the plant to manage independently:

- As soon as the manufacturer for a project is finalized, local operators or entrepreneurs chosen from a village should be sent to the OEM for training to get familiarized with the equipment and its operations. Following this the entrepreneur should be sent to a VESP village for a period of at least 30 days where the system is operational, to learn from peers on operations, maintenance, repairs, and managing revenue and expenditure.
- Once the equipment is installed in their own village, strong technical handholding support through a local diesel mechanic and an electrician should be ensured for three months after installation to prevent mishandling due to improper understanding of the operations and maintenance procedures.

3.3.3 Change the focus from output reporting to outcome monitoring

16. Currently, monitoring of projects is limited to output reporting mainly by the PIA or by the SNA, as a monitoring agency hired by MNRE. However, this information is useful only from an audit and administration point-of-view. Therefore, there is a need to shift the focus from output reporting to measuring outcomes, such as uptime and revenue versus expenditure. Every PIA should be mandated contractually to maintain and report information as per the monitoring and evaluation framework developed by the national consultant under the World Bank supported technical assistance grant. This would ensure that the focus is on performance rather than on mere completion of a set of activities.

17. The state and the central program management units should develop a database to collect, update and maintain a log of the performance of every VESP project over the lifetime of the equipment. This performance data should form the basis for the release of the viability gap fund (output based aid) to the VEC. Further, to check the veracity of the data being reported, there should be third party monitoring (both at the state level program management units and the central level unit, 25 percent and 5 percent, respectively) on a monthly basis to check if all projects are being implemented. The state level and the central third party monitors should be separate organizations.

18. Thus, shifting the focus to outcome monitoring, integrating the monitoring and evaluation framework into the contractual obligations of the PIA, tying the release of the viability gap funding to performance data and finally constituting a two-tiered external data verification and monitoring system would help in ing the institutional mechanism to deliver in terms of performance rather than in terms of the number of project completed.

3.4 Improving Technical Performance

3.4.1 Build a robust aftersales service network of third party local service providers

19. Inadequate aftersales service response is the key reason identified for poor technical performance (poor uptime) of the VESP projects. At present, OEMs are unable to provide quick and quality aftersales services due to logistic and financial reasons. In a gasifier power plant, there are more engine breakdowns than gasifier breakdowns. Most of the engines in the 10–20 kW range are modified diesel engines. Given this situation it is better to hire local diesel mechanics[20], train them in repair and maintenance of gasifier engines (modified diesel engines) and use them to support local operators than sign an annual maintenance contract with the OEM.

20. However, the local service provider should be certified by the OEMs and warrantee claims submitted through such certified local service providers should be honored by the OEMs. This would ensure the continued responsibility and liability of the OEM after commissioning the power plant. In addition, the process would help create an aftersales network for the concerned OEM. Given

[20] This approach has been tried in Chattisgarh by CREDA and also by TERI in Jambupani, in Madhya Pradesh.

that the biomass gasification market is still at a nascent state, this indirect support to the OEMs is justified. However, local service providers should be located so that they can serve VESP projects conveniently rather than to meet the requirements of the OEM.

21. Based on the state level plans submitted by the SNAs, the MNRE should support the SNAs to identify and create a pool of third party local service providers who are well trained in operations, maintenance and repairs of biomass gasifier-based power plants. The process of identifying and training local service providers should be start well before the roll out of VESP projects in a state. The SNA should take an area-based approach to developing local service providers. For example, if as per a state's VESP roll out plan, the majority of villages are located in the northern districts of the state, then the maximum number of local service providers should be developed there. Before sanctioning a VESP project, the SNA must ensure the presence of a trained and accredited local service provider in the vicinity of the proposed project and make certain that the local service provider is willing and able to service the plant.

22. Further, at the time of the DPR itself the local service provider should be identified and willingness to provide aftersales service should be recorded. This local service provider would be a technical mentor for the entrepreneur or local operators. Thus, ensuring a trained and dedicated local service provider would help in increasing the confidence of the operators, reduce the frequency and length of breakdowns, increase uptime and thus improve the technical performance of the VESP at the project level.

3.4.2 Impart modular and graded training to help develop specific skills and knowledge

23. Inadequate training of operators was identified as another key reason for poor technical performance of the VESP. Currently, training is being imparted to local operators and VEC members, mostly on an ad hoc basis. Training of local operators in most cases is limited to the OEM's representative teaching them how to start and stop the power plant. A few get sent to the OEMs factory for a week's training where all parts of a gasifier and engine are explained, including its operation and maintenance. Quite obviously, this training is not adequate since the power plant breaks down often due to improper handling.

24. Training of VECs has to be more organized. Presently, it consists chiefly of explaining roles and responsibilities than converting a group of individuals into a team and building their leadership capabilities to take decisions. Therefore, it is important to clearly identify the key skills and knowledge (required by the operators, entrepreneurs and the VEC) to manage the power plant successfully. The central program management in consultation with the state program management units should design a set of training modules aimed at developing specific skills and knowledge in a specific set of stakeholders. The training should be practical and hands-on, rather than being classroom based. For example, local service providers should be trained like authorized mechanics of automobiles, and at the end of the training they should be able to take apart an engine and reassemble it, rather than merely knowing the theory behind it. Similarly, for the local operators, the training should deal with the operations of the power plant, including routine maintenance and minor repairs. Further, because the local operator would also be responsible for the financial

management, training on how to log operational and financial data is also essential.

25. Obviously, all skills and knowledge cannot be gained in a couple of training sessions, and thus, training should be designed in a modular fashion, such that it is a graded process. Finally, innovative avenues for providing training should be explored. For example, local service providers and local operators can be trained in the following manner:

- Training at the OEM facility to understand gasification and operation and maintenance of the power plant.
- This should be followed by a deputation to a successfully operating VESP project for hands-on learning. During this phase, the trainee would learn about problems encountered during operations in a village.
- Finally, the trainee may be sent to a local engineering college, a polytechnic, or a reputed engine workshop for hands-on training on taking a producer engine apart and reassembling it.

26. Thus, the technical performance of the VESP can be vastly improved, if local service providers, operators and VECs are trained to develop specific skills and knowledge that are vital for executing their respective tasks well.

3.5 Improving Financial Performance

3.5.1 Link viability gap funding to outcomes to ensure better performance

27. An analysis of the financial parameters of a typical VESP project shows that revenues that are based solely on just what the domestic users pay would not be sufficient to cover the cost of operations and maintenance. This "viability gap" has to be bridged for the project to be feasible. In general, rural electricity consumers served by the grid enjoy considerable subsidies. Given this situation, providing viability gap funding (subsidizing operational costs) to encourage entrepreneurs to serve customers in areas that cannot be served by the grid is justifiable. Moreover, this subsidy is a "targeted" subsidy that is aimed at remote, rural communities that are excluded from mainstream development activities.

28. Based on current load levels and the capacity utilization factor, the viability gap is Rs10,000–Rs 50,000 per annum per project. This is about 10 percent of the project cost over the lifetime of the equipment. A budgetary provision should be made to cover this viability gap and made available to the VEC and entrepreneur periodically to help cover their costs and leave a regulated amount of profit. A step of this kind, however, is not without a precedent. The guidelines for the DDG program of the MoP explicitly recognize that there could be viability gaps, for which the DDG would compensate the entrepreneurs. The guidelines further protects consumer interests by stipulating that the entrepreneur may set a tariff that is comparable to that being paid by grid connected customers in the vicinity of the DDG project.

29. However, to ensure that the entrepreneur has an interest in constantly improving the technical performance and economic efficiency, the viability gap funding should be provided on a decreasing scale over a period of time and clearly linked to agreed upon performance parameters, such as uptime, number of units generated, among others. This means that at the beginning when the entrepreneur

has just taken over and is on a learning curve, the load is largely domestic and the viability gap should be covered liberally.

30. However, over a period of time (in about a year), the entrepreneur should have learnt how to manage the power plant as a business, where productive loads have been added and revenue streams have been secured. Subsequently, the viability gap funding should be reduced steadily. This means close and regular mentoring and monitoring of the performance of the entrepreneurs. A two-tier monitoring system should be instituted to establish the performance of the entrepreneur and the quantum of viability gap funding required. Similarly, to help improve plant performance, mentoring should be provided by the PIA with support from the state level PMU over an extended period of at least three years from the commissioning of the power plant. Thus, even in an entrepreneur based model for implementing VESP-like projects the SNAs of the government have an important role to play in monitoring and improving plant performance.

31. Finally, the viability gap funding (operational subsidy) should be routed through the VEC with whom the entrepreneur has a performance contract. This would ensure that the VEC has a continued and meaningful role to play in managing the interests of the user community. The PIA and the SNA should work with the VEC and the entrepreneur to ensure that this procedure functions in a transparent and smooth manner.

3.5.2 Secure convergence and revenue streams of VESP at a policy level

32. While the viability gap funding should be decreased to encourage the entrepreneurs to perform better, the implementing mechanism of the VESP should secure certain revenue streams at the policy level and for the entrepreneur. For example, under the 73rd Amendment, Panchayats are responsible for providing drinking water and street lighting. In grid-connected villages, the electricity charges for pumping drinking water and street lighting is borne by the Panchayat and is paid out of the annual grant-in-aid that it receives from the state department of rural development. In the VESP villages too these services are being provided (at least street lighting in all cases) but no payment has been secured from the Panchayat system. In most of the villages where the domestic consumer payment is the only source of revenue, the consumers are also footing the street lighting bill. It is important to note that remote and backward communities are not only being made to pay higher tariff per unit of power consumed (~Rs6–8/unit), compared to the subsidized tariff being paid by grid-connected customers, but they are also being made to pay for other electrical services that the Panchayat pays for in other villages.

33. During the pilot phase of the VESP, securing such revenue streams was discussed extensively, though without any positive results. Therefore, it is suggested that the Government should institutionalize this type of convergence with other relevant departments. For example, the MNRE could enter into a MoU with the Ministry of Rural Development and the Ministry of Panchayat Raj to secure such a convergence. At the state level too, the SNA should enter into a MoU with the relevant departments and share the VESP roll out plans with other departments. A system should be instituted such that whenever a new VESP project is sanctioned, a copy of the sanction letter should be marked to the District Commissioner and the Project Director of the District Rural

Development Agency (DRDA), informing them of the project and requesting them to facilitate convergence with the energy systems.

34. Thus, the main thrust in improving financial performance is to provide financial gap funding, but by using it judiciously so as to drive economic efficiency. There is also the need to help secure other revenue streams by facilitating convergence through policy measures rather than leaving this difficult job to the PIA.

3.6 Improving Biomass Supply and Sustainable Plantations

3.6.1 Monetize the biomass supply

35. The MNRE chose biomass-based technologies as the first option to drive the VESP because it reasoned that unlike other renewable energy technologies biomass was not site specific and could be grown almost anywhere in India. It also took into account that with most of the potential VESP villages being located in remote forested areas, biomass supply would not be a barrier in the short run. However, as a measure of caution, it also included biomass plantations as a core component of the VESP.

36. In terms of implementation, the sourcing and supply of biomass was not even perceived as an issue that merited attention. Given the abundant biomass source in the form of forests, it was assumed that the community would collect firewood and deliver it to the power plant. However, with no one assuming responsibility for organizing a steady biomass supply, quite often the plant had to be shut down due to lack of biomass supply. The current arrangement of every household supplying a certain quantity of biomass regularly has not been successful. The way forward is therefore to monetize the biomass supply.

3.6.2 Emphasize on sustainable biomass plantations

37. The major thrust of the VESP in this regard was to establish biomass plantations on common land and secure the biomass supply. However, this initiative faced the familiar pitfall of common property resources being owned by everyone and being cared for by none. The result was poor survival of biomass plantations. In the short term, the relative ease of availability of biomass from existing forest sources has helped many VESP projects to meet its fuelwood requirements, albeit from non-sustainable sources. However, in the long term the VESP should try a three-pronged approach for securing a steady supply of biomass from a sustainable source. The primary thrust of the VESP to secure biomass supply from sustainable sources should continue to be from biomass plantations on community lands. Currently, issues, such as the lack of institutional commitment and short runs, are more of a concern than technical reasons for poor performance of biomass plantations. Biomass plantations should be treated as an integral component of the VESP package and included in the ambit of performance (outcome) measurements. The two-tiered performance monitoring approach should also cover this aspect of the VESP.

38. In addition to community plantations, the VESP should explore the possibility of farmers growing fuelwood in private lands to feed the power plant. The Biomass Energy for Rural India (BERI, see Annex 9), a project being implemented in Karnataka with UNDP support, has pioneered a system of planting trees in trenches dug along the field bunds of farmlands. In this system, the farmer continues growing field crops, but also gets the benefit of growing trees.

Typically, in an acre about 400–600 trees are planted without affecting or replacing the field crops being grown. These trees are periodically cut and the wood is supplied to the power plant at a rate that is determined by the VEC. Thus, farmers get an incentive to support tree-based farming while the power plant is assured of a constant biomass supply.

39. Finally, as a third level strategy to tide over the need for biomass sources before VESP plantations produce yields, the VEC and entrepreneurs should try to forge tie-ups with the village forest committees, if present within a distance of 10km radius from the VESP village. These committees under the Joint Forest Management Act are encouraged by the forest department to take up plantations on certain categories of forestlands. At the time of harvest, the village forest committees have a right over a certain share of the proceeds. Since these plantations are replanted or rejuvenated after harvest the supply of biomass is sustainable.

40. While these are initiatives that need to be taken at the village level, the MNRE and the SNA should at the central and state levels, respectively, forge a tie-up with the forest department. The SNA should discuss with the state forest department its state plan for VESP roll out and seek cooperation in identifying forest lands that can be used for planting, creating village forest committees in VESP villages and/or identifying village forest committees with sustainable biomass plantations in the vicinity of the VESP village that can act as a source of biomass until the project's plantations produces yields.

41. In the long term it is safe to assume that any existing and future large-scale program on biomass-based applications, would add to the demand for biomass supply. There is a risk that this could lead to biomass being extracted from more unsustainable sources and the price of such biomass would steadily keep increasing. Therefore, for large scale biomass based programs the MNRE and the state renewable energy agencies would need to assess the feasibility of supporting plantations through appropriate biomass policy options which include incentives for production in community and individual lands, buy-back mechanisms, farmer education and extension services and area-based convergence with programs of the forest institutions. Although not immediately relevant to VESP if large scale biomass-based energy programs are to be promoted in India then policy measures for linking biomass plantations to organized markets have to be assessed and initiated.

3.7 Improving the Policy Framework for the Village Energy Security Programme

3.7.1 Ensure a level-playing field for VESP vis-à-vis DDG programme of MoP

42. The DDG scheme of the MoP was formulated in response to the Eleventh Plan objective of electrifying all households by 2012, as was the VESP. It is similar to the VESP in seeking to serve those communities that would not be covered by the grid even by 2012. But, it differs from the VESP in that it is technology neutral and permits the use of any renewable energy technology or combinations thereof. The most significant way in which it differs from the VESP also confers it certain advantages. For example, the DDG covers only villages that have more than 100 households, thereby conferring economies of scale. In contrast, the average size of VESP villages is just 50–70 households. The DDG guidelines

promise entrepreneurs a viability gap funding right from the first day up to five years. The VESP on the other hand has no such mechanism and may not be financially viable by itself.

43. The DDG guidelines also stipulate that consumers should not be charged more than the tariff being paid by users in grid-connected villages in the vicinity of the DDG village. In contrast, pursuing the goal of making VESP projects financially self-sustaining, the VESP consumers are expected to pay (as high as Rs6–8/unit) to cover the expenses of running the plant. As discussed above, consumers are even paying for powering their streetlights, whereas this is paid by the Panchayats in grid-connected villages. Thus, although both the VESP and the DDG programme ostensibly serve the same set of deprived communities, the levels of policy support and therefore, subsidies are entirely different. The MNRE should work to ensure a level playing field for both programs and finally for the end consumers. Given that the VESP villages are likely to be more remote, inaccessible, scattered and tiny compared to DDG villages, the case for ensuring a level playing field and even a higher degree of support is a compelling one.

3.7.2 Adopt a technology-neutral and scale-neutral approach

44. The VESP guidelines specify the size of the power plant based on the number of households in the village. While the number of households is a good indicator of the load and therefore, the power plant size, it is not the only factor. The few VESP projects that had irrigation loads, could not be catered to since the effective capacity of the power plant was only about 8–9 kW (a gasifier power plant consumes about 10 percent to 20 percent of its capacity for its own operations). Further, when the number of households determines the size of the plant, carrying out a survey to prepare a DPR for estimating the size of the plant would be redundant. Therefore, as a policy the VESP should adopt a scale-neutral approach and support plant sizing based on load, load factors and economics.

45. Similarly, on the technology front, currently, the VESP is based on the premise that biomass-based technologies are most widely feasible since biomass can be grown in almost all parts of India. However, sometimes, a picohydelpower technology may be a cheaper and more reliable alternative than a biomass-gasifier. In Naringinpadar village in Orissa, a picohydel power technology would have been the ideal choice given that there were streams flowing nearby and the villagers knew about this technologysince many villages around Naringinpadar had been electrified with picohydelpower plants.

46. The MNRE should adopt a technology-neutral approach to the VESP. It may provide guidance for the preparation of DPRs by providing a hierarchy in terms of technology based on factors such as costs, reliability, ease of operations, rather than insisting upon the use of biomass technologies alone. However, it should take care to ensure that the VESP does not merely become a home lighting initiative and continues to focus on providing grid-like power to remote communities.

3.7.3 Focus on delivering grid-quality electricity

47. A key assumption of the VESP is that the introduction of improved cookstoves and biogas plants would help in reducing the consumption of biomass in the

cooking sector and that the surplus biomass from this sector would be diverted to the gasifier power plant. The underlying expectation is that women, who usually collect the fuelwood for cooking, would continue collecting the same amount of fuelwood, but supply the surplus (on account of use of improved cookstoves and biogas) to the gasifier power plant. In reality, however, the improved cookstoves and biogas plants distributed among the villagers have not been monitored for their actual usage. Even where usage was good, no attention was paid if biomass was being supplied to the power plant. Indeed, in most cases interventions in improved cookstoves and biogas did not result in more biomass being delivered to the power plant. Given this situation the MNRE should reconsider the relevance of interventions in cooking energy. Undoubtedly, interventions in cooking energy lead to a better quality of life, especially for women and children. But in the context of the VESP, which has the task of electrifying remote and inaccessible villages, these components are perhaps best done outside of the VESP, because they do not contribute to better achievement of the core objective of electrification.

3.8 Conclusion

48. The pilot phase of the VESP showed several lessons and need for improvements. Two very important issues were highlighted: first, that the VESP is important and relevant, in the absence of any other Government initiative for bringing grid-quality power to the poor, undeveloped and underserved communities residing in the remotest corners of the country; second, the poor performance of the VESP during the pilot phase was due to reasons that are not entirely intractable or insurmountable.

49. Thus, the VESP that is focused on performance, backed by greater policy support and a vastly ed institutional mechanism for implementation is the way forward. In conclusion, the relevance or need is not in doubt, but rather the commitment for meeting the challenges of scaling-up the VESP as a national program.

Annex 1: Contribution of the Technical Assistance to Programme Performance

This chapter presents the details of the design of the recipient-executed technical assistance and its contribution to improving the performance of the Village Energy Security Programme (VESP). The technical assistance was designed to complement the efforts of the Ministry of New and Renewable Energy's (MNRE's) support to eight states (Assam, Andhra Pradesh, Chhattisgarh, Gujarat, Maharashtra, Madhya Pradesh, Orissa[21] and West Bengal) that were covered under the VESP. These states were chosen on the basis of geographical coverage, presence of state nodal agencies (SNAs) and a rapid assessment of the state's potential to execute at least 15–20 new test projects in the next couple of years.

Grant Objectives

The key development objective of the grant[22] was to identify and test scalable models for designing and implementing community-driven programs for meeting the complete village energy needs. The program's focus would be on business models for small-scale biomass-based renewable applications that could meet the energy needs related to productive uses, cooking and lighting. Further, the climate change related objectives were to:

- remove barriers and reduce implementation costs for productive and household use of biomass-based renewable energy in support of sustainable rural development.
- reduce greenhouse gas emissions by substituting fossil-fuel–based energy and traditional greenhouse gas-intensive biomass energy with modern renewable energy technologies.

Scope of the Grant

The scope of the grant was defined as follows:

- Providing technical assistance to projects being implemented under the VESP, with the objective of testing the sustainability of institutional arrangements and business models for community driven initiatives to meet their total energy needs through biomass-based or other renewable energy sources.
- Promoting knowledge sharing with the aim of propagating sustainable models of energy service delivery in remote villages.
- Identifying interventions that promote synergy between energy services and environment management, rural employment and incomes, and social service delivery.

Main Beneficiaries

The project sought to target remote village communities, often poor and tribal villages with unique socio-cultural beliefs and traditions, which do not have access to modern energy services and opportunities for productive activities. In 2005–2006, the MNRE

[21] Orissa replaced Tamil Nadu, which was dropped on account of non-availability of unelectrified (non-grid) villages.
[22] As defined in the grant proposal.

selected remote villages from a list of 20,000 villages that would not be connected to the national grid in the near future. The list was agreed upon jointly with the Ministry of Power (MoP). During the detailed scoping of the grant activities, it was decided to target the recipient-executed technical assistance investments in energy service delivery to 95 such villages. The other indirect beneficiaries of the activity included local grassroots non-governmental organizations (NGOs) and local government bodies through capacity building efforts; and state and national level agencies in-charge of rural renewable energy through institutional ing.

Table: PHRD TA Grant Allocation and Expenditures from 2006-2009

	Category 1 **Consultancies**	**Category 2** **Local training and stakeholder workshops**	**Category 3** **Goods and Works**	**Total**
Grant Allocation	808900	79800	110000	998700
Expenditure	467745.02	39865.11	16902.01	524512.14
Disbursement				52.2%

Components of the Grant

The recipient-executed technical assistance was designed to complement the eight states that were covered under the VESP: Assam and West Bengal (eastern region); Gujarat and Maharashtra (western region); Chhattisgarh and Madhya Pradesh (central region); and Andhra Pradesh and Orissa (southern region). These states were chosen on the basis of geographical coverage, presence of SNAs and a rapid assessment of the state's potential to take up at least 15–20 new test projects in a couple of years. The technical assistance grant was spread over the following two components:

Component A: Design and implementation of pilot projects

The objective of this component was to test the sustainability of institutional arrangements and business models for community-driven initiatives to meet the total energy needs through biomass-based and other renewable sources. This was done by providing technical assistance related to design and implementation for 95 pilot projects (including old, current and new) focusing on the sustainability of investments. Four regional consultants, each covering two states[23] were hired with the following responsibilities:

[23] TERI-West Bengal and Assam (eastern region), READ Foundation-Maharashtra and Gujarat (western region), Winrock International India-Orissa and Andhra Pradesh (southern region) and SR Corporate Consultants Ltd-Chhattisgarh and Madhya Pradesh (central region).

- Provision of extensive capacity building and recipient-executed technical assistance to various stakeholders to facilitate the implementation of existing test projects sanctioned by the MNRE; and
- Provision of recipient-executed technical assistance for identification, preparation and assistance with the implementation of new test projects.

The *output indicator* of this component was identified as the implementation of successful test projects to demonstrable business and institutional models that could scale-up biomass-based renewable energy applications for meeting the energy needs of remote villages.

Component B: Institutional development and knowledge sharing

This component was aimed at: building capacity and knowledge sharing across various stakeholders with respect to small-scale biomass-based applications; evaluating the performance of the VESP projects; and learning lessons on the viability of technology options, consumer acceptability, costs and other financial requirements and institutional arrangements. A national consultant (The Energy and Resources Institute; TERI) was hired with the following broadly defined tasks:

To develop a financially viable framework for different end-use applications focusing on capital costs, user charges, as well as operation and maintenance costs;

To develop a reporting and monitoring framework for VESP projects; and

To review performance, impacts and lessons of the test phase for drawing institutional and design recommendations for a larger operational program.

The *output indicators* of this component were: training workshops held as well as training materials, reports and dissemination materials developed for improving capacities; and lessons learned for scaling up to a larger program.

The consultancies, both national and regional under the two components, provided support for improving community mobilization and participation, defining and implementing institutional models, refining delivery mechanisms, conducting economic analysis, undertaking capacity building and training, exploring carbon finance linkages and sustainability issues, and developing and implementing a monitoring and evaluation framework.

Assessment of Outputs and Outcomes

11. The component-wise achievement of outputs are as follows:

Expected Output	Actual Output
Component A: Design and Implementation of test projects The 95 pilot projects would receive the benefit of a regional consultant's expertise and pass through the four stages of a typical project cycle: 1. Preparatory phase 2. Planning phase 3. Implementation phase 4. Post-implementation phase	• Only 45 projects, i.e. just 47% (45 projects out of 95 project submitted) of the targeted number of Village Energy Security Programme projects could reach the post-implementation stage. • Only 34 projects, i.e. just 36% of the targeted number of VESP projects could reach the implementation stage. • The regional consultants under the grant helped prepare detailed project reports for 45 new projects, of which the Ministry has sanctioned 17. • Four state-level workshops were organized on the VESP including topics, such as biomass based electricity generation and its utilization, development of productive loads and augmentation of livelihoods in Programme villages, and, institutional arrangements of Programme sub-projects. These workshops were held at Raipur (for Madhya Pradesh and Chhattisgarh); Pune (for Gujarat and Maharashtra); Kolkata (for Assam and West Bengal); and, Bhubaneswar (for Orissa and Andhra Pradesh). • In addition, separate orientation training workshops were organized for VECs and operators in the respective states. These workshops focused on awareness creation, knowledge about technology and equipment, project management, synergies with income generating activities among other topics.

Expected Output	Actual Output
Component B: Institutional development and knowledge sharing • Develop an economic and financial viability framework for different end-use applications focusing on capital costs, user charges, and overview and maintenance costs. • Develop a reporting and monitoring framework for Programme projects. • Review performance, impacts and lessons of the test phase with a view to drawing institutional and design recommendations for a larger operational program.	• A report that presents various economic and financial scenarios based on a combination of subsidy and plant load factors has been prepared. However, since the pilot projects themselves had very little to show in terms of technical performance, development of productive loads and financial performance, the scenarios tend to be theoretical. • A detailed monitoring and evaluation framework was prepared but not implemented satisfactorily. • A community operations manual has been prepared on the Programme and disseminated to all the state agencies and implementing partners. • Since the results of the test phase are still very tentative on the three parameters of technical, financial and managerial performance, the recommendations for a scale-up program would also be inconclusive. o The Ministry and national consultant organized two national workshops in October 2007 and June 2009 that brought together a wide range of stakeholders from the government and non-government sectors including the Ministry of New and Renewable Energy, Ministry of Power, Planning Commission, Rural Electrification Cooperation, state renewable energy agencies, Indian Renewable Energy Development Agency, and several donor partners.

Value Addition by the Technical Assistance

The recipient-executed technical assistance sought to enhance the effectiveness of delivering the Programme by providing the following support:

ing project implementation at the MNRE level

The technical assistance grant thus aided in providing additional workforce to the functioning of the project implementation team at the MNRE. This helped improve the processing of detailed project reports (DPRs) and faster sanctioning of VESP projects. It also resulted in better management and updation of data with respect to the progress of VESP implementation. Before the technical assistance grant was operational, a typical project took nearly 30 months to be commissioned from the date the DPR was submitted to the MNRE. With a ed team at the MNRE and regional consultants providing technical and managerial support to the PIAs, the time for a project to get commissioned reduced considerably to 12–14 months.

Providing expert technical and managerial support through regional consultants to PIAs and VECs at the grassroots level

Revival of old Village Energy Security Programme projects

Regional consultants can be credited with the revival of many of the older projects that were neglected because of the lack of initiative or information on the part of the PIAs and lack of constructive support from the SNAs. In Karrudoba in West Bengal, for example, the forest department was the PIA, when TERI took over as the regional consultant. Realizing that the forest department did not have the required skills to manage a project of this nature, TERI brought in another NGO (FOSSET) to help mobilize the community and build the capacity of the operators and the VEC. The project was revived and is currently running successfully. Similarly, in Maharashtra, the regional consultant (READ Foundation) coordinated between the PIA (Dicholi and Mokhyachapada), the SNAs and the manufacturers in ensuring that additional funds were released to the manufacturer for ensuring power plant supply. Until the regional consultants took an initiative to resolve the issue, the project was delayed for more than a year even after the MNRE had sanctioned it.

Improving performance of projects

In Orissa, the regional consultant (Winrock, along with their partners CEE) provided a series of trainings to the PIAs and the VECs apart from regular review of the projects. In a World Bank mission to Orissa in early 2008, Siunni was categorized as a project without much potential because the PIA lacked a rapport with the community, the VEC was virtually non-existent and the power plant was not being operated. With the regional consultant’s help power plant operations were revived and uptime in Siunni improved from a mere 10–13 percent to nearly 30 percent. The local operator even offered to manage the entire operations including sourcing of biomass, if he were paid a sum of Rs 3000/month — a vast change from when the community was not interested in the project at all.

Faster commissioning of projects

The regional consultants also ensured commissioning of new projects in an extremely shorter time compared to the early VESP projects. In Chattisgarh, the regional consultant (SRCCL) along with CREDA (the SNA which is also the PIA) ensured that all the nine new projects sanctioned by the MNRE were commissioned in a record time of 3–4 months.

Complementing the skills of PIAs

The regional consultants brought in skills that were lacking in some of the PIAs and thus complemented their strengths. In Orissa, Winrock-CEE brought in professional training skills as well as technical skills and helped the forest department to handle issues related to these areas. Similarly, in Maharashtra, the READ Foundation brought in process and technical skills in helping the PIAs select and source equipment while adhering to proper procedures. Thus, the regional consultants' contribution to improving the process and quality aspects of the VESP was commendable. Having regional teams with technical and social skills would be vital for managing the VESP even at current levels.

Providing knowledge products to help make the design, implementation and monitoring a systematic process

Improving the village energy plan preparation process

Before the technical assistance grant became operational, the content and format of the DPRs varied between organizations. In Kanjala, Bharatiya Agro Industries Foundation (BAIF) (the PIA) prepared a village energy plan based on their assessment of the field situation. However, the project could not be sanctioned in that form by the MNRE because it contravened the VESP guidelines. Because the sanctioned version would also have been difficult to implement by the BAIF in the field, it led to delays.

The process of preparing a village energy plan was seldom based on ensuring community participation. This led to a lack of community ownership of the project and wrong assessment of the needs and resources in the village. In Naringipadar in Koraput district of Orissa, a 20 kW biomass gasifier was identified as the required power plant to be installed. However, the village energy plan overlooked the fact that the village was already facing a severe biomass deficit even to meet its cooking energy needs. Further, with many streams flowing nearby, a picohydel power plant would have been a more appropriate solution. When a World Bank mission visited the village, the community mentioned that they were confident about the picohydel technology because there were 3–4 picohydel projects in the neighboring villages for the past 4–5 years.

To streamline the village energy plan process, the national consultant prepared a manual that laid down the steps to be followed by a consultant in preparing a village energy plan (also called DPR). The emphasis is on ensuring that the community actually prepares it while the consultant acts as a facilitator in the process of participation and preparation. The consultant is required to ensure that VESP guidelines are followed in formulating the plan. The village energy plans prepared through this process have been acceptable to the community and the MNRE, leading to a faster processing of plans and approval by the MNRE.

Design of the performance monitoring system for Village Energy Security Programme

The national consultant also designed a system to monitor the performance of a VESP project at the village level. This covered all aspects of the VESP, such as technical, economic, management, and biomass plantations and supply. With the help of the regional consultants, the monitoring system was deployed in a few of the VESP projects as well. However, implementation, usage and continued reporting using the formats developed were not systematically done leading to poor data output. However, the monitoring system is a readymade product that could be used by projects of similar nature in the future.

Conclusion

Overall, the Bank team conducted several implementation support missions, and participated in about 15 detailed review meetings in Delhi with key counterpart agencies and in state-workshops and national-level workshops.

Two areas were given special attention by the Bank team during the course of the technical assistance: (i) focusing on select test projects in each state to be considered as ‘model’ sub-projects (these model sub-projects were to be pursued aggressively by the regional consultants and state administration to achieve positive outcomes and show signs of long term sustainability); and (ii) helping to develop a monitoring and learning framework for the VESP to be implemented at various levels (namely at the level of the operators, the VEC, regional consultants, PIAs and the national consultant).

During the course of the technical assistance, the Bank team met regularly and briefed senior representatives from the MNRE and several other key government (Planning Commission, IREDA) and donor (IFC, UNDP, SDC) agencies that were already engaged (or plan to engage) in similar activities on rural energy service delivery and had an interest in VESP outcomes. Consistently throughout these discussions, the mission noted that the policy circles recognized the ambitious guidelines governing VESP operations and associated challenges in developing successful projects. They echoed that sustainable financial models are difficult to achieve in community-driven VESP models without cluster-based settings and entrepreneur-led approaches for service delivery. There is now a growing acceptance within the MNRE to consider decentralized approaches in villages that have grid connectivity, as a prerequisite for success.

In conclusion, the recipient-executed technical assistance has improved the performance of the VESP in specific instances and provided an opportunity to gain insights into barriers and constraints faced by DDG energy programs.

Annex2: Power Generation Technologies in the Village Energy Security Programme

Biomass gasification based power plant[24]

It consists of the following components:

- Biomass gasifier
- Sub-systems of biomass gasifier
- Producer gas engine generator

BIOMASS GASIFIER

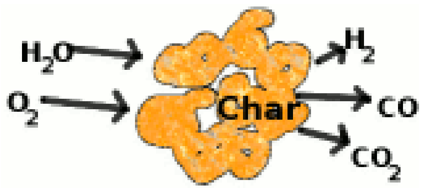
Definition

Biomass is any organic material, which contains molecules of hydrogen, carbon and oxygen.

Biomass gasifier is a reactor that produces a gaseous fuel from solid biomass through partial combustion.

Working Principle

Gasification is a process, which converts any carbonaceous material (like biomass) into carbon monoxide (CO) and hydrogen (H_2) at high temperature with a controlled supply of oxygen and / or steam.



The *gasification* process occurs as the char reacts with carbon dioxide and steam to produce carbon monoxide and hydrogen, via the reaction

$$C + H_2O \dashrightarrow H_2 + CO$$

The resulting gaseous mixture called producer gas or syngas is itself a fuel.

Salient Features

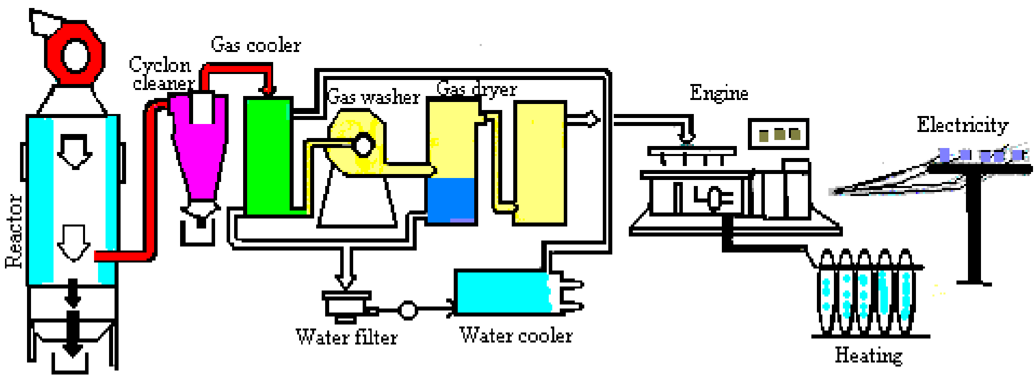
- Gasification is a very efficient method for extracting energy from many different types of organic materials. It converts about 75% of solid fuel energy content into a combustible gas (producer gas) that can be used as fuel for the internal combustion engine.
- The reaction takes place at high temperatures (> 700°C) with a controlled amount of oxygen (partial combustion) and / or steam.
- This gas requires elaborate cleaning as well as cooling before it goes into the engine as it is produced at a high temperature of 700°C–800°C. and also contains solid particulates and tars (black sticky substance).
- It is a low energy intensity gas — approximately 900 Kcals/nm^3 to 1100 Kcals/nm^3
- 1.5 kg of biomass can generate 2 nm^3 of producer gas
- 2 nm^3 of producer gas can generate 1 unit of energy (1 kWh)

[24] Reproduced from VESP Training Manual prepared by Winrock International India under the recipient-executed technical assistance grant support of the World Bank for VESP.

Technical Specifications

Model	WBG-20 in scrubbed, clean gas mode
Mode	Gas power pack model GAS-11 giving a gross output of 11 KWe in 100% producer gas mode
Gas flow	50 nm^3 / hour
Gasifier type	Downdraft
Average gas calorific value	1000 Kcals/nm^3
Gasification temperature	1050°C – 1100°C
Fuel storage capacity	150 kg
Ash removal	Manual, dry ash discharge
Start-up	Through scrubber pump
Fuel type and size	Wood / woody waste with maximum dimension not exceeding 25 mm
Permissible moisture content in biomass	Less than 20% (wet basis)
Biomass charging	On-line batch mode, by topping up once every one hour
Rated hourly consumption	13–15 kg
Rated hourly ash discharge	5–6 %
Typical conversion efficiency	> 75 %
Typical gas composition	CO : 19$\pm$3% H_2 : 18$\pm$2% CO_2 : 10$\pm$3% CH_4 : up to 3% N_2 : 50%
Biomass drying system	Based on hot engine exhaust, output = 20 kg/hr of wood pieces approximately 25 x 25 mm size

SUBSYSTEMS OF BIOMASS GASIFIER

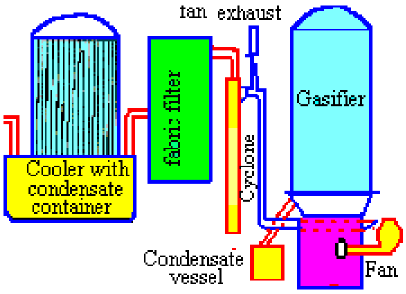


Gas conditioning

A. Gas cleaning

- The gas generated by the gasifier is unclean. It is loaded with tars, soot and ash particles.
- Trouble free operation of an internal combustion engine requires a fairly clean gas.

- The major problem in producing an engine quality gas is that of dust and tar removal.



Fabric filter cleaning system

- The amount of dust that is present in the producer gas at the outlet of the gasifier depends on the design of the equipment, the load of the gasifier and the type of fuel used.
- The amount of dust present in the gas per m^3 generally increases with the gasifier load, because higher loads give rise to higher gas velocities and more dust dragging.
- Hardwoods generally generate less dust than softwoods. Maize cob gasification leads to severe dust contamination.

Gas cleaning and cooling for the gasifier system is accomplished by a gas cooler with some scrubbing action and a packed bed filter.

Scrubber / fine filter

A packing bed wet scrubber is used to remove pollutants and solid particles in the gas while cooling the gas at same time. The scrubber consists of packing, liquid, support grates and distributors plates. Packing is made from a wide range of materials — wool, wood chips, coke, gravel, etc. Gas is passed through the bottom and removed from the top.

Safety filter

This is a fabric filter which is one of the most suitable filters for electrical application. It is placed immediately after the scrubber / fine filter. Woven glasswool filter bags withstand a gas temperature up to 300°C. It is recommended that the gas flow rate throughout the filter box does not exceed 65 m^3/h. Pressure loss over filter is affected by the load and the amount of dust in the producer gas.

B. Gas cooling

- Gas cooling mainly serves to increase the density of the gas to maximize the amount of combustible gas entering the cylinder of the engine at each stroke.
- A 10% temperature reduction of the gas increases the maximum output of the engine by almost 2%.
- Cooling also contributes to gas cleaning and makes it possible to avoid condensation of the moisture in the gas after it is mixed with air before the engine intake.

- A 12 Volt DC centrifugal pump (shown beside) is used to pump water into the scrubber to cool the gas. The unclean water is drained into a sump located outside the DG shed.

Wood dryer

Hot exhaust from the engine is diverted at the bottom of a bucket that holds wood pieces. The hot exhaust passes through the wood pieces and dries them. The capacity of the rectangular bucket is about 12 kg and 30% of wetness can be dried to 15–20% in about 10–15 minutes when the engine is running. Wood pieces must not be left for long in the drying system as they will start pyrolysing and may start burning. This is because the engine exhaust temperature can be 250°C at the bottom of the bucket. Hand gloves are provided to handle the bucket, as if it will be hot. The exit of exhaust is kept above six feet so that is does not harm the operator. The exhaust pipe from engine to drying system is provided with an asbestos sheet covered heat shield on two sides to avoid harm to operator by accidental contact with the pipe.

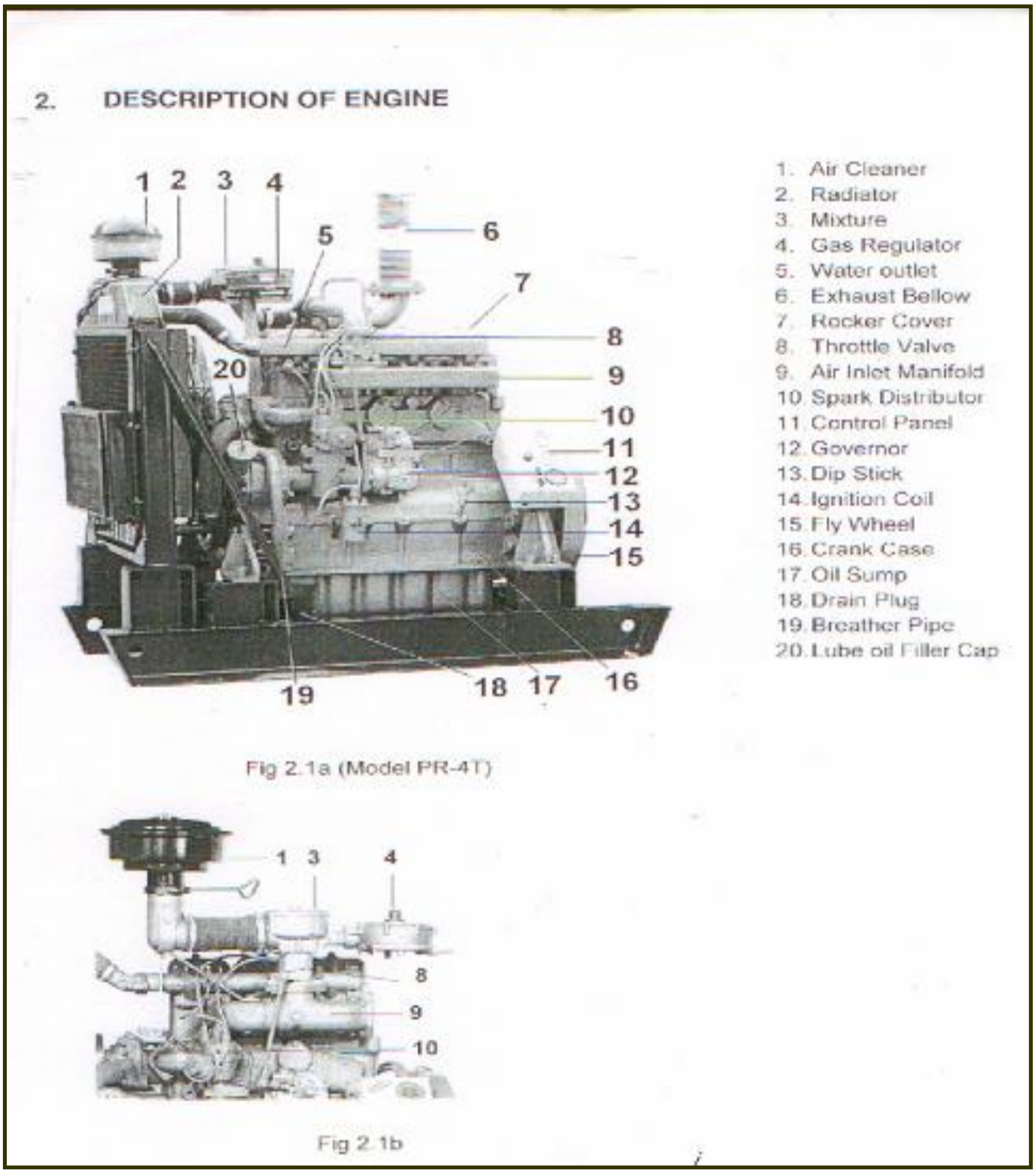
Wood cutter

A wood cutter operating with a half horsepower, single-phase motor is provided to produce wood pieces of 25 x 25 mm size, conveniently. The sawdust during cutting is directed in a different direction and the cut pieces fall separately down a chute. The cutter is hand operated and has a nearly balanced movement to obtain a stress-free operation. It is recommended that the cutter is operated when the engine generator is running in the day on pump alone or when the generator is not fully loaded. The 6” dia-carbide tipped cutter blade can last for 1–2 years if used properly without giving severe jerks during the cutting process. The cutter output is approximately 40 kg/hr.

Producer gas engine and generator

Producer gas generated by the biomass gasifier is used as fuel to drive producer gas engines which are basically spark ignition engines.

A. Parts of the engine

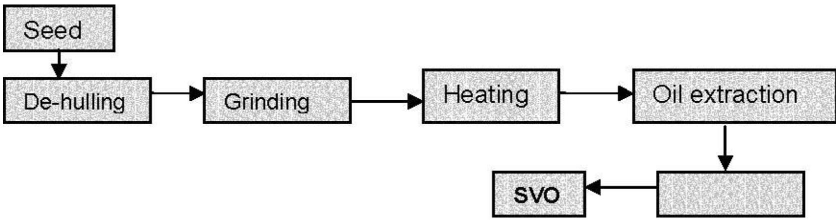


B. Technical specifications

ENGINE SYSTEM	
Description	“PRAKASH” MAKE ,Sr. No. 70308 Twin cylinder, 1500 rpm, 20 kW/BHP (nominal as diesel engine). Water cooled, fitted with spark ignition and governor controlled as butterfly with electric and handle start.
ELECTRIC GENERATOR	
Description	“PRAKASH” MAKE ,Sr. No. 70303 P. NO. ACT 4006A Directly coupled to engine, 1500 rpm, 415 V, 3-phase, 50 Hz, 15 KVA Alternator, self regulated exciter, including battery charger DC output at 12-V.
VIBRATOR MOTOR“ELCEN” MAKE Sr. No. 49718	
HP	0.12
RPM	1370
Full load Current	0.5 Amp
Voltage	415
Vibrator weight	150 g maximum on both sides.
Frequency	50 Hz
COMB ROTORSINGLE Φ, AC SYNCHRONOUS MOTOR	
Torque	40 Kg cm
Voltage	240
Full load Current	1.0 Amp
Frequency	50 Hz
GEAR BOX(COMB ROTOR)“ SHANTH” MAKE , SA 200 Sr.No.7325	
Ratio	60:1
SCRUBBER PUMP“ROTOMAC” MAKE, Sr. No. P 110207 D.C CENTRIFUGAL PUMP	
Voltage	12
MOTOR (WOOD CUTTER)MODEL CTC 150 Sr. No. GCAM 9648	
HP	0.5
RPM	2800

Straight vegetable oil (SVO) based power plant

Figure: Production process for SVO



The SVO referred to as neat vegetable oils are derived from oil seeds either edible or non-edible seeds oil and can be directly used in the diesel engines. SVO engines are a clean, effective and economical option. The project will comprise of installation of SVO engines for power generation in the capacity range of 10 HP systems. The fuel for the engines will be based on collection of naturally occurring non-edible oilseeds from the forests near to the project or from the seeds harvested from the plantations to be undertaken as part of the project. The sequence of operations employed for the production of SVOs is shown in the figure above.

Various technologies are used for oil extraction. Mechanical oil extraction is the most common technology in use for extracting non-edible oils. The typical recovery efficiency of good expellers is 80–85% of the oil content in the seed. Mechanical crushing is preferred for smaller plants because it requires a smaller investment. Typically plants that process less than 100,000 kg/day (100 TPD) use mechanical crushing and plants that process more than 300,000 kg/day (300 TPD) use solvent extraction. The main problems by using vegetable oil as engine fuel are associated mainly with its high viscosity and high flash point. The high viscosity interferes with the fuel-injection process in the engine, leading to poor atomization of fuel and inefficient combustion. Oil carrying pipeline is wound around the engine exhaust pipe to preheat the oil before supplying it to the injector. This is done to reduce the viscosity by increasing the oil temperature; at 1100°C viscosity of jatropha oil reduces below 8.0 cSt in the range of diesel fuel (2.5 to 7.0 cSt) as specified by the BIS. Engine operation can also be made smooth and long-lasting by using the two-tank SVO systems.

In India, many diesel engine suppliers, modify and supply engines to run on SVO for decentralized power generation. Low-speed engines (600–1000 rpm) are more suitable with lesser maintenance problems compared to the normal 1500 rpm diesel engine.

Annex 3: Background Data of Short-listed Village Energy Security Programme Projects

Village	Dicholi	Bhalupani	Rapta	Mokhyachapada	Kanjala	Mahisiakada	Mankidiatala	Siunni	Kudrichigar	Jambupani	Ranidehra
Date of visit for collecting this data	16-Apr-09	20-Jun-09	13-Apr-09	19-Mar-09	15-Apr-09	09-Apr-09	20-Jun-09	09-Apr-09	14-Apr-09	4-Apr-09	31-Mar-09
Background information											
Location	GP-Dicholi, Block -Patan, District -Satara, State - Maharashtra	GP- Dhalbani, Block- Joshipur, Dist. Mayurbhanj, State-Orissa	GP- Nakia, Block & District Korba, State - Chattisgarh	GP-Kaulale, Jawahar Taluk, Thane district, State-Maharashtra	Kanjala, Sahada, Nandurbar, Maharashtra	GP- Bandhamunda , Block- Ranpur, Dist.Khurda, State-Orissa	Borigumma Block, Koraput District, State - Orissa	Block - Umerkote Dist - Nabrangpur, State - Orissa	GP- Nakia, Block & District Korba, Chhattisgarh	GP- Jambupani, Block & District Burahanpur, Madhya Pradesh	GP- Bairakh, Block Bodla, District Kabirdham, Chhattisgarh
Implementing agency	Shramjeevi Janta Sahayak Mandal	SAMBANDH	Earlier - State Forest Department, Now CREDA	Pragati Pratishthan	BAIF	READ Foundation	State Forest Department	Gramodaya	Erstwhile - Forest Department, Now CREDA	TERI	WII
No. of Households	85	50	56	52 (80 households at the time of DPR, of which 30 belonged to a hamlet which has since been electrified has since been electrified	90	85	84	141	75	107	128

Annex 4: Technical Performance Data of Short-listed Village Energy Security Programme Projects

Sl. No.	1	2	3	4	5	6	7	8	9	10	11
Village	**Dicholi**	**Bhalupani**	**Rapta**	**Mokhyachapada**	**Kanjala**	**Mahisiakada**	**Mankidiatala**	**Siunni**	**Kudrichigar**	**Jambupani**	**Ranidehra**
Date of visit for collecting this data	16-Apr-09	20-Jun-09	13-Apr-09	19-Mar-09	15-Apr-09	09-Apr-09	20-Jun-09	09-Apr-09	14-Apr-09	4-Apr-09	31-Mar-09
Technical Performance											
Power generation technology and specs	1x10kW Ankur Gasifier	Biomass gasifier 1 x 10 kW	2x10kW Aruna Gasifier	1x10hP (7.5kW) biofuel engine of Field Marshall make, 1000rpm, alternator of Field Marshall make, 1500rpm. One Oil Expeller with Filter Press, 50kg/hr, One Shell Decorticator and one Baby Boiler	1x 7.5kW FM Bio fuel Eng.	1x10kW Ankur Gasifier 1 x 10 kW Biofuel Engine	Biomass gasifier2 x 10 kW	Biomass gasifier 2 x 10 kW	1x10kW Aruna Gasifier	2x10kWTERI Gasifier	3*6 HP and 1*10 HP Biofuel Engine
Status of implementation	1x10kW Gasifier is installed and commissioned.	Installed and commissioned .	1x10 kW installed	Installed. Filter press and baby boiler is not being used	Implemented August 2008	1x10kW Gasifier is installed and commissioned. 1 x 10 kW Biofuel engine is not commissioned.	Installed and commissioned.	Installed and commissioned .	1x10 kW installed	2x10kW Installed and commissioned . Only one is in use. Other one is kept as standby	Installed and commissioned
Status of working	Working, run by local youth.	Working. Run by local operator	Working, run by local operator with support from CREDA supported mechanics and electricians	Working, run by local operator. Stopped at the time of visit due to non-technical reasons	Run by VEC President	Working.	Working. Only 1x 10kW Gasifier is in use, the other is on standby or under repairs	Working. Only 1 x 10kW Gasifier is in use, the other is on standby or under repairs	Working, run by local operator	Working, run by local operator	Working, run by local operator under the supervision of WII

Sl. No.	1	2	3	4	5	6	7	8	9	10	11
Village	**Dicholi**	**Bhalupani**	**Rapta**	**Mokhyachapada**	**Kanjala**	**Mahisiakada**	**Mankidiatala**	**Siunni**	**Kudrichigar**	**Jambupani**	**Ranidehra**
Date of visit for collecting this data	16-Apr-09	20-Jun-09	13-Apr-09	19-Mar-09	15-Apr-09	09-Apr-09	20-Jun-09	09-Apr-09	14-Apr-09	4-Apr-09	31-Mar-09
Estimated connected load kW	7.8	2 kW domestic + 4 kW commercial	7	4	6	6	7	8	5.4	7.2	2.68
Load factor in %	78	60	70	53	80	60	70	80	54	72	54
Capacity Utilization Factor in %	10	14	12	9	13	10	12	13	9	12	7
Running since	May-08	14-Nov-07	Dec-08	Mar-08	Aug-08	Apr-07	14-Nov-07	14-Nov-07	-	-	-[25]
Energy meter reading	4235	4437	615	No Energy meter has been installed	No energy meter Installed		3801	3400	552	3959	2552
Estimated power supplied/day in kWh	23.40	34.00	28.00	~4.0kW @ 80 W/household for 50 households	24	24	28	32	21.6	28.8	10.72
Uptime	50%	24%	37%	80% during the period April 2008-November 2008. At the time of visit in March 2009, it was not being operated since users were not willing to pay and were awaiting the extension of grid	23.00%	28.00%	28.28%	22.14%	28.40%	26.95%	39.68%

[25] To be added later

Annex 5: Biomass Supply and Management in Short-listed Village Energy Security Programme Projects

Sl. No.	1	2	3	4	5	6	7	8	9	10	11
Village	**Dicholi**	**Bhalupani**	**Rapta**	**Mokhyachapada**	**Kanjala**	**Mahisiakada**	**Mankidiatala**	**Siunni**	**Kudrichigar**	**Jambupani**	**Ranidehra**
Date of visit for collecting this data	16-Apr-09	20-Jun-09	13-Apr-09	19-Mar-09	15th April	09-Apr-09	20-Jun-09	09-Apr-09	14-Apr-09	4-Apr-09	31-Mar-09
Biomass Supply & Management											
Status of Plantations	10 hectares plantation of Subabul, washed away due to heavy rain.	5 hectares of Simarouba plantation. Well maintained. Attained 3 to 5 ft. height. Planted in 2006	10 hectares plantation of Subabool was carried out by Forest Department, Mortality quite high, proposed to be replanted during June-July	25000 jatropha planted of which nearly 80% have survived. Expected to be harvested in 2010. Well cared for plantations	10 hectares of Mahua and Pongamia	10 hectares of Simarouba, First plantation was done in the month of August-2006 and Gap filling was done in the month of Nov-2007		10 hectares of Acacia, maha neem and chakunda - attained a height of 13 to 14 ft.	10 hectares Plantation of Subabool was carried out by Forest Department, Mortality quite high, proposed to be replanted during June-July	10 hectares Plantation of Subabool is being carried out by Forest Committee	Ok
Fuel supply arrangement and performance	Being a forest area, current supply arranged by each household and operator from the nearby forest.	No supply problems. Well organized	Available in Plenty. Presently supplied by villagers. Satisfactory till date	Jatropha and pongamia seeds are being procured from outside the project area. This is proving costly as well lack of adequate stocks has meant that plant is being operated only for 1-2 hours per day as against the planned 6 hours per day	Fuel supply are not sufficient run in mixture with kerosene	Not organized, but available in plenty. Village is surrounded by forest.	Wood supply mechanism ed.	Wood supply mechanism ed.	Available in Plenty. Presently supply from forest department	Available but not organized	Partially supplied by villagers and partially from local market

Annex 6: Financial Performance of Short-listed Village Energy Security Programme Projects

Sl. No.	1	2	3	4	5	6	7	8	9	10	11
Village	**Dicholi**	**Bhalupani**	**Rapta**	**Mokhyachapada**	**Kanjala**	**Mahisiakada**	**Mankidiatala**	**Siunni**	**Kudrichigar**	**Jambupani**	**Ranidehra**
Date of visit for collecting this data	16-Apr-09	20-Jun-09	13-Apr-09	19-Mar-09	15-Apr-09	09-Apr-09	20-Jun-09	09-Apr-09	14-Apr-09	4-Apr-09	31-Mar-09
Financial Performance											
Units consumed/month/HH	8.26	6.00	12.00	4.62	8.0	8.5	10.0	6.8	8.6	8.1	2.5
LUCE as per TERI report at existing operating conditions in Rs/kWh	8.88	6.49	7.59	21.00	21	8.68	9.15	8.13	9.54	7.40	21
Amount to be charged as per LUCE/month/HH	73.33	38.93	91.02	96.92	168	74	92	55	82	60	53
Willingness to pay Rs/month/ households	50.00	45.00	60.00	30	50	35	25	50	60	50	60
Difference between willingness to pay and LUCE in Rs / households/month	-23.33	6.07	-31.02	-66.92	-118	-39	-67	-5	-22	-10	7
Amount needed/year to bridge the viability gap for the project	-23,801.14	3,642.78	-20,848.28	-41,760.00	-127440	-39318	-67072	-9115	-20152	-12549	11117

Annex 7: TERI's approach to LUCE

LUCE = [Levelized (operations and maintenance) + Levelized (capital)]/ Levelized (Electricity generation)

Where,

Levelized (O&M) is the present value of annual maintenance costs (including interest payment, if applicable);

Levelized (capital) is the present value of all capital expenditures;

Levelized (electricity generation) is the present value of electricity generation over the life of the system.

LUCE has been estimated for various possible cases considering input parameters and information gathered from existing Programme projects. The key technical, operational and financial parameters and assumptions considered for estimating the LUCE for all possible cases are presented below[26].

Technical parameters

- Plant load factor (PLF)
- Capacity utilization factor (CUF) of energy production system engines
- Specific fuel consumption (SFC)
- Useful life of the energy production system

Input parameters	Unit	VESP Guidelines (Released during 2004)	Adequacy assessment (Conducted during 2008-09)		
Biomass energy technology		Biomass gasifier	Biomass gasifier		SVO engine
Rated Capacity	kW	18 (2x9)	10	20	10
Life of gasifier system/SVO system	Years	10	10	10	10
Plant Load Factor	%	80	40	40	40
Hours of operation per annum	hours	10	4	4	4
Distribution line network (average)	km	2	2	2	2
SFC	kg/kWh	1.5	2.0	2.0	0.35
Auxiliary consumption	%	NA	10	10	5

Note: SFC for SVO engines is in litre/kWh

Financial parameters

- Price of biomass feedstock and oil seeds
- Capital cost of energy production systems
- Operation and maintenance cost of gasifier systems

[26] This note is based on TERI's report titled "Economic & Financial Analysis Report", April 2009, Project No. 2007BE07

- Maintenance cost of engine generators
- Subsidy provided by the MNRE under the VESP
- Debt repayment period
- Debt/equity, interest rate and discount rate

Particulars	Unit	VESP Guidelines (Released during 2004)	Adequacy assessment (Current prices)		
Biomass energy technology		Gasifier	Gasifier		Bio fuel
System Capacity	KW	2x9	10	20	10
System Cost	Rs	7.5	7.75	15.5	3.75
Civil Shed	Rs	1	1	2	1
Cost of laying PDN	Rs/km	1	1.5	1.5	1.5
Interest rate	%	3	11.25	11.25	11.25
Escalation in O&M	%	NA	5	5	5
Escalation in fuel cost	%	NA	5	5	5
Discount rate	%	3	12	12	12

Based on these parameters the LUCE for the various scenarios for biomass gasifiers and SVO based power plants are as follows:

Biomass gasifier based power system

Possible Scenarios	Levelized total expenses (Rs/annum)		Annual Electricity sold (kWh)		LUCE Rs/kWh	
	10 kW	20 kW	10 kW	20 kW	10kW	20 kW
With subsidy at 5% CUF (30% PLF, 4 hrs of operation)	475676	587908	22273	44546	21.36	13.20
With subsidy at 7% CUF (40% PLF, 4 hrs of operation)	495513	627582	29,698	59,935	16.69	10.57
With subsidy at 13% CUF (40% PLF, 7.8 hrs of operation)	570893	778341	57,910	115821	9.86	6.72
With subsidy at 20% CUF (80% PLF, 6 hrs of operation)	654207	944970	89,093	178,185	7.34	5.30
With subsidy at 25% CUF (80% PLF, 7.5 hrs of operation)	713718	1063990	111,366	222,732	6.41	4.78
With subsidy at 33% CUF (80% PLF, 9.9 hrs of operation)	812902	1254424	148,488	294006	**5.50**	**4.27**

SVO based power system

Possible Scenarios	Levelized total expenses (Rs)	Electricity sold (kWh)	LUCE Rs/kWh
	10 kW	10 kW	10kW
Without subsidy at 33% CUF (80% PLF, 9.9 hrs of operation)	2920404	155170	18.7
With subsidy at 7% CUF (40% PLF, 4 hrs of operation)	670375	31347	21.3
With subsidy at 13% CUF (40% PLF, 7.8 hrs of operation)	953049	61127	15.6
With subsidy at 20% CUF (80% PLF, 6 hrs of operation)	1265479	94042	13.4
With subsidy at 25% CUF (80% PLF, 7.5 hrs of operation)	1488643	117552	12.6
With subsidy at 33% CUF (80% PLF, 9.9 hrs of operation)	1845705	155169	**11.9**

Annex 8: Impact of Load and Capacity Utilization Factor on LUCE

The key factors that affect the LUCE are the capacity utilization factor (CUF), the specific fuel consumption (SFC) and the price of biomass. The CUF itself is dependent on the load factor and the hours of operation/day.

The load factor and the CUF have a significant impact on the LUCE (see following table).

Factor	Scenario 1	Scenario 2	Scenario 3
Load factor %	80	80	40
Hours of operation	10	5	10
CUF %	33.33	16.67	16.67
SFC kg/kWh	1.5	1.5	2
Salary Rs/month	3000	2000	3000
LUCE Rs/kWh	4.86	6.61	8.38

A comparison of Scenarios 1 and 2 shows that although the load factors are the same, since the hours of operation was higher in Scenario 1 the LUCE was also lower. This is because the capital and the fixed operating costs, such as salaries, are spread over a higher number of units of power generated in Scenario 1 compared to Scenario 2.

However, to ascertain it is the CUF that determines the LUCE, a comparison of Scenarios 2 and 3 are required. The comparison revealed that even though the CUF was similar (16.67%), the LUCE was lower in Scenario 2. This is due to the higher load factor leading to better operating conditions for the engine resulting in a lower SFC. Further, since the plant is operated for lesser duration at higher loads in Scenario 2, the salary cost is lower, while the number of units generated is the same in both the cases.

Thus, not only does the CUF but also the load factor and the number of hours of operation at that load that actually determine the LUCE. Therefore, for a given load, it is better to load the power plant optimally and run the plant for shorter periods than to split the load and run the plant sub-optimally for longer periods.

Annex 9: Experience with DDG Projects in India

Decentralized Energy Systems India (DESI) Power

DESI Power is a no profit-to-the-promoters company formed jointly by Development Alternatives and DASAG. It supplies electricity and energy services through setting up of Independent Rural Power Producers (IRPP) for villages and semi-urban areas. *The power plant is integrated with energy services and with a number of micro enterprises, largely engaged in agro-processing work.* To ensure that both the power plant and the village organization become self-reliant and profitable within a reasonable time, the business plans of the IRPP and the village organization (which may be the village panchayat, a company, a cooperative, or an NGO) are evolved jointly and simultaneously.

One of the first successful projects implemented by DESI Power is at Baharbari in Bihar. DESI Power facilitated the formation of a local cooperative and jointly implemented rural electricity related activities in these villages. Whereas DESI Power is the IRPP, the local partner arranges biomass, distributes the power and collects the bill from the consumers. Local women's groups are encouraged and supported to take charge of the decentralized energy service activities, such as cooking and lighting for households. A mutually beneficial partnership was created under which reliable power supply and rural energy services ensured local income generation, while the assured off-take of power and energy services ensured profitable operation of IRPP.

The success of the model in Baharbari village prompted DESI Power to launch the Employment and Power partnership (EmPP) program targeting villages in Aarariya district of Bihar, where diesel gensets have been providing power. The EmPP program was initiated in Gayari village with the commissioning of two 75 kWe biomass gasifier based power plants. The village is located about 2 km from Aararia town and is also the peri-urban industrial zone of the town. A company called DESI Power Kosi (DPK) Pvt. Ltd was formed a under the aegis of DESI Power to run the power plant and supply power to micro industries and for irrigation and lighting. The GRID (Group of Rural Industry Developers) cooperative, with nine entrepreneurs and six farmers, was set up and the members of the cooperative were granted use of the electricity generated.

The finance of the projects under the EmPP program are being arranged through equity participation by stakeholders and social entrepreneurs, debt from banks (such as ICICI Bank) and sale of CERs in the voluntary market. The typical investment needs for one village is about Rs 8 million as reported by DESI Power, of which the power plant (70 kWe) cost is about Rs 3.9 million; cost of promotion of small and micro-enterprises, local distribution, lighting, energy and water services and bio businesses is about Rs 3.3 million and the balance sum is spent on capacity building, training and support services. The return on equity for the first three years is usually nil, for next the five years it is about 5–10%, and thereafter (after repayment of the loan) it is 15–20%. The IRR is in the range of 10–15%, as reported by DESI Power.

Experiences and Key Lessons

Viable commercial model of rural electrification

The biomass gasifier projects at Gayari and Baharbari represent viable (or close to) commercial models of rural electrification. The pricing of electricity at Rs 4.50–5.50 per kWh is positioned above the price for that from grid power but below the diesel generated electricity. DESI Power's emphasis on multiple micro-enterprises and sale of power to these enterprises instead of the village community ensures a high PLF and mitigates the risk to achieve financial sustainability.

Fuel supply linkages through agreements with local self-help groups

Proper biomass fuel management through fuel supply agreements with local self-help groups proved to be one of the most critical factors in making the project successful. The fuel supply arrangement entered at a pre-determined price not only ensured regular fuel, achieving higher uptime, but also created a market for the otherwise waste biomass fuel.

Local capacity development ensured better project performance

The project at Bahabari and Gayari demonstrated the effectiveness of training of local people to operate, repair and service the power systems. The development of local capacity through DESI Mantra (Management Training) reduced the dependence on outside expertise and is now facilitating project replication with minimal ongoing outside support.

Divided ownership model ensured better project sustainability

The divided ownership model between the implementing agency and the cooperative is also one of the key success factors. Whereas, DESI Power concentrated on: power plant operation and maintenance; bill collection; connecting new customers; and determining whether plant operations are being carried out by the local cooperative.

Off-grid projects in the Sunderbans

WBREDA developed a local mini-grid (both 11 kV and LT) depending on the capacity and evacuation of power from the power plant. To maximize the load and PLF, the plant is established close to the load center and a 2–4 km mini-grid is established in the area for supply. The mini-grids are managed by cooperative societies formed by the local people (see figure below), whereas WBREDA, through a system operator, is responsible for power plant operation. The responsibilities of the societies includes selection of consumers, planning for the distribution networks, tariff setting in consultation with WBREDA, revenue collection from consumers and passing them on to WBREDA and consumer grievance redressal. With the capital cost of the system being subsidized to a large extent, the tariff takes into account the operation and maintenance of the systems. The revenue collected from the consumers covers all operational costs and about 20% of the capital costs.

Experiences and Key Lessons

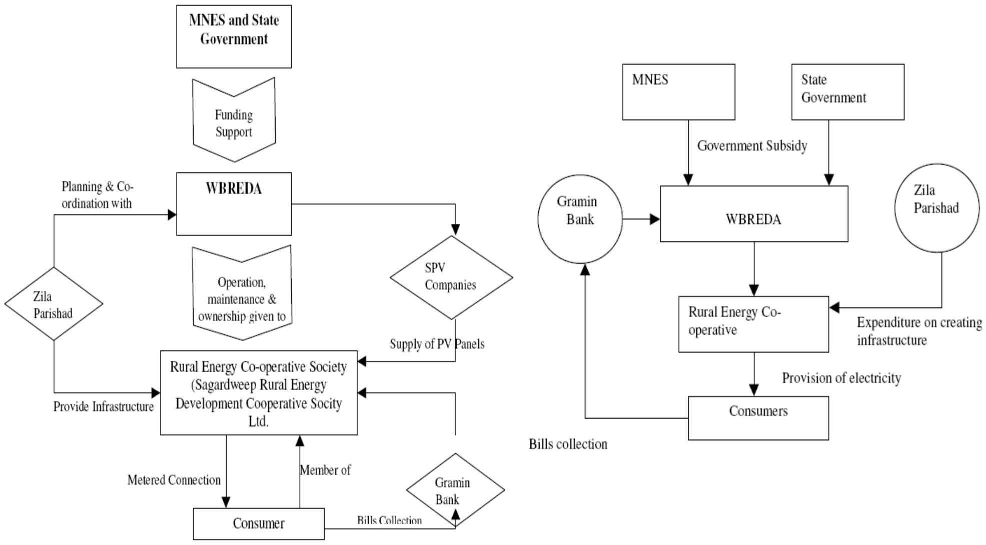
Supply of quality power ensured better willingness to pay

Regular and reliable grid quality power from the projects is supplied to the consumers for 6–8 hours. This resulted in a positive response from the consumers which in turn increased their willingness to pay.

Proper tariff setting ensured better payment records

Another key reason for the success of the off-grid power projects is appropriate tariff setting in line with the existing diesel generation tariff and willingness to pay of the consumers. Whereas the tariff for the SPIV power plant are is Rs. 2.5–3.75/kWh, the biomass power project in Osaka Island charges Rs 3.25/kWh to domestic users and Rs 3.75/kWh to commercial consumers. On the other hand, private diesel operators supplying electricity mainly to the markets charge Rs 6–8 per day (4–5 hours in the evenings) for 100 W bulbs.

Figure: The Sunderbans Institutional and financial Model (Source: WBREDA)



Irregular supply of biomass hampers power generation in the Gosaba biomass gasifier project

Fuel supply remains a major issue for the biomass gasifier project in Gosaba Island. Although a 75 ha energy plantation has been raised to ensure a consistent supply, there is a deficit in the supply and demand of woody biomass, which sometimes restricts the power generation.

Biomass Energy for Rural India

The Biomass Energy for Rural India (BERI) is an initiative of the UNDP/GEF, ICEF, GoI and the Karnataka government that was implemented in a cluster of 29 villages in Tucker district of Karnataka. The project seeks to provide the unnerved and poorly served households with quality rural energy services and envisages developing technical, institutional and financial mechanisms to overcome barriers for large-scale adoption and commercialization of bio-energy technology packages.

A 500 kWe gasifier power plant unit (1 x 200 kW and 3 x 100 KW) was installed in Kabbigere village and commissioned in January 2006. Though the BERI manages the overall project, the power plant is managed by a *Village Samithi*, formed as a sub-committee of the Village Panchayat. The generated power is fed to the 11 kV grid of BESCOM (Bangalore Electricity Supply Company) for which BERI and BESCOM have signed a power purchase agreement with feed in tariff @ Rs 2.85/kWh. The capital cost of the power plant is being borne by BERI. The approximate generation cost is Rs 7.76/kWh. The power fed to the grid is distributed among the local households by BESCOM as per the hours of service governed by the norms of the BESCOM. The consumers pay the prevalent tariff accorded to rural homes directly to the BESCOM in Karnataka.

To ensure a sustainable supply of biomass for the project, fuel linkages were made an integral part through biomass development on the degraded forestland and community land involving village forest communities with the help of the state's forest department. The gasifier plant is operated with biomass obtained from both farmland and energy plantations created in the project villages. However, the supply is not sufficient and at times, biomass is also procured from neighboring non-project villages at a higher price.

Experiences and Key Lessons

The experiences and lessons from the BERI project could be summed up as follows:

Grid connection reduced the revenue risk from consumers

The project envisaged selling electricity directly to the consumers. However, the net electricity generated is now fed to the distribution grid of BESCOM to minimize the perceived risk of lower revenue collection from the consumers.

High maintenance requirement leading to frequent shutdowns

The power plant requires maintenance after every 100 hours of operation. This frequent maintenance results in shut down of the plant for 1–2 days every week. There are initial teething issues with the gasifier system, particularly related to the gas cleaning system and engine. In addition, the operation of the power plant also gets affected because of low reliability (because of such as regular fluctuations and outages) of the 11 kV line leading to plant shutdown.

Fuel supply linkages through involvement of the local community

The involvement of the community and formation of Village Biomass Energy Management Committees have made the plantations successful. This has not only ensured a sustainable supply of biomass for the gasifier plant but also enhanced the farmers' income through sale of fuelwood. However, in the absence of an organized network for fuel supply and remunerative pricing, the supply of biomass is sometimes hindered resulting in non-operation of the power plant.

High cost of operation of the power plant

The SFC is very high at 2.0 kg/kWh against the desired 1.3 kg/kWh. The specific maintenance cost is also high at Rs 0.8/kWh against the desired Rs 0.62/kWh. This is resulting in a high power generation costs (Rs 7.76/kWh).

Case study: Biomass Gasifier Powered Drinking Water Supply System — Odenthurai Panchayat

Introduction

This case study highlights a pioneering and highly successful biomass gasifier powered rural drinking water supply system that has been implemented in Odenthurai Panchayat in Coimbatore district of Tamil Nadu. This model focuses on a rural community, backed by the Panchayat, financing and managing a biomass gasifier powered drinking water supply system.

Drinking water – a major problem

Odenthurai comprising nine villages with its headquarters at Oomapalyam is a small panchayat near Mettupalayam at the foothills of the Nilgiris on the Coimbatore–Ooty road. Mr Shanmugam, a highly committed, motivated and progressive *Sarpanch*, has been heading it since 1996.

For a long time, the close to 400 families of Odenthurai had no access to a drinking water supply system at all. They used water from river Bhavani that flows through the Panchayat.

In 1998, the Panchayat requested the district administration for extending the protected water supply system that was serving Mettupalayam town. However, it was rejected on technical grounds since Odenthurai was on the northern bank of river Bhavani while the town was on its southern side.

Setting up a drinking water supply system

At this stage that the Panchayat became aware of the newly launched Rajiv Gandhi Drinking Water Mission. The Sarpanch with the support of the District Collector, galvanized the people into action.

On January 26, 2000 at a Grama Sabha meeting, a resolution was passed to approach the Mission for support. People also agreed to bear 10% of the capital costs as required under the Mission's scheme of funding.

In April 2000, Mr Shanmugam attended the First South Zone Conference of the Mission at Mangalore. Unlike other participants, he went armed with a detailed project proposal with a cost estimate of Rs 48 lakh, which included a water treatment plant, 12 km of pipeline, 2 overhead tanks of 30,000 liters, 1 overhead tank of 1 lakh liters capacity and 1 booster pumping station.

Odenthurai's proposal was accepted at the Conference itself and was held up as a model plan for others to emulate. In May 2000, the Rajiv Gandhi Desiya Kudineer Thitta Kudumbam (Rajiv Gandhi Local Drinking Water Management Committee) was formed with nine members comprising three Panchayat members, a retired teacher and other elected members. The Sarpanch was the ex-officio Chairman of the Committee. A separate bank account was opened to manage the finances of the water supply system.

The drinking water scheme was inaugurated on September 9, 2000. Of the Rs 48 lakh, the people of the village contributed Rs 4.8 lakh. In addition, each household paid Rs 1000–2000 as deposit for securing a drinking water connection in their homes. The households also agreed to pay Rs 30 per month as water supply charges.

Mounting electricity costs – a major problem

The electricity bill to pump nearly 2.5 lakh liters per day over a 12 km pipeline was very high. The Water Management Committee was paying nearly Rs 8,000 every month towards electricity bills alone of the Rs 12,000 collected every month. This meant that there was very little money to meet other expenses, leave alone capital expenses, such as for major repairs.

Setting up a biomass gasifier for power generation

At this stage, the District Rural Development Agency, Coimbatore and the Tamil Nadu Energy Development Agency approached panchayath all over Coimbatore district to put up biomass gasifiers for generating electricity to meet drinking water pumping needs. Mr Shanmugam, along with other Panchayat presidents visited Thanjavur and Trichy, where they saw a gasifier (dual fuel mode) for the first time. Following this, TEDA organized a workshop in the PSG College of Technology, Coimbatore, where all leading manufacturers of gasifiers demonstrated their systems. Mr. Shanmugam selected a system designed and supplied by Ankur Scientific Systems, Vadodara, Gujarat because "this was the only one in the range of 10 kW that was on demonstration. Moreover, this looked simple, while the one from IISc looked very complicated. For simple, people like us, I thought the Ankur system was the best.” He also visited Ankur at Vadodara for a detailed demonstration as well as training. Following this an order was placed with Ankur through the DRDA for a 9 kW biomass gasifier that produces electricity from a producer gas engine. With financial support of Rs 1.35 lakh from DADA and TEDA and with an investment of Rs 1.75 lakh from the Water Management Committee, the gasifier was installed and commissioned on January 4, 2004.

Engineers from Ankur trained local youth and women in operating and maintaining the system. The producer gas engine (DIPCO company make) that was supplied originally was soon replaced with one from Kirloskar, since it did not operate smoothly. Apart from this, the operators claim that they have had no major problems.

Today it powers a 3 hp centrifugal pump that is used to draw raw water from river Bhavani into the settling and treatment tanks and a 6 hp clear water pump that delivers bacteria-free water to 405 households over a 12 km pipeline network. Both these pumps work for about 13 hours every day.

The average downtime reported and recorded in the well-maintained logbook is about 2–3 days per month. Of this a few days are due to non-availability of dry wood during rainy months. Biomass is sourced from sawmills that dot the villages at an average price of Rs 0.80/kg. This is then cut further down to the required size on a star cutter at the gasifier center.

Economics

Capital costs

The total cost of setting up a 9 kW biomass gasifier for generating electricity for pumping drinking water in Odenthurai Panchayat is approximately Rs 500,000. Of this, Rs 135,000 came as a subsidy from the MNES through TEDA and DRDA. The balance amount of Rs 365,000 was provided by the Water Management Committee and the Panchayat. The capital cost included among other things:

- A biomass gasifier
- A producer gas generating set
- A shed for housing the equipment
- Control panels for evacuating the power generated
- A star wheel cutter for cutting wood into the appropriate size.

Operating cost

The table below gives details of cost of operating the biomass gasifier per hour:

Odenthurai - Operating cost of gasifier

Sl. No.	Parameter	Details
1	Biomass consumed/hr in kg	10
2	Cost /kg of biomass in Rs	0.8
3	Cost of biomass/hr in Rs (A)	8
4	Cost of labour/hr in Rs (B)	2
5	Maintenance cost/hr in Rs (C)	1
6	Cost of operating biomass gasifier/hr (D) = (A+B+C)	11

Net savings by using biomass gasifiers

The table below shows the net savings per month gained by Odenthurai panchayath by using biomass gasifiers instead of grid electricity:

Odenthurai gasifier net savings calculations

Sl. No.	Parameter	Details	Parameter	Details
	Grid electricity		Biomass gasifier	
1	Cost of grid electricity/unit in Rs	3.50	Cost of operating the biomass gasifier/hr	11
2	Units consumed/hr	7	Units produced/hr	7
3	Cost of grid electricity/hr in Rs	24.50	No. of hours of operations/day	12
4	No. of hours of operations/day	12	No. of days operated/month	30
5	No. of days operated/month	30	**Cost of operating the gasifier/month in Rs**	**3960**
6	**Cost of grid electricity/month in Rs**	**8820**		
7	***Net savings/month by using biomass gasifiers in Rs***		***4860***	

Capital cost and simple payback

The table below shows the simple payback calculations for the biomass gasifier at Odenthurai Panchayat with and without subsidy:

Simple payback calculations

Without subsidy		**With subsidy**
Parameter		
Capital cost of gasifier in Rs	500000	365000
Payback in months	102.9	75.1
Payback in years	**8.6**	**6.3**

Critical success factors

Commitment and dedication of Panchayat: The Odenthurai Panchayat adopted a problem solving approach. First, for solving the drinking water needs and second, by solving the problem faced by galloping energy costs of pumping drinking water. In both instances, it demonstrated a high degree of commitment and dedication to working for the betterment of the people of their Panchayat.

Choosing the right model of gasifier: The Odenthurai Panchayat with help from the DRDA, chose the model of the gasifier that met their needs and was simple enough to operate and maintain.

Choosing the right load: The biomass gasifier is being used to cater to loads that are regular and for a reasonable period of time ever day. This ensures efficient and trouble-free operations. Currently, it is only being used for 13 hours every day. The plant load factor can be improved by extending the use to the rest of the time, if appropriate loads can be identified. This would further reduce the payback period.

Training and aftersales support: Even before the gasifier was purchased by the Odenthurai Panchayat, key members were trained in operation and maintenance of the gasifier at Ankur's factory in Vadodara. This helped build confidence among the operators in the Panchayat. This also ensured that initial problems could be handled by the operators themselves. In addition, prompt aftersales service ensured that the downtime of the gasifier was low, building further confidence among the users. Where, the situation demanded, Ankur even replaced the producer gas engine to ensure that the system worked in a trouble-free manner.

Facilitation by DRDA: By conducting seminars, arranging for demonstrations and organizing visits to user and manufacturer sites, the DRDA, Coimbatore merely played the role of a facilitator and left it to the panchayats to decide suitable options for themselves. While this helped the panchayats to gain knowledge about new technologies, it also gave them the time and space to make their own decisions, which fostered ownership of the project among the panchayat members.

Contribution to capital costs: The DRDA offered only Rs 1.35 lakh of a total project cost of Rs 5lakh. The rest was mobilized by the panchayat. This needed concurrence from the general public and thus ensured that the public's stake was built into the project and thus it was not another "demonstration project". A strong commercial approach from the beginning helped in making the project and a commercial and managerial success.

Conclusion

The biomass-gasifier powered drinking water supply system at Odenthurai Panchayat demonstrates that biomass gasifiers are:

- technically reliable (small downtime/month)
- technically appropriate for rural areas (can be operated and maintained by local people with adequate training)
- commercially viable (reasonable payback period)
- managerially sustainable (local source of fuel wood, local operators, local management.