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DEVELOPMENT OF SMALL ESCOS TO UNDERTAKE BIOMASS GASIFICATION PROJECTS FOR INDUSTRIAL APPLICATIONS

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Executive Summary

‘Producer gas’ is produced through the process of gasification - an efficient method of extracting heat from biomass. Natural gas, diesel or furnace oil can be replaced by producer gas for making steam in order to generate electricity and heat for industries.

It is estimated that for each 100 kcal of potential energy in solid fuels, gasification can extract about 80 kcal in hot raw gas. The process is more efficient than many other devices that burn biomass directly in a hearth or firebox. Also, very little modifications are required in most conventional oil-fired installations to run on producer gas.

Potential users of low-calorific fuel-gas are found among ceramic, metal reheating, food processing and chemical drying units. Producer gas generators in several industrial plants may also substitute small steam boilers (non IBR) and thermic fluid heaters. Production of CO2 for aerated drinks is another application.

Implementation of gasifier-based systems in medium industries offers the possibility of increasing the efficiency of process-heat delivery. In some cases, biomass-based electricity may also allow the replacement of grid power or other existing fuels for electricity generation (individually or in clusters).

The study here assesses the applicability of the concept of small Energy Service Companies (ESCOs) for biomass gasifiers. It also evolves a mechanism to tap the concept as a tool, and propagate its extensive commercialization in India. It is based on CII‘s information base updated with selective literature survey, questionnaire survey, field visits and interactions with some of the stakeholders.

SWOT analysis

Strengths	1. Abundant biomass potential. 2. Severe energy problems faced by various industries, especially the Small and Medium-sized Enterprises (SMEs) 3. Biomass gasification has matured over the past 20 years due to efforts by involved stakeholders. 4. Favorable cost economics. 5. Substantive R&D efforts fructified in several installations. 6. Environmental advantage – carbon neutral. Positive environmental impact can be tapped for Certified Emission Reductions (CER) credits. 7. ESCO concept is not new in India. It is slowly evolving.

Weaknesses	1. Spreads sporadically. Massive efforts are needed for market development of reliable, safe and environmentally compatible solutions. 2. Manufacturers efforts are not enough. 3. Lack of branding by service providers in providing advisory services. 4. High transaction costs. 5. Consultancy activities are at the stage of infancy.
Opportunities	1. Large market size and contiguous locations, e.g., clusters. 2. This would pave way for consultancy markets for making efforts to improvise /optimize performance. 3. Outsourcing of the problem areas involves risks and professionals involvement.
Threats	1. Indian ESCOs are still to reach the take-off stage and generally prefer large clients in the organized sector. 2. May change over to non-biomass gasification route. 3. ESCO's efforts for a comprehensive solution and risk sharing are not well appreciated by the stakeholders. This calls for hard selling and an inventive mind to address the technical, legal, commercial issues.

A general notion is that for its proper application, a gasifier system needs constant supervision from the experts who developed it. The few demonstration systems run as showcases have the requisite support. There are several other systems 'acquired' at marginal or no cost by the user. In such cases they just wither off despite having been potentially viable.

The spoon-feeding has been somewhat less in systems sold on a commercial basis to industrial users. This could be attributed to user-training needs. It has been seen that over time, serious users learn to grapple with the various maintenance problems. Having paid for the system, and benefiting substantially from fuel savings, they have the incentive to do so.

On the other hand, there are users who have not been able to tackle all problems. This might also mean that the developers themselves have not resolved the issues conclusively. In such cases, the systems run on and off, with lower benefits.

A wholly different approach is a pro-business model. Here professional firms undertake the responsibility for ensuring best possible performance of the systems. They are paid on the basis of a performance contract. This is likely to transform the nature of business, manufacturing and research efforts.

In the present scenario, the program related to industrial applications of biomass gasifiers needs a boost. In order to accelerate the tempo of the on-going efforts, it is necessary to construct a framework for developing ESCOs.

ESCOs will provide various forms of energy services to the industrial users based on biomass gasification system by,

a) Managing physical and financial resources,
b) Successfully demonstrating operation and maintenance of the technology,
c) Proving its benefits and sharing technical and commercial risks out of the realized benefits.

These modalities would provide a win-win situation for the stakeholders, including the MNES and encourage entrepreneurs at local levels to implement biomass gasification projects.

Recommendations

1. The ESCO route is a logical step for propagating biomass gasification, covering small and medium enterprises in the semi-urban, moffusil and rural locations. There is no good understanding of ESCO in the market, especially in the medium segment where it can make some significant dent. End-users have more distrust and suspicion than it deserves. However, an ESCO is expected to participate with higher stakes, sharing financial and operational risks, in a result-oriented manner where benefits commensurate with performance.

2. The contract between the end user and ESCO will guarantee a certain level of monthly energy savings. If under normal circumstances, the savings fall short of the guaranteed amount, the ESCO may be required to compensate for the difference. Ideally, Guaranteed Energy Cost Savings Performance, which guarantees all or a major chunk of savings, is a preferable choice for the emerging ESCOs.

   It is generally the customer's responsibility to obtain a bank loan for the equipment's payment. However, sometimes the ESCO may also provide financing. For units unwilling to mobilize equity, the ESCO may consider operating lease or other financial instruments based on a suitable agreement. Another option provides for a portion of the cost of equipment and/services to be shared by the ESCO with the balance provided by the beneficiary unit.

3. A revenue-benefit-sharing model with negotiations between the stakeholders catering to the interests of all is the key. For payments to ESCOs by users, a reasonable strategy is to set the baseline on the same benchmarks as the existing system/practice. The project is expected to sustain on the basis of energy-cost savings. The revenue streams would take care of the interests of the stakeholders.

   A typical model is one where 10 per cent benefits over energy purchase costs are offered to the user on a recurring basis over the contract period; besides meeting all obligations regarding operation, maintenance, fuel supply, taxes, loan repayments including borrowings for equity, monitoring, audit, etc. out of accruals. At the end of the contract period, gains are computed and shared equitably between the user and the ESCO in a transparent manner. After the transfer period, the user receives the agreed benefits and is responsible for all obligations beyond the contract period.

4. Accruals from the ESCO projects would be utilized to meet loan repayments, working capital and risk coverage heads of expenditure. An escrow account has to be opened for this purpose. For high investment projects of more than five years duration, such as the ones greater than Rs 5 crores, benefits could be computed after clearing the equity borrowings. For example, if it is computed from the fourth year onwards, 30 per cent benefit is provided to

the user to retain their interests in the ESCO project over and above the receivables for future liability for loan repayment.

5. An important component of the program is the ability to accurately monitor the effectiveness of the energy efficient equipments to determine energy cost savings. The ESCO will prepare a contract guaranteeing the equipment's energy efficient performance and cost savings.

6. The MNES, instead of providing capital subsidy may support ESCO projects by:

   a. Supporting marketing. This may be linked to the release of 10 per cent of the cost of the project to the escrow account after successful negotiations of the project.

   b. Contributing to Biomass Gasifier Financing Risk Mitigation Fund. This fund can be used to refinance the banks for projects, which have failed and recovery is unlikely.

   c. Bearing the cost of induction training for the ESCO staff and other capacity building measures.

7. The MNES may nominate state nodal agencies (SNAs) to track the projects on a regular basis. SNAs would function as MNES's arm, linking it to the financial entity and the end user. It will provide feedback on the status of the contract between the stakeholders – its signing, breach and closure on a regular basis.

8. To start with, the MNES may support at least 10 ESCO projects. Based on lessons learnt from these projects, the MNES may evolve suitable long-term strategies. Special purpose instruments may facilitate such tie-ups between ESCOs and the financial institutions.

9. ESCOs may be manned by a breed of young engineers. Good choices could be candidates who might have cleared the examination conducted by the Bureau of Energy efficiency for certification of energy auditors and currently not employed, or people looking for opportunities in the ESCO field and willing to diversify into the biomass gasification field.

10. The ESCO mechanism is an innovative market driven path for financing the projects. We are yet to shape popular ESCO models for the medium sector, where it can make a big dent in the near future. It, however, needs some triggers like the present joint initiative of MNES and CII. It is aimed at making concerted efforts towards an acceptability of the business-like concept. Installation sizes which are too small (below 100 kWe or 300 kWth) or need massive research, development and demonstration efforts are outside the scope of the present assignment which focuses on commercially feasible options.

One can expect the ESCO model to be fair to the stakeholders. A good deal of transparency and active support of the Government would pave the way for a wider acceptance of the concept. In the long run, it is expected to become popular as it evolves, based on field interactions. It would also provide an innovative mechanism to sustain environmentally compatible CDM initiatives.

Part I

Suggested Framework for the Development of ESCOs based on Biomass Gasification Systems

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1. POLICY ISSUES TO PROMOTE SMALL ESCOS, SPECIFIC TO BIOMASS GASIFICATION

1.1 Hard selling the concept (intensive promotion)

The ESCO mechanism is likely to yield sustainable results as payments are based on verifiable pre-agreed performance contract. It strives for a comprehensive solution, thereby providing an innovative market driven path, instead of the conventional direct sales by the manufacturers or their dealers.

ESCO efforts, so far in this field, are at the stage of infancy. This is somewhat related to the slow acceptance of the ESCO concept in other spheres – energy efficiency, renewable technologies, distributed generation, etc. Risk sharing by ESCOs is not well appreciated by the stakeholders.

This calls for hard selling and an inventive mind to address the technical, legal and commercial issues in the competitive business environment. A promising concept, it needs to be nurtured and tracked by MNES, IREDA and SNAs in its initial phase for wider acceptance by the market.

1.2 Pilot programme to start with

MNES, IREDA and the SNAs may take up a pilot scheme to track 10 ESCO biomass gasification projects to provide a need-based support for capacity building. Besides, it can draw lessons for future policy interventions for advocacy and follow up actions. MNES may provide limited funds, say Rs five crores for technical assistance for kick starting, training, monitoring and evaluating the outcome of the pilot programme.

The pilot program may commence after the project roundtable, which is jointly organized by MNES and CII on conclusion of this study. It would pave the way for short-listing a few ESCOs (or candidates willing to form ESCOs) who would implement the aforesaid project on ESCO route. A few (around three to four) states would be focused depending on the initial feedback from SNAs and IREDA.

Candidates would be selected based on the responses received after advertisement in the national dailies. Frequently asked questions may be prepared and made available through the internet. Expressions of interest may be obtained and the eligible candidates may be short-listed. Preference would be given to candidates with tie-ups/sponsorship with existing ESCO/energy audit firms, technical institutes/engineering colleges/chartered accounting firms, and NFBC/leasing firms/manufacturers.

Preferred candidates may have one or more of following attributed –

a) Qualified young engineers with desired entrepreneurial skills.
b) Candidates who have already cleared the examination conducted by the Bureau of Energy efficiency for certification of energy auditors.
c) Are not employed.
d) And have a tie up with the ESCO or energy audit firms.

The short-listed ESCOs would be provided with an MNES-supported short refresher training on biomass gasification and performance contracting for about 3 weeks. Thereafter, the participants are expected to develop a detailed project report for a bankable biomass gasification project as an outcome of the training.

The project reports from the prospective ESCOs would be scrutinized by the SNAs and appraised by IREDA/other financial institutions. Good quality projects would be provided with support for capacity building, marketing and risk mitigation fund.

a. Support marketing: This may be linked to release of 10 per cent of the project cost to the escrow account for the project. This will be after signing of contracts with the beneficiary unit, financial institutions and other stakeholders, if any.

b. Contributions to that can be used to refinance the banks for projects, which have failed and recovery is unlikely. Contributions to the risk mitigation fund would be made as per the following terms and conditions -

i. MNES would release15 percent of the cost of the ESCO project for contribution towards Biomass Gasifier Financing Risk Mitigation Fund to the escrow account. ESCO or the beneficiary unit may not be entitled to the MNES Capital Subsidy for Biomass gasifiers for thermal and electrical applications, vide MNES circular F.No 2/2/2005-UICA dated 25 July 2005.

ii. The contribution to the Biomass Gasifier Financing Risk Mitigation Fund would be released to the Escrow fund after clearance of the DPR and signing of the contracts with the beneficiary unit, financial institutions, and other stakeholders, if any.

iii. ESCO can avail assistance /loan from other sources after keeping MNES /SNA informed about the same.

iv. ESCO shall repay the contribution to the Biomass Gasifier Financing Risk Mitigation Fund commencing one year after inception of the ESCO project, in 15 equal monthly installments. The repayment would be made to SNA/ IREDA/ financing agency nominated by the MNES.

v. A penal interest of 15 per cent per annum would be levied on delayed monthly re-payments towards Biomass Gasifier Financing Risk Mitigation Fund.

vi. The contribution of the risk mitigation fund to take lower priority in loan repayment

A project monitoring and evaluation system would be instituted. A suitable outside agency would be outsourced to keep track of the pilot project and draw some lessons during the course of execution. As an outcome of the monitoring and evaluation activity, a review of the policies would be taken up after the completion of the pilot projects to their logical conclusion or after 5 years, whichever is earlier.

1.3 Sizeable projects for feasibility

Installation sizes that are too small (below 100 kWe or 300 kWth) need massive research, development and demonstration efforts, and are outside the scope of the pilot project. Perhaps, there are some avenues to catalyze small /tiny (informal) sector beneficiaries.

To start with, the short listed ESCOs would focus on sizeable biomass gasifier projects (more than 100 kWe or 300 kWth). While appraising the projects, adequate stress on the environmental compatibility would be made.

1.4 Advocacy of the concept and need based support

MNES would take a comprehensive look at the concept of ESCO for providing innovative financing options. It would also provide need-based technical support to the SNAs and industry associations/NGOs for carrying out the promotional activities. This would include carrying out an initial exercise in market assessment, raising awareness of the grass-root financing institutions, sensitising the state government machinery and local stakeholders and develop a suitable capacity building mechanism for creating awareness among the end users about the ESCOs for financing renewable energy projects such as biomass gasification products/projects.

The MNES may support SNAs/Financing Institutions and ESCOs and professionals through a host of Biomass Information Exchange Functions such as documentation of standard contract agreements and of first–of–kind transactions. This can help future projects, promotions of linkages between various stakeholders like financiers, manufacturers, and state level policy makers, building local capacity to configure products around technologies so as to meet user local needs, facilitating partnerships, that support the activities of early technical and financial intermediaries and instil confidence among Financial Institutions and banks to fund biomass gasification applications for which there are several different markets. Thereafter, experiences being gathered though the aforesaid pilot projects would be disseminated.

2. BARRIERS AND SUGGESTIONS OF POSSIBLE SOLUTIONS IN PROMOTING ESCOS FOR BIOMASS GASIFICATION

2.1 Credibility

ESCOs generally act as project developers for a wide range of tasks and undertake the technical and performance risks associated with the project. Indian ESCOs are still to reach the take-off stage, and they generally prefer large clients in the organized sector.

Large and professionally managed energy intensive industries are not interested in hiring an ESCO to reduce energy costs because they have the equity, the know-how and engineering divisions to implement recommendations on their own. All that they need are 'ideas' provided by a fixed fee based energy audit.

These firms are well aware that an ESCO approach is the most expensive way to reduce energy costs, since an ESCO shares in verified savings and provides financing usually at higher costs. In other words ESCOs and well-managed large Indian firms do not match.

However, under an ESCO service model, the ESCO undertakes 100 per cent risk - technical misjudgment risk, financial risk, the risk of noncompliance of the firm with its obligations under an ESCO contract and the risk of the firm going out of business before the project cycle is complete. Last but not the least, there is the risk of providing actual energy savings to the firm in a challenging environment full of statistical uncertainty and complicacy in data collection and analysis.

Smaller firms, with little know-how and no access to finances and capability to implement recommendations would greatly benefit from an ESCO, even at higher costs. Consequently, the most desirable clients are not interested in the ESCO, and those firms that may sign up with an ESCO will not find it willing to take the risks.

Lack of conceptual knowledge in potential clients is an equally important barrier. For quite some time, there has been a lot of suspicion regarding the ESCO approach. There is no good understanding of what an 'ESCO' or an 'ESCO project' is, in the market. There are apprehensions regarding extremely high entrepreneurial profits, poor performances, and complicated business models. The end-users seem to have more distrust and suspicion than the ESCOs actually deserve.

Energy Efficiency (EE) equipment manufacturers or big business houses support some of the active ESCOs in India. The credibility problems arise from the lack of successful success stories. ESCOs promoting their own products may lack some credibility, as the products might not be best suited for specific projects. In the long run, only real value-added projects can bring credibility in the market.

Also, the ESCO product line is not popular with major biomass gasifier manufacturers who prefer dedicated regional associates/franchisees in providing direct consumer interface, marketing, erection and after sales-service. Manufacturers are expected to challenge the new breed of ESCO businesses that may compete against their interests. Thus the established business model is a challenge to the prospective biomass gasifier ESCOs.

Non-availability of appropriate human resource has been one of the biggest constraints in developing the ESCO business. A fairly high degree of competency in project management and client relationship management is required at different levels, in addition to analytical skills including risk evaluation and mitigation management. In fact, technical competency plays a small part as compared to the array of operational expertise and skills required. ESCOs are thus expected to address the organizational barriers based on their inherent advantages.

2.2 Financial

ESCOs have to contend with high up-front project development costs. This makes development of ESCO projects rather risky and expensive. It includes planning the projects for investment, preparing end-users to take decisions, developing and providing appropriate enhancements to create creditworthy finance structures, and arranging financing.

Development costs are high compared to the value of the project. Cost recovery is also uncertain, as the end-user may decide to select a different implementation model or entrepreneur. The costs and risks involved hinder the development of projects, and wean ESCOs away from smaller projects.

ESCOs perform a role similar to project developers of energy generation projects (including RE projects), in that they undertake market studies, provide pre-investment funding, design and implement the project, and arrange for financing. Yet, ESCOs have had different risk profiles than the developers. They tend to take less equity in projects. In fact, most EE projects are financed mostly by commercial debt in the form of working capital to the ESCO or credit to the end-user, backed by the reputation of the ESCO and, more importantly, a strong contract with the end-user.

The end-user's creditworthiness is the key to financing most EE projects. However, there is often little or no collateral provided. Therefore, banks, leasing firms, and vendors rely on the capability of the ESCO, besides taking into consideration the belief that savings will be realized, the strength of the contract with the end-user, and the willingness of the end-user to pay. Sometimes financial institutions will receive guarantees of repayment from the ESCO or the users, but most of them are too small to provide adequate balance sheet for a loan.

The ESCO provides a comprehensive service to the customers. It includes project design, installation and operation and even appropriate finance repayable through a long-term contract. The ESCO has to identify, develop, market and execute projects, developing commercial risk and entrepreneurial skills to convert opportunities to business propositions. Marketing and pricing the services are critical as it influences the fate and the direction of the projects.

Guaranteed performance by definition includes risks. ESCOs that master risk assessment and cost-effectively manage/mitigate them will be the most successful ones. Managing risks through the financial structure of a deal is an essential business strategy.

ESCOs may commit itself to procuring and installing the appropriate versions of the equipments, providing and developing human resources, sourcing biomass, tackling suppliers and government agencies such as state pollution control board, mobilize equity (partially or fully) manage working capital and track receivables from the project by monitoring and verification of performance and other attributes spelled out in the contract.

2.3 Legal: contracting

Legal hassles pose a major challenge to an upcoming ESCO. Performance guarantee is the key, which involves full payment dependent on a successful demonstration of the energy efficiency measures and provision of comprehensive services including the provision of finance with repayment from achieved savings through long-term contract between user and the ESCO.

ESCOs may evolve based on a business-like relationship between the beneficiaries and the service providers. It calls for a fair degree of transparency and mutual understanding. One perquisite is to define a clear contract spelling out the terms and conditions, rewards and penalties with respect to performance benchmarks like output, reliable operation, and reduction in purchased energy. The parties may have a comprehensive operations and plant maintenance contract with payment linked to the deliverables.

Measurement and Verification (M&V) is the foundation of an effective energy efficiency program planning. It is critical to performance contracting. M&V is indispensable for indicating what was saved, how effective a particular measure or a program is, or whether the engineers' predictions are correct. Of course, for any M&V program to be of value a base-year/baseline adjustment procedure needs to be established.

However, base-year data is not only about consumption history, but also the causes of consumption. Project reliability, financing, market acceptance, engineering and ESCO industry growth, all depend on broadly accepted measurement, verification procedures and sound contracting practices.

The success of the ESCO is related to the drafting of a good performance contract satisfying both ESCO and beneficiary units. The same should be religiously followed during the execution period of the contract. Performance contracts range in investment sizes, from Rs 50 lakhs to Rs 5 crores. Prudent users should follow independent legal and financial advice to clearly understand the risks, if any, that they might be exposed to.

This is not to imply that the ESCO is seeking a win-lose relationship. On the contrary, a qualified ESCO has many incentives to establish a true working partnership with the user for a contract term lasting 3-8 years.

Performance contracts are reasonably complex from a legal and financial perspective. Users should not hesitate to request the ESCO to explain its program, more than once, to colleagues and to external advisors. A confident user results in a smooth project, besides excellent customer relations. A clear understanding of ESCO and user-individual responsibilities reduces the risk of transaction disputes and any potential financial hardship.

2.4 Government support

Historically, MNES, through the network of the SNAs for renewable energy, has been supporting the development of biomass conversion technologies, technology application packages, strategic developmental demonstration pilot projects, improvement in efficiency, reduction in cost and commercialization and development of biomass power/cogeneration on an industrial-scale through a package of fiscal incentives/subsidies.
Besides, financial institutions such as IREDA have been playing a crucial role in the promotion of biomass gasifier projects through provision of credit on soft terms. The Ministry also channels some of its financial incentives, such as interest subsidy through these institutions. Fiscal incentives catalyze market development.

For SMEs, the subsidy driven programs contribute to a skewed market growth for renewable energy products like gasifiers. This is due to the fact that such programs are subsidy driven targeted at specific products. Poor economics is not conducive for technology development.

An ESCO model is more result oriented. There is an obvious need to encourage it, as it is likely to ensure the best possible performance, with payments based on performance contract. This is likely to transform the nature of business, manufacturing and research efforts.

2.5. Technical, environmental and other barriers

Some of the barriers like inconvenience in operating biomass gasifiers, the large space required for such systems, emission of effluents, though not specific to the ESCO mode (attributable to the technology itself) are also cited as potential barriers by the stakeholders for the development of ESCOs based on biomass gasification technology.

2.6. Market assessment and non-availability of developed fuel market

No market assessments have been done to identify and measure business opportunities available to the aforesaid ESCOs. While this study provides some pointers on possible applications, it is far from exhaustive. This leaves a huge gap in the market development of ESCOs. ESCOs based on biomass gasification are also likely to face risks generated due to the underdeveloped biomass fuel market.

3. EVALUATION OF BENEFITS DUE TO ESCOS IN BIOMASS GASIFICATION SECTOR

3.1 Employment generation

ESCO in the biomass gasification sector is expected to boost the market prospects of a well-established technology. This will be ensured by the sustenance of the system with concerted efforts by professionals. Consequently, the number of biomass gasifier systems in operation is expected to grow by at least 20 per cent in the future. At present, with installed capacity of 60 MW, it would be about 12 MW per annum.

A key priority of the nation is to generate job opportunities for the growing needs of the people. A biomass energy system will create huge employment avenues and skills development in the rural areas – direct and indirect. It will create jobs for energy engineers, scientists for research and development, specialists and skilled workers in biomass manufacturing industries, sizing and installing systems, marketing and transportation/delivery of components; technicians and electricians for installation, reparation and maintenance, managers, workers in biomass gasification power plants and other related systems.

The productive uses of the biomass energy will have a multiplier effect. Biomass gasification program has a unique advantage of generating eco-friendly jobs. The program is pro-poor, knowledge and labour (not capital) intensive.

A major potential lies in tapping the employment intensive technology in the vicinity of biomass source. Varieties of jobs, including petty ones, will be generated in the area for biomass collection, stock production, handling and transportation and trade. Biomass processing is a labour intensive technology with resources available at the grass roots. Local manufacturing of components is also possible. The level of linkage of the allied jobs will depend on the local economy.

According to Mr. Pradeep Monga, Senior Technical Advisor, UNIDO, one MW of biomass gasification system can have job opportunities of 500 (presentation made at a Seminar in Hyderabad, 2003). The petty jobs that are created directly for setting up biomass gasifier systems in remote areas and indirect jobs could be as high as 300 per cent. Thus the employment generated would provide people with regular income and uplift their economic conditions.

3.2 Environment benefits

Renewable energy development programs have emerged as viable options for achieving the goal of sustainable development. Power generation from renewable energy sources has assumed significance in the context of environmental hazards posed by the excessive use of fossil fuels.

However, due to various reasons, such as lack of investment capital, biomass based technologies and biomass gasification in particular have not been able to achieve a breakthrough in the market, as compared to other renewable energy technologies, such as wind turbines and small-scale hydro power plants.

The Clean Development Mechanism (CDM) to be implemented within the Kyoto Protocol, as an instrument to reduce CO2 emissions and to foster sustainable development, is an interesting tool to overcome the lack of investment capital and to implement decentralized energy projects in India.

Environmental benefits are mainly due to the following reasons:

a. While biomass power generation is carbon neutral and eco-friendly, fossil fuel-dependent grid-based or diesel oil-based captive fuels contribute to CO2 emissions. CO2 reductions from biomass gasification are significant - conventional grids produce as much as 1 kg of CO2 per kWh of electricity generated. For a typical plant size (500 kW) providing 3000'000 kWh per year, this would amount to a saving of 3000 tons of CO2 per year.

b. Low transportation costs for fossil fuels, as end-use application is nearer to the fuel source.

c. Low transmission and distribution losses for the decentralized/off-grid generation compared to electric grid.

d. Low sulfur emissions with biomass fuels.

Reduction of one ton of CO2 through a biomass gasification power plant costs around $ 18. The added value of the project though exceeds these costs by providing a multitude of benefits, both direct and indirect, to rural communities. Securing these benefits through channels other than carbon credit sales in the current context would be difficult.

With the 10th Conference of Parties to United Nations Framework Convention on Climate Change (UNFCCC) adopting the modalities and procedures for operationalising Clean Development Mechanism (CDM) under the Land Use, Land Use Change and Forestry (LULUCF) activities such as forestation /reforestation, sink projects such as commercial plantations are now included under the CDM.

Growing energy plantations in the wastelands of the country for the purpose of generating energy through biomass gasification is a particularly climate-friendly technology eligible for CDM funding. These efforts are at the early stages of their development cycle and biomass gasification projects are creating an interest among professionals, NGOs and entrepreneurs.

In sectors like small biomass gasification programs for thermal or power applications, bundling several small projects is called for. The following box depicts the two examples of CDM projects relevant to this sector.

Case: Agro Biochem (India) Private. Limited, Karnataka

Agro Biochem (India) Private Limited is a company processing flowers for making natural dyestuffs. It has a marigold-processing unit situated in Telegi village, Harihar, Karnataka. Drying is one of the major processes in the company. Formerly liquid fuel was used for drying, which was inefficient and environment-unfriendly. The gasifier system was introduced here for utilizing the waste generated in the industry and replace diesel/furnace oil used in the fluid bed drier thus reducing the fuel cost to a major extent. Two gasifier systems of 250Kg/hr and 500 Kg/hr were installed to generate about 2 MWth thermal power. The producer gas generated by the gasifier is drawn through a blower to a burner where combustion takes place. After combustion it is farther diluted by ambient air to produce clean hot gas at 100°C and is fed to two dryers. The system uses the wastes from the Harihar poly-fiber factory as fuel, which are Eucalyptus Citridora branches and twigs. It also uses the residue from the marigold flower after the chemical extraction. The waste from the Marigold, which is in a powder form, is turned into briquettes using a briquetting machine. This then creates the secondary fuel for the gasifier system. Prior to installation of the biomass gasification systems the fossil fuel consumption was approximately 100 liters of diesel per hour in one drying unit and 135 liters per hour in the second unit. The emission reductions achieved after installation of the gasifiers is approximately 1143 tCO2 per annum. Women for Sustainable Development facilitated CDM project and has a role for monitoring the CERs.

Environment Canada has committed to hosting or participating in carbon neutral conferences as a concrete way to offset emissions. Through the Federal House in Order (FHIO) initiative, the Government of Canada is working to reduce GHG emissions from its operations and government business travel. The purchase of carbon credits to offset emissions from conferences has been identified as an effective way to achieve this goal.

Environment Canada purchased 212.5 tones of CO2 equivalent from a renewable fuel project located in Karnataka, India, that was created by the group called Women for Sustainable Development. These credits were purchased in order to make Canada's participation at the Eighth Conference of Parties to the United Nations Framework Convention on Climate Change (COP 8) in New Delhi, India, carbon neutral. Through this initiative, greenhouse gases (GHG) associated with the Canadian delegation's travel to and from New Delhi, as well as accommodations, were offset through the purchase of these credits. The renewable fuel project will reduce carbon dioxide and other air emissions, while

delivering high sustainability and social benefits.
PDD: 2MW-5 Biomass Gasification Projects; Women for Sustainable Development, Bangalore, DESI Power and Netpro and others **Promoters are establishing 5 biomass gasification based power plants at different locations in the states of Karnataka and Tamil Nadu in India. In fact, there were serious attempts to cobble up 9 projects of 2.25 MW in 2003. This is a renewed attempt. The new plants of 100 – 1500 kWe units will provide power to micro industries in semi-urban areas. One plant of 1.5 MW of Arashi Power Limited will supply power to the national grid. 2 colleges will also use the biomass gasifier as an additional source of power for their hostels, workshops and teaching spaces, and two plants are for a municipal water supply. Two plants will substitute captive diesel power plants, which meet 75% of the present power needs. Biomass proposed is coconut shell, casurana, eucalyptus, jungle wood (through auction by the forest department), and prosopis juliflora, which are available in plenty at the local sites. The developers propose to use producer gas in the engines. Monitoring activities are designed and executed by CERs to be traded over 10-year project cycle is 108170 tCO2.** **This project was included in the pipeline of the Finnish CDM/JI Pilot Programme already in Spring 2003. The PDD after registration has closed for comments by 31 March 2005. The PDD has received some adverse comments from Axel Michaelowa, Hamburg Institute of International Economics relating to: a) likely soil and ground contamination by by-product black liquor generated in the biomass energy system. Technology is not environmentally friendly and environmental impact assessment is needed. b) Likely chances of CO contamination at the plant site while encountering unreliable operation failures causing frequent shut down and start up of the plant in the absence of CO monitors. c) PDD has no coverage of leakage due to diversion of fuels from other uses in two case- eucalyptus is used is raw material and prosopis juliflora as domestic fuel; unless dedicated fuel plantations are estimated for these projects, leakage of 100% may be taken d) additionality argument is weak as more than 100 gasfiers are already in operation with Government subsidies without CDM support. e) Emission numbers for power plants are disputed, as there are other efficient power plants and hydel projects as well.**

Obvious benefits would be generated by reduced CO2 emissions, compared to the conventional power plant operations. High capital cost, CO2 emissions and transaction costs in preparing, registering and administering these projects are a deterrent to the growth of CDM market in the related field. It is expected that the market players, especially CDM project developers will mature in the near future to accept the challenge.

3.3 Tangible benefits

Biomass based energy systems, which provide reliable energy services would boost setting up of agro-based industries and SMEs in agrarian areas. Biomass can be used for process or electricity generation linkages and with local enterprises. Biomass gasifier systems are widely acclaimed to be engines for rural development.

Studies by Nimbkar Agricultural Research Institute (NARI) in Phaltan, Maharashtra, have shown that each taluka in the country produces enough agricultural residues to meet all its electricity demands by using them in 10-20 MW biomass-based power plants. The NARI study also showed that besides providing power, the taluka energy self-sufficiency plan could also create 30,000 jobs per year.

With the Electricity Act, 2003, in force, the taluka energy self-sufficiency can become a reality, since the utility can produce and supply power to its customers without the need to go through SEBs. The taluka utility company can also utilize the existing transmission and distribution infrastructure of the SEBs and need not make further investments in developing its own infrastructure. This will also help the SEBs to obtain regular incomes from their infrastructure.

The NARI study also showed that the taluka energy programs could create wealth amounting to Rs 100 crores/year for its inhabitants in terms of biomass production and setting up of new electricity-based industries. With about 3,500 talukas in the country, it is therefore possible to produce about Rs 3,50,000 crore/year extra wealth.

Thus, by involving local communities, technology will thus build local socio-economic know-how and generate employment at various levels. Biomass gasifiers will provide reliable and cheap electricity to the communities and reduce environmental impacts.

The electricity produced could be distributed through local mini-grids that are eventually owned by the community and thus is far cheaper than energy from conventional grids. Consequently, energy from a sustainable source becomes available to local businesses, dramatically increasing the potential range of products and services that can be offered.

4. PREFERRED COMPOSITION OF THE ESCOS

A few possible options to organize activities related to biomass gasification projects in SMEs may include the following:

a. **Business firm by chartered accountants**

   Fairly complex nature of activities widely varying in different locations would be expected. The Chief Executive has to comprehend reasonable details and appreciate finer intricacies in the ESCO operations. In fact, BEE or PCRA have recognized the technical biasing of such activities while empanelling energy specialists. Buying technical services to manage the ESCO business is another possibility.

b. **Associates of non-financial banking or leasing firm**

   NBFCs or leasing companies may be at ease in financing these projects. They are also expected to develop expertise in identifying and implementing the projects. Technical complexities would call for additional resources to take care of operational activities. This restrains their business prospect in the early stage of the organization.

c. **Associate to equipment manufacturers (gasifiers, engines, capital equipment)**

   The manufacturers themselves may be responsible for distribution, especially if they are small scale, and hence local, entities. Large, non-local, manufacturers may prefer to handle the distribution through local retailers. Still, the process of selecting, customizing (to the extent needed), and assembling requires some technical skills, as do the operation and maintenance of the system. As to whether they would be interested in ESCO, the answer was not in the affirmative. Though a few of them may extend their business line to capture prospective clients in the SME sector.

   As highlighted in section 5, the ESCOs tied up to manufacturers would involve suspicion from the prospective beneficiaries. At times, some biasing in favour of the models by the parent company may not lead to the best solutions.

d. Technical institutes /engineering colleges

These organizations have provided services for several years in the past. However, their role becomes limited to R&D activities, which are usually sponsored by the Government or international agencies. Ideally, they can provide useful ideas. They may have long-term associations with private consulting firms and nurture them in their field operations rather than taking massive plunge into activities like ESCOs. Perhaps, the charter of their employers would restrict such a role.

e. Existing ESCO/energy audit firms

Most of them may not be keen for reasons elaborated in section 5. Besides, biomass gasification projects would call for concerted efforts to develop the business line and marketable products and services. A few organizations, usually new individual organizations are expected to evince interest.

f. Associates to existing ESCO/energy audit firms

The existing organizations may want to expand their field of operation. The synergy may be mutually rewarding and constraints could be tackled based on the experience of the senior partners.

g. Alliance of young entrepreneurs

Even though they might make a good network, managerial problems would do creep in, in common areas. They could be useful with demarcated areas of activities and their collective strengths could be exploited.

h. Fresh unemployed BBA/ engineers/ MBA/ M. Tech from management institutes/ engineering colleges

This offers a huge potential, though the vast majority of the aspirants opt for greener pastures. Fresh /unemployed managers/engineers would be novices and might not be able to deal with live situations in the beginning of their career. Engineering graduates with business education background would an ideal choice.

Possible solutions

Points f, g and h mentioned above may be the desirable choices as the new breed of technically qualified personnel appear to be the most sought after characteristic. Ideally f is a good choice. However, for g and h, the incumbents may associate with a, b, c, and d. Further, as per the Energy Conservation Act 2001, practicing energy audit firms have to appear in a qualifying examination. Even candidates who have already cleared the examination, presently not employed or looking for opportunities in the field, and are willing to diversify into the sphere of biomass gasification could be a good choice.

5. MODEL BENEFIT SHARING ARRANGEMENT BETWEEN ESCO AND USER, BETWEEN ESCO AND MANUFACTURER AND BETWEEN USER AND MANUFACTURER

5.1 ESCO and user

Model - Fees for services: An ESCO owns the system, provides energy services to the end user, who pays a monthly or a quarterly fee to the ESCO. The end user is not responsible for the maintenance of the system and never becomes the owner, although the end user is responsible for the rent payments to supplier.

Model - Shared savings: Under a 'shared savings' contract the cost savings are split for a pre-determined length of time as per a pre-arranged percentage. There is no 'standard' split as this depends on the cost of the project, the length of the contract and the risks taken by the ESCO and the consumer.

Model - Guaranteed savings: Under a 'guaranteed savings' contract the ESCO guarantees a certain level of energy savings, shielding the client from any performance risk.

An important difference between guaranteed and shared savings models is that in the former case the performance guarantee is the level of energy saved, while in the latter it is the cost of energy saved.

Under a guaranteed savings contract the ESCO takes over the entire performance and design risk, due to which it is unlikely to be willing to assume further credit risk. Consequently guaranteed savings contracts rarely go along with an ESCO borrowing. The customers are financed directly by banks or by a financing agency.

Since financial institutions are better equipped to assess and handle the credit risk of the customers than an ESCO, it is an advantage of this model. The customer repays the loan and assumes the investment repayment risk. If savings are not enough to cover debt service, then the ESCO has to cover the difference. If savings exceed the guaranteed level, then the customer pays an agreed upon percentage of the savings to the ESCO.

Usually the contract also contains a provision that the guarantee is sound, i.e. the value of the energy saved will be enough to meet the customer debt obligation, when the price of energy does not go below a stipulated floor price. A variation of guaranteed savings contracts are 'pay from savings' contracts whereby the payment schedule is based on the level of savings - the more the savings, the quicker the repayment.

The guaranteed savings scheme is likely to function properly in countries with well-established banking structure, high degree of familiarity with project financing and sufficient technical expertise within the banking sector to understand energy-efficiency projects.

The introduction of the ESCO concept in developing markets like India would be a difficult exercise because customers are required to assume investment repayment risk. However, it fosters a long-term growth of ESCO and the finance industries. Newly established ESCOs with no credit history and limited resources would be unable to invest in the project they recommend. They may enter the market only if they guarantee the savings and the client secures the financing on its own.

Conversely, under a shared savings model, the client takes over some performance risks. Hence it will try to avoid undertaking credit risks. This is why a shared savings contract is more likely to be linked with a mixed scheme, with finances coming in from the client and the ESCO, whereby the ESCO repays the loan and takes over credit risk. The ESCO therefore assumes both performance and the underlying customer credit risk. Hence, if the customer goes out of business, the revenue stream from the project will stop, putting the ESCO at risk.

In addition, such contractual arrangement may give rise to leveraging problems for ESCOs, because ESCOs become too indebted. Besides, at some point, financial institutions may refuse to lend to an ESCO due to high debt ratio. In effect the ESCO collateralizes the loan with anticipated payments from the customer, based on a share of the energy cost savings. The financing in this case goes off the customer's balance sheet.

A situation, where savings exceed expectations, should be taken into account in a shared savings contract. This setting may create an adverse relationship between the ESCO and customer, whereby the ESCO may attempt to 'lowball' the savings estimate and then receive more from the 'excess savings'.

Furthermore, to avoid the risk of energy price changes, it is possible to stipulate in the contract, a 'single energy price'. In this situation the customer and the ESCO agree on the value of the service upfront and neither side gains from changes in energy prices. If actual prices are lower than the stipulated floor value, then the consumer has a windfall profit, which compensates the lower return of the project.

Conversely, if actual prices are higher than the stipulated ceiling, then the return on the project is higher than projected, but the consumer pays no more for the project. In effect this variation sets performance in physical terms with fixed energy prices, which makes the approach resemble guaranteed savings approach.

The shared savings concept is a good introductory model for developing markets because customers assume no financial risks. From an ESCOs' perspective the shared savings approach has the added value of the financing service.

However this model tends to create barriers for small companies. Small ESCOs that implement projects based on shared savings rapidly become too highly leveraged and unable to contract further debt for subsequent projects.

Shared savings concept may, therefore, limit long-term market growth and competition between ESCOs and financing institutions. For instance, small and/or new ESCOs with no previous experience in borrowing and insufficient resources are unlikely to enter the market if such agreements dominate. It focuses attention on projects with short payback times ('cream skimming').

Another variation is the 'first out' approach whereby the ESCO is paid 100 per cent of the energy savings until the project costs – including the ESCO profit – are fully paid. The exact duration of the contract will actually depend on the level of savings achieved - greater the savings, shorter the contract.

Table 1 summarizes the features of the guaranteed and shared savings models.

Table 1. Guaranteed savings and shared savings: a comparison

Guaranteed savings	Shared Savings
Performance related to level of energy saved	Performance related to cost of energy saved; the ESCO bills upon actual results
Value of energy saved is guaranteed to meet debt service obligations down to a floor price	Value of payments to ESCO is linked to energy price; betting on price of energy can be risky
ESCO carries performance risk Energy-user/customer carries credit risk	ESCO carries performance and credit risk as it typically carries out the financing
If the energy-user/customer borrows, then debt appears on its balance sheet	Usually off the balance sheet of energy-user/customer
Requires creditworthy customer	Can serve customers that do not have access to financing
Extensive M&V	Equipment may be leased
ESCO can do more projects without getting highly leveraged	Favours large ESCOs; small ESCOs become too leveraged to do more projects
More comprehensive	Favours projects with short payback ('cream skimming')
	How to share the 'excess' savings

5.2 ESCO and manufacturer

ESCO and the manufacturer may agree to acquire equipments on lease/hire/purchase, with ESCO making the monthly/quarterly payments. The ESCO may extend the warranties over the lease period with provisions for penalties/nominal costs for spare parts/items to be replaced. The manufacturer may offer discounts to the ESCO for marketing and customer related services such as erection, after sales services. It may also provide useful tips/guidelines for optimal performance, predictive and preventive maintenance, repairs and overhauls and training for productive maintenance.

5.3 User and manufacturer

The supplier/dealer sells the system to the end user who enters into a credit arrangement. Depending on the arrangement or when all payments have been made, the end user becomes the owner of the system. There may be a penalty for shortfall in performance.

Often the end user obtains consumer credit from a third party institution. The supplier/financial intermediary leases the system to the end user. At the end of the lease period, ownership may be transferred to the end user. During the lease period the lessor remains the owner of the system and is responsible for its maintenance and repairs.

6. Model agreements among all the parties involved

A typical agreement between User and ESCO is given in annex.

7. Should ESCO be only for biomass gasifier system or for comprehensive energy conservation activities?

A typical ESCO for promoting biomass gasification projects is expected to be a good role model. A few generic characteristics in its operations especially in the SME sector might be depicted.

a. The firm is expected to establish credentials through a professional approach in its dealings with the clients, prospective beneficiaries and business network.

b. The ESCO is expected to conceive smart projects that make business sense for the stakeholders.

c. It is expected to depict sound business acumen in selling project ideas and shaping up model contracts.

d. It is expected to undertake business risks, acquire adequate risk coverage and compensation for managing the same.

e. To start with, it is expected to be a lean set up with adequate tie-ups and resources - physical and fiscal commensurate with the tasks being contemplated.

f. The ESCO has to be prepared to commence its operations in a small way and expand gradually.

g. ESCO is expected to learn from experience and consolidate its experiences.

An ESCO engaged in biomass gasification may be open to expand the scope of its activities to a) businesses allied to biomass gasification such as biomass handling b) energy auditing and energy efficiency c) power distribution and demand side management d) identifying and implementing projects for cogeneration, distributed generation, renewable energy, process optimization e) distribution loss reduction f) turnkey projects on plant renovation and modernization.

These allied services will improve the viability of ESCO operations.

8. The mechanism for financing, including desired role of Ministry and financial institutions such as IREDA

8.1 To start with, the MNES may provide support to the ESCO biomass gasification projects by:

a) Support marketing - This may be linked to release of 10 per cent of the cost of the project to the escrow account for the project after successful negotiation of the ESCO project.

b) Contributing to Biomass Gasifier Financing Risk Mitigation Fund that can be used to refinance the banks for those projects, which have failed and recovery is unlikely.

c) Bearing the cost of induction training for the ESCO staff and other capacity building measures.

d) These incentives would also entail no capital subsidy as permitted to the conventional biomass gasification projects from MNES for the pilot ESCO biomass gasifier projects.

8.2 An important factor affecting the growth of biomass gasification sector is that most of the small ESCOs lack access to funds for carrying out the trail blazing activities viz., carrying out the initial exercise in assessing the market, raising awareness among the grass-root financing institutions and convincing them for financing, sensitizing the state government machinery and local stakeholders etc. Possible solutions to address the above problems/constraints/barriers may be:

a) To evolve a good blend of top down and bottoms up approach for developing biomass gasification policy framework.

b) To establish a funding mechanism for carrying out the trail blazing activities.

c) Carry out a thorough 'need assessment' for estimating the market potential and then match the need assessment with the technology.

d) Develop a suitable capacity building mechanism for creating awareness among the end users about ESCOs and develop innovative financing schemes for financing biomass gasification products/projects.

e) Support SNAs /financing institutions and ESCOs and professionals through host of Biomass Information Exchange Functions as detailed in the box.

Major benefits of these interventions would be:

a) Documentation of standard contract agreements and of first–of–kind transactions that can help future projects.

b) Promotions of linkages between various stakeholders like financiers, manufacturers, and state level policy makers.

c) Building local capacity to configure products around technologies so as to meet user local needs.

d) Facilitating partnerships, which support the activities of early technical and financial intermediaries and instill confidence among FIs and banks to fund biomass gasification applications for which there are different markets. As, the evolution of policy and finance is different for each market.

8.3 Risk guarantee fund

The purpose of the risk guarantee fund is to provide relief to the stakeholders, including financial institutions to safeguard against eventualities like project failures due to unforeseen factors. This however calls for a detailed exercise –

a). To study, evaluate and finalize risk guarantee fund components to be provided for prospective ESCO projects.

b) To work with and assist financial institutions in designing appropriate financial structuring models for ESCOs, including risk assessment, selection criteria, actual selection of ESCOs, risk guarantee fund components, conventional term loan components, etc. and achieve financial closure of select ESCO projects.

c) To assist FIs in developing approaches and strategies for creating and operating a contingent fund for ESCO projects. Such agencies may be IREDA, SBI Caps Limited, IL&FS, IFCI, international financial structuring expert or agency or any other agency having the relevant experience, expertise and interest.

In this context, the MNES may evolve a mechanism to redesign these subsidies and substitute them with Risk Guarantee Fund to offload certain financial risks perceived by FIs/ ESCOs while funding them. This is likely to induce funding of ESCO projects.

To start with, Rs 10 crores may be set aside. Equity/subsidy support from MNES may be expected to be recycled into this fund. In the event of the ESCO project encountering major default in repayment due to technical or commercial reasons, ESCO/FIs may be partly compensated for the non-recovery of the receivables from the beneficiaries after taking into account the reasons for default, payments already received, resale value of the assets and reduction in the working expenses of the project, if terminated prematurely.

For reasons, beyond ESCO control, up to 75 % of the losses incurred by ESCO may be compensated. It would be mandatory for ESCO and FIs to re-negotiate the conditions for term loan and revise its agreement for loan repayment on mutually agreeable terms.

9. MINIMUM QUALIFICATIONS OF PROMOTING GROUPS

Minimum qualification for the promoting group is Bachelors of Engineering / Management or Chartered Account with suitable internal /external support for the related technical and managerial functions.

10. NEED AND IDENTIFICATION OF OUTREACH MECHANISMS AND POPULARIZING THE CONCEPT AMONG THE POTENTIAL GROUPS

MNES may also concentrate on the following areas -

The SNAs have to aim at creation of business support centers for promotion of energy service companies or ESCOs. Equally important are dealer and service networks; credit establishments, financial intermediaries, vendor development, and access to venture capital. These efforts can be fostered and sustained through entrepreneur associations and cooperatives that can provide training in business management. Developing the requisite institutional capacity is a major challenge.

The MNES is expected to nurture the program for ESCO development by dint of its catalytic role. It may consider the following activities, though its mandate to support the ESCOs may not necessarily be limited to them:

a) Guiding IREDA and state level nodal agencies.

b) It may issue suitable directives from time to time to IREDA and SNAs for a review of the ESCO activities and provide need-based support in terms of exchange of ideas, successful cases and organizing meets/workshops.

c) Aggressive marketing is essential in order to change the end-user mindset. MNES may plan a publicity program through newspapers or other means to the target audience about the merits of the concept.

d) In the long term, its role should be to develop regulatory mechanisms, as well as guidelines and norms for energy services. Local entrepreneurs need both guidelines and incentives to operate as service providers.

Host of Biomass Information Exchange related functions

To encourage new entrepreneurs, in a few focused states like Kerala, Karnataka, Tamil Nadu, Andhra Pradesh, Maharashtra, Gujarat, Madhya Pradesh, Chattisgarh, Jharkand, Uttar Pradesh, Punjab, Bihar, West Bengal (list may be altered if needed) may be selected. The MNES may improve the on-going information development/dissemination activities. There is a need to target additional or missing details as part of the generic information dissemination on the potential of biomass for power generation.

Increased Information with project promoters and all stakeholders in the focused states and their enhanced knowledge base

A review of biomass resource mapping exercise of the Ministry may be taken up to generate location and specific investors profile for different capacity and types of biomass based projects for market penetration.

Other sub-activities may include creation of up-to-date information, database on biomass power project commissioned, under construction or in pipeline, technology update, newsletter on biomass power, development of data bank on biomass power technologies, preparation of biomass power directory hand book, preparation of model pre-feasibility, techno-economic feasibility and detailed project reports, model energy purchase agreements, Memorandums of Understanding, project development agreements, fuel supply agreement, package or Engineering, Procurement & Construction (EPC) bid documents. Appraisal guidelines for different types of biomass power projects may also be prepared.

Create online databases for biomass projects promotion and development in focus States

MNES may sponsor the activity to develop a database on biomass power depots in the focused states, based on a review of all information/data/documents on biomass assessment. It will identify high potential districts/tehsils, carry out laboratory analysis of different biomass materials and mapping of potential sites for biomass depots. The database would provide information on land and equipment requirements for setting up of biomass depots, investment and operating costs. It will also suggest a strategy for the development of depots through consultative processes involving local entrepreneurs/Non Government Organizations (NGOs) / Self-help Groups (SHGs), villagers, particularly landless village level entrepreneurs and women

Develop ESCO Project Development Agreements

This activity will compile and review the existing project agreements for different combinations of entrepreneurs and biomass power hosts for target biomass power sectors following ESCO or business models like BOO/BOOT. It will identify and evaluate key elements of each of the models and deliberate the issues through a consultative process and interactions with existing and potential entrepreneurs, SEBs, and FIs. Typical project agreements between an independent power plant promoter or developer and biomass host in each target sub-sectors may include i) land lease agreements ii) captive electricity and steam supply agreement iii) water supply agreement iv) effluent supply agreement.

Develop project management and information systems

Biomass projects commissioned in the past do not have systems for monitoring key biomass power project performance parameters related to technology, finance, implementation and operation. In the absence of effective systems, the overall project performance cannot be evaluated. This activity would help in designing an appropriate MIS based on identification of key data needs, sources, analysis for optimizing performance and providing feedback to the concerned stakeholders.

Improved capacity of key stakeholders and project promoters in the targeted states

This sub-activity will aim at conducting consultative meetings and workshops for identifying specific capacity building needs and devising time bound capacity building programmes and their implementation. The proposed strategy for capacity building would have components of communication and advocacy, information dissemination and exchange programmes. A board spectrum of stakeholders would be participating in this activity, including R&D institutions, State Electricity Boards (SEBs), CERCs/ SERCs, State and Central Government Agencies, financing institutions and banks, engineers and consultants, NGOs (local, regional, national agencies), service entrepreneurs, technology and equipment suppliers, project developer, sugar mill/rice mill owners, micro entrepreneurs and project promoters.

Communication and advocacy

This activity will make efforts to sensitize key policy makers and institutions on biomass power sector issues – regulatory, financing and institutional. Need-based policy research studies would be commissioned on the specific issues identified through consultative processes (consultative workshops) for each target biomass sector. This would be supplemented by preparing articles, both in English and local languages in the focused states and their wider dissemination through different mass media, namely, print, audio/video and multimedia. The activities will include selection and appointment of teams of experts, issue of contract to the lead agency/institution and arrange for publication of articles, generation of public debates, participation in public hearings of SERCs, TV/radio/multimedia presentations etc.

Improve access to information through website

This activity will provide comprehensive and up-to-date information required on biomass power projects development. It will support designing a website to meet the information needs of various stakeholders on different aspects of biomass power sector. The website, which would be interactive, may cover various aspects of biomass power including information on potential, achievements, performance, policy and regulatory framework, institutions, experts, consultants, equipment/ technology suppliers, related Central and State government agencies, fiscal incentives, technology status would link to the databases being created on biomass resources, technologies, project profiles in the focus states.

Develop and test capacity building modules in the focused states

This activity will develop capacity building modules through consultative and orientation meetings with key stakeholders in primary focus states. Regulators, consumer forums, State government departments, SNAs, industry associations, key institutions including NGOs/SHGs/industry associations and project promoters would participate in these meetings. These modules will be tested through organizing and evaluating specific skill up-gradation and training programs at all levels, including in the interior areas. A number of sub-activities will be required to accomplish the objectives indicated above.

A critical review of the kind of business, commercial and support service networks/institutions/professionals required for this sector and assessment of the capability of existing institutional framework would be taken up. This would involve an in-depth study of equipment procurement mechanisms, sourcing different biomass resources, institutional mechanisms for delivery of biomass fuels, feasibility of biomass depots, financing of such support services and relevant policy interventions. Since biomass would be produced locally, efforts would be made to involve appropriate institutions (NABARD, Commercial Banks and micro-lending institutions) at all levels through participatory approaches and consultative processes with particular focus on gender issues.

Study of required institutional mechanisms for biomass power projects development

This activity will identify required business, commercial and support service mechanism for promoting, executing, operating and sustaining biomass power projects of target sub-sectors, through interaction with experts, associations, financial institutions, entrepreneurs, equipment suppliers etc. The key elements of the required institutional mechanisms for biomass power sector will be developed and finalized through feedback.

Evaluate existing commercial and institutional framework in focused states for their suitability to promote biomass power projects

This activity will identify and evaluate available business, commercial and support service institutional mechanisms in the focused states for promoting, executing, operating and sustaining biomass power projects of the target sub-sectors, and evaluate key institutions therein. The specific gaps in the required and available mechanisms will be identified.

11. List of potential small ESCOs who would be interested in Biomass gasification projects

1. Agni Energy Services Pvt. Ltd., Hyderabad
2. Auroville Renewable Energy, Pondicherry
3. Chandrapur Engineering works, Yamunanagar
4. Cosmo Products , Raipur
5. DCM Shriram Consolidated Ltd., New Delhi
6. Energreen Power Limited, Chennai
7. Enhanced Wapp Systems (India) Pvt. Ltd. New Delhi
8. INTESCO Asia Ltd., Bangalore
9. Netpro Renewable Energy (I) Ltd. Bangalore
10. See Tech solutions Pvt. Ltd., Nagpur
11. Thermax Energy Performance Services Limited, Pune
12. Sudnya Industrial Services Pvt. Ltd., Pune
13. Separation Engineers Pvt. Ltd. Chennai
14. Shri Shakti Alternative Energy Limited, Hyderabad
15. Desi power, New Delhi

The list may also include TERI's franchisees as well as IISc affiliates

12. Development of an ESCO model suitable for Indian conditions

ESCOs projects and revenue models for the biomass gasification systems are likely to be site specific. Mutual faith and management style and practices needs to be synthesized into the ESCO models. Financing models suiting a set of circumstances are presented below:

12.1 Framework 1:

a. Characteristics:

The end user has full confidence in the biomass gasification technology, and in the cost saving resulting from switchover to biomass.

b. Recommended Model:

If the proprietor of an industrial unit has the full confidence in the biomass gasification technology and believes that huge fuel cost saving is possible through the use of bio-energy, the remaining task becomes quite simple. Most of such industrial users themselves would like to reap the advantages of fuel switching and hence would be willing to invest the required capital and cover some risk. In such cases, the appropriate role for the ESCOs can be following:

a) During the conceptualization of the project, it can work as an independent consultant and prepare the detailed project report (DPR) and establish possible cost savings due to the project.

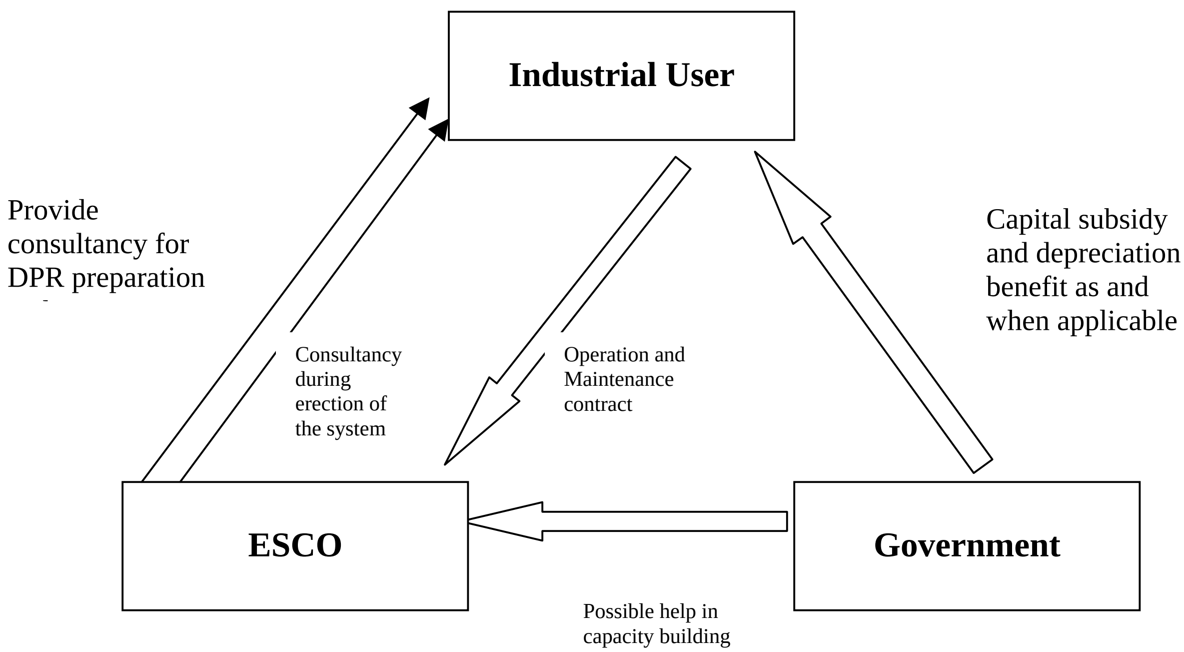
b) Provide engineering consultancy during the project erection/installation phase.

c) Work as an operation and maintenance (O&M) contractor during the life of the project.

d) The industrial user can provide regular payments to the ESCO. It can be decided mutually and can be based on the cost incurred by the ESCO in the operation and maintenance, along with some service margin.

e) The industrial user can take advantage of the capital subsidy available for such projects to make the whole operation more profitable. The schematic below expresses the model more lucidly.

Schematic 1



12.2 Framework 2:

a. Characteristics:

a. Confidence level about this technology among the end users and/or the resulting cost savings is very low.
b. The biomass project size is likely to be relatively large.
c. The ESCO believes that the estimated cost savings due to switchover towards biomass is quite substantial.

b. Recommended model

When the end user does not have the adequate confidence in the fuel cost saving (or in the biomass technology), ESCOs will invariably be required to bear the risk of performance. The suggested route, in this case, is that the ESCOs guarantee the regular supply of energy and the cost savings (due to fuel switchover) to the industrial user.

The industrial user and the ESCO can enter into a contract where industrial units can guarantee regular utilisation of biomass based energy to the ESCO and agrees to make payment on a regular interval. ESCO in turn can guarantee the uninterrupted supply of energy in the desired form and quantity and also guarantee average per unit energy cost savings. Tariffs (paid to the ESCO by the industrial user) can be decided upon prior to taking into account the benefits (cost savings) to be shared between the industrial user and ESCO. One model formula, suiting to this model, is presented below:

Tariff (per unit) = 0.60 x fossils fuels based energy tariff baseline during the project period.

Payments to be released in the escrow account every month or a periodicity prior to implementation of the ESCO project.

Actual savings over the entire project period to be monitored computed and audited every year in a transparent manner and shared as per pre-determined formula.

c. Financing arrangement

Once the contract between the ESCO and the industrial user is signed, ESCOs have a guaranteed cash flow stream, which can be utilized to obtain the term loan. ESCOs can try to obtain the term loan to meet the initial capital expenditure by securitizing the future cash flows/receivables. The loan will be backed by the receivables to mitigate the counter party credit risk for the banker.

The advantage of this mechanism is that ESCO can procure the term loan even when its perceived creditworthiness (by the banker) is low. However, bankers may still doubt the creditworthiness (and/or strength of the businesses of the industrial units), wherefrom the cash flow is deemed to be originating. This issue can also be taken care of if the ESCO is approaching the banker of the industrial units (local banker) to implement this framework.

13. Concluding remarks

The ESCO mechanism is an innovative market driven path for managing change. We have to go a long way ahead in shaping some popular ESCO models for the medium industry sector where it can make a big dent in the near future. It however needs some triggers, like the present joint initiative of the MNES and CII that aims at making concerted efforts in garnering acceptability by the people.

One can expect the model to be fair to all the major stakeholders. A good deal of transparency and active support of the professionals would pave way for a wider acceptance of the concept. In the long run, as it evolves, it is expected to become popular based on field interactions. MNES-CII may continue the relationship for developmental activities related to biomass gasification projects.

Part II

Discussion on various aspects of ESCO Mechanism mainly based on Biomass Gasification Systems

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Discussion on various aspects of ESCO Mechanism mainly based on Biomass Gasification Systems

Table of Contents

Chapter 1: Introduction

Fossil fuels have traditionally been the fuel of choice for several thermal and electricity related industrial applications. However, the upsurge in the oil prices, insecurity of supply and several environmental considerations have started weighing heavily towards other possible alternatives to fossil fuels.

In India, at least for several niche applications including those using electricity and heat in industries, biomass can be an appropriate alternative. India generates a vast amount of biomass material through its agricultural and agro - forestry operations, estimated at around 400 million tons of coal equivalent.

Biomass fuels and residues can be converted to energy via thermo-chemical processes. The use of biomass gasifiers (for fuel switching, especially petroleum-based fuels) is very attractive for furnaces, kilns, thermic fluid heaters, ovens, and crop drying systems.

The ceramic industry is a very good example where around 100 large systems have been installed mostly without any subsidy. These systems have a payback period of a few months. Although the systems are less attractive for electric generation, success of 100 per cent gas engines is expected to improve their financial viability. Thus producer gas could be either burnt directly for thermal applications or replace diesel oil for small power plants.

In spite of the financial attractiveness, users are still reluctant to adopt biomass gasification systems. The reasons are perceived to be lack of confidence in a new technology, reluctance in the employment of extra manpower, lack of expertise in regular efficient operation, etc. To overcome these hesitations, a few of the manufacturers are offering the systems on a build-own-operate-transfer (BOOT) basis where the monetary savings are shared between the user and manufacturer, with a built in provision for transfer of the ownership after a fixed period.

A similar model where Energy Service Companies can own the system and install it for replacing oil could be useful for expanding the use of biomass gasification systems in industrial applications. The Energy Service Companies (ESCOs) can be floated by groups of young unemployed engineers, which will also improve employment opportunities. Such groups can be trained by a competent agency. These groups can avail of loan from financial institutions at appropriate terms and conditions. The advantage of such groups over the manufacturers (BOOT mechanism) will be that their overheads will be lower and manufacturers will be able to concentrate on their core business activity.

In this report, various aspects of the above-mentioned possible ESCOs (institutional, financing, policy-level) have been discussed in detail. As envisaged, the ESCOs can provide energy services to industrial units based on biomass gasification systems. A discussion about the technology detailing its all merits and shortcomings have been presented to help develop better understanding of all technological issues with respect to biomass gasifiers.

The cost effectiveness of this technology has been reinforced in this report with the help of calculations presented in the financing section. At various chapters of the report, recommendations have been made for various stakeholders to enable the conception and functioning of aforesaid ESCOs. These recommendations have also been compiled in the executive summary.

Chapter 2:Gasification technologies- an overview

2.1 Biomass gasification – its need

Biomass is any natural substance available, which stores solar energy through the process of photosynthesis in the presence of sunlight. Biomass has been a major energy source, even prior to the discovery of fossil fuels like coal and petroleum. Even though its role has diminished in the developed countries, it is widely used by the rural communities in the developing countries, for their energy needs in terms of cooking and limited industrial use.

Biomass, besides its use in solid form, can be converted into gaseous form through the gasification route. It can be converted into energy via thermo-chemical and biological processes.

Biomass can be classified into two broad types:

1. Solid biomass, such as any types of branch, stems of weeds like ipomoeas and lantana and agricultural residues like coconut shell, cotton stalk, mustard stalk, corncob, etc.

2. Powdery biomass, which exists either naturally in a powdered form or may be crushed into powder, like sawdust, agricultural residues like rice husk, groundnut shell, coffee husk, sugarcane trash, or dry leaves and grass.

India generates a vast amount of biomass material through its agricultural and agro-industrial operations, estimated at over 500 million tonnes every year. On the basis of calorific value, this amount is equivalent to around 400 million tonnes of coal. Only a small portion of this material is utilized productively. Examples are crop-stalks, straws, sugarcane trash, rice-husk, groundnut shells etc.

The technology of gasification is more than two centuries old. Age-old moving bed atmospheric air blown gasifiers are still relevant and functional in many installations around the world, including India. In the pre-petroleum era, these gasifiers were used for production of town gas (for domestic heating and lighting), industrial heating and manufacturing of chemicals.

Recent interest to provide energy security in coal-based Integrated Gasification Combined Cycle (IGCC) power plants has fuelled the development of large gasifiers. Besides, since biomass can be CO_2 neutral in terms of emission, its relevance in the coming millennium is clear - an option to reduce GHG emissions.

Biomass gasification has attracted the highest interest amongst the thermo-chemical conversion technologies, as it offers higher efficiencies in relation to combustion while flash pyrolysis is still in the development stage. Gasifier output is practically smokeless where no concentration of carbon monoxide and methane are recorded.

The development of biomass gasification technologies will meet the demand for high quality energy in the decentralized locations, in the vicinity of abundant biomass sources. The gasification technologies can make good use of the local agro wastes and enjoy great potentiality in the rural areas, especially, considering the cleanliness and environment-friendliness of the gas produced.

2.2 Concept and principle of gasification

Biomass chiefly contains cellulose, hemicellulose and lignin, with an average composition of $C_6H_{10}O_5$, with slight variations depending on the nature of the biomass. Theoretically, the ratio of air-to-fuel required for the complete combustion of the biomass, defined as stoichiometric combustion, is 6:1 to 6.5:1, with the end products being CO_2 and H_2O. In gasification the combustion is carried at sub-stoichiometric conditions with air-to-fuel ratio being 1.5:1 to 1.8:1. The gas so obtained is called producer gas, which is combustible.

This gasification process occurs in a gasifier that basically comprises of a reactor, where the gas is generated. In the reactor, the biomass pieces after undergoing drying and devolatisation in the upper zones leave behind the char. The volatile matters undergo oxidation in the combustion zone, with air being partially supplied by the surrounding nozzles, and the remaining drawn from the open top. The product gases of oxidation further gets reduced by a bed of charcoal and yields a combustible gas having a calorific value of 4.5-5.0 MJ/Kg, with an average composition of CO: 20 $\pm$ 1%; CH_4 : 3 $\pm$ 1%, H_2 : 20 $\pm$ 1%, CO_2 : 12 $\pm$ 1% and rest, N_2.

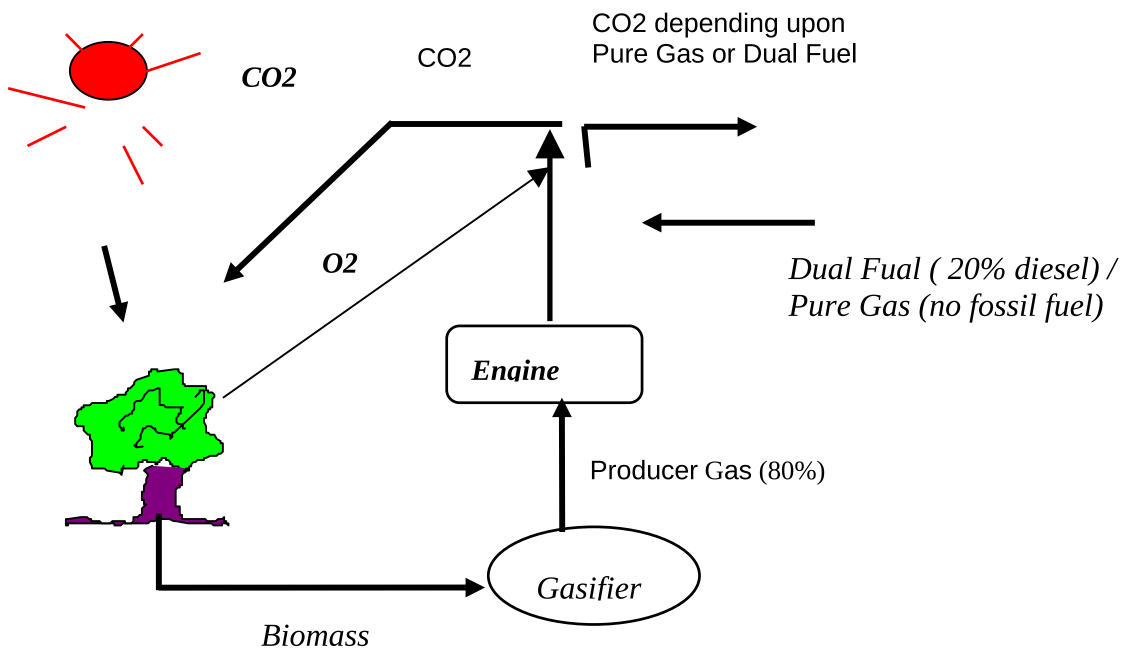


Fig 2. 2: CO_2 cycle

The reactor is followed by a cooling and cleaning system, which cools and cleans the gas. The clean combustible gas is thus available for power generation application. This gas is then fed into a conventional diesel engine modified to suit specific requirements to generate power.

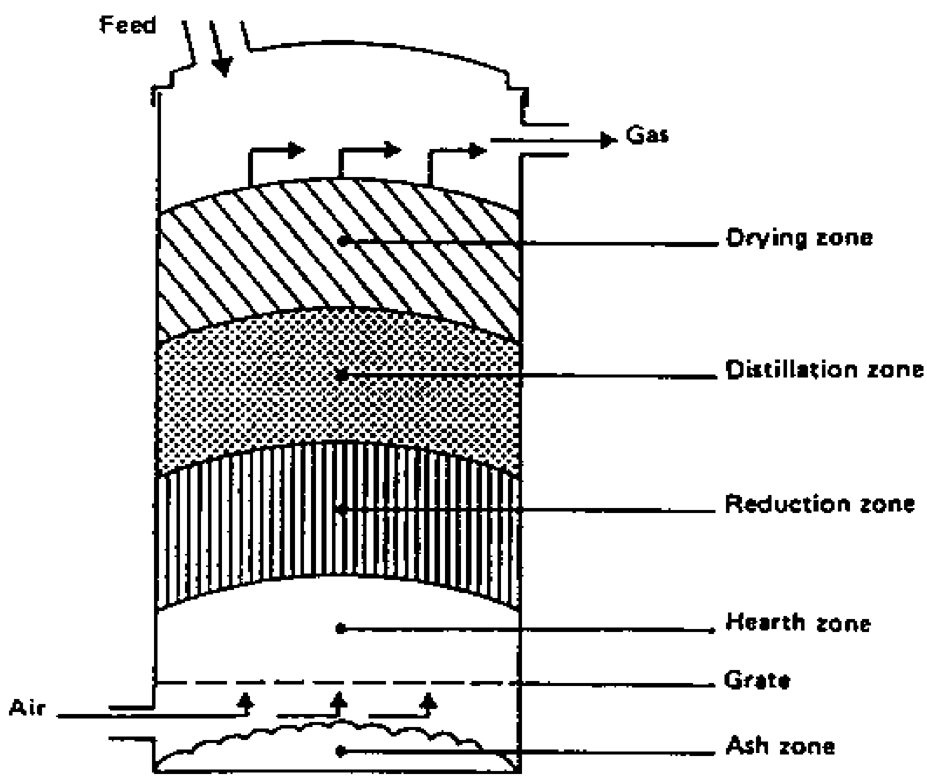
The modifications can be either for dual fuel operation when a mixture of gas and diesel is fed into the engine or for only gas operation. In the case of dual fuel operation, the replacement of diesel by producer gas from biomass can be to the extent of up to 80% of the normal diesel consumption. The waste heat from the engine can also be recovered for drying, heating or boiling water, or for running air-conditioning or cold storage plants. Biomass combustion is CO_2 neutral. The figure 2.1 above depicts the CO_2 cycle.

2.3 Types of gasifiers

a. Updraught or counter current gasifier

The oldest and simplest type of gasifier is the counter current or updraught gasifier shown schematically in Fig. 2.2.

Figure 2.2 Updraught or counter current gasifier

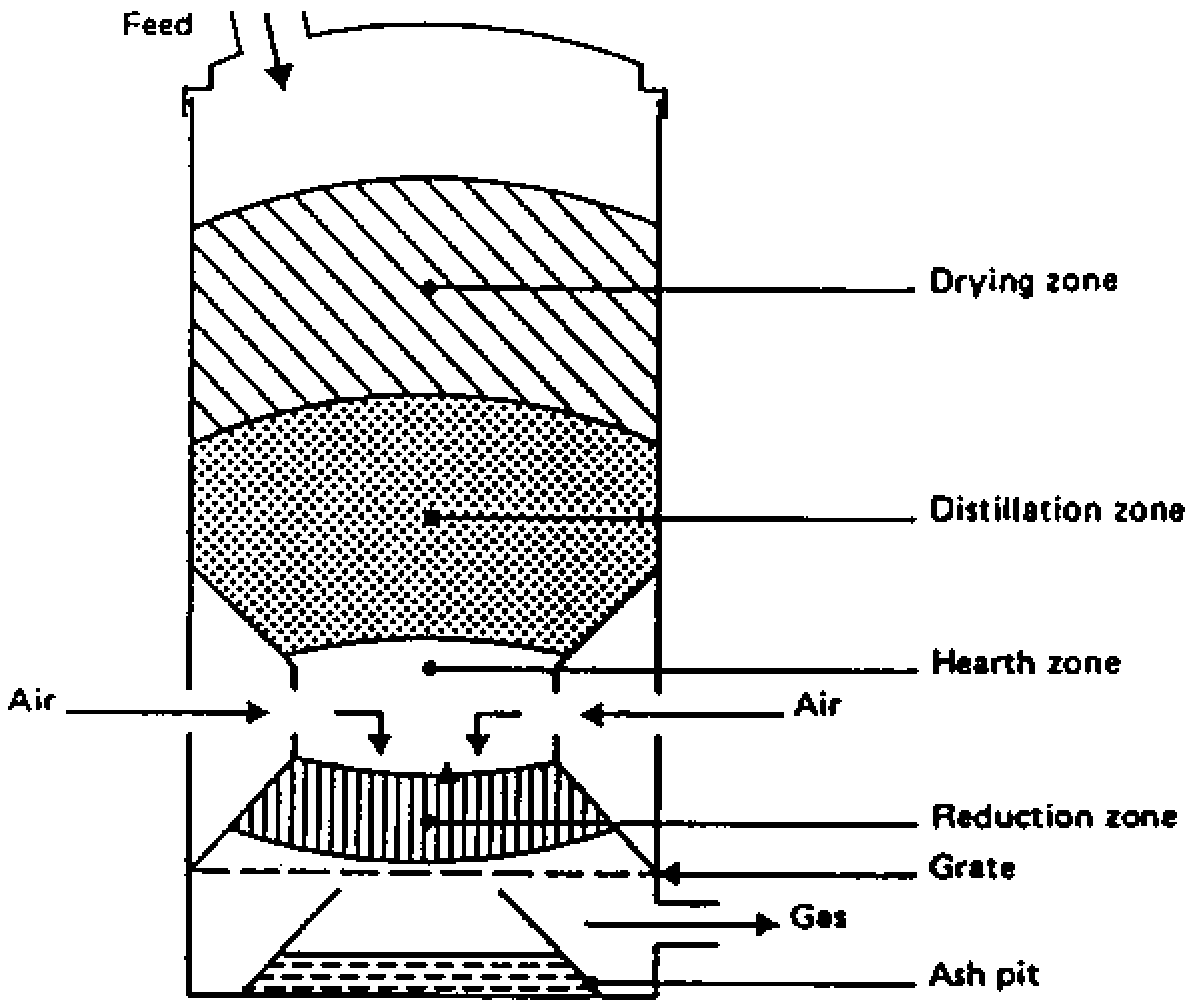


The air intake is at the bottom and the gas leaves at the top. Near the grate at the bottom the combustion reactions occur, which are followed by reduction reactions somewhat higher up in the gasifier. In the upper part of the gasifier, heating and pyrolysis of the feedstock occur as a result of heat transfer by forced convection and radiation from the lower zones. The tars and volatiles produced during this process will be carried in the gas stream. Ashes are removed from the bottom of the gasifier. The major advantages of this type of gasifier are its simplicity, high charcoal burn-out and internal heat exchange leading to low gas exit temperatures and high equipment efficiency, as well as the possibility of operation with many types of feedstock (sawdust, cereal hulls, etc.) . Major drawbacks result from the possibility of "channelling" in the equipment, which can lead to oxygen break-through and dangerous, explosive situations and the necessity to install automatic moving grates, as well as from the problems associated with disposal of the tar-containing condensates that result from the gas cleaning operations. The latter is of minor importance if the gas is used for direct heat applications, in which case the tars are simply burnt.

b. Downdraught or co-current gasifiers

A solution to the problem of tar entrainment in the gas stream has been found by designing co-current or downdraught gasifiers, in which primary gasification air is introduced at or above the oxidation zone in the gasifier. The producer gas is removed at the bottom of the apparatus, so that fuel and gas move in the same direction, as schematically shown in Fig. 2.3.

Figure 2.3 Downdraught or co-current gasifier



On their way down the acid and tarry distillation products from the fuel must pass through a glowing bed of charcoal and therefore are converted into permanent gases hydrogen, carbon dioxide, carbon monoxide and methane. Depending on the temperature of the hot zone and the residence time of the tarry vapours, a more or less complete breakdown of the tars is achieved. The main advantage of downdraught gasifiers lies in the possibility of producing a tar-free gas suitable for engine applications.

In practice, however, a tar-free gas is seldom if ever, achieved over the whole operating range of the equipment: tar-free operating turndown ratios of a factor 3 are considered standard; a factor

5-6 is considered excellent. Because of the lower level of organic components in the condensate, downdraught gasifiers suffer less from environmental objections than updraught gasifiers.

A major drawback of downdraught equipment lies in its inability to operate on a number of unprocessed fuels. In particular, fluffy, low-density materials give rise to flow problems and excessive pressure drop, and the solid fuel must be pelletized or briquetted before use. Downdraught gasifiers also suffer from the problems associated with high ash content fuels (slagging) to a larger extent than updraught gasifiers.

Minor drawbacks of the downdraught system, as compared to updraught, are a somewhat lower efficiency resulting from the lack of internal heat exchange as well as lower heating value of the gas. Besides this, the necessity to maintain uniform high temperatures over a given cross-sectional area makes impractical the use of downdraught gasifiers in a power range above about 350 kW (shaft power).

c. Cross-draught gasifier

Cross-draught gasifiers are an adaptation for the use of charcoal. Charcoal gasification results in very high temperatures (1500 °C and higher) in the oxidation zone, which can lead to material problems. In cross draught gasifiers, the fuel (charcoal) itself provides the insulation against the high temperatures.

Advantages of the system lie in the very small scale at which it can be operated. Installations below 10 kW (shaft power) can under certain conditions be economically feasible. The reason is the very simple gas-cleaning train (only a cyclone and a hot filter), which can be employed when using this type of gasifier in conjunction with small engines.

A disadvantage of cross-draught gasifiers is their minimal tar-converting capabilities and the consequent need for high quality (low volatile content) charcoal. It is because of the uncertainty of charcoal quality that a number of charcoal gasifiers employ the downdraught principle, in order to maintain, at least a minimal tar-cracking capability.

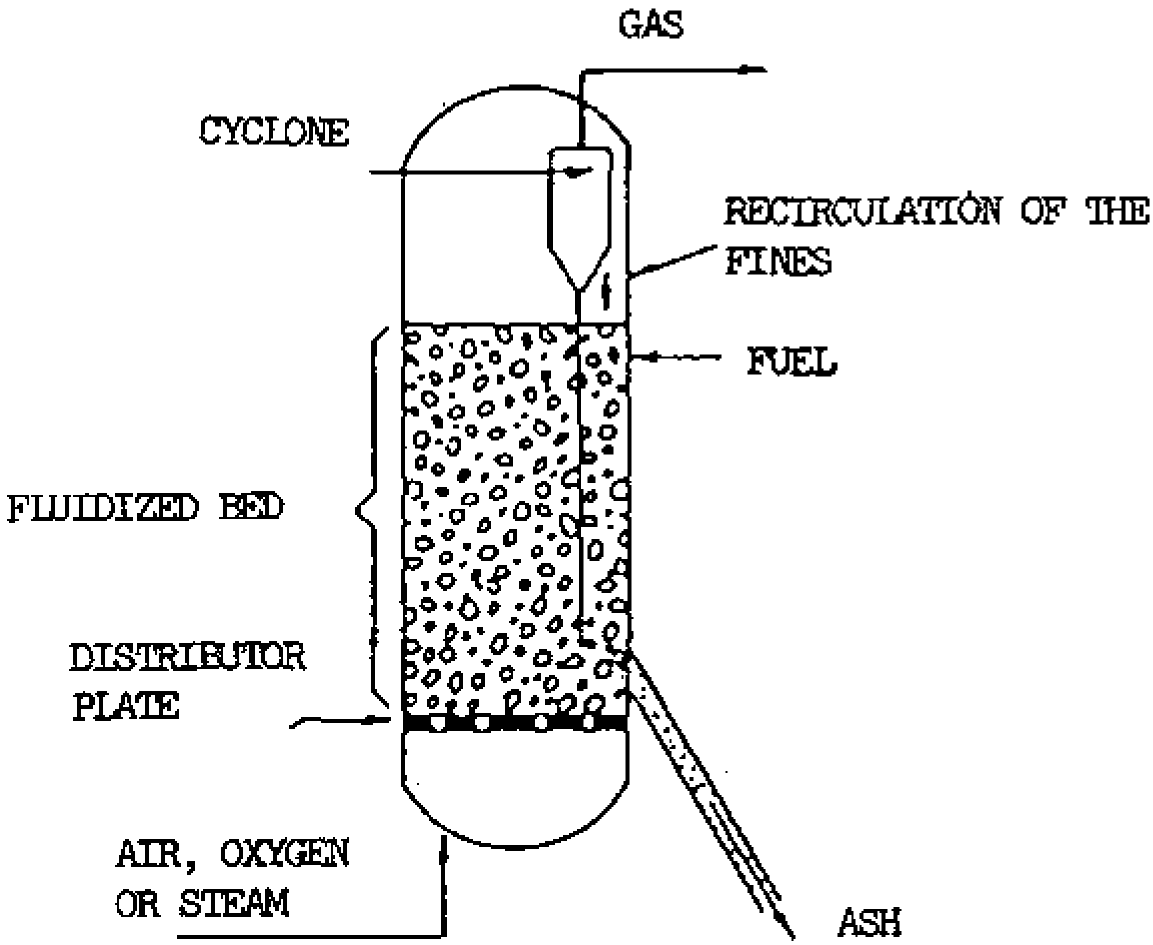
d. Fluidized bed gasifier

The operation of both up and downdraught gasifiers is influenced by the morphological, physical and chemical properties of the fuel. Problems commonly encountered are: lack of bunker flow, slagging and extreme pressure drop over the gasifier.

A design approach aiming at the removal of the above difficulties is the fluidized bed gasifier illustrated schematically in Fig. 2.4. Air is blown through a bed of solid particles at a sufficient velocity to keep these in a state of suspension. The bed is originally externally heated and the feedstock is introduced as soon as a sufficiently high temperature is reached. The fuel particles are introduced at the bottom of the reactor, very quickly mixed with the bed material and almost instantaneously heated up to the bed temperature. As a result of this treatment the fuel is pyrolysed very fast, resulting in a component mix with a relatively large amount of gaseous materials.

Further gasification and tar-conversion reactions occur in the gas phase. Most systems are equipped with an internal cyclone in order to minimize char blowout as much as possible. Ash particles are also carried over the top of the reactor and have to be removed from the gas stream if the gas is used in engine applications.

Figure 2. 4 Fluidized bed gasifier



The major advantages of fluidized bed gasifiers, as reported in the literature, stem from their feedstock flexibility resulting from easy control of temperature, which can be kept below the melting or fusion point of the ash (rice husks), and their ability to deal with fluffy and fine grained materials (sawdust etc.) without the need of pre-processing. Problems with feeding, instability of the bed and fly ash sintering in the gas channels can occur with some biomass fuels.

Other drawbacks of the fluidized bed gasifier lie in the rather high tar content of the product gas (up to 500 mg/m^3 gas), the incomplete carbon burnout, and poor response to load changes. Particularly because of the control equipment needed to cater for the latter difficulty, very small-fluidized bed gasifiers are not foreseen, and the application range must be tentatively set at above 500 kW (shaft power). Fluidized bed gasifiers are currently available on a semi-commercial basis.

e. Other types of gasifiers

A number of other biomass gasifier systems (double fired, entrained bed, molten bath), which are partly spin-offs from coal gasification technology, are currently under development. In some cases, these systems incorporate unnecessary refinements and complications, in others, both the size and sophistication of the equipment make near-term application in India unlikely. For these reasons they are omitted from this account.

Modern gasification systems that generate *ultra-clean gas* with high gasification efficiency for nearly any given biomass or non-biodegradable organic dry material, enables the use of the gas for high-grade heat or electricity generation via reciprocating engines or gas turbines in dual-fuel mode or gas–alone mode.

2.4 Gasifier for power generation

The mixture of final product gases (producer gas) consisting of 18-25% CO, 13-15% H_2, 3-5% methane (CH_4), 0.2-0.4% heavy hydro carbon, 5-10% CO_2, 45-54% N_2, 10-15% H_2O and particulate matter is drawn into the clean up system at about 250°C. In clean-up system, the gas is cooled and cleaned to remove particulates, and later introduced into the engine.

Commercially available biomass gasification system for power generation covers the range of 3-500 kW. The major areas where this system is relevant for power generation in a decentralised manner are:

(a) Village electrification in remote areas
(b) Energisation of a number of pump sets located in a cluster,
(c) Captive power for industrial units located in rural areas
(d) Captive power for industries that have biomass waste processes such as paper mills, sawmills, rice mills, etc.

The reactor is basically a downdraft system, where both gas and feedstock move downward as the reaction proceeds. The air required for gasification is partly drawn from the top, and the remaining from the air nozzles surrounding the combustion zone. The required suction for this process is obtained by using either a blower or an engine.

Woody biomass after drying and pyrolysing in the upper zone of the reactor undergoes volatile combustion leaving fixed carbon or char by the time it reaches the oxidation zone. In the oxidation zone the volatises undergo oxidation with the release of CO_2 and H_2O. These product gases undergo reduction, in the presence of hot bed of charcoal, and yield a combustible gas mixture.

The hot gas exiting at the reactor bottom is passed around the upper region of the reactor, where some sensible heat is transferred into the wood chips thereby assisting drying of biomass chips in the reactor. The hot dust laden gas exiting from the top of the reactor is led through a cooling and cleaning train, where the raw gas is cooled to ambient temperature in the cooling section and cleaned in the coarse and fine quartz filters. The gas then flows either to engine or to the flare.

2.5 Safety features

The fact that the gasifier generates a combustible gas needs safety measures to prevent any undesirable combustion of the producer gas before the engine or flare. Even though frequent leak tests are done to detect any leakage of air into the system (that causes the undesirable combustion of the gas), there are certain safety measures built to prevent any serious damage to the system in case of any explosion.

A number of special safety features such as water bubblers, water seal for all components, rupture diaphragms, etc. are incorporated in the plant. The operating manual describes the special operating procedures to prevent any air ingress, such as regular checks to ensure leak proof joints and maintaining the water levels in the seals. An oxygen sensor connected in the gas line before the engine also provides the check. Thus the system is quite safe for operation at any location.

2.6 Specifications for biomass

Any solid biomass (branches, stalk, weeds, shrubs, shells, corn cob, etc) with a dry bulk density (as fired) of more than about 200 Kg/m^3 can be gasified in the gasifier. It has to be cut to size. The optimum dimensions of the cut pieces change for different ratings of the gasifier, but as a rule of thumb, the length should not be more than about 100 mm and the other two dimensions not more than 30 mm (if circular, not less than 5mm in diameter).

The biomass has to be sun dried, air dried or dried with waste heat to less than 20% moisture content (the best results are obtained at less than 12% moisture).

2.7 Table 2. Solid biomass tested in various gasifiers

Species	Density (kg/m^3)
Casuarina	550 - 650
Eucalyptus	400 - 650
Phadauk	1'050 - 1'100
Silver oak	250 - 300
Pine (European)	200 - 250
Mulberry stalk	300 - 350
Ipomea	200 - 250
Jungle wood	300 - 600
Coconut shell	1'100 - 1'200
Cotton stalk	150 - 200
Buynath	1'100 - 1200
Rice husk, Sawdust and Coffee husk briquettes	900 – 1000

2.8 Gas cooling and cleaning system

a. Cooling system

There are two techniques - direct and indirect. In direct cooling, water at ambient temperature is sprayed into the duct carrying the gas. The other method is to cool via a heat exchanger so that water is not contaminated. The cooling surface required will be very large and the system design for large power levels (even 20 kWe system) will be unwieldy.

In order to preserve the quality of water to certain extent, one can combine both direct and indirect cooling. Direct cooling also washes the gas off particulates and some tar.

In some arrangements, liquid ejectors are used to cause good mixing between gas and water and hence have a very short section for cooling. The disadvantage with this technique is the need for large pressure drop across the cooling system - as much as 300-500 mm (water gauge).

Typical pressure drop across cooling system is between 10-50 mm wg.

b. Cleaning system

The cleaning system is expected to reduce the particulate content in the gas.

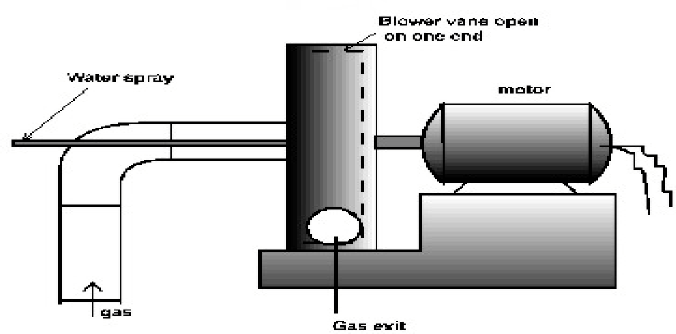
Cyclones are well known for reducing the particulate content. They are passive and work with moderate pressure drop ~ 20-50 mm wg.

For large power levels (therefore flow rates) cyclones are to be replaced by multi-clones. At the same flow rate, dividing the flow into several cyclones and maintaining the same velocity of the inlet of the cyclone, several smaller cyclones remove more fine dust.

Sand beds of varying particle sizes offer an excellent particulate collection system. They are a positive method of eliminating fine dust. The bed also collects some tar. Typical pressure drops ~ 20-50 mm wg.

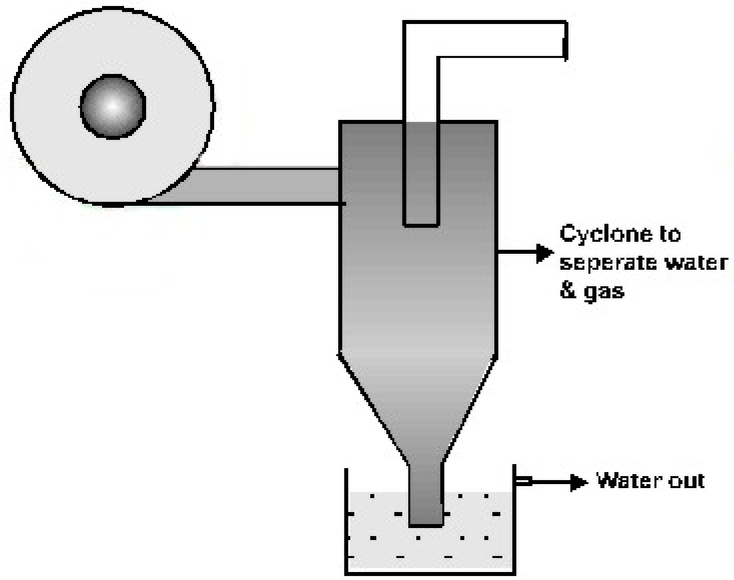
A novel method adopted is to take the gas through a blower and introduce a water spray at the centre (at IISc.).

Fig:2.5



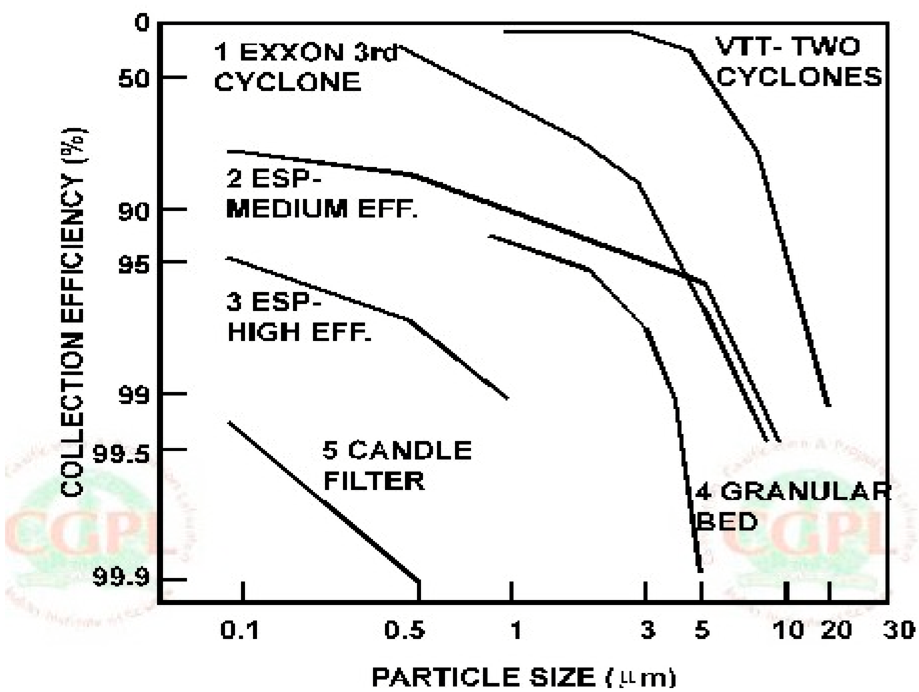
The water spray hits the outer wall of the blower and any condensed particulate matter is taken off the gas. This technique has been found excellent as the maintenance of the system can be handled very easily.

Fig: 2.6



For high pressure gasifiers the cleaning system uses a candle to permit filtration of high quality, but at the expense of the high pressure drop (of the order of an atmosphere or more).

Fig: 2.7



2.9 Table 3. Some typical data on a 100 kWe biomass power plant

1. Capital cost of Power Plant = Rs. 3.5 million; Rs. 35,000 / kW
2. Biomass price: Rs 400 – 1200/tonne (Varies from region to region and site to site.)
3. Cost of generation: Rs. 3 – 4/kWh (with a dual fuel engine) depending on the plant load factor
4. Electricity price for lower quality commercial and industrial loads charged by the local grids: Rs. 4 - 5 / kWh depending upon the State Electricity Board (without connection charges).
5. Electricity price of DG set power on 100% diesel: Rs. 6 – 8/kWh depending on the plant load factor
6. Pay back period: 2.5 to 4 years.

In view of both technical as well as economic feasibility of biomass gasification for power generation, the industries for captive use, besides rural areas for agriculture and domestic needs must use this technology for decentralised power generation.

Besides being an environment-friendly technology, it has the added advantages of employment generation and rural development. This also helps bridge the widening gap between supply and demand to some extent at reduced transmission and distribution losses.

Table 4. Solid biomass tested in various gasifiers

Species	Density (kg/m^3)
Casuarina	550 - 650
Eucalyptus	400 - 650
Phadauk	1'050 - 1'100
Silver oak	250 - 300
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Rice husk, Sawdust and Coffee husk briquettes	900 – 1000

Table 5. Typical data for a 100 kWe biomass power plant

1. Capital cost of Power Plant = Rs. 3.5 million; Rs. 35,000 / kW
2. Biomass price: Rs 400 – 1200/tonne (Varies from region to region and site to site.)
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4. Electricity price for lower quality commercial and industrial loads charged by the local grids: Rs. 4 - 5 / kWh depending upon the State Electricity Board (without connection charges).
5. Electricity price of DG set power on 100% diesel: Rs. 6 – 8/kWh depending on the plant load factor.
6. Pay back period: 2.5 to 4 years.

The final configuration for the reactor resembles very little with its parent of the mid-forties. It separates storage of biomass as a part of the reactor, as in classical design of the mid-forties and devotes it only to the conversion process.

It draws air from the top and from the sides permitting re-burn of the gases, hence creating a second high temperature zone where tar cracking can occur due to the simultaneous action of heat and catalytic action of hot char. The bottom section has a vertical grate and screw extractor for the ash and perhaps some char. The choice of the screw system instead of grate arises from the need to extract much larger amounts of ash compared to what would happen with woody fuels with low ash.

The first extraction of dust in the gas occurs in a cyclone. The gas may then have an indirect cooling system to extract clean heat. Subsequently, it passes through an ambient temperature ejector cooler-scrubber using water and chilled liquid ejector-scrubber before going through a very fine fabric filter.

The gas qualifies for being ultra clean. The gas that goes into a furnace or an engine is sampled by bubbling it through a transparent clean solvent to enable the gasifier operator to be sure of the quality of the gas in terms of presence of tar or particulates.

That the solvent remains clean and transparent hour after hour, day after day, gives innate confidence to the power plant operator. The engine or critical components of the control system in a thermal application will also operate in a manner that he is accustomed to when using fossil fuels.

It is possible to operate the gasification plant running on coconut shells or wood chips with low ash content such that one can extract char about 5% of the throughput. This char has properties of activation directly or with thermal treatment. This product has a sale value that can pay or more than pay for the cost of the raw material.

In power plants – gasification or direct-combustion using rice husk, the residue after combustion has considerable carbon – typically, 10 % and amorphous silica, if the combustion process is handled with limited residence time at high temperatures. This residue is a waste and current uses are in brick making and cement industries; even so, the waste generation far exceeds current utilisation.

Amorphous silica is a valued industrial product that can be extracted from the rice husk char/ash at production costs lower than the current prices at which Silica from sand produced in large amounts is sold. This can be used in conjunction with the power generation plants using rice husk.

Using biogas, it is possible to operate a diesel engine on dual fuel mode. Diesel substitution of the order of 80 to 85% can be obtained at nominal loads. The mechanical energy thus derived can be used either for energising a water pump set for irrigational purposes, or for coupling with an alternator for electrical power generation, either for local consumption or for grid synchronisation.

An appropriate site to realise the above application is an unelectrified village or hamlet. The benefits derived from this could be many, right from irrigation of fields to the supply of drinking water, and illuminating the village to supporting village industries. The other suitable sites could be sawmills and coffee plantations, where waste wood (of course of specified size) could be used as a feedstock in gasifiers.

2.10 Typical issues related to biomass gasification

a. Operational and maintenance issues - operational and other problems of gasifier systems

A typical starting problem of the gasifier is that after the ignition of the fuel bed, continuous and stable gas production does not occur, even after prolonged torching of the fuel bed. This almost always happens if the fuel is very wet. Sometimes, even though the gasifier can be started without any problem, gas production will either cease or gas quality will deteriorate (lean gas, smoky, and unable to sustain combustion). The two main reasons for this are bridging and clinker formation.

Bridging is caused if all fuel in the vicinity of air entry is burnt out and no fresh fuel drops into the empty space thus created. There could be several reasons for this but unless poking the fuel bed or shaking the grate or the gasifier itself breaks the bridge, gas production will not resume.

The operator usually resorts to opening the top of the gasifier and poking the fuel bed with a long rod. Some gasifier manufacturers provide openings or ports on the sides of the gasifier so that one does not have to use a long rod. Some designs try to overcome this problem by insisting on a certain size of the fuel but it is not very practical to obtain consistent size always unless good care is taken for fuel preparation.

Clinker formation occurs if the ashes contained in the biomass melt easily. Clinker usually develops over time, almost always near the nozzles or grate where combustion occurs. Many times this occurs when the gasifier is re-started after allowing it to cool overnight. Clinker formation is particularly difficult to handle because it cannot be observed visually, and if it is suspected after the bed is completely charged, removing the fuel becomes an arduous task. Then the clinker should be broken into pieces so that the pieces can be pushed through the grate. Coconut shells with fiber, firewood with bark, cashew shells, and briquettes are usually susceptible for clinker formation.

Another problem that occurs is the build-up of ash on the grate, especially for high ash fuels like rice husk. A very effective continuous ash removal system has to be designed to tackle this problem. In all the above cases, fresh fuel does not fall into the combustion zone, and the circular chain 'fuel-air-temperature' breaks, and gas production ceases.

Another frequent problem interrupting stable and continuous gas production is related to the deposition of impurities anywhere in the gas cleaning and cooling train. Such depositions lead to an increase in pressure drop and reduce the gas flow rate and ultimately prevent operation of the gasifier.

Attempts to continue operation by keeping the blower on and tinkering with the system without making an educated guess or without a measured parameter that indicates the location and nature of the problem often result in accumulation of gases in the reactor leading to an explosion.

Most gasifiers experience explosions (or back-fire) at some point during their operating lifetime. Fortunately, the explosions are not very strong but can unnerve a new or untrained operator or user.

As gasifiers are high temperature reactors and the resulting gases are corrosive in nature, it is quite logical that many kinds of material problems occur and questions on the lifetime of the various components keep arising. Some attempts have been made to analyze these problems but there are no standard material selection procedures or codes to be followed.

It is generally assumed (erroneously) that by using stainless steel (AISI 304) all materials problems can be solved. Many manufacturers tend to cut corners by using mild steel (MS) without adequate thickness or by using scrap material. Any future attempts of technology or component standardization should include a thorough study of the suitability of different materials for different parts of the gasifier system. Following early leads by TERI to use high-temperature castables, many manufacturers use such materials at present, but there are no set standards yet.

Operating an installation with a biomass gasifier means additional fuel processing, fuel handling, and system service compared with using liquid fuel. In particular, the regular cleaning of gas filters can be a dirty and therefore less attractive job. Service intervals for biomass gasifier plants are shorter than for plants using liquid fuels, which mean that the requirements on operator discipline are higher if operational disturbances are to be minimized. Operation itself also requires a higher time input, since high-tech control and safety systems that allow unattended operation are more difficult to justify financially for small-scale installations. Even with regular service, some operational disturbances, such as those that may be caused by irregularities in fuel properties, are likely to occur at irregular intervals. Such disturbances will demand intervention of higher skill and understanding of the process from the operator than is normally the case in liquid fuel operation. These skills can be transferred through proper training if the trainee has a reasonable level of diagnostic aptitude and ability.

The implication is that successful operation of a small-scale gasifier power installation calls for a more skilled, motivated, and disciplined operator than is normally needed for diesel engine operation. In addition, this operator must be willing to do dirty work. Often such operators are sometimes difficult to find on sites and in situations where small-scale power gasifiers are financially feasible. Some plants would have performed much better had the operators shown more skill and dedication in their tasks. More specifically, DG set operators are oriented as gasifier operators, especially without adequately adapting their skills and remuneration to the new and more demanding tasks. Introducing an incentive scheme based on fuel-cost savings, or both may be thought of.

The above-mentioned labour problems were not encountered at heat gasifier plants, probably because operating a heat gasifier intrinsically calls for less skill, motivation, and discipline than are needed for running a power gasifier.

Since it is more complex to fuel an engine with producer gas than with liquid fossil fuel, it is very likely that advice and technical support will be needed in the initial phase of the project, which may last for a year.

If other similar installations are operated in the neighborhood, the necessary support may be obtained from the users of these installations. In pioneer installations, however, support must be arranged either through the equipment manufacturer or through a technical consultant. This initial support must not be neglected or underestimated. Many if not most failures of biomass gasifier projects can be attributed to lack of sufficient technical assistance.

b. Skill development

A comparison of relatively successful and unsuccessful projects reveals that both sorts experienced problems during the initial period after startup, but the successful projects were those that had the expertise and resources to modify and 'debug' their plants and, in the end, arrive at more-or-less trouble-free operation.
Successful projects had the commitment of the gasifier manufacturer for a prolonged period to help the local operators immediately with technical, material, or spare-part supply problem. They also evidenced a strong (usually financial) motivation of management and operator alike to keep the gasifier working. The usual practice is to train the plant personnel on the shop floor by the supplier staff for about one week.

The commercial market for small-scale gasifiers is relatively small and widely dispersed. Plants that are installed are the ones generally funded by subsidies. Under such circumstances, technical and operational problems are to be expected, especially because the performance of power gasifiers appears to be sensitive to relatively small changes in fuel and energy demand related parameters.

Nevertheless, the results often show that some small-scale biomass gasifiers finally achieved reliable and relatively trouble-free operation. Experience and expertise in building and operating reliable, safe, and pollution-free gasifiers is thus now available.

The proper operation of a biomass gasification system requires training and experience. The labor required to operate the plant is quite different from that required to run a diesel engine of equivalent output. This difference is not only quantitative but also qualitative. During operation, the operator must frequently check a number of temperature and pressure meters and use the information so gleaned to make decisions on addition of fuel, shaking the grate, cleaning the blocked filters, and adjusting valves. At the end of the daily operation, the operator normally cleans the reactor and the filters of ash and dust. He may also be in charge of fuel preparation and fuel quality control. This means that, contrary to diesel engine operation, where the engine operator has time to take on additional and unrelated tasks, a small-scale gasifier requires a full-time operator.

It is generally found that that not every operator can master the required competencies for the operation of gasifiers. Besides motivation and discipline, the operator also must be able to react adequately on two or three input parameters, and master some basic technical skills. Biomass gasifier operations thus, require not only an adequate initial training program for operators but also a continuous technical backup for a period of at least a year.

Recent developments in the automotive industry have resulted in mass-produced hardware and software that may greatly increase possibilities for automatic control of gasifiers. The automotive industry manufactures and uses a number of inexpensive temperature and shock resistant sensors and attenuators. In combination with the corresponding multi-parameter input logic software, such instruments could conceivably monitor and control a biogas engine and reactor, thereby, largely reducing or eliminating the need for highly trained and experienced gasifier personnel. Although such a development would improve the current economic competitiveness of small biomass gasifiers only marginally, it would certainly increase the possibilities for speedy introduction of the technology.

Any activity not carried out with a motivated local partner is also destined to have no future. The most effective gasification programs have resulted from the formation of strong and experienced local organizations that enable the training of local personnel in different aspects of the technology and the adaptation of the process to suit local circumstances.

Therefore, an in-country group of competent and dedicated professionals with experience in technology development and implementation seems to be an essential starting point for any sustained expansion in the use of biomass gasification. Probably, it can be nurtured by bringing up a cadre of energy service companies.

c. Emissions and hazards

Biomass gasification systems produce solid, liquid, and gaseous wastes, which, if not adequately controlled, harm the environment. Solid wastes are primarily residue ash. The amount produced may vary between 1 and 20 percent, depending on the type of biomass fuel. In most cases, disposal of this ash is not a problem, and in other, such as rice husks, the ash may have value for use by industries or as a filler material for fuel briquettes.

Gaseous emissions from biomass gasifiers are also a significant factor in a few cases – updraft versions on start up or ash-cleaning operations in the immediate vicinity of the system, where CO leakages could be hazardous to workers. Compared to alternatives, especially fossil-fuel-based systems, biomass gasifiers are relatively benign in their environmental emissions, producing no sulphur oxides and only low levels of particulates.

The situation is not as encouraging as when large quantities of liquid effluents are produced, as is the case in updraft and 'open core' power gasifiers. The situation is exacerbated if wet-gas cleaning systems are used, which can dramatically increase the volumes of contaminated liquid effluent. In all cases, the effluent can be highly toxic, and untreated disposal of such effluent can lead to contamination of drinking water, fish kills, and other negative impacts. At present, additional research and development are needed to find solutions to this problem.

Fortunately, most downdraft and cross-draft power gasifiers can be equipped with dry-gas clean-up systems, which drastically reduce the quantity of liquid effluent produced. As a result, disposal can be accomplished in a more controlled and acceptable manner. The problem does not arise in heat gasifiers, because such systems usually combust the dirty hot producer gas completely, that is, inclusive of the tarry components, which are gaseous at higher temperatures.

Issues of industrial safety and environmental compliance as highlighted in World Bank report 2003 with reference to biomass gasification upscaling in India

Some important industrial safety issues pertain to exposure to high temperature surfaces, exposure to CO emissions, and prevention (and control) of explosions and backfires. The first item requires good insulating system design (and just not wrapping glass-wool sheets as is done too often) and the last two items require good instrumentation and control. Especially if the gas is burning inside a vessel (such as a furnace or a drier), there is a strong possibility that the flame might extinguish during the operation and with the blower on, combustible gases will accumulate in the closed space. So when the burner is restarted, an explosion takes place. A control mechanism that stops the blower if the flame extinguishes or a pilot injection, which will always allow the gas to burn, is thus highly desirable. Similarly when people are working in restricted spaces and if leakage of gases occurs, they will be exposed to dangerous emissions. It is required that CO alarms be installed in such situations but this is not usually done. Environmental compliance issues pertain to emission levels of exhaust gases and wastewater treatment. CO emissions from producer gas engines, especially 100 % gas engines, can easily exceed emission norms if catalytic converters are not employed. Water is used for scrubbing the gas and cooling and if the tar levels in the gas are very high (especially for updraft gasifiers), highly polluted wastewaters are produced. Chemical oxygen demand (COD) levels of up to 70,000 mg/lit have been observed in wastewaters from gasifiers and these waste streams are generally not treated at present.

Operation of biomass gasifiers may result in exposure to toxic gaseous emissions (i.e., carbon monoxide), fire and explosion hazards, and toxic liquid effluents. Avoiding poisoning by toxic gases is mainly a matter of following sound workplace procedures, such as avoiding inhalation of the exhaust gas during startup and ensuring good ventilation of gas-filled vessels before the personnel enter them for service and maintenance.

Avoiding fires and explosions is also primarily a matter of following sound procedures. In addition, however, it is important that the system is designed such that any internal explosion that may occur can be relieved to avoid damage to the system. Avoiding contact with carcinogenic compounds in the condensates requires the use of protective gloves, clothing, or both.

From the above, it may be concluded that with proper operator training, equipment and procedures, health and safety hazards and adequate care at the project design stage, these problems can be minimized or even eliminated.

d. Biomass availability, logistics and preparation

Often, there are concerns related to the logistics and the techno-commercial operations of biomass briquetting plants impeding their wide spread use. Some of these issues are not insurmountable - there are a few islands of successes that are worth emulating by the prospective users.

Coming to biomass required for gasification, demand is very low - present demand being not even 5 million tonnes, as against rising demand for industries, housing and agricultural sectors estimated at around 125 million tonnes which is growing.

Woody biomass is found in the form of branches and twigs gathered from the forest ground. Only 30-40 % of the bio-fuel is in the form of wood and 10-15 % are from the forests, most of the supply being from social forestry, waste lands, road side trees and agricultural operations. Besides, there is also a good case for accelerating growth in the use of agro residues estimated to be about 320 million tonnes. A large portion of agro residues is either wasted or used inefficiently.

Agro based biomass is not available throughout the year. Besides, rainy season constrains the users/suppliers by additional ingress of moisture and constraints of additional capacity or space for drying and storage. Besides, the biomass sector that usually depends on causal labour is also subject to the seasonal availability of work force affected by spells of agricultural seasons and other extraneous factors.

Seasonal availability of bio-energy resources, particularly agro-residues, necessitates storage or resorting to other alternate biomass. An associated consideration is that of storage requirements, with implications for both physical space and inventories resulting in added interest costs. In many instances, storage of specific feedstock may require special care to avoid fire hazards, etc.

Dependence on multiple feedstock because of the seasonal availability of biomass residues also means very elaborate procurement strategies, with a need to deal with many more suppliers, etc.

The high moisture content and relatively low bulk density affects agro-residues and biomass. This puts a toll on the logistics of transportation from the field in the rural environment. There are intermediaries to take care of the related issues of procurement, processing, storage, transportation and trading.

Assured supply of the biomass at a fair price is quite pertinent for the spread of its use for switching over to conventional fuels. The influence of the vagaries of market forces is difficult to predict on a long-term basis. In markets, where there are several options such as imported coal, domestic coal, lignite, wood, charcoal, biomass, biomass briquettes, fuel oil, etc, the cost prices are determined taking into account the efficiencies of utilization and calorific values. This is reflected in terms of prices for different fuels prevailing in Morbi, Gujarat as depicted in the following table:

Table 6. Comparison of fuel costs prevailing for competitive solid fuels

Fuel	Calorific value K.Cal/kg	App. Fuel to replace 1litre of oil	Approximate Rate in Rs/kg	Fuel Bill *
Steam Coal(B)	4500-5000	2.25	2.50	0.804X
Steam Coal (C & D)	4000-4500	2.75	2.00	0.786X
Steam Coal-Imported	5500-6000	2	3.25	0.929X
Briquettes-biomass	3800-4000	3.5	2.00	X
Charcoal	6000-6500	1.75	4.00	X
Wood- dry	3000-3500	4	1.50	0.857X
Lignite	3400-3500	3.5	2.00	X

* Variations are related to approximations as well as the inherent difficulties in sourcing the consistent quality by the market players

The managements may evolve suitable strategies to tackle these issues. A periodic review of the market trends may provide useful clues. Outsourcing the task of biomass procurement may be entrusted to an outside agency on a turnkey basis.

So far, biomass sourcing has not posed any serious challenges to the hundreds of existing gasifier users. It would be appropriate to orient the prospective users to the commercial issues such as procurement, logistics, storage, preparation, outsourcing intermediaries for optimal result oriented performance to convert the challenges into business opportunities.

e. Emerging trends

Gasification is an efficient way to extract heat from biomass. It is estimated that for each 100 kcal of potential energy in solid fuels, gasification can extract about 80 kcal in hot raw gas. This is more efficient than many other devices that burn biomass directly in a hearth or firebox. Besides, producer gas can be piped over short distances. It can be used for industrial purposes like fuel kilns, brick kilns, ceramics, glass pottery, etc., for boilers in rice mills, sawmills, and cashew industry or for power generation.

In any case, while using producer gas for heating, the burner must be designed for operation on low energy gas. Such schemes would fuel the demand to scale up the size of biomass gasifiers and versions that are adaptable for multi-fuel operations. Alternatively, feasibility to operate efficiently the captive briquetting or charcoal production units needs to be looked into.

Efforts are going on at the research stage for IGCC/Co-generation plants that would offer higher system efficiencies. Sterling engines that are relatively more efficient than the conventional internal combustion engine technologies, is another area for concerted research to tap the biomass potential. So far, the limited research efforts made to develop the technology has yet to fructify.

As gasifier technologies evolve, scale up of the modular units in commercial use is expected to increase due to economies of scale. It would also necessitate stepping up of the efforts in the direction of developing standards for gasifiers, engines, gas cleaning, effluent and waste disposal systems for emulation by the manufacturers, system integrators/professionals, testing agencies and users. This major area needs urgent attention by the MNES and professionals looking at the fairly large number of users in the far-flung locations and the future potential of the gasifier energy systems.

Biomass gasification is basically the conversion of solid biomass. It provides a valuable fuel for both mobile and non-mobile uses. Producer gas can replace natural gas, gasoline or fuel oils used to make steam for generating electricity and fire boilers, and produce heat for industries and domestic purposes. It can also be used as fuel for internal combustion engines for a wide array of purposes.

Biomass conversion in combustion engines can be far more efficient than the current bio-energy recovery technologies that burn the biomass in boilers and generate steam to recover useful energy in endothermic power plants. Research is also going on for modular package design of power plants using local distribution lines. This provides voltage support in rural areas and reduces high voltage transmission lines.

To sum up, a lot of new applications are likely to open up. However, major stress has to be on areas already tried out for the benefit of enterprises that would gainfully utilize the same on the basis of commercial returns. The application systems which are too small (below 100 kWe or 300 kWth) or need massive research, development and demonstration efforts are outside the scope of the report that is focusing on commercial exploitation of the feasible options, as delineated in the next section of the report.

Chapter 3: Potential applications of biomass technologies

In the past, initiatives have been extensively deployed by the industries, commercial establishments. SNAs, R& D organizations and NGOs have contributed to extensive applications. These include i) medium industries - thermal applications ii) small and rural industries iii) captive power to small enterprises iv) other miscellaneous uses including decentralized power v) tiny applications (7 - 30 kW) vi) Micro applications (1 - 7 kW). This section of the report presents an overview of the same.

3.1 Medium industries - Thermal applications

a. Industrial furnaces

There are a variety of fuel-fired furnaces that are ideal candidates for switching over to producer gas from biomass. Some typical furnaces are described below:

a.a. Forging furnaces: There are about 300 forging units widely spread in India. The forging furnace is used for preheating billets and ingots to attain a ‘forge’ temperature. The furnace temperature is maintained at around 1200 to 1250°C. Forging furnaces use an open fireplace system and most of the heat is transmitted by radiation. The typical loading in a forging furnace is 5 to 6 tons, with the furnace operating for 16 to 18 hours daily.

a.b. Re-rolling mill furnaces: There are over 2000 re-rolling units widely dispersed in the country. The furnaces may be batch or continuous type.

i. Batch type: A box type furnace is employed for batch type re-rolling mill. The furnace is basically used for heating up scrap, small ingots and billets weighing 2 to 20 kg. Re-rolling, charging and discharging of the material is done manually and the final product is in the form of rods, strips etc. The operating temperature is about 1200 °C.

ii. Continuous pusher type: The process flow and operating cycles of a continuous pusher type is the same as that of the batch furnace. The operating temperature is about 1250 °C. Generally, these furnaces operate 8 to 10 hours, with an output of 20 to 25 tons per day. The material or stock recovers a part of the heat in fuel gases as it moves down the length of the furnace. Heat absorption by the material in the furnace is slow, steady and uniform throughout the cross-section compared with batch type.

iii. Steel re-heating furnaces: Steel re-heating furnaces are deployed for metal forming and heat treatment operations. There is very little precise information about the number of furnaces. It is expected to be a few thousand, widely dispersed throughout the country.

The main function of a reheating furnace is to raise the temperature of a piece of steel to, typically between 900 and 1250°C, until it is plastic enough to be pressed or rolled in the desired section, size or shape. The furnace must also meet specific requirements and objectives in terms of stock heating rates for metallurgical and productivity reasons. In continuous reheating, the steel stock forms a continuous flow of material and is heated to the desired temperature as it travels through the furnace.

Continuous reheating furnaces are classified by the method through which stock is transported through the furnace. There are two basic methods:

- **Pusher type furnaces:** Here stock is butted together to form a stream of material that is pushed through the furnace. Such furnaces are called pusher type furnaces. The pusher type furnace is popular in the steel industry.

- **Moving hearth furnaces**: Stock is placed on a moving hearth or supporting structure which transports the steel through the furnace. Such types include walking beam, walking hearth, rotary hearth and continuous re-circulating bogie furnaces.

The pusher furnaces have relatively low installation and maintenance costs compared to moving hearth furnaces. The furnace may have a solid hearth. It is also possible to push the stock along skids with water-cooled supports that allow both the top and bottom faces of the stock to be heated.

Table 7. Operating temperatures of typical furnaces

Slab Reheating Furnaces	1200 degree C
Rolling Mill furnace	1200 degree C
Bar furnace for sheet Mill	1200 to 1250°C
Boggey type annealing furnace	650-750 degree C
Brass melting furnace	800 degree C
Alumuium Melting	60 degree C
Oil quenching Furnace	800-850 degree C

Furnaces that burn oil can be easily converted to burn producer gas through the installation of a conversion burner. It is not necessary to replace the entire furnace. A few case examples depicting biomass gasifier applications from the engineering industry are given in box-3.

Unique Structures and Towers, Urla Raipur

Urla Raipur Unique Structures and Towers, Urla Raipur, is a re-rolling unit producing angles, channels, rounds, and flats in 16-150 mm. The production capacity of the plant is 5-8 tons/hour. Normally the mill operates for 8 hours a day and the furnace about 3 hours, before the start of the mill.

Originally, the reheating furnace was furnace oil fired with average consumption at 280 liters/hour. Cosmos Powertech, Raipur installed a husk fired multi fuel updraft gasifier in October 2001, as part of the MNES sponsored project done by the unit with collaborative efforts from IIT, Mumbai. 140-150 liters/hour of fuel oil was switched by resorting to 500-600 kg/hour of wood or 700-750 kg/hour of rice husk. 25-30 % of fuel bill is reduced depending on the oil and biomass price variations.

Kesari Metals, Ural Raipur

The aluminum melting industry could benefit a lot by using biomass gasifiers. Aluminum melting units are basically in the small-scale sector, serving as ancillaries to major automobile and other large industries. These units use diesel for firing their furnaces, and procure diesel on a day-to-day basis at the prevailing market rate.

Kesari Metals, Ural Raipur produces extrusions. For extrusions, the aluminum ingots are heated up to a temperature of 450 degree C in a reheating furnace. The original design had an oil burner with consumption of 12 liter/hour. In 1998, the unit procured a wood gasifier and switched to producer firing. The fuel oil bill was reduced by over 50 % by this proposition.

Steel annealing

There is a steel pipe annealing plant located in Vadodara that has a gasifier installed for substituting furnace oil usage in its steel-annealing furnace. A 60 kW gasifier was installed in 2002. Burning of the producer gas at the burner attains temperature in the range of 950 to 1000 degrees Celsius, and is sufficient for the annealing operations. There are no supplementary fuel requirements for firing in the furnace.

The gasifier manufacturer, Ankur, supplied the modified burners, compatible for burning producer gas (burner design modifications are necessary for switching from liquid fuel to producer gas). The unit has a system of continuous ash disposal by a vibrating grate placed at the bottom of the gasifier and the ash is pumped out with the water stream. This method saves the cost of a water tank construction, besides the space required for tank installation. It also reduces water consumption amount and makes the disposal process of ash easier. The additional cost is that of a motor.

The capital cost for the gasifier installation was Rs 3.75 lakhs. It has completely eliminated the furnace oil consumption, and resulted in a 25 per cent savings on fuel cost which is an annual savings of Rs 4 lakhs with a payback period of less than a year. The user perceives low skill requirements for operating the gasifier unit. The unit performs well when run continuously, but problems are encountered in starting up the gasifier after shutdown. The gasifier throat needs to be replaced after every six months. For undertaking periodic maintenance activities, the user has a five year Annual Maintenance Contract (AMC) with Ankur. The manufacturer-user linkage seems to be strong – Ankur provides reliable assistance in solving technical problems.

Wood supply is reliable and of good quality. American babul that is available in abundance is supplied to the firm. The user is very well ware of biomass gasifier applications for power generation, but is unwilling to go for gasifier application for captive power requirements. He perceives uncertainties with respect to the reliability of technology and high system costs.

Tahafet, Hosur, Karnataka

Tahafet, Hosur, an industry involved primarily in heat treatment of castings uses about 90-100 unit/hr of LDO for the process. **The process, being an incremented value addition for minimal costs as perceived by the market, with rising costs of fossil fuels the entire operation become only marginally industrially sustainable.**

The replacement by gaseous fuel generated from solid briquettes of coconut shells was an economical choice, reducing the cost of the fuel to a third of the original cost. A 300-kg/hr coconut shell-based gasifier with a reactor, hot cyclone, waste spray cooling, and blower with gas being led to eight furnaces of different capacities, and operating with different duty cycles with producer gas both for the gasifier and the furnace, was installed in 2001 by NATRO. Temperature of furnaces is between 600 to 900 degree Celsius. Diesel/producer gas or a combination is allowed for.

b. Fired heaters

Direct-fired process heaters provide heat energy directly to an industrial process without the use of steam or a heat exchanger to heat fluids or solids. Direct-fired process heaters exist in a variety of forms to serve a variety of functions. Examples of industries that use this technology are the food, textile, paper, printing, chemical, rubber, plywood and plastic industries. The food industry uses direct fired process heaters to cook soups, fry, and sterilize; the textile industry uses direct fired process heaters for washing, scouring, and singeing; and the chemical industry uses direct fired heaters to heat liquids.

c. Dryers

Dryers are used in manufacturing processes by various industries to remove liquid (s) from wet solid. Examples of industries that use dryers are the paper, cardboard, wood and lumber, textile, ceramic, tobacco, plastic, paint, food, and pharmaceutical industries.

Due to the fact that many industries use dryers, they exist in a variety of forms. In these industries the dryer might be used to remove moisture used for washing, strengthening the product, or to facilitate handling of the product. Typical applications for agro industries are depicted in box-4. The paper and textile industries use cylinder dryers with multiple hot rollers to dry continuous sheets of paper or fabric.

One way to classify dryers is by the heat transfer method they use. There are three general heat transfer methods: direct, indirect, or radiant. In direct dryers, the product to be dried comes in direct contact with hot combustion gasses in a chamber and the excess moisture is vaporized and carried away.

In indirect dryers the product is not in direct contact with the heat, but is separated by a wall. Often the heat used in indirect dryers is steam generated.

Finally, in radiant dryers, infrared or dielectric radiation is used to transmit energy to the product for the purpose of heating and vaporizing the moisture. Thus, typical ceramics tile units use electrical pre-heaters to pre-dry the wares at temperatures ranging between 100-140degree Cesius.

Dryers are also classified as batch or continuous operations. In a batch operation, the product is grouped together and dried at one time, while in a continuous operation, the drying process is uninterrupted, i.e., the product is fed through the dryer on a conveyor system. Producer gas based system would need marginal process modifications/retrofits in the conventional fuel/steam heated systems.

Drier applications in agro - industries

Several regions in India are rich in horticultural production. However, horticultural produce, unlike agricultural produce, cannot be stored, and needs to be either quickly consumed locally or sold and transported. Although India is among the biggest producers of fruits and vegetables in the world, 30 % of this production is wasted and only 1.5 % is processed/preserved.

Some of the reasons are the lack of preservation/processing facilities at or near the point of cultivation and inadequate or expensive transportation facilities from the point of origin to the point of consumption. The absence of infrastructure leads to a distress sale of fruits and vegetables by the grower.

One reason why processing facilities have not reached the rural areas is due to the lack of reliable power. Drying of fruits and vegetables is a well-known method of preservation and value-addition. Through a DST supported project, TIDE (Bangalore) adapted and used the biomass-fired driers developed by ASTRA (IISc) to evolve drying protocols for a variety of fruits and vegetables and to promote women's entrepreneurship in rural areas.

The drier is a device made from locally available materials and uses biomass as the source of energy. It is easy to use and simple to maintain. It can be used to dry a variety of raw materials and can be operated by the local population with minimum training. It is fuel-efficient and can be designed to use a variety of bio-fuels. The operating cost of the drier is low. This technology is of great significance to rural areas.

Advantages

- Easy to use and operate with minimum maintenance
- Simple design
- Can be constructed locally or prefabricated
- Can be designed for various drying temperatures and drying capacities
- Dried products are of good quality
- Designs available for room driers to dry up to 1 ton of raw materials
- Rural population can be easily trained in drier operation and maintenance

A few topical case studies are given below:

Marigold tea drying - Sriguru Tea Estates, Coonoor, Tamil Nadu

The tea drying technology uses indirectly heated air in fluid bed dryers. The indirect heating was done in a furnace across which tubes were arranged to draw air from the ambient. Loading firewood, or lignite in some places, was periodic – through a manhole, generally kept open.

Tea drying involves reduction in the moisture content from 55 % to 65 % initially to less than 3 % finally. The latter is called 'made tea'. Performance of these dryers showed that the amount of firewood used was 1.5 to 2 kg per kg of made tea.

A gasifier based system involving the following elements was conceived at Marigold drying Sriguru tea estates, Coonoor, Tamil Nadu: (a) reactor for generating producer gas, (b) removing the dust by passing the gas through a cyclone, drawing the gas through a blower into which water in injected to reduce the dust level significantly, (c) a jacket surrounding the cyclone and other elements to extract heat by re-generation, (d) a burner to combust the gas with air drawn separately, and (e) mix the hot gas directly with cold air to produce the desired temperature of 100 to 1100 C and send to fluid bed dryer. The system was installed in a private tea-drying unit and the performance was checked.

Tea drying could be accomplished with 0.35 kg firewood at (greater than 15 % moisture) per kg of made tea. Standard tea brokers cleared the made tea. The system worked with coconut shells and other biomass that are agro residues and not firewood obtained by felling trees - an act which remains banned in this area.

The substantially reduced consumption of biomass compared to the classical indirect heating is due to several reasons: No serious assessment of the moisture in the incoming biomass was made. During summer it would be very dry and during rainy season very wet (up to 50 % moisture). The process of indirect heating has an efficiency of 30 % to 50 %. The fluctuating power of the furnace due to improper feeding would cause additional loss of energy in the chimney attached to the furnace. At Sriguru tea industry, a total of 100 tonnes of tea has been dried, using 35 tones of coconut shells in one season. At this time, the industry is sold out and the system remains unused.

Synthite, Karnataka

Synthite is a company in Karnataka involved in fine chemical extraction from flowers like Jasmine, Marigold and others. The oleoresin, from which one gets Xanthophylls, is extracted from Marigold flowers. The process involves setting, drying, and solvent extractions. The drying process uses about 50 % of the total energy cost in the product. Currently it uses diesel (not furnace oil since its large sulphur content leads to contamination). The waste from the process is the pulverized flower that has lost a tiny fraction of the chemical. This material has an ash fraction of 6 % without soil/inorganic pickup and 12-15 % with limited inorganic/soil pickup.

The technology by IISc implemented through NETPRO as the manufacturer, involves use of appropriate sized briquette material in a gasifier specially designed to substantially reduce, if not totally eliminate the ash fusion problems associated with the inorganic content that reduce the ash fusion point. The reactor designed for lower velocities through the system has, in addition, screw extraction facility for taking out ash/fused char matter from the bottom of the reactor.

It can successfully operate for about 100 hours on the briquette biomass, and since the industry wanted to use coconut shells as the fuel, the entire operations are being conducted using coconut shell. Another specialty of this design is that the same reactor is able to handle both the fuels.

Operational performance:

1600 hrs of run 130 – 140 l/hr diesel replaced
400 – 420 kg/hr coconut shells consumed
System capacity - 2 MWth (450kg/hr)

Elements: Reactor/screw extraction systems/cyclone/spray water/blower with variable speed control. Instrumentation and an automatic plant management system in its operation it replaces 130-140 liters /hr of diesel at one third of the cost of the fuel. 1 liter/8 Rs, 3 kg / 6 Rs

Agro Biochem (India) Private Limited, Harihar

Agro Biochem (India) Private Limited, Harihar is involved in Marigold flower drying and extracting the oleoresin leading to Xanthophylls extraction. Way back in 1998, they felt the need to reduce the cost of drying, by replacing diesel by a gaseous fuel produced from solid accessible to them.

This led to the development and supply of the gasifier for drying applications. The thermal system is meant to produce about 1 MWth (250 kg/hr) wood chips/juliflora prosopis chips as the fuel. Fine dust is removed via a hot cyclone. The gas is burnt in a combustor and the burnt gases are diluted to generate hot gas at the desired temperature. The first version has a bottom ceramic shell and the top twin SS shell. A central air nozzle located 0.5 m above the air nozzle around the periphery is arranged to enable the central region get air for flaming combustion/subsequent char reduction. The system has run for over 1500 hours without any problem. Subsequently ceramic sections have been restored, particularly the hot section tiles.

The project has been handled commercially by M/s I. J. Machines/Confabs for Agro Biochem company. Subsequent product support, introduction of new generation concepts sought from ABETS, CGPL, IISc. A 2 MWth system, similar to the one built at Synthite, has been built to meet the total drying requirements of the industry. The system elements are similar to the ones in case of Synthite. The system uses Juliflora Proropis, as it is available locally. The dried flowers are sent to 300 km to another location for the extraction of the Xanthophylls, briquette and shipment back to the location where drying is performed and contemplated in the next phase.

Performance:

750 hrs of run 120 l/hr diesel replaced
350 – 400 kg/hr wood consumed

Bagavathi Bio-Power, Metupalyam, Tamil Nadu, India

Bagavathi Bio-Power, Metupalyam, Tamilnadu is a group company of United Bleachers Limited, Metupalyam, one of the largest textile processing facilities in Tamil Nadu. UBL imports over 270 kWe of power from TNEB grid at the rate of Rs 4.50 (US c 10)/kWh. The power plant is 120 kWe supported by 150 kg/hr gasifier commissioned in August 2003.

It is a 100 % gas based system with Cummins gas engine - GTA 855 G, having special IISc designed carburetor and air gas regulation. Feedstock is coconut shell and Prosopsis. It has a 150-kg/hr waste heat drier installed to dry biomass, using energy from engine exhaust. The system has operated over 7500 hours and for 24 x 6 days continuously. Maximum load of 130 kWe has been achieved, with 35 % fluctuation in load. Fuel consumption is 1.15 $\pm$ 0.1 kg/kWh. In addition, it generates value added product - activated carbon. The Cummins R&D team inspects the system periodically. The P&T level collected in the engine at periodic interval of 1000 hrs amounted to 30 ppb. Overall operations have been satisfactory.

d. Kilns

Primarily the stone and clay industries use kilns to melt and heat different substances. Examples are the gypsum, vitreous china-plumbing fixture, brick and structural clay, and concrete industries. The five above mentioned industries use kilns specifically designed for their needs.

Table 8. Typical firing and operating temperatures prevailing in ceramic units

Nature of ware	Type of firing	Operating Temperature	Type of kiln
Stoneware	Single	1220-1250 deg C	Tunnel kiln
Bone china	Biscuit & glost	1200-1250 deg C 1025-1050 deg C	Tunnel kiln
Porcelain	Biscuit & glost	1000-1020 deg C	Tunnel kiln
Sanitary ware	Biscuit & glost	1250-1300 deg C	Tunnel kiln/roller kilns
Vitreous China	Biscuit & glost	1250-1300 deg C	Tunnel kiln
Wall tiles	Biscuit & glost	1100-1120 deg C	Tunnel kiln/roller kilns
Insulators	Firing & Cooling	1280-1320 deg C	Tunnel kiln/roller kilns

Morbi in Gujarat is known for its ceramic tile units, including those making sanitary ware and roofing tiles. These units have furnaces for biscuit making and for glazing of the tiles. A majority of these units use liquid fuels such as kerosene, furnace oil, LPG etc. to meet their energy needs.

Biomass gasifiers were tried out for biscuit making and later for glazing of tiles. The capacity of gasifiers is between 60 kW – 300 kW. The main users are ceramic tiles manufacturers in Morbi for thermal applications, with which they save up to 50 % of the fuel cost.

Replication of this case, in similar units across the country, could lead to a substantial saving for the ceramic industry as a whole, besides a significant reduction in the consumption of fossil fuels and the consequent reduction in oil imports thereof. The box below depicts case studies for this sector.

Jyoti Ceramics, Morbi

Ankur installed its first gasifier in Jyoti Ceramics, Morbi, a ceramic tile unit in Gujarat in 2001. Most of the ceramic tile units use liquid fuels like kerosene and furnace oil, and a few advanced units have roller kilns that use LPG.

The owner of the unit where the first gasifier was installed was reluctant for fear of not being able to reach a temperature level sufficient for his operations (1050-1100 °C). The furnace consumed 1500 liters of kerosene daily, and a kerosene replacement of only 50 to

70 percent was planned in the initial stages. The gasifier installations led to a 90 percent reduction in the kerosene consumption.

Fuel supply is from Prosopis Juliflora, a sturdy species that is found in saline/arid areas. Its growth is highly prolific and encroaches upon agricultural lands. Therefore the government of Gujarat announced a policy, a couple of years ago, for harvesting this species and containing its growth. This has reduced prices from Rs 1000 per ton to Rs 500 to 600 per ton and the biomass is readily delivered to the ceramic units.

For a representative ceramic tile unit, a gasifier capacity of 300 kWe requires an investment of Rs 3 million. Kerosene consumption before gasifier installation is estimated to be 3,800 liters/day and the reduction in consumption after gasifier installation is 3,400 liters/day. The daily wood consumption is around 13,000 kg. This results in a payback period of 4 to 5 months for the unit.

At present, there are fifteen applications in a cluster of ceramic manufacturing units in Gujarat, and many of these have crossed 10,000 hours of operation. Based on these encouraging results, two other firms installed gasifiers in biscuit making and glazing furnaces- each gasifier resulted in a saving of 1300-1500 liters per day of kerosene by substituting it with a wood consumption of 6 MT per day (250 kg/hr/day of biomass consumption). The daily monetary savings were estimated to be above Rs 14,000 per gasifier and has enhanced the competitiveness of these firms.

e. Ovens

Ovens are used by the industry for low temperature (ranging between 20 to 370 degree Celsius) cooking, baking, curing, or to vulcanize (a treatment that stabilizes and adds elasticity) rubber or plastic. The food industry uses ovens to bake bread, cookies, crackers, pretzels, while the rubber and plastic industries use the lower temperature heat produced in ovens in the production of tires, footwear, hosiery, and rubber belts (e.g., fan belts).

While many different types of ovens exist, they can generally be thought of as batch ovens or continuous ovens. In batch ovens, the product is placed in the oven, heated, and then removed. In continuous ovens, a conveyor system is used to move the product through the oven.

In general, ovens are direct fired. In a direct-fired oven the heat is generated through combustion of the fuel. Indirect fired ovens are prevalent for applications that may get contaminated with particulate matter in the products of combustion.

f. Small Boilers

Small sized baby boiler, used at present in many small industries such as food processing and chemical can be retrofitted easily to burn producer gas. Installation of the gasifier helps in replacing the oil, coal or burning biomass for raising steam. Alternatively, installation of gasifier helps in replacing wood/ biomass burning-boilers, which are generally bulky and polluting. As gasifiers are not covered under IBR, it may be favored by the small firms, which are not so comfortable with IBR.

Boilers can also be retrofitted easily to burn producer gas. Users of LDO and furnace oils can shift to firewood/wood waste briquettes at specific sites where biomass is available at low cost. For thermal applications like hot air generation, drying, cooking and steam generation, cost per unit of useful energy through the gasification route is 60 % cheaper than furnace oil/diesel option at the current prices of furnace oil/diesel and biomass fuels. The technology offers advantages similar to commercial fuels like LPG, diesel and kerosene, but at much lower costs.

g. Carbon dioxide plants

An excellent example of biomass gasifier is for process use is carbon dioxide manufacture for aerated drinks as depicted by typical case examples in the box

Case: Mahabhadra Industrial Gases, Gujarat

Mahabhadra Industrial Gases, a bottled carbon dioxide (CO2) manufacturing plant located near Vadodra, Gujarat, uses a downdraught gasifier developed by Ankur. The system, with a capacity of 150 kW, has been operating since 1993, and is somewhat unique in that the producer gas, is not only used for process heat applications, but also serves as a raw material from which CO2 is extracted.

The gasifier application has led to improvements in the product quality, as the producer gas is a better feedstock for CO2 extraction than the kerosene that was used before the installation of the gasifier. The manufacturing unit has completely substituted its kerosene and other liquid-fuel usage with producer gas from the biomass gasifier. Gasifier installation has also led to the elimination of sulfur dioxide scrubbing. Due to this, there have been large gains to the owner, and the product quality has also improved.

The total cost investment for the gasifier was Rs 600,000 and the MNES subsidized 20 percent of the cost. Gasifier installation led to an increase in the production capacity of the system from 80-90 kg of CO2 per hour to 120 kg per hour along with the elimination of diesel consumption of 35 liters/hr. The savings in fuel cost alone are estimated to be over 60 percent. With savings in liquid fuel consumption, as well as elimination of the scrubbing process and overall improvements in plant productivity, the payback period of the investment was eight months.

The owner of the firm does not experience any problems with respect to biomass supply. Wood supply is from a plant named 'babul' that grows mainly on degraded land. It is delivered to the factory in truckloads at a price of Rs 1/kg and dried in the open in the factory premises. The quality of the dried wood is judged visually – there are no moisture meters for monitoring the wood quality.

A person is employed for cutting the wood into specific lengths by a mechanical saw cutter. The gasifier is fed every 2 hours manually from sacks full of wood pieces. At the time of installation, the technology supplier, Ankur, trained the users for a week on the operation and maintenance procedures. The firm owner perceives the gasifier operation to be relatively simple with a low level of skill requirement and he has deployed existing plant personnel for its operation and maintenance.

The user-manufacturer linkage is strong and the manufacturer's participation in major maintenance activities is satisfactory. Regular maintenance requirements are perceived to be low – problems are encountered only if there are interruptions in gasifier operations and in subsequent start-up. Some periodic maintenance is required for repairing the construction materials that get corroded with operation.

Case: Nahta Metals and Air Products, Urla Raipur

Nahta Metals and Air Products, Urla Raipur is an industrial gas production unit. It is a continuous plant, manufacturing CO2 for pure drinks and inert gas welding applications. The unit was originally designed to produce 80-200 kg/ hour of CO2 by burning 65-75 litres/pour of oil. Cosmo Powertech, Raipur, supplied the gasifier. After Installation of the gasifier, about 200-210 kg/hour of CO2 is being produced. The saving achieved in fuel costs is more than 50 %.

3.2 Small and rural industries

Biomass fuels are the main source of energy for a large number of tiny cottage and rural industries in the unorganized sector, with scant information about the industry or energy profile. These industries provide employment to millions of people and are a very important part of the national economy. Biomass consuming industries may be:

a. Traditional rural cottage industries that depend on biomass fuels, such as wood or local residues with assured supply at very low costs. These include brick kiln units, crop drying and baking units, small artisans engaged in the production of potteries, small hand tools, etc.

b. Potential biomass based industries willing to switch over, at least partially, to biomass fuels due to sheer cost benefits. These may include textile dyeing, limekilns, khandsari units, mini cement plants, etc.

A few interesting applications include cardamom curing, silk dyeing ovens and crumb rubber drying applications (Box –I) developed by TERI. The new gasifier powered silk reeling system developed by TERI is a substantial improvement over the other traditional oven systems.

Crumb Rubber Manufacturing - Alwaye Rubex, Kerala

There are about 60-crumb rubber units at the small-scale level, mostly situated in Kerala. The process of crumb rubber manufacturing, involves the collection of auto-coagulated rubber from rubber trees, reducing it to small crumbs, and the reduction of moisture content. The small crumbs of rubber having about 40-50 % moisture are filled in perforated trays (35-45 kg/tray) and placed on carriers, which move inside tunnel drier. Hot air at about 120 degree Celsius is blown throughout the length of tunnel drier. The returning cooler air is recycled after heating.

The heating is thermostatically controlled. After approximately 4.5 hours, dried rubber at about 85-90 degree Celsius is delivered. It is then cooled and baled into blocks of 25 kg using a hydraulic press. These rubber-making units use either diesel or electricity for the generation of hot air.

Initially, to encourage the sector, the state government provided subsidized electricity to these units at the rate of Rs 0.50 /kWh for the first five years of operation. This has been phased out. The very fact that now they have to pay the normal electricity tariff at the rate of Rs 2.60 /kWh compelled the units to shift over to diesel as fuel.

However, since the domestic rubber industry faces stiff competition from imported rubber from Malaysia, Indonesia and Thailand due to higher energy costs, these units started exploring alternative energy options, and biomass gasification appeared as the most cost-effective solution.

For thermal applications like hot air generation, drying, cooking and steam generation, cost per unit of useful energy through the gasification route is 75 % cheaper than furnace oil/diesel option at the current prices of diesel, electricity and biomass fuels. The technology offers the advantages of commercial fuels like LPG, diesel and kerosene, but at much lower costs.

This case study is based on the data collected from Alwaye Rubex Private Limited, Alwaye, Kerala. The unit has two tunnel-drier and combined rated output of 16 MT of dried rubber per day. The option of using biomass gasification instead of diesel-fired oven was deployed. Gasifier capacity was to be 2,25,000 kcal/hr for each tunnel drier. Gasifier capacity is 100 kW with the consumption of 100 kg of coconut shells per hour. Capacity of one tunnel drier is 8 MT/day; diesel consumption is 50 lit/MT; diesel consumption per day is 400 liters; total production per tunnel is 2500 MT/annum; Total diesel consumption is 1,25,000 lit/annum; Energy Cost savings is Rs 6000/day or Rs 20 lakhs per annum.

3.3 Captive power to small enterprises

Biomass based technologies are a very promising option for decentralized energy generation in India, particularly in the areas, which suffer from frequent power shortages. Given the vagaries of grid-connected power in many developing countries, a captive generation system also offers the benefit of a reliable electricity supply.

Such biomass based projects bear a great potential to trigger sustainable development, both from a socio-economic and an environmental perspective. This category pertains to the use of gasifier-based electricity generation systems to utilize the excess/waste biomass that is available as a by-product of agricultural or industrial processing.

Hence the key features of the biomass supply are, large quantities, relative uniformity of composition, and one single supply source. It is these features that make this category of applications particularly attractive. Examples include rice mills that have an abundance of waste rice husk, sugar mills that have large quantities of bagasse/cane leafy matter, cashew-processing enterprises producing cashew-nut shells as waste, wood based saw mills, etc. The generation of captive power is intended to replace the grid-based supply, which is the existing source of power for these enterprises.

Depending on the size of the enterprise, the gasifier-based electricity generation system would have capacities in the range of 100-500 kW. While the gasifier can be coupled to a duel-fuel diesel engine, the economics are far more favorable with 100 % producer-gas operation. Given the large scale of the overall system, and the relative uniformity of the feedstock across most of the firms in any category (for example, the rice husk produced by all rice mills will be rather similar), it may be possible to standardize the elements (i.e., the gasifier, engine, etc.) as well as the system design. In general, power plant design, generating capacities in the range of 100 kW and above with high load factors have also been identified as more cost efficient due to economies of scale.

Captive power plant for a potassium chlorate unit

A 200 kW biomass gasifier system has been installed for power generation in a potassium chlorate manufacturing company in Andhra Pradesh. An average of about 3800 units is generated in a day. Of the total power generated, about 12 % is being consumed by axillaries.

The gas produced contains tar, particulate matter, etc. and is being filtered and cooled with scrubbers and micro filters. The electricity generated is used for electrolysis to produce potassium chlorate. The cost of power generation works out to Rs 3.0 per unit vis-à-vis the present grid electricity charges of Rs 4.50 for HT industries.

Total investment for this project was Rs 61.0 lakhs. The estimated annual savings of this project is about Rs 17.0 lakhs per annum that was paid back within two years, after considering the subsidy component.

Ma Bhabani Rice Mill, Burdwan, West Bengal

Around 6 MW capacity of rice-husk based generation for captive power production has been set up in West Bengal, with most of these units being installed by a single manufacturer, Ankur. Rice mills usually meet their captive power requirements using grid power or diesel (in the latter, the cost of generation can be as high as Rs 9-10/kWh). Electricity has a very high share in the monthly expenditure of a rice mill.

Setting up of gasifiers based on rice-husk, the by-product generated in the mill, offers a commercially attractive alternative for meeting captive power requirements. Rice mills pay as high as Rs 150,000 as monthly electricity bill. The payback period for investments in biomass gasifier for captive power generation in a rice mill is around 12-18 months. Given that most of the installations are quite recent, it is difficult to assess the performance of these units at this time. An example of a rice-husk based gasifier project follows:

A 250-kWe rice-husk based biomass gasifier is installed at Ma Bhabani Rice Mill at Burdwan in West Bengal. This utilizes a closed-top throat-less downdraft gasifier coupled to a dual-fuel engine supplied by Ankur.

The biomass fuel input requirement is around 250 kg/hr. The system is usually operated at a load of 180 kW for which the biomass feed requirement is about 150 kg/hr. The gas cleaning procedure is more elaborate for rice-husk based gasifiers as compared to those based on woody biomass, as the producer gas generated from rice-husk as feedstock has higher tar content.

The gasifier costs around Rs 1.4 million, with an added cost of Rs 150,000 for installations. The diesel generator set (supplied by Greaves) costs Rs 1.2 million. There was an additional cost of Rs 230,000 associated with civil works construction. Hence, the overall project cost was around Rs 3 million. Subsidy by MNES was Rs 700,000.

With the gasifier, the monthly electricity bill has been reduced from Rs 35,000 to Rs 10,000. While the quality of electricity supply from the grid was poor with low voltages and large voltage fluctuations, the captive generation from the gasifier has resulted in much better electricity supply. By spring 2003, the system had operated for 1800 hours.

Three skilled personnel per shift operate the plant. They are responsible for feeding the gasifier at regular intervals and ash removal. The plant personnel are adequately trained for undertaking O&M, and hence, there is no need for hiring any additional personnel. The plant owner feels that the gasifier installation has increased the competitiveness of the unit.

Maa Tara Modern Rice Mill, Burdwan, West Bengal

A 350-kWe-biomass gasifier system, with rice husk as fuel, has been installed at M/s Maa Tara Modern Rice Mill, Burdwan (West Bengal). This has resulted in an average diesel replacement of 80 % at full load condition. The system has been under operation for the past three years and was supplied by Grain Processing Private Limited, West Bengal. It has led to an average diesel saving of 35 litres per hour and 280 litrers per day. The mill owner has reported that within five months of operation, he has saved Rs 4.5 lakhs.

3.4 Other applications

a. Institutional/large-scale cooking

Fuel wood is presently used in large quantities for cooking in hostels, hospitals, hotels, and community kitchens like mid-day meals for school children, marriage parties, and sweet shops. Thermal efficiency of large stoves using firewood is low (approximately 10 %) and necessitates the use of large quantities of firewood. Use of gasifier reduces fuel wood consumption by about 50 %. Power delivered can vary over large range, making cooking faster. Depending on the availability of biomass and space, LPG users can shift to firewood/biomass gasifiers.

b. Cremation

Cremation is a major consumer of fuel wood in India with an estimated annual consumption of about 5 million tonnes. Many times the body is not completely burnt due to scarcity of fuel wood and is thrown into the river causing considerable pollution of water.

TERI has demonstrated the feasibility of a gasifier based crematorium as an alternative efficient and eco-friendly option for cremation, under an MNES sponsored project, with substantial fuel saving (over 50 %) and pay-back period of about one year. Unlike electric crematoriums, gasifier systems are likely to receive cultural and social acceptability, as the body will be burnt into flames of producer gas obtained through gasification process.

c. Small power plants in the rural / semi- urban areas

Unreliable grids that reach few regions or, more often, generators that run on fossil fuel, supply electricity in the decentralized areas. Unreliability of power supplies, and the costs related to the more reliable, but expensive and polluting diesel generators, are important barriers to business activities relying on modern technology in rural locations.

Biomass gasifiers can play a significant role in helping to bring modern energy services to villages that do not have access to electric power by virtue of their geographical remoteness from the power grid. For example, the only source of lighting in many villages is kerosene lamps.

One of the problems in trying to provide decentralized power to the villages is that the cost of power is highly dependent on the load factor. The box below presents a few cases for biomass based decentralized power generation.

Gasifier power for remote island

The Chhottomollakhali Island in the Sunderbans area of South 24 Parganas district of West Bengal is an island located in the Bay of Bengal, with population of about 28,000 whose main occupation is fishing and agriculture. It is difficult to extend grid electricity to this island due to the prohibitive cost involved in crossing various rivers and creeks. In the absence of electricity, the economic development of the Island was suffering.

The switching on of the 4x125 kW power plant based on biomass gasifier on 29th June 2001 has changed the lives of the inhabitants of this remote Island. The plant is catering to the electricity needs of domestic, commercial and industrial users, such as drinking water supply, hospital, ice factory, etc. Four villages of the island have benefited from the power plant.

Built at a cost of Rs 1.46 crore, the gasifier power plant has 800 consumers and is supplying power for six hours from 5 PM at the rates of Rs 4.00, Rs 4.50 and Rs 5.00 per unit for domestic, commercial and industrial consumers respectively. It has an energy plantation area of 40 hectares. Under full load condition the fuel consumption comprises 70 % biomass and 30 % diesel.

Captive power at MVIT Bangalore

This is an independent rural power producer that supplies reliable and standard quality electricity to a technical institute on the outskirts of Bangalore. It falls in the category of industrial and institutional power plants, located in a semi-urban area where biomass is available from sustainable sources. Such plants are designed to run round the clock through out the year.

The project has been built as a captive facility of Sir M. Vishweswaraya Institute of Technology, (MVIT). It is one of the leading technical institutes affiliated to the Bangalore University. The institute is located in one of the prime areas on the outskirts of Bangalore, near the proposed international airport site. National Highway 7 from Bangalore to Hyderabad runs by the side of the institute.

The project has been undertaken with a 2x100 kWe biomass gasification based power generation facility in the BOO category. The college campus is spread over an area of 135 acres. Apart from branches of engineering studies, the campus also houses a dental college and a well-equipped hospital with Sri Krishnadevaraya Educational Trust.

MVIT was forced to run diesel generators because of the unreliable supply of bad quality electricity by the local utility. DESI Power has set up this plant as a successful demonstration of how decentralized generation can be profitable in a semi-urban area where grid supply is available.

Hence an energy project aimed in providing only improved basic amenities such as lighting and water will be economically infeasible due to heavily time dependent or intermittent nature of the load. However utilizing the output of the gasifier for thermal or electrical productive uses (such as irrigation, telephony, oil pressing, cold storage, etc.) can greatly help increase the load factor, besides providing a smooth load.

Under such a scenario, gasifiers can play a significant role in meeting both basic human needs, as well as providing better livelihoods for rural people through the creation of a rural infrastructure. Hence the social return to rural energy provision can be enormous.

The gasifier size requirements for such rural applications are of the order of 10-30 kW. As in the informal sector, the large-scale deployment of gasifier-based energy systems depend on the availability of robust, low-cost gasifiers for major feedstock. Given that there are enormous numbers of villages that could benefit from such a rural energy provision approach, large volumes of gasifier production may be warranted with its attendant economic and other benefits mentioned previously.

If the design of the complete package is standardized, a number of different manufacturers could produce the systems and compete in the market. For such rural applications, NGOs or community-based organizations are likely to be best suited to undertake the dissemination of these systems, since no individual in a village would have the incentive or the skills to install, operate and maintain them. In fact, these intermediary organizations would need to act as energy service companies (ESCOs), effectively providing the energy service to the villagers.

The collection of biomass itself could be used as a livelihood enhancing activity, with the ESCO offering to procure biomass from the individuals. Manufacturers and local technical institutes could provide the technical support, as required. Applications are foreseen in small to medium size forestry and agro-allied industries (secondary wood industries, sawmills, coconut desiccating factories, etc.) as well as in power supply to remote communities.

3.5 Tiny applications (7 - 30 kW)

This size would be appropriate for a multitude of village applications (e.g. Village maize and cereal mills, small-scale sugar crushers, looms, etc.). Usually these applications heavily depend on subsidies and require substantive efforts to sustain them.

3.6 Micro applications (1 - 7 kW)

This is the range used by small and medium farmers for lift irrigation systems. The markets, despite being large size, are difficult to develop and sustain.

3.7 Ultimate market

Gasifiers can provide producer gas for combustion purposes. But for the sake of simplicity, most conventional oil-fired installations can be converted to producer gas. Potential users of low-calorific fuel-gas can be found in ceramic, metallurgical, limekilns, food processing and chemical drying units.

Besides, producer gas generators may substitute small steam boilers (non IBR) and thermic fluid heaters in several industrial plants. The production of CO2 for aerated drinks is another good application. In these industrial branches the conversion of kilns, furnaces, ovens and driers from oil to producer gas operation is a quite simple operation.

To outline briefly, the first two categories mainly focus on thermal productive applications. In the first case, the implementation of gasifier-based systems in medium industries offers the possibility of increasing the efficiency of process-heat delivery. In some cases, biomass-based electricity may also allow the replacement of grid power or other existing fuel use for electricity generation in (individually or in clusters). For economies of scale, installation size may preferably be at least 500 kWe or 2000 kWth.

The category - the tiny unorganized sector, also presents significant growth opportunities in an economically favorable manner, in a large number of enterprises. In addition to aiding natural resource conservation, it would also result in the improvements in local and workplace environments.

The economics of shifting to GESs from liquid-fuel based heat delivery, as is often the case in small /rural enterprises, or from traditional biomass burning, as is the case in informal enterprises, are quite favorable. In addition to this, both the categories of applications also have other characteristics that would aid or facilitate the large-scale deployment of gasifier-based energy systems. These include, the huge number of such enterprises, and the large scale aggregate energy utilization; ready availability of gasifier technologies for thermal applications; the significant existing or potential for biomass supply options; and the possibility of standardization of designs and hence volume-manufacturing.

Small industries often lack the institutional capacity to operate and maintain these technologies. They also do not evince willingness to accept new technologies. Small, informal enterprises, on the other hand may be unwilling to make a shift from the status quo. Besides, they will not have the financial resources to change over to gasifiers. Considering the practical constraints, the focus of the present exercise excludes the tiny unorganized sector as well as the tiny and micro enterprises.

The other two categories center around the delivery of electric power by GESs. The first is, captive power in enterprises with access to excess and waste biomass, seems attractive because of the potential to replace significant amounts of grid power (generally dominated by fossil-based generation) by biomass-based power, which can be cheaper and highly reliable. This category of application offers a significant potential for power generation because of the large quantities of biomass available as waste and/or by-products of industrial and agricultural processing.

Furthermore, the replication potential and the scale of each individual transaction should make this an attractive opportunity, as will the uniformity of the feedstock in any given facility. More importantly, though, the development of suitable institutional mechanisms to deliver, operate, and maintain the gasifiers and the associated systems take prominence as a critical issue. Overcoming the lack of financial resources will also require the development of appropriate financing mechanisms. These interventions are however outside the preview of this assignment.

3.8 Concluding remarks

Technology/product needs will be determined by the energy needs of the users, by the available biomass feedstock as well as by the human and financial resources that can be mobilized for utilization of the gasifiers. The needs will be very different for electrical and thermal applications. Some inducement by the service providers in managing the risks associated with the applications would encourage acceptance of the technology by the prospective users. Table below provides indicative list of potential applications of the biomass gasifier systems.

Table 9: Potential applications for switching to biomass gasifier systems

Sr. No	Applications	Type	Indicative market size*
1.	Ceramic kilns for tiles, refractory, pottery, insulator manufacture	Thermal	500
2.	Steel re- rolling furnaces	Thermal	300
3.	Heat treatment furnaces	Thermal	500
4.	Kilns /ovens for drying chemicals and other process industries	Thermal	500
5.	Driers in food processing industries, plywood /plantation based industries	Thermal	1000
6.	Thermic fluid heaters/hot air generators in textile and other process industries	Thermal	1000
7.	Steam heated systems with non IBR oil fired boilers	Thermal	500
8.	Carbon dioxide plants	Process	100
9.	Captive power- rice mills	Electric	500
10.	Captive power- cold storages	Electric	300
11.	Captive power- SMEs	Electric	5000
12.	Captive power- cluster of small enterprises	Electric	1000

* Projections based on conservative estimates. Projects below 100 kWe or 300 kWth or low benefits excluded.

Chapter 4: Promotion of biomass technologies in India

4.1 Nodal agencies

The Government of India's Ministry of Non-Conventional Energy Sources (MNES) promotes all renewable energy use, including biomass energy, in the country.

The other main stakeholders in the biomass energy development in the country are the ☐ State Nodal Agencies (SNAs) for renewable energy. The Ministry implements most of its programs through the State Governments, all of whom have created special agencies for renewable energy development.

Besides, financial institutions have been playing a crucial role in the promotion of biomass energy projects through provision of credit. The Ministry also channelises some of its financial incentives, such as interest subsidy through these institutions.

☐Research Institutions have also played a key role towards the development and commercialization of advanced technologies. For this purpose, the MNES sponsors research in various institutions, and sets up demonstration projects based on the developed technologies.

The program on biomass gasification is being implemented with the objective of development and promotion of conversion and utilization technologies for various end-use applications in rural and urban sectors. MNES is associating SNAs in implementing the program throughout the country.

The program also includes R&D on biomass production and gasification. The R&D component aims at the development of biomass conversion technologies; technology application packages; strategic developmental demonstration pilot projects; improvement of efficiency; reduction of cost and commercialization and development of biomass power/cogeneration on an industrial scale.

The biomass resource assessment component seeks to develop a biomass resource atlas based on the biomass resource assessment studies in different agro-climatic regions of the country, and the use of computer modeling and GIS mapping techniques. The National Biomass Resource Assessment Program (NBRAP) is currently being executed in 17 states/union territories. The objective is to prepare a national biomass resource atlas. The NBRAP is being implemented through a three-tier implementation arrangement consisting of SNAs, apex institutions (AIs) and a national focal point. The IISc (Indian Institute of Science), Bangalore is the national focal point and the apex institutions are TERI, New Delhi; Anna University, Chennai; ORG (Operations Research Group), Vadodara; and ASCI (Administrative Staff College of India), Hyderabad.

4.2 Development and commercialization efforts

Historically, development and dissemination of modern biomass gasifiers in India began in the early 1980s. During this period, a number of research institutions commenced efforts to examine the different aspects of biomass gasifier use, as well as develop indigenous gasifiers and GESs. Much of the initial work centered on small wood-based gasifiers that would be useful for applications such as powering irrigation pump-sets.

A number of other institutions also started work on gasifiers in the early 1980s. Dr. H. S. Mukunda and Dr. U. Srinivasa, in 1981, at the Indian Institute of Science, Bangalore (IISc), initiated the efforts with financial support from the Karnataka State Council for Science and Technology. The research was catalyzed by the work done at the Solar Energy Research Institute (SERI) in the US, and the initial focus was to study and modify the SERI design for a 5 hp gasifier for coupling with an internal combustion engine for power generation.

Researchers from TERI were first trained on gasifiers at JSERI in 1982. Eventually, researchers at TERI's Field Research Unit, then at Pondicherry, constructed a 5 hp gasifier by 1984. The effort was funded by TERI, with the institute providing the hardware components and manpower.

A group at IIT, Bombay, led by Dr. P. P. Parikh started initially with a collection and review of the gasification literature. Later, realizing the need for appropriate testing facilities to support the nascent gasifier efforts in the country, the group also set up a testing laboratory with government funding. Thus work on biomass characterization was initiated at IIT-Delhi. Other institutes such as Punjab Agricultural University, Ludhiana, and Nimbkar Agricultural Research Institute, Phaltan, also started work on biomass gasification. In the private sector, Jyoti Limited, Vadodara took some major initiatives.

The effort focused on systems for irrigation pumping and power generation, with the former application utilizing gasifiers of 5 and 10 hp, and the latter application focusing on 30 to 100 kW. A generous subsidy was provided for this scheme – the cost borne by the users was only between 20 to 50 % of the total capital cost of the system (the highest subsidy being for irrigation pump set application).

The Government (MNES) identified six manufacturers as potential suppliers under this program but only three of these eventually supplied gasifiers. These were: Ankur (with its own design), M&M Engineers and Fabricators (using the design licensed from Professor Mukunda's group at IISc), and Associated Engineering Works (AEW) (using design licensed from SPRERI in Gujarat).

These early examples of transfer of technology from research institutions to manufacturers heralded a trend that continues until the present. Among a few other organizations include Chanderpur Works (Haryana), Cosmo (Raipur), Figu Engineering Works (Gangtok), Grain Processing Industries (Calcutta), Netpro (Bangalore), Paramount Enviro-energy (Kottayam), Radhe Industries (Rajkot), Silktex (Bangalore), Vijay Engineering (Bangalore), 3M Industries (Mumbai).

The scheme was quite successful in placing gasifiers in the field – over a thousand systems were disseminated with an overwhelming fraction being those for powering irrigation pump sets. However, subsequent surveys found that most of the systems did not operate for long durations for a number of reasons, including materials and other technical problems and poor maintenance.

With inputs from the initial initiatives, the dissemination regime for promoting gasifiers was revised in the early 1990s. Subsidy levels were substantially lowered and set as fixed amounts that varied by gasifier ratings and applications (rather than percentages of the capital cost, as earlier). Furthermore, diesel engines were not subsidized any more, which eliminated a significant distortion in the previous scheme.

The government also widened the applications that would receive subsidies. At the same time, the commercial feasibility of gasifiers for thermal applications was also being demonstrated. The combination of the modified subsidy program and the emergence of commercial opportunities provided a boost to gasifier development and deployment in India. As a result, there has been substantial activity in a number of research institutions aimed at various scientific and technical aspects of gasifier design.

The efforts were directed at □utilizing various types of biomass in gasifiers such as rice husk, sugarcane waste, and mustard stalks. There were also efforts to a) use biomass in powdery and briquette form to improve the feasibility of gasifying a range of feed stocks, b) □□developing and incorporating technical improvements to improve performance, robustness, as well as lifetimes of gasifiers c) meeting different thermal productive applications such as drying of agricultural products (cardamom, tea, rubber, marigold, etc.), brick processing, silk reeling, textile dyeing, chemicals processing and institutional cooking as well as d) enhancing gasifier-based electrical generation.

All this required an improvement in the quality of gas being produced (especially in terms of particulate and tar content). It also required modifications in the diesel engines and development of control systems to improve the effectiveness of coupling these engines and gasifiers. Some efforts were also made in modifying gasifiers and engines so as to have a 100 %-producer-gas-based power generation system (as opposed to the traditional duel-fuel operation).

Gasifiers up to 500 kW for electrical and even larger sizes for thermal applications are now available.

The institutional landscape has also somewhat evolved, over the years. While the major R&D institutions that had begun work in the early 1980s continue to be active in the area, only a few other R&D actors have emerged subsequently, and that too with government support. Though, now, there are a large number of gasifier manufacturers in the country.

They can generally be classified into two categories - those that license technology from research institutions and those that have developed it on their own. Notably, most of these manufacturers operate at small-scale level, selling about 10-20 gasifiers a year.

Some donor agencies have also supported specific gasifier development and dissemination activities. For example, the Swiss Agency for Development and Cooperation (SDC) has provided support for the development of gasifiers for silk reeling and cardamom drying enterprises. The Shell Foundation, FREND (a Swiss Foundation), and the Government of the Netherlands have supported DESI Power, among others.

4.3 Program evolution and review

The biomass gasification program till 1992-93 was at the nascent stage of its development (first phase - eighties/early nineties), with many small application units in the lift irrigation pump-set sector. Serious problems of economic viability for irrigation pump sets were encountered in a number of cases during this phase of the program, both limited number of hours of operation (generally between 400 and 800 hours per annum) and their use as stand-bys.

However, positive feedback was also received from a number of users who enjoyed almost free availability of biomass, and in some cases involving locally well established and VAs /NGOs.

While a number of interested users were involved in field trials and technology demonstrations, generous cost-sharing also created some users, such as for getting subsidized diesel engine pump sets or diesel gensets.

The basic issue of technology/policy push versus market pull also came to the fore as the subsidies on prevailing electricity tariffs and diesel prices dampened the potential motivation of the end-user by operational savings. It became clear that in the prevailing energy-pricing situation, one could only go so far (and no further) through a technology/policy push-based program. A dispassionate review of this phase of the national program shows that it was a mixed bag of successes and failures.

4.4 Lessons learnt

Taking clues from the lessons learnt during the first phase, phase II (from 1993-94 onwards) was pursued by increasing market orientation which include, a) Restriction of subsidy to gasifier only, with no subsidy on user equipment such as diesel engine pump sets b) equipment pricing being left to manufacturers with available subsidy being fixed on the basis of application mode (i.e., irrigation, cooking, other thermal applications or power generation) and output rating. These correctives had impacted the tempo of the program.

There has not been a concomitant increase in the total number of gasifier sales per annum in Phase II as compared to Phase I. ☐Gasifier-based irrigation pump sets were almost totally eliminated (due to the lack of economic viability). Manufacturers shifted focus to thermal and power applications.☐ Many systems saw more regular operations, particularly in industrial settings.

Table 10. The results are visible in terms of average size of installations as depicted

Year	Installations no	Capacity kW	Average kW/ Installation
1992-93	1337	8471	6.33
1995-96	1511	21725	14.38
2000-01	1719	35510	20.66
2002-03	1817	55104	30.33

Table 11. The following depicts the incremental capacity addition achieved in this period.

Period	Installations added Nos	Additional Capacity kW	Incremental kW/ Installation
1993-94	61	2135	35
1995-96	74	6717	91
1995-96	39	4402	112.8
1.4.1993-31.3.2003	480	46633	97.2

While significant progress has been made in terms of increased market orientation over time, phase II still encounters certain distortions and aberrations. It becomes clear that the gasifier programs has stabilized in the past 13 years and needs a fresh look for enhancing long-term development and optimal results.

4.5 Present capacity

The present population of gasifier installations in the country is around 2000. The MNES targeted additional biomass gasifier capacity of 10000 kW in the year 2004-05, 5000 kW in the year 2003-04 and 10000 kW in the year 2002-03. Achievements were 2070 kW in 2002-03 and 4850 kW in 2003-04 and 4850 kW in 2003-04. Aggregate gasifier capacity as on 31.3.2004 was around 60000 kW.

Table 12. Installed capacity in a few major states with gasifier population as on 31.3.2003

Sr. No	States	Installations- nos	Capacity KW
1	Andhra Pradesh	231	15384
2	Gujarat	237	11961
3	Madhya Pradesh	144	4529
4	Karnataka	476	4499
5	West Bengal	27	4100
6	Maharashtra	316	3823
7	Uttar Pradesh	50	2746
8	Tamilnadu	83	2652
9	Kerala	13	725
10	All India	1817	55104

4.6 Key research organizations and their initiatives for commercialization

Recognising the need for R&D in harnessing biomass energy, MNES supported the establishment of action research centers during the early nineties in the country. They focused mainly on basic R&D, testing, training, and other aspects leading to dissemination of gasifier technology for various end uses in the country.

Five Gasifier Action Research Programs (GARPs) have been supported at different institutes namely,

1. Indian Institute of Science, Bangalore
2. Indian Institute of Technology, New Delhi
3. Indian Institute of Technology, Bombay
4. Madurai Kamaraj University, Madurai
5. Sardar Patel Renewable Energy Research Institute, Vallabh Vidyanagar

Key among these is the Indian Institute of Science, Bangalore and Sardar Patel Renewable Energy Research Institute, Vallabh Vidyanagar, Gujarat.

a. IISc, Bangalore

In a major project initiative on 'Strategic Development of Bio-energy', developmental studies are being carried out at IISc to run a 300-kVA gas engine on producer gas with an instrumented 250 kg/hr bio-residue gasifier built for the purpose. IISc, Bangalore (Combustion, Gasification and Propulsion Laboratory, CGPL) carries out the research, development, design and testing programs which provide a solid basis for all commercialization activities.

DASAG Seuzach, a Swiss company, was the original licensee of IISc for the 100 kW range. It undertook the re-engineering and design improvements of the gasifier-based power plants. In addition, it coordinated the development, pilot and field-testing activities in India and Switzerland, and undertook the technical and financial packaging of projects for the commercialization of the technologies.

NETPRO Renewable Energy Limited, Bangalore, promoted by DASAG, Switzerland, is now the licensee of IISc for its entire range of ratings. NETPRO designs and supplies the gasification island, packages the total power plant including the engine, provides site services and trains the customers' staff.

The IISc gasifier, designed and developed by the Combustion Gasification and Propulsion Laboratory, Indian Institute of Science, Bangalore (CGPL), has been engineered to thermal power plant standards by DASAG Energy Engineering Limited, Switzerland, and supplied by Netpro, Bangalore for commercial applications. There are over 30 units of power gasifiers based on IISc Technologies functioning successfully all over India.

b. Other research and development centers

TERI

The Energy Research Institute (TERI) is engaged in the development of appropriate technologies for efficient conversion of biomass fuels into useful energy. This involves the processing of agro-residues and industrial waste to make them suitable for gasification.

Presently, the activities relate to the development of biomass gasifier for thermal and electrical applications. TERI has developed a 50 kWe gasifier-based power plant. Significant progress has been achieved in cleaning the producer gas before using it in the engine. It has also developed a 100 % producer gas engine, which is being lab tested. Field-testing of power gasifiers for rural electrification application is being planned.

TERI has done significant work in the development and dissemination of gasifiers for thermal applications in small industries. For the silk industry, gasifier based silk reeling oven, cottage basin oven and drying systems have been developed. A system for drying large cardamom was developed and demonstrated in Sikkim. It has also demonstrated biomass gasifiers for institutional cooking, magnesium chloride manufacturing, boiler applications etc. New research work relates to the development of biomass gasifier based crematorium and gasifier using rice husk in loose form.

DESI Power

DASAG, an engineering consultancy organisation in Switzerland, initiated a program to commercialise the biomass energy technologies developed at IISc. Decentralised Energy Systems India Private Limited, DESI Power, New Delhi, is the Indian counterpart of DASAG to promote and establish local cluster companies which build, own, operate and transfer Independent Rural Power Producers (IRPPs) in the Indian villages by using biomass power plants based on the IISc gasifier system.

DESI Power is expected to transfer the plant /technology to local partners when they are ready. It has, until now, built a few commercial demonstration plants located in villages, at technical universities and in factories.

It is now increasingly concentrating on building EmPower Partnership Projects in rural and semi-urban areas for supplying electricity to micro-enterprises, irrigation water to farmers and energy services to local customers.

4.7 Gasifier manufacturers

There are six manufacturers in the area of biomass gasifiers. Twelve models of biomass gasifier systems up to the capacity of 500 kW have been developed and commercialised for thermal, mechanical and electrical applications.

The systems have been designed for a variety of biomass materials, and have been integrated for different application packages. The entire technology and know-how for design, manufacture, supply construction, operation and maintenance of bagasse/biomass-based cogeneration power plants are indigenously available in India.

The state of technology and the current manufacturing infrastructure have put the country in the forefront in the global market as evidenced by exports to countries such as Africa, Bangladesh, Indonesia, Guatemala, USA, Burma and Switzerland. A few prominent ones covered up during study are highlighted below:

a. Ankur Scientific Energy Technologies Private Limited, Baroda

The company headed by Dr. B. C. Jain, an internationally acclaimed technocrat in renewable energy, was set up in 1986. It has been in the forefront of development activities in the area of biomass gasification. Solar water heating systems is also its side activity.

The company has successfully developed and commercialized a very wide range of biomass gasifiers, ranging in size from as small as 5-kWe output to 500-kWe output. It has to its credit a large number of field installations, both in the industrial thermal and captive power. It has also successfully demonstrated quite a few applications in rural electrification. These field installations have proved their worth by replacing expensive conventional liquid fuels with cheap, locally available biomass.

Continuous development and improvements in product design have helped it to retain the position of a pioneer and the market leader. It has developed a number of patented designs and has achieved wide recognition in the form of the National Award for Technology Development, besides a number of awards for excellence in this field.

It has established state-of-the-art facilities (to undertake in-house research and development) and a band of dedicated employees. The company has extensive research, development, manufacturing and testing facilities, including gasifier set-ups for demonstration and training. The company also has its own captive power generation through gasification - a facility that was used for a decade to feed surplus power into the GEB grid. These facilities include manufacturing bay, extensive testing facilities, including a number of test beds for gasifiers and solar systems and a well-planned and well-equipped laboratory.

Damodar Process Plant Private limited, Kolkata, has tied up with Ankur Scientific Energy Technologies Private Limited, Baroda, in the past two years for the supply of biomass gasifier systems to rice mills and other industries. Jointly with Ankur, it has offered over 25 projects, mostly for small captive power applications.

The firm is well experienced in the rice-milling sector for its products and services in the domain of rice milling equipment. It depends solely on Ankur for manufacturing and testing the gasifier, while its responsibility is to provide direct consumer interface, marketing, erection and after-sales service. The firm has developed its staff for catering to the services. It does not take up projects on build, own, operate and transfer basis. Usually, it receives 90 % payment from the prospective clients before dispatch of equipment and the balance is realized after successful execution of the project.

The company has tied up with its regional associates to provide prompt and efficient after-sales service to its customers. It has set up international partners catering to its interests in Mozambique, Germany, Italy, USA, Uganda, Russia and Cambodia.

b. Cosmos Powertech, Raipur

Cosmo Powertech Private Limited manufactures gasifiers, developed by the in-house R&D, in the capacity range of 60-6000 kWth (equivalent to 5-500 liters/hour oil substitution). Cosmo gasifiers operate at near atmospheric pressure and use air as the gasifying medium to convert solid biomass or coal into producer gas through partial oxidation process. Cosmo gasifiers have been developed in both downdraft and updraft designs.

c. Radhe Renewable Energy Development Private Limited

It is a Rajkot (Gujarat) based proprietary firm headed by Dr. S. V. Makadia. It has been engaged in biomass-based products for the past 15 years. It offers up-draft type of biomass gasification system and fluidised bed gasifier/furnace. Its sister organization Radhe Engineering Company claims to be successful in the field of biomass briquette plants.

Its activities cover 200 clients not only in the Saurashtra region (Morbi and Himatnagar of Gujarat) but other regions as well. It covers areas such as ceramics, rolling mills, sodium silicate, chemical industries using various solid fuels like charcoal, wood, biomass briquettes, imported steam coal, lignite, etc.

Biomass gasifier applications are primarily thermal, with paybacks of the order 6 months in switching over from petroleum based fuels to locally available biomass fuels or coal. It is also in the process of developing down draft gasifiers for small power generation.

It has established facilities and research set up for innovative application engineering. It offers after sales services and turnkey assistance through its staff. So far, it has tapped the private sector market without depending on government subsidies. It has no associates at the regional level. The firm has no interest in the ESCO concept or in associating with ESCO firms.

d. Chanderpur Engineering Works, Yamunanagar

e. Grain Processing Industries (India) Private Limited, Kolkata

It was incorporated in 1981 by taking over a partnership firm - Grain Storing and Processing Industries, Kolkata. To start with, major activities of the firm included manufacture of mechanical grain handling equipment, grain storing silo, boiler and pressure vessels. It offers state-of the-art design backed up by after-sales services. It was also associated with the Power Gas Corporation Limited, UK, in developing the biomass gasification technology in 1986.

With continuous R&D, both in-house as well as with assistance from institutions like IIT, Kharagpur, Central Fuel Research Institute, etc., GPI upgraded the technology of gasifiers. It is one of the six manufacturers approved by MNES. Its gasifiers are available in commercial sizes from 50 to 500 kW capacities in single units.

In the past, its major interest was in rice husk fired gasifiers, mainly up-draft system. It claims to have been successful in developing a unique gas cleaning system that removes tar and particulates from the gas in eight stages, to limit their concentration in the gas up to 20-mg/cubic meter at the final stage. A majority of its applications are in the power generation for captive use. It has also developed a trolley-mounted mobile gasifier of 10-20 kW for rural electrification.

It has tied up with Bio Energy Technology Services, Kolkata to participate in CDM projects. It has an associate firm - GPR Power Solutions, Chennai, to participate in small power projects as EPC contractors. GPI has its own manufacturing facilities, which has a fabrication shop, machine shop, foundry and heat treatment unit, test room and allied facilities. It has its own marketing team and has developed a dealership network for its products and services.

f. Agni Energy Services, Hyderabad

It is a ten-year-old Hyderabad-based energy services company, and has been operating gasifier-based plants for meeting the thermal and power needs of industrial customers on a shared savings basis for over 5 years. They own and operate the gasifier plants and operate as an ESCO.

4.8 Some observations on the prevailing technology

Though there is very little data on field tests, stray observations by a few recent studies endorsed by some general rounds of discussions depict that most gasifiers installed in India look, either like prototypes made in a small workshop, or, very complicated to operate and maintain.

R&D institutions, fabricators, or manufacturers - all with limited industrial design skills, carry out almost all the engineering of the gasifiers. A few exceptions are the ones where the services of an industrial design center were utilized to improve the final design of an industrial prototype - the silk reeling gasifier and the silk dyeing gasifier developed in the TERI/SDC program. Gasifier systems developed by TERI for other applications did not have such inputs.

The complete gasifier 'system' consists of several items such as blower, pipes and ducts, couplings, valves and insulation that are available in the open market and certain tailormade components such as burners, cyclones, scrubbers, mist separators and filters. The gasifier system often has scanty instrumentation and control. There is a perceived need to optimize the gasifier systems for pressure drop, parasitic power, or cost.

The fact that several entrepreneurs and manufacturers have started setting up and even selling gasifiers commercially outside the MNES program in recent years proves the potential for mainstreaming.

a. Standardization

Different designs of basic gasifier units existing presently will probably merge into standard designs, much like the collector plate of a solar water heater or a baby boiler. A standard 'bill of materials' for fabrication would benefit both users and manufacturers. It would also more comprehensively address industrial safety issues and environmental compliance. Reasonable efforts would be needed to look into standardization issues pertaining to the gasifier energy systems at this juncture.

b. Technology development issues

Testing and certification is a contentious issue, which needs some urgent attention. After an exhaustive review of the previous methods of testing and deliberations, MNES decided to de-regulate the existing GARPs, which were also the testing agencies involved in setting rigid and cumbersome testing methods and standards. At the moment, there is no institution to test and certify gasifiers.

Meanwhile, the so-called 'approved' manufacturers rule the scene and dominate the existing subsidy market. Under the circumstances, it seems appropriate to ☐☐establish an independent, sustainable and non-governmental agency to test and certify, ☐☐simplify the testing methods, establish realistic testing standards, and ☐☐promote an open door policy to encourage many more manufacturers and entrepreneurs.

As mentioned earlier, engines developed for producer gas use are still evolving. When natural gas engines or diesel engines are converted to operate on producer gas, there are problems of de-rating (loss of power), low conversion efficiency, speed control, knocking, emissions control, and engine life.

100 % producer gas engines currently being claimed as developed are really not fully commercial. More efforts are required for the development of reliable and efficient engines with more involvement of engine designers and manufacturers.

c. Application engineering

A frequent complaint with the gasifier system is that, it works with additional inputs from the team that developed it (usually a team of scientists). There are not many instances in which this kind of handholding has not occurred over a prolonged period, sometimes covering the useful life of the system.

The handholding has been somewhat less in systems that are sold on a commercial basis to industrial users of thermal systems (CO_2 manufacturers, ceramic kilns, etc). Some of this can be attributed to user-training needs. Experience shows that over time, serious users learn to grapple with the various maintenance problems, as much as they can. They might have incentives to do so, having paid for the system and benefiting substantially from fuel savings.

On the other hand, there are users who have not been able to tackle all the problems. This might also mean that the developers themselves have not been able to solve the problems conclusively. In such cases, the system runs on and off, but finally comes to a halt.

There are a few demonstration systems being run as showcases, and hence need to be maintained at any cost. And then there are systems, which have been 'acquired' at marginal or no cost to the user, in which cases the systems just wither off, even though they were potentially viable. So it seems that there is neither a simple nor single answer for the question of 'technology maturation.'

4.9 Conclusions

A clear short-term answer might emerge out of a different approach – a pro-business model with professional firms being responsible for ensuring the best possible performance and paid on the basis of a performance contract. This is likely to transform the nature of business, manufacturing and research efforts.

Chapter 5: The ESCO mechanism

5.1 Concept – knitty gritties

An ESCO is a business that develops, installs, and finances projects designed to improve the energy efficiency and maintenance costs for facilities over a longer span, say 3 to 8 years. They generally act as project developers for a wide range of tasks and assume the technical and performance risk associated with the project.

Typically, they offer the following services:

- Develop, design, and finance energy efficiency projects
- Install and maintain the energy efficient equipment involved
- Measure, monitor, and verify the project's energy savings

These services are bundled into the project's cost and are repaid through the money savings generated. ESCO projects are comprehensive, which means that the ESCO employs a wide array of cost-effective measures to achieve energy savings.

These measures often include fine tuning operational parameters, optimal insulation levels, high efficiency lighting and air conditioning, fuel switching by replacing fuel oil-fired kilns by biomass gasifiers, etc. What sets ESCOs apart from other firms offering energy efficiency like consulting firms and equipment contractors, is the concept of performance-based contracting. When an ESCO undertakes a project, the company's compensation, and often the project's financing, are directly linked to the amount of energy that is actually saved.

Usually, the comprehensive energy efficiency retrofits inherent in ESCO projects require initial capital investment and offer a relatively long payback period. The customer's debt payments are tied to the energy savings offered under the project so that the customer pays for the capital improvement with the money that comes out of the difference between pre-installation and post-installation energy use and other costs. For this reason, ESCOs have led the effort to verify, rather than estimate energy savings. One of the most accurate means of measurement is the practice of metering, which is direct tracking of energy savings according to sanctioned engineering protocols.

Most performance-based energy efficiency projects include the maintenance of all or some portion of the new high-energy equipment over the life of the contract. The cost of this ongoing maintenance is folded into the overall cost of the project. Therefore, during the life of the contract, the customer receives the benefit of reduced maintenance costs, in addition to reduced energy costs. As an additional service in most contracts, the ESCO provides any specialized training needed so that the customer's maintenance staff can take over at the end of the contract period.

Typically, they offer the following services

- Education of customers about their own energy use patterns in order to develop an 'energy efficiency partnership' between the ESCO and the customer. A primary purpose of this partnership is to help the customer understand how their energy use is related to the business that they conduct.

- Included, in the ancillary services provided in a typical performance-based energy efficiency contract, are the removal and disposal of hazardous materials from the customer's facility. When, for example, tars and fuel ash by burning biomass have to be disposed as hazardous waste.

- Continuous improvement in the maintenance practices for facilities over a 2-3 year time period.

- ESCOs generally act as project developers for a wide range of tasks and typically, they offer the following services - develop, design, and finance energy efficiency projects;

    - develop, design, and finance energy efficiency projects;
    - install and maintain the energy efficient equipment involved;
    - measure, monitor, and verify the project's energy savings; and
    - assume the risk that the project will save the amount of energy guaranteed.

Getting a project financed should be a shared effort between the ESCO, the customer, and the financier. It is the ESCO's responsibility to put together a bankable project. The ESCO typically arranges the financing. Its reputation and history often adds surety, which offers other financiers added confidence. The financier's due diligence offers the ESCO and the customer reassurance as to the economic viability of the project.

Creating bankable projects:

- Business solutions; services
- Integral solutions
- Supply efficiencies
- Comprehensive demand efficiencies

- Single measure

Comprehensive energy service offerings have evolved into two mechanisms – shared savings and guaranteed savings.

Dominant financial options:

- Shared Savings
- Level of energy saved is guaranteed
- Value of energy saved is guaranteed to meet debt service obligation down to floor price
- Owner carries credit risk
- Tax-exempt institutions can use status for much owner interest rates
- Shares % energy cost savings
- Usually of balance sheet
- Equipment may be leased
- ESCO typically carries financing; so ESCO has credit and performance risk
- Customer has more payment exposure

Most ESCOS will offer either financing mechanism at customer's request; however, about 95 per cent of the performance contracts in North America use guaranteed savings. Guaranteed savings avoids gambling on the future price of energy and thus avoiding considerable risk. In this approach the owner carries the credit risk and the ESCO carries the performance risk. In countries where creditworthiness of customers is a problem, the shared savings approach is more common.

Salient features of the North American model

- Requires credit worthy customer
- ESCO carries only performance risks
- Big items usually quicker
- ESCO can do more projects

Salient features of the French model

- Can server customers that do not have credit
- ESCO carries both performance and credit risks
- 4-step process slows down savings
- Carries problem of shared savings

ESCOs in Europe have mostly followed the French model, which is essentially shared savings. In the French Model, attributed to Compagnie General de Chauff (now part of Vivendi), the ESCO carries the financing through its own resources or third party financing.

Financing may also follow the French 'Four Step' self – funding approach,

Step1 – energy efficient operations and maintenance (O&M);

Step2 – savings from O&M and quick fix measures fund quick-fix (low investment) items;

Step3 – savings from O&M and quick-fix measures fund mid-range items (moderate capital costs and paybacks); and

Step4 – savings from first three steps fund the "big ticket" items (costlier measures and/or longer paybacks).

In the four-step method, risk management benefits are attractive and the projects generally do not required and outside financing. Under this approach, however, the owner must wait longer for major pieces of equipment and the potential are lost in the interim period.

To the extent that the ESCO carries the debt obligation as in the French model, the ESCO must be very large with deep pockets or it will soon become too highly leveraged to do any more projects. The only way around this problem is to use one or all of the following options:

- Use only very short payback measures (often called 'cream skimming')
- Sell the paper; or
- Carry on a parallel business with a strong revenue stream

An ESCO with somewhat limited resources has a much better opportunity to grow using guaranteed savings.

ESCOs originated in France before the World War II when engineers evolved a business-like mechanism for providing expert services to reduce the heating bills of properties and were paid for the fuel savings delivered by them. The concept was adapted in the USA in the seventies. Electric power regulators compelled that electric utilities adopt demand-side management and take up integrated resource planning before sanctioning the cost of new power plants as a part of the electricity rates. Most of them out-sourced this function to professional ESCOs, though a few of them established their own subsidiaries or took over ESCOs.

A recent estimate of the US ESCO market is US $ 6 billion, with over 100 active ESCOs taking up sponsored tasks under the Federal Energy Management Programs. This concept has been in vogue in several developed and developing nations.

5.2 Indian ESCOs

The Indian ESCO industry is still in its infancy. ESCO is simply a firm that convinces a client from the industry to let the ESCO (i) conduct an energy audit, (ii) prepare an investment grade paper and strategy on how to reduce energy cost in a firm, and (iii) invest in the firm to implement the recommendations, and (iv) prove the energy cost reduction to get paid.

Another approach, which comes closer to the definition of an ESCO is the following concept common in Europe,

An ESCO signs a contract with a client in need of electricity and process heat, and simply sells these two forms of energy at a cheaper rate to the firm. In other words the ESCO generates and sells energy in terms of kWh or tons of steam on the premises of the client. All investments, operational costs and maintenance are with the ESCO. The client only buys electricity and steam.

Based on either definition, there are a few ESCOs operating in India so far. It is also highly doubtful that an ESCO may be a successful business model for industrial clients in the future. The following paradox has so far prevented ESCOs from providing services in India although they have tried, Large and professionally managed energy intensive industries are not interested in hiring an ESCO to reduce energy costs because they have the equity, the know-how and their engineering divisions to implement recommendations on their own. All that they need are ‘ideas’ provided by a fixed fee based energy audit.

These firms are well aware that an ESCO approach is the most expensive way to reduce energy costs since an ESCO shares in verified savings and provides financing at usually higher costs. In other words ESCOs and well-managed large Indian firms do not match.

EE equipment manufacturers or big business houses support some of the active ESCOs in India. Some are the Indian counterparts of international ESCOs. Certain far-sighted EE equipment manufacturers like Thermax - a major manufacturer of packaged boilers, heat exchangers, reaction vessels and pressure vessels etc., which has a joint venture with Energy Performance Services [EPS] of USA) and Asea Brown Boveri Limited (ABB) - an international major that manufactures motors, drives, instrumentation, control systems, air-handling systems, meters etc. with an ESCO wing (ABB Capital Services).

Others are certain large business houses like DCM Sriram Consolidated Limited (DSCL), which is a US$220 million, public listed company with a core sector business portfolio comprising fertilisers, chlor-alkali, chemicals, plastics, cement, textiles and sugar and power.

Other players in the business are Saha Sprague Limited (a joint venture between US based capacitor manufacturer Commonwealth Sprague and Energy Venture Capital Limited, a Mumbai based ESCO that specialises in utility and municipal based ESCO projects and demand-side-management) and INTESCO that has supported Intesco Asia Limited, a Bangalore based ESCO.

Asian Electronics Limited, Thane Maharashtra is another company, which has developed energy efficiency programmes with utilities and consumers.

However under an ESCO service model, the ESCO carries 100 % of the risks, including, the risk of technical miss judgment, the financial risk, the risk of non-compliance of the firm with her obligations under an ESCO contract and the risk of the firm going out of business before the project cycle is complete, and last but no least the risk of proving to the firm actual energy savings in a challenging environment of statistical noise in data collection and analysis.

Smaller firms, with little know-how, no access to financing and no capability to implement recommendations to reduce energy cost, would greatly benefit from an ESCO, even at higher costs. Consequently the most desirable clients are not interested in the ESCO and those firms that may sign with an ESCO will not find an ESCO willing to take the risks.

5.2.a. Operating environment

The Indian ESCO industry at present faces certain constraints relating to credibility and neutrality. While the issue of neutrality may be one of perception, other problems such as inadequate support from utilities or the government, as well as the issue of wider acceptance and credibility of the ESCO concept, are real barriers.

In addition, the system of legal redress in India also leaves much to be desired. Some of these constraints in the operating environment have forced certain industrial houses or equipment manufacturers to discontinue their ESCO operations.

According to Pierre Langlois, President, Econoler International, which is represented in India by Econoler International India, "Perhaps the credibility problems comes from a lack of successful demonstration projects ESCOs who promote their own products may lack some credibility, since their product might not be the best one for a specific project. Only real value added projects can bring such credibility in the market in the long run".

b. Marketing models

The ESCO business appears to be a logical extension for some of the equipment manufacturers. Crompton Greaves, a manufacturer of motors, switchgear and control equipment, Tata Honeywell and Invensys sold energy efficient motors under guaranteed improved performance. Crompton Greaves, however had to eventually close its energy services business, as the market was not yet ready for such ventures.

According to Dr. G. C. Datta Roy, Vice President, Energy Services, DSCL, for these companies performance contracts (PC) can be considered as a sales tool. The market for energy services would develop under several models, including ESCO models in different shapes and forms. Various initiatives under donor-funded activities and the BEE would significantly influence this market development.

The existing ESCOs, with the exception of DSCL and some others, have until now focused on providing services to organisations or companies with which they have prior business dealings. The ESCO concept has spread more by word-of-mouth rather than any concerted marketing effort. As a result the client community remains by-and-large sceptical of the ESCO concept – in fact, they prefer to see Monitoring and Verification (M&V) protocols largely as a means of safeguarding their interests.

However, some ESCOs such as DSCL have involved their clients in the development and adaptation of the M&V system, in most of their projects. The existing ESCOs have begun offering energy services to a select clientele in a limited way.

After succeeding in small projects they move ahead with projects of a larger scale in the same organization. The existing ESCOs may provide only basic energy audit or consulting services or EPC type services (in which they are paid over a period of time). Their small scale of operations may be because of their limited technical know-how, or limited capacity to develop and implement bigger projects, and due to lack of risk mitigation options.

As far as performance contracting (backed by appropriate M&V protocols) is concerned, the following type of structures are only now beginning to surface,

- The client is responsible for raising funds for efficiency improvements and making repayments to lenders, while the ESCO would guarantee savings in the sense that it would pay the difference in case repayments exceeded savings. In this guaranteed savings approach, the guarantee is provided in the form of the contract itself at this point and the client requests no other 'real' guarantees.

- The client is responsible for raising funds for efficiency improvements and making repayments to lenders, while the ESCO is more like an EPC contractor but whose payments are related to certain milestones over an extended time period.

c. Government or utility support

None of the existing ESCOs are supported by, either the central or the state governments, nor the utilities. Such support is unlikely to emerge in the near term.

Pierre Langlois of Econoler International, points out that, “No direct governmental support is available for ESCOs anywhere in the world. It is pretty rare that there would be direct governmental support for ESCOs. Government could support energy efficiency projects which ESCO could then follow up, not the other way around”.

d. Credibility of the concept

Not all the existing ESCOs have a strong balance sheet. It would take considerable time in building the balance sheet to a significant size based on which project borrowing can be done. The ESCO supporters or promoters, to a large extent, are big enough to take on contingent liabilities on their balance sheets for a large number of ESCO projects.

The supporters or promoters can take on liabilities to the extent of ESCO revenues only. The main balance sheet would be required for maintaining or enhancing the **primary particularly of the company or group**, particularly in view of the current economic uncertainties. Their sphere of activity may remain small in the foreseeable future.

Furthermore, there are no successful ESCO project sites as yet, which could attract prospective clientele, unless innovative financing programmes such as venture capital equity support become available.

Pierre Langlois of EII says, “One of the great mechanism developed by International Finance Corporation (IFC) and the Global Environment Facility (GEF) in Central Europe is partial guarantee fund to help solve part of this loan leveraging limitation. The final user in case of default by the ESCO can work out other mechanisms as a guarantee. The only mechanism that will not work out on the long run would be a loan guaranteed merely on the balance sheet of the ESCO. Limitations will be rapidly reached by the ESCO and no sustainable ESCO activities can be done that way”.
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e. Neutrality

A large number of lenders, industry associations and NGOs among others, are of the view that an ESCO should not be perceived as being aligned to particular manufacturers. Industry associations (such as the motor manufacturers association), or a venture capital fund, or an appropriate Government of India fund should support ESCOs.

According to Manoj Saha (SSL), “Product-based ESCOs are more likely to take off, than neutral ESCOs. Perhaps more initiative should be made wherein manufacturers of EE products are encouraged to behave as ESCOs for their specific technology…this will yield better results faster in general”.

Pierre Langlois of EI adds that, “This is true indeed and this why a great majority of ESCOs in North America are not manufacturer based. This is a bit different in Europe, but still, a strong ESCO industry would not be limited to manufacturer ESCOs.

f. Multiple benefits

No ESCO project in India, have relied on a classical or pure performance contract. DSCL ESCOs have executed one project under shared savings with DSCL financing, and several others under guaranteed savings. Even in advanced economies like USA, ESCOs are now doing projects more under guaranteed savings.

During the year 2000-2001, only 5 per cent of the energy savings performance contracts (ESPCs) were under shared savings. Both in USA and Canada, project recourse financing options are available for ESPC projects.

However, according to Manoj Saha (SSL), Leading Financial Institutions are the prime reason why pure PCs haven't taken off…'technical risk' is incomprehensible within the lending community. Pierre Langlois of EII says "Financial Institutions will never want to take the technical risk, all they want is the commercial risk."

5.3 Charting a growth path for Indian ESCOs

The development of ESCOs and the energy efficiency market has followed an identifiable path. Trends in other countries also show the following stages in the evolution of ESCOs in terms of their technical expertise and proficiency, marketing and risk taking skills and financial and contractual expertise.

The following system of classification would help us in understanding the growth of energy efficiency services and indicates a path for evolution of ESCO market in India.

Stage 1 - Provision of energy advice and consulting services and supply of equipment.

Stage 2 - Performance guarantee whereby full payment is dependent on successful demonstration of the energy efficiency measures, and

Stage 3 - Provision of comprehensive ESCO service including the provision of finance with repayment from achieved savings through long-term contract between user and the ESCO.

Generally, ESCO market development progresses from a stage of 'no market' through stage 1, where there are consultants and equipment suppliers who develop a market for supply and manufacture of EE equipments. Thereafter, in stage 2, the aspiring ESCOs provide turnkey contracts on performance guarantees. At the next level, stage 3, genuine ESCOs implement long term shared savings contracts. In this case the ESCO provides a fully comprehensive service to customers including project design, installation and operation, plus the provision of appropriate finance repayable through a long-term contract.

External support at stage 1 focuses on projects that develop technical skills. In stage 2 and 3, the projects will be directed towards developing commercial, risk and entrepreneurial skills to convert opportunities to projects.

Based on their past experience in this sector DSCL Energy Services, observes that there are several significant lessons to be learnt in the area of skill competency requirement for ESCO projects. In their view, the non-availability of appropriate human resources has been the biggest constraint in developing ESCO business.

Each member of the ESCO team should have a fairly high degree of competency in project management and client relationship management at different levels in addition to analytical skill and skills in risk evaluation and mitigation management. In sum, technical skill competency plays a small part in the ESCO scheme of things, compared to the array of expertise and skills needed for an effective ESCO operation.

While agreeing with this Pierre Langlois of EI adds "Lack of financial facilities and lack of knowledge of the concept by potential clients would be equally important barrier".

The outcome of this development process encompasses awareness amongst customers and provision of cost effective solutions by the ESCOs. A fully functioning EE market would require technical resources to analyse potential measures; financial and contracting skills to establish viable contracts; suitable supply of EE equipment and plant operators who are sufficiently motivated to optimise the benefits within the life of the agreement. ESCOs have built up sufficient track record and skill base that will attract clients and local finance for both business development and projects.

Thus, the ESCO team apart from having technical expertise on (i) evaluating best technical option among available products and technologies and (ii) project management skill should be able to grasp various financing issues and able to create a risk mitigation methodology to make the project a success.

5.4 Key factors influencing ESCO performance

a. Services, not equipment

Too many consumers and ESCOs, especially those belonging to a manufacturer, think performance contracting is about selling or acquiring equipment. But this is not the case. If customers want to buy equipment, they can go directly to the manufacturer. Performance contracting should be a value added proposition. If an ESCO cannot provide a service, that goes beyond equipment purchasing, to its customers, it should exit the business.

The focus on equipment persists partially due to ESCOs, which do not belong to manufacturers, repeatedly stressing their equipment-neutral positions. It should be kept in mind that 'ESCO' is a service company and equipment is only a vehicle to deliver the expertise and services.

b. Investment grade audits

The traditional audit is not good enough for performance contracting. An Investment Grade Audit is a must. ESCOs cannot afford to base their guarantees on an audit that does not seriously consider the behaviour of the implemented measures over time. An audit should address more than the recommended measures, which will effectively reduce energy consumption. It should serve as a financial investment guide. Recommendations on how the owner can enhance the physical assets are an important part of the organization's investment portfolio.

Attempts are being made by BEE to pre-qualify and certify energy auditors. Such efforts are also needed for certified measurement and verification professionals.

c. The technology trap

The owner's insistence on the 'latest', besides the competitive demands on ESCOs, too often prompt the use of new technologies before they have proven their performance records. ESCOs can only guarantee the performance of equipments that has a proven savings track record and a history of maintenance and operations needs/costs.

Start-up ESCOs try to get into a new field aggressively by offering the latest in technology. It typically spells disaster. If new technologies are required in a project, they should be implemented outside the guarantee package.

d. Underestimating the importance of operations and maintenance

O&M capabilities and attitudes can make or break a project. A U.S. Department of Energy (DOE) study revealed that in an effective energy management program, up to 80 percent of the savings could be attributed to the energy efficiency practices of the O&M personnel.

For an ESCO guaranteeing results, this fact can be very daunting. If the equipment is to operate near design, it must be well operated and maintained. Clearly, it is in the ESCO's interests that the O&M personnel have the training and the oversight to be sure this happens. If the potential customer's maintenance officer declares that the performance contracting will not work in that facility, it sure will not work. Supervisors of operations, and plant managers all play pivotal roles in a project's success.

e. Measurement and Verification is Essential

Measurement and Verification (M&V) is the foundation of an effective energy efficiency program planning and is critical to performance contracting. Without an M&V it cannot be said what was saved, how effective a particular measure or a program is, or whether the engineers' predictions were correct.

When money changes hands based on the savings achieved, commissioning and monitoring are just not enough. Of course, for any M&V program to be of value, a base-year/baseline adjustment procedure need to be established. However, base-year data is more than consumption history, it must include what caused the consumption. Project reliability, financing, market acceptance, engineering and ESCO industry growth, all depend on broadly accepted measurement and verification procedures.

f. Performance contracting is risk management

Guaranteed performance by definition includes risks. ESCOs who master risk assessment and cost-effectively manage/mitigate those risks, will be the most successful in the industry. Managing risks through the financial structure of a deal is an essential business strategy.

g. Project management

A general attitude that project management is 'construction' is often a barrier. An energy efficiency project is not complete as soon as it is 'in the ground', but when a true savings project begins. It is the careful and continuous management of the project over its life that produces savings and profit.

h. Relevance to biomass gasification program

A new customer in a typical SME has to contend with the field staff of the agency or the equipment supplier spending one to weeks at the plant, customize the applications and orient the plant personnel about the operational, maintenance and safety features.

The user is expected to release the full payment after the successful demonstration of its operation. They are then tied through a warranty of 1-2 years and attend to customer complaints as per warranty clause.

At times, a maintenance contract is signed between the suppliers and the beneficiaries as part of which most users seek annual overhaul of the major equipments. It is not unusual for consumers to award these contracts to third parties, or partially take up these activities on their own.

Very rarely are efficiency, productivity, cost reduction possibilities and overall plant optimization activities outsourced. Perhaps, when outsourced, a plant's major concern in addressing reliability and trouble-shooting are unattended. In this context, It is quite appropriate to address the customer-technology issues through an external agency e.g. ESCO.

ESCO may evolve based on the business-like relationship between the beneficiaries and the service providers. Marketing and pricing the services is the key. This calls for a fair degree of transparency and mutual understanding between them.

One way to tackle the issue is by defining a clear contract spelling out the terms and conditions, rewards and penalties with respect to achievements of performance benchmarks such as output, reliable operation, reduction in purchased energy. The parties may have a comprehensive operations and plant maintenance contract with payments linked to the deliverables.

The ESCO may commit itself to procuring and installing the appropriate versions of the equipment, providing/developing human resource, sourcing biomass, tackling suppliers and government agencies such as state pollution control board, mobilize equity (partially or fully), manage working capital, institute a system of monitoring and verification of performance and other attributes spelled out in the contract. The service provider is expected to devise the package and sell the same to the management at the inception of the project. Obviously, the formula looks good, if it were to be implemented on these lines.

i. Likely direction

To start with, an ESCO needs to tread the path quite cautiously. They might have to contend with high up-front project development costs. The finance related issues are deliberated in the subsequent sections.

For quite some time now, there has been a lot of suspicion regarding an ESCO approach. There is no good understanding of what an 'ESCO' or an 'ESCO project' is, in the market. There are perceptions related to huge entrepreneurial profits, poor performances, and complicated business models. The end-users have more distrust and suspicion than the ESCOs deserve.

Low quality products used in retrofits or new projects are another contiguous issue to be dealt with by the stakeholders. At times, quality is often neglected in gasifier projects. The end-users' efforts to keep first costs low may result in the use of extremely low quality equipment. End-users who opt for such products become dissatisfied, sooner or later, and the news spreads in the market quickly.

State-of-the-art technologies in most cases are neglected, as they are perceived to be 'exotic' and worthless. Studies show that while the use of certain technologies is out of question for many end-users, there is a significant scope for feasible technologies.

As far as services are concerned, there is no one universal formula. It has to evolve based on specific needs at the site and the business acumen of the service provider. A certain degree of professionalism, especially management practices would be necessary to facilitate accounting of the delivered outputs. A good deal of simplification may also be called for.

Chapter 6: Financial Framework for ESCOs

6.1 Cost-benefits of biomass

This project makes it clear that biomass is one of the least cost energy alternatives available in various pockets in India. For industrial applications, both thermal and captive power uses were found to be economically viable in various places. Particularly, several thermal applications like low temperature and high temperature heat requirements (as listed in section I) present very attractive cost economics.

The benefits associated with the production and use of biomass is not limited to energy cost savings for industrial users. It has several other positive social, environmental and macroeconomic spin-offs that need to be properly accounted while reviewing the costs and benefits associated with the use of biomass as a fuel at a broader level.

As focus of our study, in this report, we shall qualify the commercial benefits to the end users only, and not enter into the contingent valuation of other social and environmental benefits. However, in passing, we may note several other benefits associated with bio-energy production and use besides, commercial costs and benefits as depicted in the Annexure.

Most of the potential cost savings of biomass emanate from its ability to replace fossil fuels in various industrial applications. Several fossil energy-dependent industries have already been adversely affected due to the high costs of energy inputs. Prices of most of the fossil fuels (petroleum products, NG/LNG etc.) have demonstrated a long-term rising trend.

According to the Energy Information Administration (EIA) forecasts, crude oil prices in both short term and the long term is likely to increase, from moderate to high level. In view of this, attractiveness of alternative energy sources, such as biomass, is likely to increase even more in the future.

6.2 Economics of biomass gasification for thermal applications

Typically, the up-front capital cost of biomass gasification system is higher compared to the fossil fuel based systems. However, the high capital cost of biomass gasifiers is usually recovered within a very short period (ranging from 3-4 months to 1-2 years), depending upon the quantity of diesel/petrol consumption foregone.

With some assumptions, biomass fuel cost has been estimated to be 25 % of the fossil fuel cost. To provide a rough idea on the issue, a simplified version of the life cycle costing is presented below in table 1.

Assumptions:

1 liter of fossil fuels = 3.5 kg of biomass
Life of the system: 25 years (with equipment replacement and maintenance as required by the design)

Table 13. Economics of gasifier based operation for thermal application

Life cycle cost estimates	Gasifier based systems	Diesel based system
Initial capital cost (USD per kw thermal)	118.75	10.00
Life cycle O&M cost (USD per kw thermal)	37.82	15.13
Life cycle fuel cost (USD per kw thermal)	189.11	1210.27
Total life cycle cost (USD per kw thermal)	345.68	1239.50
Overall unit cost of energy (cents per kw thermal)	0.97	3.42

Source: Dasappa S. et al.

As reflected above, on life cycle basis, the per unit cost of energy based on biomass is between 25-30 % only, compared to the unit cost of energy from diesel based system. The initial capital cost of 118.75 USD per kW thermal can be recouped in 2-3 years due to heavy cost savings in fuels.

The attractiveness of biomass gasification systems can be further increased if the generated CERs (carbon credits) can be validated and sold under the CDM mechanism and the benefits ploughed back.

The above-presented statistics may not exactly represent the current dynamics of biomass costing due to the fact that the source paper was written quite some time back. Therefore, a number of underlying facts might have changed significantly.

However, it is also possible to present the cost economics for industrial applications on the basis of current parameters. In the following sections, we have presented the cost economics (daily, monthly and yearly) of biomass gasifiers for both thermal and electricity application.

6.3 Typical cost economics of biomass gasifiers for thermal applications

In our hypothetical case, we take an application where 13,00,000-k cal per hour energy is needed. (For example, most of the small sized ceramic units need energy in that range only. The calculation may be equally relevant for any other thermal applications where heat requirement is about 13,00,000 k cal).

Certain thumb rules used for cost calculations:

Capital cost per MW

- Hundred percent gas based: Rs. 4.4 crores
- Dual fuel mode: Rs. 3 crores
- Gasifier + Existing set modified: Rs. 2 crores
- Thermal [1](1Mwe): Rs. 1.2 crores

Operation and maintenance requirement (on account of repair and replacement)

- Thermal: 2% of the capital cost per year
- Dual fuel engine: 3% of the capital cost per year

Installation cost

- Electricity applications: 5% of the capital cost
- Thermal application: 10% of the capital cost

[1] As a rule of thumb, it is estimated that 1 MW capacity of electricity is equivalent to 3 MW thermal energy. Therefore cost of 1 MW of thermal is much lower than 1 MW of electricity. Also, capital cost of system for thermal application is lower on account of cost of engine, which is not there.

- **1 litre of liquid fuel = 3.5 kg of biomass**

On the basis of these thumb rules, the typical cost economics of a biomass gasifier system for thermal applications can be presented in various forms (per day basis, per month basis and per annum basis).

a. Per day fuel cost savings due to use of biomass gasifier in place of diesel system:

- Assumption 1: PLF: 80 %
- Assumption 2: Price of biomass: 1500/tonne
- Assumption 3: Capital costs (1.8 crore for 1.5 MW energy capacity; Rs. 1.2 crore capital investment required for 1 MW energy capacity), manpower costs, O&M not taken into account.
- Assumption 4: Thermal requirement: 13,00,000 kcal/hour (equivalent to approx 1500 kw energy)
- Assumption 5: Price of diesel: Rs. 28 per litre

Table 14. Energy bill per day in case of diesel

Particular	Figure	Note
Consumption of diesel per day	2,400 litres	3,000 litre per day is consumed to generate 13,00,000 per hour with 100% PLF
Price of diesel per unit	28 Rs/Litre	Price as on April 2005
Total fuel cost per day	67,200 Rs	

Table 15. Energy bill per day in case of biomass based system

Particular	Figure	Note
Consumption of biomass per day	8.4 tonne	1 litre oil = 3.5 kg of biomass
Price of biomass per unit	1500 per tonne	Price as on April 2005
Total fuel cost per day	12,600 Rs	

Total fuel cost savings per day = 54,600 Rs (Fuel cost reduces by 81%)
** With per day saving of 54,600 Rs, total capital cost of 1.8 crore (without any subsidy) can be recouped in 330 days (less than 1 year)

Sensitivity analysis

Table 16. Fuel saving per day at various PLF, cost of biomass and cost of diesel, the per day fuel saving and pay back differ as follows:

Sensitivity Factor	Per day fuel cost savings (in Rs.)	Pay back period in days
100 % PLF (ceteris paribus)	68,250	264
60% PLF (ceteris paribus)	40,950	440
30 % PLF (ceteris paribus)	20,475	880
Diesel price 35 Rs/litre (ceteris	71,400	252

paribus)		
Diesel price 40 Rs/litre (ceteris paribus)	83,400	216
Biomass price 2000 Rs/tonne (ceteris paribus)	50,400	357
Biomass price 2500 Rs/tonne (ceteris paribus)	46,200	390
Biomass price 3000 Rs/tonne (ceteris paribus)	42,000	429

b. Monthly cost economics if biomass gasifier is used in place of diesel system for thermal application

Assumption 1: PLF: 80 %
Assumption 2: Price of biomass: 1500/tonne
Assumption 3: Capital costs: 1.8 crore for 1.5 MW energy capacity (Rs. 1.2 crores capital investment required for 1 MW energy capacity)
Assumption 4: Thermal requirement: 13,00,000 kcal/hour (equivalent to approx 1500 kw energy)
Assumption 5: Price of diesel; Rs. 28 per litre
Assumption 6: Installation costs: 0.18 crore (10% of capital cost for thermal application)
Assumption 7: Operation and maintenance costs: 0.04 crore per year
Assumption 8: Both diesel and biomass systems have a life of 10 years
Assumption 9: Cost of land has not been accounted for, in any of the system
Assumption 10: Manpower cost (Skilled technician: Rs. 8,000 per month, Unskilled technician: Rs. 4,000 per month)
Assumption 11: Overheads are not accounted for.
Assumption 12: While amortising the capital cost, time value of money has not been added

Table 17. Monthly cost estimation of thermal application based on diesel

Particular	Figure (in Rs)	Note
Capital cost (amortized on monthly basis)	4,000	Capital cost of approx. 5 lakhs have an estimated life of 10 years
O&M (amortised on monthly basis)	6,250	Total cost of approx. 7.5 lakhs in the total life of 10 years
Total monthly cost of diesel	20,16,000.	2400 l per day, 30 days a month with 28 Rs/l price
Manpower cost	24,000	At least two unskilled technicians required per shift with 3 shifts in operation

Table 18. Monthly cost estimation of thermal application based on biomass

Particular	Figure (in Rs)	Note
Capital cost (amortized on	1,50,000	Capital cost of approx. 1.8

monthly basis)		crore with an estimated life of 10 years
Installation cost (amortised on monthly basis)	15,000	10% of the capital cost
O & M (amortised on monthly basis)	30,000	2% per year of the capital cost
Total monthly cost of biomass	3,78,000	2400 l = 8400 kg of biomass per day, 30 days a month with 1500 per tonne price
Manpower cost	48,000	At least one skilled technician and two unskilled technicians required per shift with 3 shifts in operation
Total monthly cost	**6,21,000**	

** Total monthly saving with use of biomass based system: 14,29,250 Rs. Hence payback perid for biomass gasification system is 12.6 months**

Sensitivity Analysis:

Table 19. Monthly savings and pay back at various PLF, cost of biomass and cost of diesel is as follows:

Sensitivity factor	Monthly savings (in Rs)	Pay back period in months
100 % PLF (ceteris paribus)	18,38,750	9.8
60% PLF (ceteris paribus)	10,31,750	17.5
30 % PLF (ceteris paribus)	4,93,750	36.5
Diesel price 35 Rs/litre (ceteris paribus)	19,33,250	9.3
Diesel price 40 Rs/litre (ceteris paribus)	22,93,250	7.9
Biomass price 2000 Rs/tonne (ceteris paribus)	13,03,250	13.8
Biomass price 2500 Rs/tonne (ceteris paribus)	11,77,250	15.3
Biomass price 3000 Rs/tonne (ceteris paribus)	10,51,250	17.1

c. Typical cost economics of biomass gasifiers for electricity applications

Assumption 1: PLF: 50 %
Assumption 2: Price of biomass: 1500/tonne
Assumption 3: Capacity of the captive power plant: 500 kW
Assumption 4: Capital costs: 2.2 crore (4.4 crore per MW), assuming the plant is 100 % producer gas based.
Assumption 5: Installation costs: 0.11 crore (5 % of capital cost for electricity application)
Assumption 7: Operation and maintenance costs: 0.07 crore per year (3 % of the capital cost)

Assumption 8: Biomass system has been assumed to have a life of 10 years
Assumption 9: Cost of land has not been accounted for, in the system
Assumption 10: Manpower cost (Skilled technician: Rs. 8,000 per month, Unskilled technician: Rs. 4,000 per month). For biomass based power systems, 1 skilled technician and 3 unskilled technicians are needed per shift. 50 % PLF would means at least manpower planning for 2 shifts.
Assumption 11: Overheads are not accounted for.
Assumption 12: While amortising the capital cost, time value of money has not been added

Table 20. Annualized cost estimation of electricity generation based on diesel

Particular	Figure (in Rs)	Note
Annualised capital cost	1,86,666	Capital cost of approx. 28 lakhs for 500 kw diesel genset with an estimated life of 15 years
Annualised installation cost	9333	Installation cost approx. 5 % of capital costs in case of diesel based systems
Annualised O&M	3733	Approximately 2 % of capital cost per year
Total cost of diesel in a year	1,10,37,600	90 litre per hour at 50 % PLF with diesel price of 28 Rs/l price
Per annum manpower cost	1,92,000	At least one skilled technicians required per shift with 2 shifts in operation
Total annual cost	**1,14,29,332**	

** Total units of electricity produced in a year: 21,90,000 (50% PLF, 500 KW capacity)
** Per unit cost of power with diesel based generation: Rs 5.22/kwh (Total annualised cost/total units generated in a year)

Table 21. Annualised cost estimation of electricity application based on biomass

Particular	Figure (in Rs)	Note

Annualised capital cost	22,00,000	With a benchmark of 4.4.crore/MW for biomass system for electricity application with 10 years of life
Annualised installation cost	1,10,000	Installation cost approx. 5 % of capital costs in case of biomass based systems for electricity
Annualised O&M	66,000	Approximately 3 % of capital cost per year
Total cost of biomass in a year	21,35,250	3.9 tonne (50 % PLF) per day with a price of 1500 Rs. /tonne
Per annum manpower cost	4,80,000	At least one skilled technicians and three unskilled technicians required per shift with 2 shifts in operation
Total annual cost	**49,91,250**	

** Total units of electricity produced in a year: 21,90,000 (50% PLF, 500 KW capacity)
** Per unit cost of power with biomass based generation: Rs 2.28/kwh (Total annualised cost/total units generated in a year)
** Pay back period of additional information (in years) if biomass system is installed instead of diesel system: Approx. 3 years

Table 22. Biomass based electricity vis-à-vis electricity through other routes

Per unit cost of electricity based on 500 KW capacity diesel engine	5.22 Rs/kwh
Per unit cost of electricity based on 500 KW capacity biomass gasification system	2.28 Rs/kwh
Average tariff of grid electricity to the industrial customers (all India average)	4.00 Rs/kwh (according to some estimates)

Sensitivity Analysis

Table 23. Per unit cost of biomass based electricity for various PLFs and cost of biomass is as follows:

Sensitivity factor	**Per unit cost of electricity based on 500 kw biomass system (in Rs)**
60 % PLF (ceteris paribus)	2.06 Rs./kwh
30 % PLF (ceteris paribus)	2.97 Rs/kwh
Biomass price 1000 Rs/tonne (ceteris paribus)	1.95 Rs/kwh
Biomass price 2000 Rs/tonne (ceteris paribus)	2.60 Rs/kwh

6.4 ESCOs based on biomass gasification projects – financing requirements

As mentioned in the previous sections, under the present circumstances, the ESCO concept can be very pertinent in promoting the use of biomass (and biomass gasification technology) for industrial applications.

a. Financial issues concerning ESCOs

Various financial aspects of envisaged ESCOs (based on biomass gasification system) could be summed up as follows:

- Low net worth*:* Net worth of these ESCOs (value of their assets over liabilities) may be *very low*

- Low perceptive creditworthiness: These ESCOs are likely to have very *low perceptive creditworthiness* among banks, financial institutions and NBFCs due to the non-commonality of the concept and ESCOs having no sound track record.

- Significant working capital requirement: Working capital requirement of biomass based ESCOs can be very high due to the daily requirement of biomass purchases and expenditure in lieu of operation and maintenance.

- Up front capital cost: The capital cost of biomass-based systems is very high compared to fossil fuel based systems of similar capacity. Therefore, capital budgeting is an important issue for all biomass gasification projects promoted by ESCOs.

- Low resale value of the asset: The resale value of the assets is very low and once the systems are installed at one place, it may be very difficult to reinstall it at some other location due to *logistic problems and huge costs* involved.

- Business risk: ESCOs face significant amount of business risk that mainly emanates from the *counter party credit risk* and *performance risk*.

- Fluctuating cost of biomass: This is due to seasonal variations, market making and hosts of other factors. Cost of biomass, which is an important component of the working capital requirement of these kinds of ESCOs, has been observed to be very fluctuating. Broadly speaking, cost of biomass exhibits a rising trend in the local area, once some demand (and an organised market) is created due to the project. Later on the biomass cost tend to stabilise in a range.

- Growth imperative of ESCOs: Once stabilised with the help of one or two projects, these ESCOs are definitely expected to upscale their activities. This would mean capital requirements on a larger scale. Also, to meet the growth imperatives, these ESCOs would seek project based non-recourse financing, so that the ability of their net worth in attracting loan for their own requirement is not impaired.

- Lack of confidence at the end user level: As demonstrated in the previous sections, there is tremendous fuel cost saving potential, if industrial energy requirements are met with biomass instead of fossil fuels. However, in various places, this becomes difficult as the industrial units lack confidence in the efficacy of this technology. As a result, both performance risks and financing risks (ESCOs need to mobilise the financing) have to be covered by the ESCOs. This makes the position of ESCOs very vulnerable and contingent upon a variety of internal and external factors.

b. Capital budgeting for ESCOs

In view of the sizeable up-front capital requirements for ESCO driven biomass gasification projects and the problems faced therein (as discussed above), the following options could be explored, envisaging the role of various stakeholders:

(i) **Loans from banks/NBFCs/Financial Institutions:** Discussions with some of the bankers/financial institutions revealed the hesitation that today exists, among the financing community about funding such ESCOs. This hesitation is due to several factors like:

- Lack of awareness among the financing community about the commercial attractiveness of biomass gasification projects and their low level of comfort with the technology.

- High transaction costs of loan disbursements and repayment, due to non-scalable size of projects.

- High perceived credit risk due to lack of long successful history of ESCOs.

Some of these concerns can be circumvented, if ESCOs approach the banker of the end user (industrial unit where system is being installed) for loans. This will reduce the transaction costs of financing, and also since the cash flows of the ESCOs are based on the payments made by the end user – the industrial units, the local banker will have higher confidence in the ESCO guaranteed by the end user (due to the already existing relationship with the industrial unit).

(ii) **Owner's capital:** Though as envisaged, most of the ESCOs to be started under this concept, may lack in-house funding, it can certainly be expected that some of them would be able to invest a certain percentage from their own resources. This owner's capital if available will certainly improve the viability of the ESCOs and also their creditworthiness (as judged by the financial institutions).

(iii) **Capital funding by the end user:** Industrial units, where the biomass systems are installed, are also found to be willing to invest in the gasifier plants, provided there is enough confidence in the performance and cost saving capacity, besides the additional benefits. These investment decisions are also driven by a depreciation tax shield, which is available for the biomass based systems and may be advantageous to the end user, to reduce the tax liabilities from the profit generating operations.

(iv) **Depreciation benefits:** The accelerated depreciation benefit (which is presently at 80 % of the total capital cost) available for biomass gasifiers addresses the issue of low resale value of biomass based systems and also provides a mechanism for capital financing through industrial units/ESCOs having high corporate tax liability.

Table 24. The capital cost implications of the subsidy (according to present level) and the applicable depreciation can be shown with the help of an example: Single WBG-850 system of 'Ankur':

	Rupees (WBG – 850, Hot gas Mode)
Basic cost of gasifier	2975000
Subsidy (estimated)	1062500
IT saving due to 80 % depreciation in the first year (@35.875 %)	548888
Net investment	**1363613 (Only 45.84 % of the basic cost of gasifier)**

Source: Ankur Scientific Industries

c. **Working capital for ESCOs**

As discussed in the previous section, working capital management is of critical importance for the successful operation of biomass-based ESCOs. Under the proposed mechanism, the following could be the possible options for arranging working capital for the day-to-day operations of ESCOs:

- Overdraft facility by banks to meet the working capital shortages.
- Average working capital requirements incorporated in the term loan, and later separated out to meet working capital need.
- Monthly payment by the industrial user to the ESCOs (as part of the contract between them)

6.5 Possible models for financing ESCOs suiting various needs

ESCOs projects and revenue models for the biomass gasification systems are likely to be site-specific. Mutual faith and management styles and practices needs to be synthesized in the ESCO models . Financing models suiting a few typical set of circumstances are presented below:

a. Framework 1:

Characteristics

The end user has full confidence in the biomass gasification technology and in the cost savings resulting from switchover to biomass.

Recommended model

If the proprietor of an industrial unit has full confidence in the biomass gasification technology and believes that a huge fuel cost saving is possible, the remaining task becomes quite simple. Many of the industrial users would like to reap the advantages of fuel switching and hence would be willing to invest the required capital, and cover some risk.

In such cases, the appropriate role for the ESCOs can be the following:

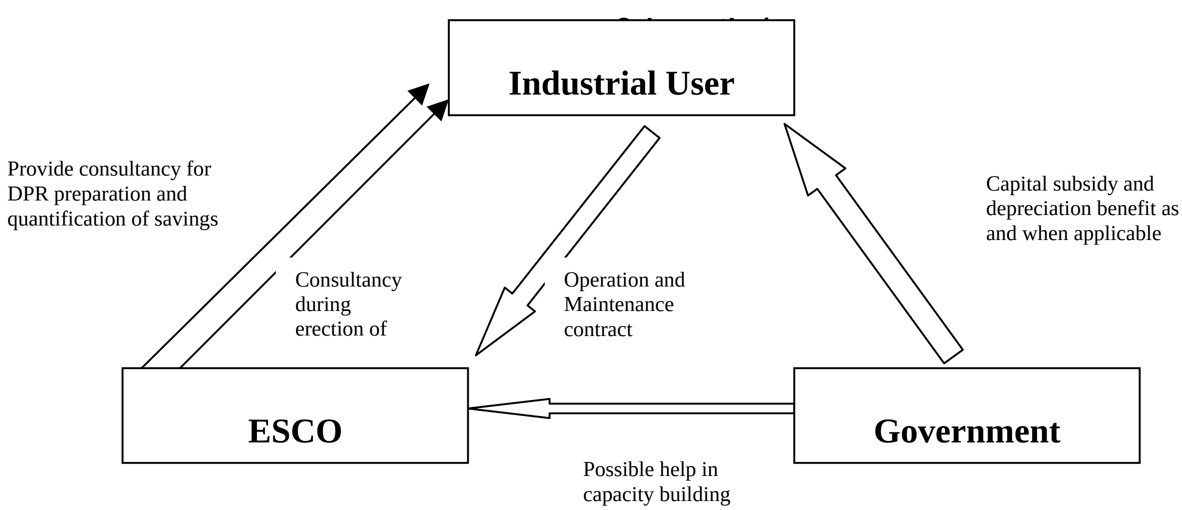
- During the conceptualization of the project, work as an independent consultant and prepare detailed project report (DPR) and establish possible cost savings due to the project.

- Provide engineering consultancy during project erection/installation phase.

- Work as an operation and maintenance (O&M) contractor during the life of the project.

- The industrial user can provide regular payments mutually decided upon, to the ESCO and it can be based on the costs incurred by an ESCO for O&M, with some service margin.

- The industrial user can take advantage of the capital subsidy available for such projects to make the whole operation more profitable for him. The schematic below expresses the model more lucidly.



b. Framework 2

Characteristics

- Confidence level among the end user about this technology, and/or the resulting cost savings is very low.

- The biomass project size is likely to be relatively large.

- ESCO believes that the estimated cost savings due to switchover towards biomass is quite substantial

Recommended model

When the end user does not have adequate confidence in the fuel cost saving (or in the biomass technology), ESCOs will invariably be required to bear the performance risks. The suggested route, in this case, is that the ESCOs guarantee the regular supply of energy and the cost savings (due to fuel switchover) to the industrial user.

The industrial user and the ESCO can enter into a contract where industrial units can guarantee regular utilisation of biomass based energy to the ESCO, and agrees to make payments on regular intervals. The ESCO in turn can guarantee uninterrupted supply of energy in the desired form and quantity, and also guarantee an average per unit energy cost savings.

Tariffs (paid to the ESCO by the industrial user) can be decided prior to taking into account the sharing of benefits (cost savings) between the industrial user and the ESCO. One model formula, suiting this situation, is presented below:

Tariff (per unit) = 0.90 x fossil fuels-based energy tariff baseline during the project period.

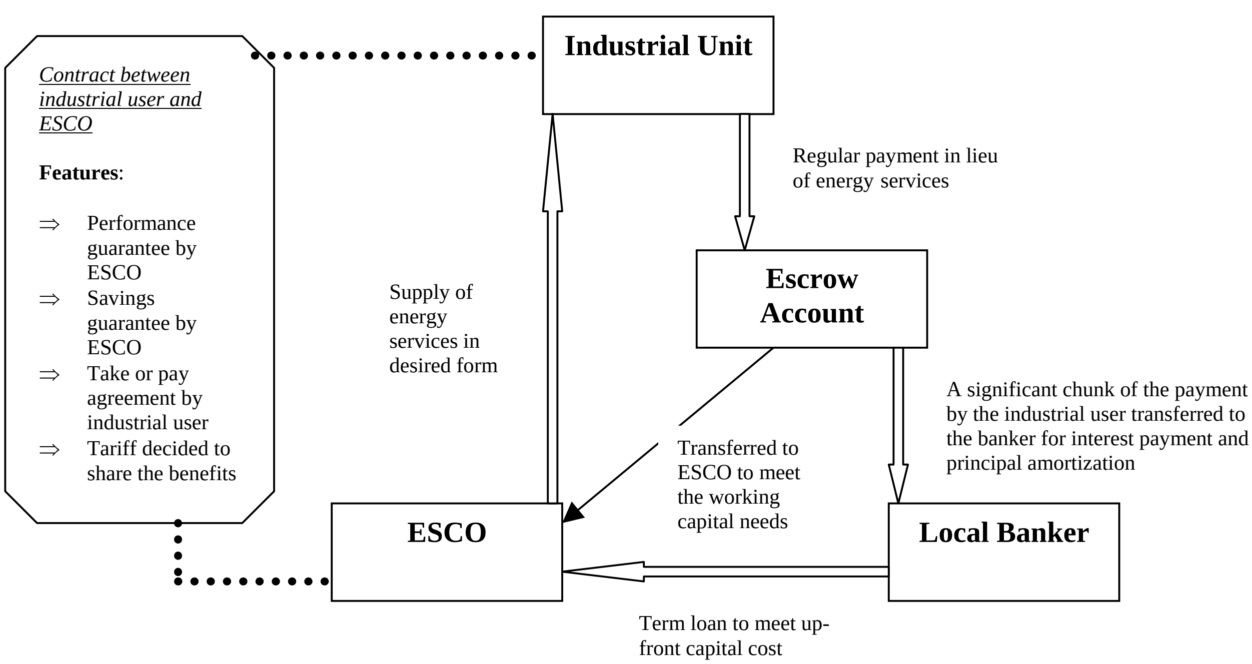
Payments to be released in the escrow account every month, or a periodically prior to the implementation of the ESCO project.
Actual savings over the entire project period can be monitored, computed and audited every year in a transparent manner and shared as per a pre-determined formula.

Financing arrangement

Once the contract between the ESCO and the industrial user is signed, ESCOs have a guaranteed cash flow stream, which can be utilized to obtain the term loan. ESCOs can try and get the term loan to meet the initial capital expenditure by securitizing the future cash flows/receivables. The loan will be backed by the receivables to mitigate the counter party credit risk for the banker.

The advantage of this mechanism is that ESCOs can procure the term loan even when its perceived creditworthiness (by the banker) is low. However, bankers may still doubt the creditworthiness (and/or strength of the business of the industrial units), wherefrom cash flow is deemed to be originating. This issue can also be taken care of if the ESCO is approaching the banker of the industrial units (local banker) to implement this framework.

Schematic 2



Chapter: 7 Institutional arrangement

ESCO product deployment routes will depend on the characteristics of the ultimate beneficiaries. Large firms will have the human resource, access to finance, as well as the motivation to install gasifies if the benefits are clear. At times, they may intend to outsource the operations to outside agencies on mutually beneficial terms. However, marketing retrofit viable options like gasifier and implementing the projects through outside agencies is not very common as highlighted in section 5 of the report.

In other cases where beneficiaries are the smaller enterprises, deployment may be contingent on the knowledge and the involvement of the entrepreneurs in various activities, presence of NGOs or other intermediaries such as faculty from engineering colleges, as well as consulting firms. Exploration of innovative institutional models may also provide as bait for catalyzing such tie-ups.

ESCOs may exercise wider business participations by integrating their sphere to allied businesses. One example in this context is managing biomass supply. In some cases, such enterprises may already exist. In other cases, especially where gasifiers are used in clusters, coordination with the market players and negotiations on favorable terms, may mean additions to the bottomline by as much as 10 %.

Besides, ensuring a reliable supply of biomass will affect the overall performance of the plant. ESCOs may have interests in overhauling internal combustion engines, ensuring cleaner production by minimizing wastes, etc. At times, he may be additionally responsible for improving productivity levels, line balancing or demand management.

Thus, ESCO should not always be expected to take care of only routine functions like turnkey operations of a retrofit project. They may be deployed by the beneficiary, in their chain of manufacturing plants, in different locations.

7.1 Broad expectations from ESCO firms

A typical ESCO firm for promoting biomass gasification projects, is expected to be a good role model, and represent a few generic characteristics in its operations, especially in SME sector.

1. The firm is expected to establish credentials through a professional approach in its dealings with clients, prospective beneficiaries and business networks.

2. ESCO is expected to conceive smart projects, which make business sense to the stakeholders.

3. ESCO is expected to show sound business sense in selling project ideas and shaping up model contracts.

4. ESCO is expected to take up business risks, get commensurate risk coverage and compensation for managing the same.

5. To start with, it is expected to be a lean set up with adequate tie-ups and resources - physical and fiscal, commensurate with the tasks being contemplated.

6. The ESCO should commence operations in a small way and expand gradually.

7. It should learn from experience and consolidate the same.

8. It is not expected to depict rigidities in dealing with clients or project design. Customer is the king, and their needs, whims and fancies have to be adequately addressed.

7.2 Likely options – pros and cons

A few possible options to organize activities related to biomass gasification projects in SMEs may include the following:

a. **Business firm by chartered accountants**

Fairly complex nature of activities widely varying in different locations would be expected. The chief executive has to comprehend reasonable details and appreciate finer intricacies in the ESCO operations. In fact, the BEE or PCRA have recognized the technical biasing of such activities while empanelling energy specialists. Buying technical services to manage the ESCO business is another possibility.

b. **Associates of non-financial banking or leasing firm**

NBFCs or leasing companies may be at ease in financing these projects. They are also expected to develop expertise in identifying and implementing them. Technical complexities would call for additional resources to take care of the operational activities. This restrains their business prospects in the early stages of the organization.

c. **Associate to equipment manufacturers (gasifiers, engines, capital equipment)**

The manufacturers themselves may be responsible for distribution, especially if they are small scale, and hence local, entities. Large, non-local, manufacturers may prefer to handle the distribution through local retailers. Still, the process of selecting, customizing (to the extent needed), and assembling requires technical skills, as do the operations and maintenance of the system. They did not seem interested in ESCO, though a few of them may extend their business lines to capture prospective clients in the SME sector.

As highlighted in section 5, the prospective beneficiaries would suspect the ESCOs tied up to manufacturers. At times, some biasing in favour of the models by the parent company may not lead to the best solutions.

d. **Technical institutes /engineering colleges**

These organizations have been providing services in the past for several years. It is generally experienced that other responsibilities limits their role to R&D activities, which is usually sponsored by the government or international agencies. Ideally they can provide useful ideas. They may have long-term associations with private consulting firms, and might nurture them in their field operations, rather than taking massive plunge into activities like ESCOs. Perhaps, charter of their employers would restrict such a role.

e. **Existing ESCO/energy audit firms**

Most of them may not be keen for reasons elaborated in section 5. Besides, biomass gasification projects would call for concerted efforts to develop the business line and marketable products and services. A few organizations – usually new individual based organizations are expected to evince interest.

f. Associates to existing ESCO/energy audit firms

The existing organizations may like to expand their field of operation. The synergy may be mutually rewarding and they might be able to tackle constraints based on the experience of the senior partners.

g. Alliance of young entrepreneurs

They may make a good network, still managerial problems do creep up in common areas. They might be of use with demarcated areas of activities and their collective strengths could be exploited.

h. Fresh unemployed BBA/ engineers/ MBA/M. Tech from management institutes/engineering colleges

This offers a huge potential, though the vast majority of the aspirants opt for greener pastures. Fresh /unemployed managers/engineers may be too raw in dealing with live situations in the beginning of their career. Engineering graduates with business education background would be the ideal choice.

Possible solutions

f, g, h above may be probable choices as the new breed of technically qualified personnel appear to be desirable. Ideally f is a good choice. However, for g and h, the incumbents may associate with a, b, c, d. Further, as per the Energy Conservation Act 2001, practicing energy audit firms have to appear in a qualifying examination. Even candidates who have already cleared this examination and are presently not employed or looking for opportunities in the ESCO field and are willing to diversify into biomass gasification may also be good choice.

7.3 Capacity building

a. Near term strategies

The following approach is suggested:

As mentioned above, to start with, pool of individuals - BEE examination pass-outs who are unemployed at the moment and are willing to participate in biomass gasification projects may be identified, seeking cooperation from BEE.

List of energy consultants on IREDA/ PCRA panel may also be included.

CII may prepare 'frequently asked questions' and their queries could be addressed through the internet. Expressions of interest may be obtained from the candidates and a short-list of the eligible candidates may be prepared. Preference would be given to candidates with tie-ups/sponsorship with existing ESCO/energy audit firms, technical institutes/engineering colleges/chartered accounting firms, and NFBC/leasing firms/manufacturers.

An advertisement may be placed in the national dailies by MNES. CII may provide the necessary support to MNES for short-listing the candidates.

The prospective candidates and their sponsors may be invited to attend an MNES sponsored national seminar to be organized by the CII. The seminar could be a business session between the prospective ESCO candidates. A gist of the interactive session could be put up on the website of the CII and the MNES for the benefit of those unable to participate.

Short-listed candidates and others keen to respond could be expected to submit their intention-cum-business plan by September 30, 2005. The list would be scrutinized by an expert committee, which may consist of nominees from MNES.

The chosen candidates would be exposed to a two-tier program for exposure to gasification technologies. MNES would bear the cost or training. The participants would however have to make their own lodging and boarding arrangements.

First tier would be a one-week exposure to the candidates on biomass gasification at IISC, Bangalore. The program would expose them to the principles, design, application, trouble shooting and successful cases. A few visits to the gasifier installations would be also organized.

Second tier would be a three-day exposure on ESCO fundamentals, financial aspects, ESCO contracting and case oriented discussions. The experienced specialists would address the participants. This module may be organized at Hyderbad by CII Green Center.

The participants are expected to market and negotiate successfully at least one biomass gasification project, keeping in view the background experience within the framework of the prevailing policy framework for such projects. The report would include signed ESCO contract between the stakeholders, salient features of the deliverables and project financials.

MNES may provide incentive to the ESCOs upon furnishing a documentary proof of having reached an ESCO contract, which includes a component of biomass gasification project and fulfilling a few other conditionalities within one year of successful completion of the induction training. This incentive is expected to provide a boost to the marketing efforts by ESCOs for biomass gasification projects in the initial period of recruiting a new incumbent.

The contract should preferably for at least 3 years. The incentive may be limited to 30 % of the average value of the annual energy savings achieved for the first project.

b. Long-term strategies

The MNES may expect the SNAs to keep track of the ESCO projects. It also expects ESCO /beneficiary sharing with MNES factual information on the performance, trouble shooting, cost break ups, etc. primarily being done for educating the FIs, professional community based on real life cases. The information gathered may be scrutinized and placed in the public domain.

Depending on the market response and achievements of the ESCO firms, MNES may at a later stage replicate these efforts and revise the modalities for training and developing ESCOs on biomass gasification technologies.

The ESCOs operating in the biomass gasification technologies may meet at least once every two years to exchange their operating experiences, draw some lessons from each other's experiences and formulate suggestions for extending the market. MNES may support these interventions.

Different stakeholders need to be involved at different stages of the GES development and dissemination process. National workshops may be organized at regular intervals in different regions to expose them to the developments on the biomass ESCO front.

An ESCO industry cannot survive without local financing. Donor agencies can foster initial growth, but the domestic banks must be viable energy efficiency lending agencies to sustain the industry. Until due diligence is provided for training in energy projects, bankers are uneasy about making loans to ESCOs.

Establishing financing institutions network (FIN) to ventilate the experience gained by leading FIs in the rural energy field would be useful.

7.4 Role of MNES and other agencies in promoting ESCO concept

An important factor affecting the growth of biomass gasification sector is that most of the entrepreneurs in the SME sector. They lack access to funds for carrying out the trail blazing activities viz., carrying out the initial exercise of market assessment, raising awareness of the grass root financing institutions and convincing them for financing, sensitizing the state government machinery and local stakeholders etc. Possible solutions to address the above problems/constraints/barriers may be:

- To evolve a good blend of top down and bottoms up approach for developing biomass gasification policy framework.
- Establish a funding mechanism for carrying out the trailblazing activities.
- Carry out a thorough 'need assessment' for estimating the market potential and then match the need assessment with the technology.
- Develop a suitable capacity building mechanism for creating awareness among the end users about the ESCOs and develop innovative financing schemes for financing biomass gasification products/projects.
- Support SNAs /financing institutions and ESCOs and professionals through host of biomass information exchange functions as detailed in the box. Major benefits of these interventions would be:
    - Documentation of standard contract agreements and of first–of–kind transactions, which can help future projects.
    - Promotions of linkages between various stakeholders like financiers, manufacturers, and state -level policy makers.
    - Building local capacity to configure products around technologies so as to meet user local needs.
    - Facilitating partnerships, which support the activities of early technical and financial intermediaries and instill confidence among FIs, banks to fund biomass gasification applications for which there are several different markets; the evolution of policy and finance is different for each market.

Host of biomass information exchange related functions

To encourage new entrepreneurs, in a few focused states like Kerala, Karnataka, Tamil Nadu, Andhra Pradesh, Maharashtra, Gujarat, Madhya Pradesh, Chattisgarh, Jharkand, Uttar Pradesh, Punjab, Bihar, West Bengal (list may be altered if needed), the MNES may improve on the on-going information development/dissemination activites.

There is a need to target the additional or the missing details, as part of generic information dissemination on the potential of biomass for power generation.

Increased information with project promoters and all stakeholders in the focused states and their enhanced knowledge base

A review of biomass resource mapping exercise of the Ministry may be taken up to generate location and specific investors' profile for different capacity and types of biomass based projects for market penetration.

Other sub-activities may include, creation of up-to-date information, database on biomass power project commissioned / under construction / in pipeline, technology update, newsletter on biomass power, development of databank on biomass power technologies, preparation of biomass power directory handbook, preparation of model pre-feasibility, techno-economic feasibility and detailed project reports, model energy purchase agreements, MoUs, project development agreements, fuel supply agreement, package or Engineering, Procurement and Construction (EPC) bid documents. Appraisal guidelines for different types of biomass power projects may also be prepared.

Create online databases for biomass projects promotion and development in focus states

The MNES may sponsor the development of a database on biomass power depots in the focused states, based on a review of all information/data/documents on biomass assessment. It can identify high potential districts/tehsils and carry out laboratory analysis of different biomass materials and mapping of potential sites for biomass depots.

The database would provide information on land and equipment requirements for setting up biomass depots, and on investment and operating costs. It would suggest a strategy for development of depots through consultative processes involving local entrepreneurs/non-government organisations (NGOs)/Self-help Groups (SHGs), villagers, particularly landless village level entrepreneurs and women.

Develop ESCO project development agreements

This activity will compile and review existing project agreements for different combinations of entrepreneurs and biomass power hosts for target biomass power sectors following ESCO or business models like BOO /BOOT. It will identify and evaluate key elements of each, and deliberate the issues through a consultative process and interaction with existing and potential entrepreneurs, SEBs, and FIs.

Based on this, model project agreements for different types of target biomass power sectors could be formulated. Typical project agreements between independent power plant promoters or developers and biomass host in each target sub-sectors may include i) land lease agreements ii) captive electricity and steam supply agreement iii) water supply agreement iv) effluent supply agreement.

Develop project management and information systems

Biomass projects commissioned in the past do not have systems for monitoring key biomass power project performance parameters related to technology, finance, implementation and operation. In the absence of effective systems, the overall project performance cannot be evaluated. This activity would help in designing appropriate MIS based on identification of key data needs, sources, analysis for optimizing performance and providing feedback to the concerned stakeholders.

Improved capacity of key stakeholders and project promoters in the targeted states

This sub-activity will aim at conducting consultative meetings and workshops for identifying specific capacity building needs and devising time bound capacity building programs and their implementation. The proposed strategy for capacity building would have components of communication and advocacy, information dissemination and exchange programs.

A board spectrum of the stakeholder would be participating in this activity, including R&D institutions, State Electricity Boards (SEBs), CERCs/ SERCs, state and central government agencies, financing institutions and banks, engineers and consultants, NGOs (local, regional, national agencies), service entrepreneurs, technology and equipment suppliers, project developer, sugar mill/rice mill owners, micro entrepreneurs and project promoters.

Communication and advocacy

This activity will make efforts to sensitize key policy makers and institutions on biomass power sector issues – regulatory, financing and institutional. Need-based policy research studies would be commissioned on the specific issues identified through consultative processes (consultative workshops) for each target biomass sector.

This would be supplemented by preparing articles, both in English and local languages in the focused states and their wider dissemination through different mass media, namely, print, audio/video and multimedia. The activity will include selection and appointment of teams of expert, issue of contract to the lead agency/institution and arrange for publication of articles, generation of public debates, participation in public hearings of SERCs, TV/radio/multimedia presentations etc.

Improve access to information through the website

This activity will provide comprehensive and up-to-date information required on biomass power projects development. It will support designing a website to meet the information needs of various stakeholders on different aspects of the biomass power sector. The website, which would be interactive, may cover various aspects of biomass power, including information on potential, achievements, performance, policy and regulatory framework, institutions, experts, consultants, equipment / technology suppliers, related central and state government agencies, fiscal incentives, technology status would link to the databases being created on biomass resources, technologies, project profiles in the focus states.

Develop and test capacity building modules in the focused states

This activity will develop capacity building modules through consultative and orientation meetings with key stakeholders in the primary focus states. Regulators, consumer forums, state government departments, SNAs, industry associations, key institutions including NGOs/SHGs/industry associations and project promoters would participate in these meetings.

These modules will be tested through organizing and evaluating specific skill up-gradation and training programs at all levels, in the interior areas. A number of sub-activities will be required to accomplish the objectives indicated above.

A critical review of the kind of business, commercial and support service networks/institutions/professionals required for this sector and assessment of the capability of existing institutional framework would be taken up. This would involve an in-depth study of equipment procurement mechanisms, sourcing different biomass resources, institutional mechanism for delivery of biomass fuels, feasibility of biomass depots, financing of such support services and relevant policy interventions.

Since biomass would be produced locally, efforts would be made to involve appropriate institutions (NABARD, commercial banks and micro-lending institutions) at all levels through participatory approaches and consultative processes with particular focus on gender issues.

Study of required institutional mechanisms for biomass power projects development

This activity will identify required business, commercial and support service mechanism for promoting, executing, operating and sustaining biomass power projects of target sub-sectors, through interaction with experts, associations, financial institutions, entrepreneurs, equipment suppliers etc. The key elements of required institutional mechanisms for biomass power sector will be developed and finalized through feedback.

Evaluate existing commercial and institutional framework in focused states for their suitability to promote biomass power projects

This activity will identify and evaluate available business, commercial and support service institutional mechanisms in the focused states for promoting, executing, operating and sustaining biomass power projects of target sub-sectors, and evaluate key institutions therein. The specific gaps in the required and available mechanisms will be identified.

The MNES may also concentrate on following areas.

The SNAs have to aim at the creation of business support centers for promotion of energy service companies or ESCOs. Equally important are dealer and service networks, credit establishments, financial intermediaries, vendor development, and access to venture capital. These efforts can be fostered and sustained through entrepreneur associations and cooperatives that can provide training in business management. Developing the requisite institutional capacity is a major challenge.

The MNES is expected to nurture the program for ESCO development by its catalytic role. It may consider the following activities, to which its mandate to support the ESCOs may not be necessarily be limited,

- Guiding IREDA and state level nodal agencies
- The MNES may issue suitable directives from time to time to IREDA and state level nodal agencies for a review of the ESCO activities and provide need-based support in terms of exchange of ideas, successful cases and organizing meets/workshops.
- Aggressive marketing is essential to change the end-user mindset. MNES may plan a publicity program through newspapers or other means to the target audience about the merits of the concept. It may sponsor industry bodies like CII to hold these events in decentralized locations.
- In the long term, the role of MNES should be to develop regulatory mechanisms, as well as guidelines and norms for energy services. Local entrepreneurs need both guidelines and incentives to operate as service providers.

7.5 Risk guarantee fund

The subsidy driven programs contribute to a skewed market growth for renewable energy products like gasifiers for SMEs. This is due to the fact that such programs are driven by subsidy with targets for certain type of products only.

This however calls for a detailed exercise,

a) To study, evaluate and finalize the components of the risk guarantee fund to be provided for the prospective ESCO projects which may be about to start

b) ☐To work with and assist financial institutions in designing appropriate financial structuring models for ESCOs, including risk assessment, selection criteria, actual selection of ESCOs, risk guarantee fund components, conventional term loan components, etc. and achieve financial closure of select ESCO projects

c) ☐☐To assist FIs in developing approaches and strategies for creating and operating contingent funds for ESCO projects. Indicative agencies may be IREDA, SBI Caps Limited, ILFS, IFCI, international financial structuring expert /agency or any other agency having relevant experience, expertise and interest.

In this context, the MNES may evolve a mechanism to redesign these subsidies and substitute them with a Risk Guarantee Fund to offload certain financial risks perceived by the FIs/ ESCOs while funding them. This is likely to induce funding of ESCO projects.

To start with, Rs 10 crores may be set aside and the equity /subsidy support by MNES for the ESCO projects could be recycled into this fund. In the event of an ESCO project encountering major default in repayment due technical or commercial reasons, ESCO/FIs may be partly compensated for the non recovery of the receivables from the beneficiaries, after taking into account the reasons of default, payments already received, resale value of the assets and reduction in the working expenses of the project, if terminated prematurely.

For reasons, beyond control of the ESCO, up to 75 % of the losses incurred by the ESCO may be compensated. It would be mandatory for ESCO and FIs to re-negotiate the conditions for term loan and revise its agreement for loan repayment on mutually agreeable terms.

APPENDIX 1

SAMPLE ENERGY PERFORMANCE CONTRACT

Note: This contract is provided as a sample and reference only. It may not identify or address all the circumstances or conditions you may encounter. Consequently, it is recommend that legal counsel and procurement staff carefully review this document and adapt it to the specific needs.
>
<SAMPLE >

ENERGY PERFORMANCE CONTRACT

This Energy Performance Contract (the "Contract") is made and entered into as of this day of ***<Date>*** , at ***<City, Address, etc.>***, in the County of ***<County>***, State of ***<State>,*** by and between ***<Name of ESCO>*** ("ESCO"), having its principal offices at ***<Address, City, State, pincode >***, and ***<Owner's Legal Name>*** ("Customer") having its principal offices at ***<Address, City, State, Zip>***, for the purpose of installing BIOMASS GASIFIER BASED ENERGY SYSTEMS described in Schedule A, and providing other services designed to reduce energy costs for the Customer's enterprises, known as***<Description used in RFP, DPR, etc.>***, located at ***<Address, City, State, Pincode , or description of location>*** (the "Premises").
RECITALS
WHEREAS, Customer owns and operates the Enterprise, and is in need of BIOMASS GASIFIER BASED ENERGY SYSTEMS and related services designed to save energy and associated energy costs at said Premises; and

WHEREAS, ESCO has developed or become knowledgeable about certain procedures for controlling energy consumption through the biomass gasifier based energy systems maintained on the premises of its customers; and
WHEREAS, ESCO has made an assessment of the energy consumption characteristics of the Premises and existing Equipment described in Schedule B, which Customer has approved.
WHEREAS, Customer desires to retain ESCO to purchase, install and service certain energy efficiency equipment of the type or class described in Schedule A, attached hereto and made part hereof and to provide other services for the purpose of achieving energy cost reductions within Premises, as more fully set forth herein; and
WHEREAS, Customer desires to compensate ESCO for its services based upon the value of energy and operations savings that are obtained; and
WHEREAS, Customer is authorized under the Constitution and the laws of the State of ***<State>*** to enter into this Contract for the purposes set forth herein.
NOW, THEREFORE, in consideration of the mutual promises and covenants contained herein, and intending to be legally bound hereby, Customer and ESCO hereto covenant and agree as follows:

SECTION 1 .
ENERGY MANAGEMENT PLAN

Section 1.1 .

Plan Details. ESCO has prepared the complete Technical Project Report for Biomass Based Energy systems at the premises set forth in Appendix C (**DPR**) and dated ***<Date>*** which has been approved and accepted by Customer as set forth in Exhibit **III** (i) (**Certificate of Acceptance—DPR**) **.** The DPR includes all techno-managerial aspects of the biomass gasifier energy systems agreed upon by the parties.

<Section 1.1: This section records the approval and acceptance by the Customer of the DPR which must be completed prior to the execution of this contract. A Certificate of Acceptance of the DPR should be signed by both parties and attached to the contract. If the list of measures is not completely finalized prior to the signing of this contract, then language to that effect should be included.>

Section 1.2.

Schedules, Exhibits and Appendices. ESCO has prepared and Customer has approved and accepted the Schedules as set forth below, copies of which are attached hereto (or will be as provided for in the Contract), set forth in their entirety as Attachment I and made a part of this Contract by reference. Any inconsistency in this Contract and its Schedules and related documents hall be resolved by giving precedence in the following order: ***<for example: the Addenda (if any); the Main Contract terms and conditions; etc.>***

Schedules Schedule A Equipment to be Installed by ESCO
Schedule B Description of Premises; Pre-Existing Equipment Inventory
Schedule C Energy savings Guarantee
Schedule D Compensation to ESCO
Schedule E Baseline Energy Consumption
Schedule F Savings Measurement & Calculation Formulae; Methodology to Adjust Baseline
Schedule G Construction and Installation Schedule
Schedule H Systems Start-Up and Commissioning; Operating Parameters of Installed Equipment
Schedule I Standards of Process parameters for the linked systems
Schedule J ESCO's Maintenance Responsibilities
Schedule K Customer's Maintenance Responsibilities
Schedule L Facility Maintenance Checklist
Schedule M ESCO's Training Responsibilities
Schedule N General Conditions
Schedule O Installment Payment Schedule ***<Or may be titled "Financing Amortization Schedule", "Debt Service Payment Schedule", etc.>***

Exhibits
Exhibit I

Performance Bond

Exhibit II Labor and Material Payment
Exhibit III (i) Certificate of Acceptance— DPR
Exhibit III (ii) Certificate of Acceptance—Installed Equipment
Exhibit IV Equipment Warranties

Appendices

Appendix A RFP for ESCO Solicitation
Appendix B ESCO Proposal
Appendix C DPR

<Section 1.2: The contract schedules detail the substantive technical parameters of the projects negotiated by the parties and accepted and approved by the Customer. These schedules are also referenced throughout the various sections of the Contract. Their titles may be included here for ease of reference or located at the end of the contract. If any schedules need to be completed after execution of the contract, language to the effect they are forthcoming should be included.

<Note for Customer: For Schedule N: General Conditions – If used, specify which articles and paragraphs of the General Conditions apply to this contract.>

< Note for Customer: Please note that descriptions for each contract schedule are provided at the end of this sample contract document, under the heading of Attachment I. >

Section 1.3.

Other Documents. This Contract incorporates herein and makes a part hereof the General Conditions set forth in Schedule N and Special Provisions as set forth in Section 36, as well as the entire RFP and ESCO Proposal for this Project labeled Appendix A (**RFP for ESCO Solicitation**) and Appendix B (**ESCO Proposal**) respectively. Acceptance by the Customer of the DPR is reflected in Exhibit **III** (i) (**Certificate of Acceptance— DPR**). Notwithstanding, the provisions of this Contract and the attached Schedules shall govern in the event of any inconsistencies between the DPR and the provisions of this Contract.

<Section 1.3: This section makes the original Request for Proposals (RFP) and the RFP General Conditions and Special Conditions a part of the contract. It also acknowledges the completion of the ESCO's DPR and its approval and acceptance by the Customer. It is recommended that the original technical audit in its entirety be attached and/or referenced as an Exhibit to this Contract. It is important to note the last sentence of this provision makes it clear that if there is any future discrepancy between the audit and any technical schedule(s), the terms of this contract shall apply.>

SECTION 2.

ENERGY USAGE RECORDS AND DATA

Customer has furnished or shall furnish (or cause its energy suppliers to furnish) to ESCO, upon its request, all of its records and complete data concerning energy usage and energy-related maintenance for the Premises described in Schedule B (**Description of Premises; Pre-Existing Equipment Inventory**), including the following data for the most current Twenty four (24) month period; utility records; occupancy information; descriptions of any changes in the building structure or its heating, cooling, lighting or other systems or energy requirements; descriptions of all energy consuming or saving equipment used in the Premises; bills and records relating to maintenance of energy-related equipment, and a description of energy management procedures presently utilized. If requested, Customer shall also provide any prior energy audits of the Premises, and copies of Customer's financial statements and records related to energy usage and operations for said thirty-six (36) month period at said Premises, and shall make agents and employees familiar with such records available for consultations and discussions with ESCO.

<Section 2: This section ensures that the ESCO has access to the historical** energy **consumption, facility operations and occupancy data necessary to formulate the facility(s) baseline utility consumption. At a minimum, there should be 24 months of data made available, however, 36 months is recommended. Existing facility conditions, operations and equipment needs to be carefully recorded to establish an accurate baseline. This will serve as a record of your buildings as they were configured prior to project installation and will be critical to the establishment and adjustment of baseline, and measurement of savings. As well, any prior technical studies and/or** energy **audits should also be made available for the ESCO's review and verification.>

SECTION 3.

COMMENCEMENT DATE AND TERMS; INTERIM PERIOD

Section 3.1.

Commencement Date. The Commencement Date shall be the first day of the month after the month in which all schedules are in final form and accepted by Customer and ESCO shall have delivered a Notice to Customer that it has installed and commenced operating all of the Equipment specified in Schedule A (**Equipment to be Installed by ESCO**) and in accordance with the provisions of Section 6 (**Construction Schedule and Equipment Installation; Approval**) and Schedule H (**Systems Start-Up and Commissioning; Operating Parameters of Installed Equipment**); and Customer has inspected and accepted said installation and operation as evidenced by the Certificate of Acceptance as set forth in Exhibit **III** (ii) (**Certificate of Acceptance—Installed Equipment** . Compensation payments due to ESCO for service and maintenance under this Contract as set forth in Schedule D (**Compensation to ESCO**) shall begin no earlier than ***<Date>*** from the Commencement Date as defined herein.

<Section 3.1: This section defines the Commencement Date which is the actual beginning date for the savings guarantee period. It is standard for this date to be the first month AFTER the ESCO has completed construction and delivered a notice that all equipment is installed and operating, and the Customer has accepted the installation by signing a Certificate of Acceptance which should be attached to the contract. It also clearly states that no payment for ESCO service and maintenance will be made prior to the Commencement Date. It is recommended that the repayment obligation of project financing be arranged to coincide with the Commencement Date. The of timing the Commencement Date may also need to be arranged to accommodate the Customer's fiscal year for the purpose of appropriations and budgeting.>

Section 3.2.

Term of Contract; Interim Period. Subject to the following sentence, the term of this Contract shall be ***<number>*** years measured beginning with the Commencement Date. Nonetheless, the Contract shall be effective and binding upon the parties immediately upon its execution, and the period from contract execution until the Commencement Date shall be known as the "Interim Period". All energy cost savings achieved during the interim period will be fully credited to Customer.

<Section 3.2: The customer needs to determine the desired and maximum length of the performance period. Prior to the Commencement Date (Section 3.1) the final contract and attendant schedules are negotiated and executed by signature. At that point in time the ESCO

typically begins the final design and construction of the project. The "Interim Period" refers to the construction period, during which an amount of energy cost ***savings will be realized. The treatment of those*** energy cost ***savings can be negotiated to be credited to the ESCO's guarantee or credited to the Customer.***

SECTION 4.

PAYMENTS TO ESCO
Section 4.1.

Energy Cost Savings Guarantee. ESCO has formulated and, subject to the adjustments provided for in Section 16, **Material Changes**) has guaranteed the annual level of energy and operations savings to be achieved as a result of the installation and operation of the Equipment and provision of services provided for in this Contract as specified in Schedule J (**ESCO's Maintenance Responsibilities**) and in accordance with the Savings Calculation Formula as set for in Schedule F (**Savings Calculation Formulae; Methodology to Adjust Baseline**). The Energy cost Savings Guarantee is set forth in annual increments for the term of the Contract as specified in Schedule C (**Energy cost Savings Guarantee**) and has been structured by the ESCO so as to be sufficient to cover any and all payments required to be made by the Customer as set forth in Schedule D (**Compensation to ESCO**) and Schedule O (**Installment Payment Schedule**).

<Section 4.1: This section establishes the term of the Energy cost ***savings guarantee to be on an annual basis and structured to cover any and all payments (debt service and ESCO fees) to be made by the Customer>***

Section 4.2.

Annual Review and Reimbursement/Reconciliation. If at the end of any year during the guarantee period as specified in Schedule C (**Energy cost Savings Guarantee**) the ESCO has failed to achieve the annual **Energy cost** Savings Guarantee specified in Schedule C (**Energy cost Savings Guarantee**), upon written request by the Customer, which shall be given no earlier than the end of such year and no later than ***<number>*** days thereafter, the ESCO will pay the Customer the difference between the annual amount guaranteed and the amount of actual **Energy cost** and operations savings achieved at the Premises in accordance with the provisions of Schedule C (**Energy cost Savings Guarantee**). The ESCO shall remit such payments to the Customer within ***<number>*** days of written notice by the Customer of such monies due. When the total **Energy cost** savings in any one year during the guarantee period exceed the **Energy cost** Savings Guarantee as set forth in Schedule C (**Energy cost Savings Guarantee**) and are in addition to those monies due the ESCO for compensation for services as set forth in Schedule D (**Compensation to ESCO**), such excess savings shall first be applied to reimburse ESCO for any payment ESCO made to the Customer to meet ESCO's guarantee for previous years in which the **Energy cost** savings fell short of ESCO's **Energy cost** Savings Guarantee under the terms as set forth in Schedule C (**Energy cost Savings Guarantee**).

<Section 4.2: At the conclusion of each year of the contract and within a specified number of days (usually 45- 60) there will be a review and reconciliation of the actual achieved savings (subject to any adjustments made for weather, operations, etc.) vs. the ESCO's guaranteed savings projections. In the event there is a savings shortfall, the ESCO is contractually liable to reimburse the Customer for the difference between what was actually achieved and the amount guaranteed. If in any future year, the achieved savings exceed the guarantee, the excess savings shall be used to reimburse the ESCO for any shortfall payments made in previous years. It is recommended that

all excess savings be retained by the Customer except when the ESCO has had a previous year's shortfall.>

Section 4.3.

ESCO Compensation and Fees.: ESCO has structured the **Energy cost** Savings Guarantee referred to in Section 4.1 above, so as to be sufficient to include any and all annual payments required to be made by the Customer in connection with financing/purchasing the Equipment to be installed by ESCO under this Contract as set forth in Schedule O (**Annual Installment Payment Schedule**). Actual **Energy cost** and operations savings achieved by ESCO through the operation of Equipment and performance of services by ESCO shall be sufficient to cover any and all annual fees to be paid by Customer to ESCO for the provision of services as set forth and in accordance with the provisions of Schedule D (**Compensation to ESCO**) and Schedule J (**ESCO's Maintenance Responsibilities**).

<Section 4.3: This section ensures that the ESCO's savings guarantee will, at a minimum, cover annual project financing costs (principal and interest). In addition, it states that all annual ESCO service fees for maintenance will also be paid from savings.>

Section 4.4.

Billing Information Procedure. Payments due to ESCO under this Section 4 shall be calculated each.***<billing period, months, days, etc.>*** in the following manner:
(i) By the ***<number>*** day after receipt, Customer shall provide ESCO with copies of all energy bills for the Premises which it shall have received for the preceding month;
(ii) Upon receipt of the required information, ESCO shall calculate the savings in accordance with the
agreed-upon calculation formulae in Schedule F (**Savings Calculation Formulae; Methodology to Adjust Baseline**).
(iii) Based upon paragraphs (i) and (ii) above, ESCO shall prepare and send to Customer *a* ***<billing period>*** invoice which shall set forth for each ***<billing period>*** the amounts of the energy and operations cost savings calculated in accordance with Schedule F (**Savings Calculation Formulae; Methodology to Adjust Baseline**). The invoice will set forth the total ***<billing period>*** payment due from Customer.

Section 4.5.

Payment. Customer shall pay ESCO within ***<number>*** days of receipt of ESCO's invoice.
<Section 4.4 & 4.5: These sections which deal with payment can be negotiated and structured to suit the needs of the Customer. It is, however, important to provide the ESCO with monthly utility bills and to do so in a timely manner. The project's billing schedule for on-going ESCO services can be set up on a monthly basis.>

Section 4.6.

Effective Date of Payment Obligation. Notwithstanding the above provisions in Section 4, Customer shall not be required to begin any payments to ESCO under this Contract unless and until all equipment installation is completed by ESCO in accordance with the provisions of Section 6 (**Construction and Equipment Installation; Approval**) and Schedule H (**Systems Start-Up and Commissioning; Operating Parameters of Installed Equipment**), and accepted by Customer as evidenced by the signed Certificate of Acceptance as set forth in Exhibit **III** (ii) (**Certificate of**

Acceptance—Installed Equipment), and unless and until said equipment is fully and properly functioning.

<Section 4.6: This section states that no ESCO fees shall be paid until all equipment in installed and operating in accordance with the agreed upon Construction Schedule and Customer has approved the completed installation and signed the requisite Certificate of Acceptance—Installed Equipment.>

SECTION 5.

FISCAL FUNDING

Section 5.1.

Non-appropriation of Funds. In the event no Customer or other funds or insufficient Customer or other funds are appropriated and budgeted, and funds are otherwise unavailable by any means whatsoever in any fiscal period for which payments are due ESCO under this Contract, then the Customer will, not less than ***<number>*** days prior to end to such applicable fiscal period, in writing, notify the ESCO of such occurrence and this Contract shall terminate on the last day of the fiscal period for which appropriations were made without penalty or expense to the Customer of any kind whatsoever, except as to the portions of payments herein agreed upon for which Customer and/or other funds shall have been appropriated and budgeted or are otherwise available.

SECTION 6.

CONSTRUCTION SCHEDULE AND EQUIPMENT INSTALLATION; APPROVAL

Section 6.1.

Construction and equipment installation shall proceed in accordance with the construction schedule approved by Customer and attached hereto as Schedule G (**Construction and Installation Schedule**).

<Section 6.1: It is important that the construction/installation phase of the project be managed in compliance with individual institutional requirements and the appropriate governing statutes. Since construction is just one component of the overall project, a separate construction contract may be desirable and in some cases necessary. The construction contract would then be referred to in the body of the contract and attached as an exhibit, appendix or other type of attachment. Another approach would be to consolidate the appropriate construction language for inclusion in the body of the final contract.>

Section 6.2.

Systems Startup and Equipment Commissioning: The ESCO shall conduct a thorough and systematic performance test of each element and total system of the installed Equipment in accordance with the procedures specified in Schedule H (**Systems Start-Up and Commissioning; Operating Parameters of Installed Equipment**) and prior to acceptance of the project by Customer. The ESCO shall provide notice to the Customer of the scheduled test(s) and the Customer and/or its designees shall have the right to be present at any or all such tests conducted by ESCO and/or manufacturers of the Equipment. The ESCO shall be responsible for correcting and/or adjusting all deficiencies in systems and Equipment operations that may be observed during system commissioning procedures.

<Section 6: This section requires the ESCO to develop a project commissioning plan to conduct performance testing of the equipment and verify the specified operating parameters to make certain the system is working properly. In most instances this activity occurs prior to the Customer's final acceptance of the project as fullyinstalled, however, if any testing is negotiated to occur after project acceptance, language to that effect should be included here. It also requires the ESCO notify the Customer of when the testing will take place and gives the Customer (or its designee) the right to be present during all tests.>

SECTION 7.

EQUIPMENT WARRANTIES

ESCO covenants and agrees that all equipment installed as part of this Contract is new, in good and proper working condition and protected by appropriate written warranties covering all parts and equipment performance. ESCO further agrees to deliver to the Customer for inspection and approval, all such written warranties and which shall be attached and set forth as Exhibit IV (**Equipment Warranties**); to pursue rights and remedies against manufacturer and ESCO of the equipment under the warranties in the event of equipment malfunction or improper or defective function, and defects in parts, workmanship and performance , to notify the Customer whenever defects in equipment parts or performance occur which give rise to such rights and remedies and those rights and remedies are exercised by ESCO. The cost of any risk of damage or damage to the equipment and its performance, including damage to property and equipment of the Customer or the Premises, due to ESCO's failure to exercise its warranty rights shall be borne solely by ESCO.

All warranties shall be transferable and extend to the Customer. The warranties shall specify that only new, and not reconditioned parts, may be used and installed when repair is necessitated by malfunction. All warranties required hereunder shall be in force for a minimum of one year from the commencement date as defined in Section 3.1 hereof. Notwithstanding the above, nothing in this Section shall be construed to alleviate/relieve the ESCO from complying with its obligations to perform under all terms and conditions of this Contract and as set forth in all attached Schedules.

<Section 7: This warranty provision requires all installed equipment be new and protected by appropriate written manufacturers warranties for a minimum of one year, covering parts and performance. It also requires warranties provide for the installation of only new parts (not used or reconditioned) be used if repair is required during the warranty period . While equipment warranties will be transferred to the Customer after completed project installation, this provision makes the ESCO responsible for pursuing any necessary remedies during the warranty period. If the ESCO fails to exercise the warranty and damages occur, the ESCO is responsible for allcosts of repair and any lost savings.>

SECTION 8.

TRAINING BY ESCO

The ESCO shall conduct the training program described in Schedule M (**ESCO's Training Responsibilities**) hereto. The training specified in Schedule M (**ESCO's Training Responsibilities**) must be completed prior to acceptance of the Equipment installation. The ESCO shall provide ongoing training whenever needed with respect to updated or altered Equipment, including upgraded software. Such training shall be provided at no charge to the Customer.

<Section 8: In many* performance *contracts the training of facility personnel is often conducted prior to acceptance by the Customer of the completed installation. There are occasions, however, where it may be necessary to conduct training after project acceptance which can be noted and included in the appropriate schedule. If there are charges for unscheduled training and such information should be noted in this section.>

SECTION 9.

PERMITS AND APPROVALS; COORDINATION

Section 9.1.

Permits and Approvals. Customer shall use its best efforts to assist ESCO in obtaining all necessary permits and approvals for installation of the Equipment. In no event shall Customer, however, be responsible for payment of any permit fees. The equipment and the operation of the equipment by ESCO shall at all times conform to all federal, state and local code requirements. ESCO shall furnish copies of each permit or license which is required to perform the work to the Customer before the ESCO commences the portion of the work requiring such permit or license.
<Section 9.1: This standard construction provision requires the ESCO comply with all code requirements, pay all associated permit fees and provide the Customer with copies of each permit and license required to do the work. The Customer agrees to assist the ESCO to the best of its ability to obtain are required permits and approvals.>

Section 9.2.

Coordination During Installation. The Customer and ESCO shall coordinate the activities of ESCO's equipment installers with those of the Customer, its employees, and agents. ESCO shall not commit or permit any act which will interfere with the performance of business activities conducted by the Customer or its employees without prior written approval of the Customer.

<Section 9.2: This standard provisions directs the Customer and ESCO to coordinate the equipment installation activities so as not to interfere with the Customer's business activities. If an installation will require interference, the ESCO must first obtain the Customer's written approval to proceed. If a facility generates revenue for the agency (e.g. civic center, theater, arena etc.) and scheduled revenue-producing activities are interrupted due to the fault of the ESCO, either during project installation or operation, then a provision for the collection of damages may be negotiated.>

SECTION 10.

PERFORMANCE BY ESCO

ESCO shall perform all tasks/phases under the Contract, including construction, and install the Equipment in such a manner so as not to harm the structural integrity of the plant or their operating systems and so as to conform to the standards set forth in Schedule I (**Standards of operations**) and the construction schedule specified in Schedule G (**Construction and Installation Schedule**). ESCO shall repair and restore to its original condition any area of damage caused by ESCO's performance under this Contract. The Customer reserves the right to review the work performed by ESCO and to direct ESCO to take certain corrective action if, in the opinion of the

Customer, the structural integrity of the Premises or its operating system is or will be harmed. All costs associated with such corrective action to damage caused by ESCO's performance of the work shall be borne by ESCO. ESCO shall remain responsible for the professional and technical accuracy of all services performed, whether by the ESCO or its subcontractors or others on its behalf, throughout the term of this Contract.

<Section 10: This section directs the ESCO to protect the premises and its contents to repair and restore to the original condition any damage caused by the ESCO in connection with this contract. Any costs incurred to correct such damage are to be paid by the ESCO. As well, the ESCO is solely responsible for the technical professional accuracy of all work performed under this Contract including work done by subcontractors or others.>

SECTION 11 .

OWNERSHIP

Section 11.1.

Ownership of Certain Proprietary Property Rights. Customer shall not, by virtue of this Contract, acquire any interest in any formulas, patterns, devices, secret inventions or processes, copyrights, patents, other intellectual or proprietary rights, or similar items of property which are or may be used in connection with the Equipment. The ESCO shall grant to the Customer a perpetual, irrevocable royalty-free license for any and all software or other intellectual property rights necessary for the Customer to continue to operate, maintain, and repair the Equipment in a manner that will yield maximal energy consumption reductions.

<Section 11.1: In most cases, this provision addresses the ESCO's proprietary rights over customized (or exclusive) software used in an energy management system which may control, manage and perform other functions in conjunction with the project (there may other technical designs, processes, formulas etc., which this provision would cover). Of particular importance is the stipulation that grants the Customer a continuing license(at no charge) to use and operate the project without violating any ESCO's proprietary rights.>

Section 11.2.

Ownership of Existing Equipment. Ownership of the equipment and materials presently existing at the Premises at the time of execution of this Contract shall remain the property of the Customer even if it is replaced or its operation made unnecessary by work performed by ESCO pursuant to this Contract. If applicable, ESCO shall advise the Customer in writing of all equipment and materials to be replaced at the Premises and the Customer shall within ***<number>*** days designate in writing to the ESCO which equipment and materials that should not be disposed of off-site by the ESCO. It is understood and agreed to by both Parties that the Customer shall be responsible for and designate the location and storage for any equipment and materials that should not be disposed of off-site. The ESCO shall be responsible for the disposal of all equipment and materials designated by the Customer as disposable off-site in accordance with all applicable laws and regulations regarding such disposal.

<Section 11.2: This provision states that the Customer has ownership of all existing equipment and the ESCO shall notify the Customer in writing of what equipment and materials are to be replaced. If the Customer chooses to keep the equipment to be replaced, the ESCO will be notified and the Customer responsible for identifying the location of where the property is to be stored or

relocated. The ESCO is responsible for all equipment and materials to be disposed. The exception to this is the treatment of any hazardous or environmentally sensitive materials.>

SECTION 12.

LOCATION AND ACCESS

Customer shall provide sufficient space on the Premises for the installation and operation of the Equipment and shall take reasonable steps to protect such Equipment from harm, theft and misuse. Customer shall provide access to the Premises for ESCO to perform any function related to this Contract during regular business hours, or such other reasonable hours as may be requested by ESCO and acceptable to the Customer. The ESCO's access to Premises to make emergency repairs or corrections as it may determine are needed shall not be unreasonably restricted by the Customer.

<Section 12: This provision states the Customer's responsibility for providing adequate space and protection for the installed equipment and authorizes the ESCO's access to the facility to perform routine and emergency operations.>

SECTION 13.

EQUIPMENT SERVICE

Section 13.1.

Actions by ESCO. ESCO shall provide all service, repairs, and adjustments to the Equipment installed under terms of this Contract pursuant to Schedule J (**ESCO's Maintenance Responsibilities**). Customer shall incur no cost for Equipment service, repairs, and adjustments, except as set forth in Schedule D (**Compensation to ESCO**), provided, however, that when the need for maintenance or repairs principally arises due to the negligence or willful misconduct of the Customer or any employee or other agent of Customer, and ESCO can so demonstrate such causal connection, ESCO may charge Customer for the actual cost of the maintenance or repair insofar as such cost is not covered by any warranty or insurance proceeds.

<Section 13.1: This section refers to the maintenance and service responsibilities of each party as they are specified in Schedules J and D. It also states that if the Customer is at fault for causing additional maintenance or repair to the equipment, then the Customer will be charged by the ESCO for the cost of the required maintenance or repair.>

Section 13.2.

Malfunctions and Emergencies. Customer shall use its best efforts to notify the ESCO or its designee(s) within 24 hours after the Customer's actual knowledge and occurrence of: (i) any malfunction in the operation of the Equipment or any preexisting energy related equipment that might materially impact upon the guaranteed energy savings, (ii) any interruption or alteration to the energy supply to the Premises, or (iii) any alteration or modification in any energy-related equipment or its operation. Where Customer exercises due diligence in attempting to assess the existence of a malfunction, interruption, or alteration it shall be deemed not at fault in failing to correctly identify a such conditions as having a material impact upon the guaranteed energy savings. Customer shall notify ESCO within twenty-four (24) hours upon its having actual knowledge of any emergency condition affecting the Equipment. ESCO shall respond or cause its designee(s) shall respond within ***<number>*** hours and shall promptly proceed with corrective measures. Any telephonic notice of such conditions by Customer shall be followed within three business days by written notice to ESCO from Customer. If Customer unreasonably delays in so notifying ESCO of a malfunction or emergency, and the malfunction or emergency is not otherwise corrected or remedied, such conditions will be treated as a Material Change and the applicable provisions of Section 16 (**Material Changes**) shall be applied.

<Section 13.2: This section requires the Customer to notify the ESCO within a specified number of hours of actually knowing about any situation that impacts the performance of the equipment. As described here, the impacts cover both pre-existing energy ***related equipment and the newly installed equipment. The impacts defined here include equipment malfunction or modification, interruption of power supply or any emergency situation which may affect the*** energy ***savings guarantee. If such an impact is known by the Customer to have occurred and the Customer delays in notifying the ESCO and doesn't correct the situation, it will treated as a Material Change and the baseline will be adjusted accordingly. If the Customer makes an effort to assess the situation and incorrectly determines it doesn't have an impact, then the ESCO will not fault the Customer ,although an adjustment to the baseline may still be warranted.>***

Section 13.3.

Actions by Customer. Customer shall not move, remove, modify, alter, or change in any way the Equipment or any part thereof without the prior written approval of ESCO except as set forth in Schedule K (**Customer's Maintenance Responsibilities**). Notwithstanding the foregoing, Customer may take reasonable steps to protect the Equipment if, due to an emergency, it is not possible or reasonable to notify ESCO before taking any such actions. In the event of such an emergency, Customer shall take reasonable steps to protect the Equipment from damage or injury and shall follow instructions for emergency action provided in advance by ESCO. Customer agrees to maintain the Premises in good repair and to protect and preserve all portions thereof which may in any way affect the operation or maintenance of the Equipment.

<Section 13.3: This section states the Customer may not make any changes to the operation and maintenance of the equipment without the prior written approval of the ESCO unless otherwise indicated in Schedule K or if there is an emergency and the ESCO can't be reasonably notified. In the case of such emergency, the Customer should follow instructions provided by the ESCO for emergency action.>

SECTION 14.

UPGRADING OR ALTERING THE EQUIPMENT

ESCO shall at all times have the right, subject to Customer's prior written approval, which approval shall not be unreasonably withheld, to change the Equipment, revise any procedures for the operation of the equipment or implement other energy saving actions in the Premises, provided that:

(i) the ESCO complies with the standards of comfort and services set forth in Schedule I (**Standards of operations**) herein;
(ii) such modifications or additions to, or replacement of the Equipment, and any operational changes, or new procedures are necessary to enable the ESCO to achieve the energy savings at the Premises and;
(iii) any cost incurred relative to such modifications, additions or replacement of the Equipment, or operational changes or new procedures shall be the responsibility of the ESCO. All modifications, additions or replacements of the Equipment or revisions to operating or other procedures shall be

described in a supplemental Schedule(s) to be provided to the Customer for approval, which shall not be unreasonable withheld, provided that any replacement of the Equipment shall be new and have equal or better potential to reduce energy consumption at the Premises than the Equipment being replaced. The ESCO shall update any and all software to be used in connection with the Equipment in accordance with the provisions of Section 11.1 (**Ownership of Certain Proprietary Rights**). All replacements of and alterations or additions to the Equipment shall become part the Equipment described in Schedule A (**Equipment to be Installed by ESCO**) and shall be covered by the provisions and terms of Section 6 (**Construction Schedule and Equipment Installation; Approval**).

<Section 14: This section describes the terms and conditions under which the ESCO may make changes to the equipment, operating procedures or take other energy savings actions. If such changes are implemented during any time during the contract they must be described in a supplemental schedule and be approved by the Customer. As well, any equipment replaced is required to be new and have the potential to produce at least as much or more savings. If computer software is updated, the licensing provisions of Section 11.1 still apply.>

SECTION 15.

STANDARDS OF OPERATIONS

ESCO will maintain and operate the Equipment in a manner which will provide the standards of operations , heating,
cooling, hot water, and lighting as described in Schedule I (**Standards of Comfort**).

<Section 15: This section references the standards of operations contained in Schedule I which the ESCO is contractually liable to maintain throughout the term of the contract. These standards are negotiated between the ESCO and Customer to reflect realistic ranges of heating, cooling and hot water temperatures, lighting levels, chilled water requirements, and other specified operating parameters to be maintained.>

SECTION 16.

MATERIAL CHANGES

<Section 16: It is usual for the percent of deviation to be negotiated as a value ranging between 2% and 5%based on aggregate consumption costs.

Material Change Defined: A Material Change shall include any change in or to the Premises, whether structural, operational or otherwise in nature which reasonably could be expected, in the judgment of the Customer, to increase or decrease annual energy consumption in accordance with the provisions and procedures set forth in Schedule E (**Baseline Energy Consumption**) and Schedule F (**Savings Measurement and Calculation Formulae; Methodology to Adjust Baseline**) by at least ***<number>*** % after adjustments for climatic variations. Actions by the Customer which may result in a Material Change include but are not limited to the following:

(i) manner of use of the Premises by the Customer; or
(ii) hours of operation for the Premises or for any equipment or energy using systems operating at the Premises; or
(iii) permanent changes in the comfort and service parameters set forth in Schedule I (**Standards of operations**); or
(iv) Production Capacity ; or
(v) Pattern of production ; or

(vi) types and quantities of equipment used at the Premises or
(vii) modification, renovation or construction at the Premises; or
(viii) the Customer's failure to provide maintenance of and repairs to the Equipment in accordance with Schedule K (**Customer's Maintenance Responsibilities**); or
(ix) any other conditions other than climate affecting energy use at the Premises.

<Section 16.1: This section defines the term "Material Change" which covers any condition other than weather, that affects building energy use and/or consumption by more than the negotiated percentage (see abovediscussion).>

Section 16.2.

Reported Material Changes; Notice by Customer: The Customer shall use its best efforts to deliver to the ESCO a written notice describing all actual or proposed Material Changes in the Premises or in the operations of the Premises at least __ days before any actual or proposed Material Change is implemented or as soon as is practicable after an emergency or other unplanned event. Notice to the ESCO of Material Changes which result because of a bona fide emergency or other situation which precludes advance notification shall be deemed sufficient if given by the Customer within ***<number>*** hours after having actual knowledge that the event constituting the Material Change occurred or was discovered by the Customer to have occurred.

<Section 16.2: This section requires the Customer to notify the ESCO in writing if there are any actual or planned changes to the facility which would effect energy consumption by more than the negotiated percentage(see above discussion). In the event of an emergency or situation that would prevent advance notification, the Customer has a specified number of hours to inform the ESCO that a Material Change has occurred.>

Section 16.3.

Unreported Material Change. In the absence of any Material Changes in the Premises or in their operations, the baseline energy consumption as set forth in Schedule E (**Baseline Energy Consumption**) should not change more than ***<number>*** % during any month from the projected energy usage for that month, after adjustments for changes in climatic conditions. Therefore, if energy consumption for any month as set forth in Schedule E (**Baseline Energy Consumption**) deviates by more than ***<number>*** percent (***<number>*** %) from the energy consumption for the same month of the preceding contract year after adjustments for changes to climactic conditions, then such deviation shall be timely reviewed by the ESCO to ascertain the cause of deviation. The ESCO shall report its findings to the Customer in a timely manner and the ESCO and Customer shall determine what, if any, adjustments to the baseline will be made in accordance with the provisions set forth in Schedule F (**Savings Measurement and Calculation Formulae; Methodology to Adjust Baseline**) and Schedule E (**Baseline Energy Consumption**).

<Section 16.3: This section states that if all building conditions and operations stay the same, then energy consumption will not vary more than the negotiated percentage (see above discussion) during any month when compared to the baseline use for that month and after adjustments for weather are made. In the event such a variation occurs, the ESCO will try to determine the cause of the deviation and report its findings to the Customer. The ESCO and Customer will then determine what adjustments will be made to the baseline as described in Schedule F. Disputes may need to be addressed here.>

SECTION 17.

PROPERTY/CASUALTY/INSURANCE; INDEMNIFICATION

Section 17.1.

At all times during the term of this Contract, ESCO shall maintain in full force and effect, at its expense: (1) Workmen's Compensation Insurance sufficient to cover all of the employees of (ESCO) working to fulfill this Contract, and (2) Casualty and Liability Insurance on the Equipment and Liability Insurance for its employees and the possession, operation, and service of the Equipment. The limits of such insurance shall be not less than ***< rupee value>*** for injury to or death of one person in a single occurrence and ***<rupee value>*** for injury to or death of more than one person in a single occurrence and ***< rupee value>*** for a single occurrence of property damage. Such policies shall name the Customer as an additional insured. Prior to commencement of work under this Contract, ESCO will be required to provide Customer with current certificates of insurance specified above. These certificates shall contain a provision that coverage afforded under the policies will not be canceled or changed until at least thirty (30) days' prior written notice has been given to Customer.

Section 17.2.

ESCO shall be responsible for (i) any damage to the Equipment or other property on the Premises and (ii) any personal injury where such damage or injury occurs as a result of ESCO's performance under this Contract.

Section 17.3.

ESCO shall save and hold harmless Customer and its officers, agents and employees or any of them from any and all claims, demands, actions or liability of any nature based upon or arising out of any services performed by ESCO, its agents or employees under this Contract.

<Section 17: This section needs to reflect the individual Customer's standard requirements with regard to insurance and indemnification.>

SECTION 18.

CONDITIONS BEYOND CONTROL OF THE PARTIES

If a party ("performing party") shall be unable to reasonably perform any of its obligations under this Contract due to acts of God, insurrections or riots, or similar events, this Contract shall at the other party's option (i) remain in effect but said performing party's obligations shall be suspended until the said events shall have ended; or, (ii) be terminated upon ten (10) days notice to the performing party, in which event neither party shall have any further liability to the other.

SECTION 19.

EVENTS OF DEFAULT

Section 19.1.

Events of Default by Customer. Each of the following events or conditions shall constitute an "Event of Default" by Customer:

(i) any failure by Customer to pay ESCO any sum due for a service and maintenance period of more than ***<number>*** days after written notification by ESCO that Customer is delinquent in

making payment and provided that ESCO is not in default in its performance under the terms of this Contract; or
(ii) any other material failure by Customer to perform or comply with the terms and conditions of this Contract, including breach of any covenant contained herein, provided that such failure continues for ***<number>*** days after notice to Customer demanding that such failures to perform be cured or if such cure cannot be effected in _***<number>*** days, Customer shall be deemed to have cured default upon the commencement of a cure within ***<number>*** days and diligent subsequent completion thereof;
(iii) any representation or warranty furnished by Customer in this Contract which was false or misleading in any material respect when made.

Section 19.2.

Events of Default by ESCO. Each of the following events or conditions shall constitute an "Event of Default" by ESCO:

(i) the standards of operation and service set forth in Schedule I (**Standards of operation**) are not provided due to failure of ESCO to properly design, install, maintain, repair or adjust the Equipment except that such failure, if corrected or cured within ***<number>*** days after written notice by Customer to ESCO demanding that such failure be cured, shall be deemed cured for purposed of this Contract.
(ii) any representation or warranty furnished by ESCO in this Contract is false or misleading in any material respect when made;
(iii) failure to furnish and install the Equipment and make it ready for use within the time specified by this Contract as set forth in Schedules A (**Equipment to be Installed by ESCO**) and G (**Construction and Installation Schedule**);
(iv) provided that the operation of the facility is not adversely affected and provided that the standards of comfort in Schedule I (**Standards of Comfort**) are maintained, any failure by ESCO to perform or comply with the terms and conditions of this Contract, including breach of any covenant contained herein except that such failure, if corrected or cured within ***<number>*** days after written notice by the Customer to ESCO demanding that such failure to perform be cured, shall be deemed cured for purposes of this Contract;
(v) any lien or encumbrance upon the equipment by any subcontractor, laborer or material man of ESCO;
(vi) the filing of a bankruptcy petition whether by ESCO or its creditors against ESCO which proceeding shall not have been dismissed within***<number>*** days of its filing, or an involuntary assignment for the benefit of all creditors or the liquidation of ESCO.
(vii) Any change in ownership or control of the ESCO without the prior approval of the Customer, which shall not be unreasonably withheld.
(viii) failure by the ESCO to pay any amount due the Customer or perform any obligation under the terms of this Contract or the Energy Savings Guarantee as set forth in Schedule C (**Energy Savings Guarantee**).

SECTION 20.

REMEDIES UPON DEFAULT

Section 20.1.

Remedies upon Default by Customer. If an Event of Default by Customer occurs, ESCO may, without a waiver of other remedies which exist in law or equity, elect one of the following remedies:

(i) exercise all remedies available at law or in equity or other appropriate proceedings including bringing an action or actions from time to time for recovery of amounts due and unpaid by Customer, and/or for damages which shall include all costs and expenses reasonably incurred in exercise of its remedy;

Section 20.2.

Remedies Upon Default by ESCO. In the Event of Default by ESCO, Customer shall have the choice of either one of the following remedies in law or equity:

(ii) exercise and any all remedies at law or equity, or institute other proceedings, including, without limitation, bringing an action or actions from time to time for specific *performance*, and/or for the recovery of amounts due and unpaid and/or for damages, which shall include all costs and expenses reasonably incurred,
including attorney's fees;

SECTION 21.

ASSIGNMENT

The ESCO acknowledges that the Customer is induced to enter into this Contract by , among other things, the professional qualifications of the ESCO. The ESCO agrees that neither this Contract nor any right or obligations hereunder may be assigned in whole or in part to another firm, without the prior written approval of the Customer.

Section 21.1.

Assignment by ESCO. The ESCO may, with prior written approval of the Customer, which consent shall not be unreasonably withheld, delegate its duties and performance under this Contract, and/or utilize contractors, provided that any assignee(s), delegate(s), or contractor(s) shall fully comply with the terms of this Contract. Notwithstanding the provisions of this paragraph, the ESCO shall remain jointly and severally liable with its assignees(s), or transferee(s) to the Customer for all of its obligations under this Contract.

<Section 21.1: This assignment provision first acknowledges that the Customer selected the ESCO for its unique expertise and qualifications to perform the services specified in the contract. The ESCO may not assign this contract to another ESCO without the written approval of the Customer and any ESCO assigned this contract must fully comply with all terms and conditions. In addition, the ESCO and any assignee remain contractually liable to the Customer for fulfilling all of the ESCO's obligations as specified in the contract.>

Section 21.2.

Assignment by Customer. Customer may transfer or assign this Contract and its rights and obligations herein to a successor or purchaser of the Plant or an interest therein. The Customer shall remain jointly and severally liable with its assignees or transferees to the ESCO for all of its obligations under this Contract.

<Section 21.2: In turn, this provision allows the Customer to transfer or assign this contract to a new owner. The Customer and its assignee, however, still remains responsible to the ESCO for the Customer's obligations as specified in the contract.>

SECTION 22.

ARBITRATION

Any dispute, controversy, or claim arising out of or in connection with, or relating to this Contract, or any breach or alleged breach hereof, shall, upon the request of any party involved (and without regard to whether or not any provision of this Contract expressly provides for arbitration), be submitted to and settled by arbitration in the State of *<State>*, in conformance with the rules of the American Arbitration Association then in effect for commercial disputes (or at any other place or under any other form of arbitration mutually acceptable to the parties). Any award rendered thereon may be entered in the highest court of a forum, state or federal, having jurisdiction. The expenses of the arbitration shall be borne equally by the parties to the arbitration, provided that each party shall pay for and bear the cost of its own experts, evidence, and counsel.

SECTION 23.

REPRESENTATIONS AND WARRANTIES

Each party warrants and represents to the other that:

(i) it has all requisite power, authority, licenses, permits, and franchises, corporate or otherwise, to execute and deliver this Contract and perform its obligations hereunder;
(ii) its execution, delivery, and *performance* of this Contract have been duly authorized by, or are in accordance with, its organic instruments, and this Contract has been duly executed and delivered for it by the signatories so authorized, and it constitutes its legal, valid, and binding obligation;
(iii) its execution, delivery, and *performance* of this Contract will not breach or violate, or constitute a default under any Contract, lease or instrument to which it is a party or by which it or its properties may be bound or affected; or
(iv) it has not received any notice, nor to the best of its knowledge is there pending or threatened any notice, of any violation of any applicable laws, ordinances, regulations, rules, decrees, awards, permits or orders which would materially and adversely affect its ability to perform hereunder.

<Section 23: This boilerplate provision states that each party has the requisite authority and ability to enter into this contract.>

SECTION 24.

ADDITIONAL REPRESENTATIONS OF THE PARTIES.

Customer hereby warrants, represents and promises that:

(i) it has provided or shall provide timely to ESCO, all records relating to energy usage and energy-related maintenance of Premises requested by ESCO and the information set forth therein is, and all information in other records to be subsequently provided pursuant to this Contract will be true and accurate in all material respects; and (ii) it has not entered into any leases, contracts or Contracts with other persons or entities regarding the leasing of energy efficiency equipment or the provision of energy management services for the Premises or with regard to servicing any of the energy related equipment located in the Premises. Customer shall provide ESCO with copies of any successor or additional leases of energy efficiency equipment and contracts for management or servicing of preexisting

equipment at Premises which may be executed from time to time hereafter within ***<number>*** days after execution thereof.

ESCO hereby warrants, represents and promises that:

(i) before commencing ***performance*** of this Contract:
(a) it shall have become licensed or otherwise permitted to do business in the State of ***<State.>***
(b) it shall have provided proof and documentation of required insurance pursuant to Section 17 (**Insurance Requirements**);
(ii) it shall make available, upon reasonable request, all documents relating to its ***performance*** under this Contract, including all contracts and subcontracts entered into;
(iii) it shall use qualified subcontractors and delegates, licensed and bonded in this state to perform the work so subcontracted or delegated pursuant to the terms hereof;
(iv) that it is financially solvent, able to pay its debts as they mature and possessed of sufficient working capital to complete the Work and perform its obligations under this Contract.

<Section 24: These additional representation address several areas specific to the performance contract. The Customer certifies it has or will provide the ESCO will all energy ***and energy -related records and all future records to be provided will be truthful and accurate. The Customer also declares it has not entered into any leases or service contracts relating to energy equipment or servicing of pre-existing equipment and will notify the ESCO within a specified period of time if it does so. As well, the ESCO certifies that before beginning work under this contract it will: have become licensed to business in the state; provide proof of required insurance; give Customer access to all document relating to the project (including all contracts and subcontracts) upon request; use state-licensed and qualified subcontractors; and is financially able to complete the project and perform under the terms of this contract.>***

SECTION 25.

WAIVER OF LIENS

ESCO will obtain and furnish to Customer a Waiver of Liens from each vendor, material manufacturer and laborer in the supply, installation and servicing of each piece of Equipment.

<Section 25: This is a standard construction contracting provision.>

SECTION 26.

COMPLIANCE WITH LAW AND STANDARD PRACTICES

ESCO shall perform its obligations hereunder in compliance with any and all applicable federal, state, and local laws, rules, and regulations, in accordance with sound engineering and safety practices, and in compliance with any and all reasonable rules of Customer relative to the Premises. ESCO shall be responsible for obtaining all governmental permits, consents, and authorizations as may be required to perform its obligations hereunder.

<Section 26: This is a standard contracting provision.>

SECTION 27.

INDEPENDENT CAPACITY OF THE CONTRACTOR

The parties hereto agree that ESCO, and any agents and employees of ESCO, in the performance of this Contract, shall act in an independent capacity and not as officers, employees, or agents of the Customer.
<Section 27: This is a standard contracting provision.>

SECTION 28.

NO WAIVER

The failure of ESCO or Customer to insist upon the strict performance of the terms and conditions hereof shall not constitute or be construed as a waiver or relinquishment of either party's right to thereafter enforce the same in accordance with this Contract in the event of a continuing or subsequent default on the part of ESCO or Customer.

<Section 28: This is a standard construction contracting provision >

SECTION 29.

SEVERABILITY

In the event that any clause or provision of this Contract or any part thereof shall be declared invalid, void, or unenforceable by any court having jurisdiction, such invalidity shall not affect the validity or enforceability of the remaining portions of this Contract unless the result would be manifestly inequitable or unconscionable.

SECTION 30.

COMPLETE CONTRACT

This Contract, when executed, together with all Schedules attached hereto or to be attached hereto, as provided for by this Contract shall constitute the entire Contract between both parties and this Contract may not be amended, modified, or terminated except by a written Contract signed by the parties hereto.

SECTION 31.

FURTHER DOCUMENTS

The parties shall execute and deliver all documents and perform all further acts that may be reasonably necessary to effectuate the provisions of this Contract.
SECTION 32.

APPLICABLE LAW

This Contract and the construction and enforceability thereof shall be interpreted under the laws of the State of_*<State.>*.

SECTION 33.

NOTICE

Any notice required or permitted hereunder shall be deemed sufficient if given in writing and delivered personally or
sent by registered or certified mail, return receipt requested, postage prepaid, or delivered to a nationally recognized
express mail service, charges prepaid, receipt obtained, to the address shown below or to such other persons or
addresses as are specified by similar notice.

TO ESCO:

<ESCO Name, Attention:, Complete address.>
< Include COPY TO: information for ESCO, if applicable.>

TO CUSTOMER:

<Customer Name, Attention:, Complete address.>
< Include COPY TO: information for CUSTOMER, if applicable. >

SECTION 34.

CUSTOMER'S COMPLIANCE WITH FACILITIES MAINTENANCE CHECKLIST

Section 34.1

The parties acknowledge and agree that ESCO has entered into this Contract in reliance upon the prospect of earning compensation based on guaranteed energy savings in energy used at Premises, as set forth on Schedules C (**Energy Saving Guarantee**) and D (**Compensation to ESCO**), attached hereto and made a part hereof.
Section 34.2.

The parties further acknowledge and agree that the said guaranteed energy savings would not likely be obtained unless certain procedures and methods of operation designed for energy conservation shall be implemented, and followed by Customer on a regular and continuous basis.

Section 34.3.

Customer agrees that it shall adhere to, follow and implement the energy conservation procedures and methods of operation to be set forth on Schedule K (**Customer's Maintenance Responsibilities**), to be attached hereto and made a part hereof after Customer's approval.

Section 34.4.

Customer agrees that ESCO shall have the right once a month, with prior notice, to inspect Premises to determine if Customer is complying, and shall have complied with its obligations as set forth above in Section 34.3 For the purpose of determining Customer's said compliance, the checklist to be set forth at Schedule L (**Facility Maintenance Checklist**) as completed and recorded by ESCO during its monthly inspections, shall be used to measure and record Customer's said compliance. Customer shall make the Premises available to ESCO for and during each monthly inspection, and shall have the right to witness each inspection and the recordations on the checklist.

<Section 34: This provision protects both the ESCO and the Customer by establishing a method for the ESCO to supervise the Customer's compliance with the scheduled routine and preventative maintenance activities to beperformed by the Customer (either by in-house personnel or existing maintenance contract). This checklist should be developed for both the newly installed and pre-existing energy -related equipment.>

SECTION 35.

HEADINGS

Headings and subtitles used throughout this Contract are for the purpose of convenience only, and no heading or subtitle shall modify or be used to interpret the text of any section.

SECTION 36.

SPECIAL PROVISIONS

The signatures of the parties follow the attached Special Provisions, which Special Provisions are included as part of this Contract.
<Section 36: Insert Special Provisions here, for state agencies or others if applicable.>

IN WITNESS WHEREOF, and intending to be legally bound, the parties hereto subscribe their names to this Contract by their duly authorized officers on the date first above written.
(Corporate Seal)
ATTEST:

____

By___________________________________

____

By:__________________________________

ATTACHMENT I: Schedules, Exhibits, Appendices

SCHEDULE A. EQUIPMENT TO BE INSTALLED BY ESCO

<Schedule A: This schedule should specify all of the newly installed equipment including manufacturer, quantity, location and warranties (you can also have a separate schedule for warranties). This schedule should also describe any modifications that may have been made to existing equipment, if applicable.>

SCHEDULE B. DESCRIPTION OF PREMISES; PRE-EXISTING EQUIPMENT INVENTORY

<Schedule B: This schedule contains basic information about the condition of the premises at the time of contract execution. Such information would include facility, major production and energy consuming equipment , demand variations, hours of operation etc., and any special conditions that may exist. The inventory is important to include for the purpose of identifying what equipment was in place and how it was configured at the time of contract execution. This schedule is important to the accurate establishment of baseline, savings measurement and may need to be referred to in the later years of the contract.>

SCHEDULE C: ENERGY SAVINGS GUARANTEE

<Schedule C: This schedule should fully describe all provisions and conditions of the energy cost saving guarantee provided by the ESCO. The guarantee should be defined in monetary value of

energy to be saved for the duration of the contract term. Reference to the annual reconciliation of achieved vs. guaranteed savings should be included (there is also language in the body of the contract regarding annual reconciliation See Section 4.2).>

SCHEDULE D: COMPENSATION TO ESCO

<Schedule D: This should contain the amount and frequency of any payments that may be made to the ESCO for maintenance, monitoring or other services negotiated as part of the contract. It should contain information about how the compensation is calculated (e.g. a percentage of savings above and beyond the guarantee, flat fee etc.), and if an annual inflation index is to be used to escalate fees over the duration of the contract term. An hourly fee structure will also likely be included to cover ESCO costs for any services provided beyond the scope agreed to at the time of contract execution.>

SCHEDULE E: BASELINE ENERGY CONSUMPTION

<Schedule E: The baseline energy consumption is the "yardstick" by which all savings achieved by the installed project will be measured. The methodology and all supporting documentation used to calculate the baseline should be located in this schedule including unit consumption and current utility rates for each fuel type. This schedule may also include baseline documentation regarding other cost savings such as material savings and cost savings associated with the elimination of outside maintenance contracts. >

SCHEDULE F: SAVINGS CALCULATION FORMULAE; METHODOLOGY TO ADJUST BASELINE

<Schedule F: This schedule contains a description of the energy cost savings measurement, monitoring and calculation procedures used to verify and compute the savings performance of the installed equipment will be contained in this schedule. This calculation will include a method to compare the level of energy that would have been consumed without the project (referred to as the "Baseline") with what amount of energy was actually consumed during a specific time period (monthly, quarterly, etc.). All methods of measuring savings including engineered calculations, metering, equipment run times, pre- and post-installation measurements, etc. should be explicitly described for all equipment installed. Periodically (at least on an annual basis), the baseline will be adjusted to account for the prevailing conditions (e.g., weather, billing days, plant loading, etc.) during the measurement period. All methodologies used to account for any adjustments to the baseline needs to be clearly defined in this schedule.>

SCHEDULE G: CONSTRUCTION AND INSTALLATION SCHEDULE

<Schedule G: The timetables and milestones for project construction and installation should be contained in this schedule. If so desired, documentation of required insurance, subcontractor lists and any MBE/WBE required subcontracts may be included in this schedule or broken out into a separate schedule. NOTE: It is important that the construction/installation phase of the project (for example bonds and insurance) be treated in compliance with individual institutional requirements and the appropriate governing statutes. Since construction is just one component of the overall project, a separate construction contract may be desirable and in some cases necessary. The construction contract would then be referred to in the body of the contract and attached as an exhibit, appendix or other type of attachment. Another approach would be to consolidate the appropriate construction language for inclusion in the body of the final contract. This will need to be decided as appropriate on a case-by-case basis.>

SCHEDULE H: SYSTEMS START-UP AND COMMISSIONING; OPERATING PARAMETERS OF INSTALLED EQUIPMENT

<Schedule H: This section should specify the performance testing procedures that will be used start-up and commission the installed equipment and total system. The schedule should also provide for the customer to be notified of and present during all commissioning procedures. This schedule should contain a provision for the documentation of the client's attendance at the various tests and their approval that the tests followed the specified procedures and met or exceed the expected results. The operating parameters should contain any specified parameters for the operation of the installed equipment such as temperature setbacks, equipment run times, load controlling specifications and other conditions for the operation of the equipment.>

SCHEDULE I: STANDARDS OF COMFORT

<Schedule I: The standards of process conditions for heating, electric loads, , facilities should be explicitly described in this schedule. >

SCHEDULE J: ESCO'S MAINTENANCE RESPONSIBILITIES

<Schedule J: A complete description of the ESCO's specific operations and maintenance responsibilities should be included in this schedule along with the time intervals for their performance of the stated O&M activities.>

SCHEDULE K: CUSTOMER'S MAINTENANCE RESPONSIBILITIES

<Schedule K: This schedule describes the operations and maintenance responsibilities that may be assigned to facility staff as agreed to by both parties. In same instances it will contain no more than a description of routine O&M currently being performed on existing energy consuming equipment in the facility. In other cases, facility staff may be used to provide some maintenance on the new equipment installed under the performance contract, with the ESCO providing any specialized services as needed.>

SCHEDULE L FACILITY MAINTENANCE CHECKLIST

<Schedule L: This checklist is a method by which the ESCO may record and track the Customer's compliance with any of the maintenance procedures being performed by facility personnel. The checklist typically specifies simple list of tasks and the corresponding schedule for the performance of the prescribed procedures. Facility staff will complete the checklist and forward it to the ESCO, usually on a monthly basis. (This checklist is a very useful tool for both the ESCO and Customer to verify that the required maintenance activities are being performed at the scheduled intervals).

SCHEDULE M ESCO'S TRAINING RESPONSIBILITIES

<Schedule M: The description of the ESCO's training program or sessions for facility personnel should be contained in this schedule. As well, the duration and frequency of the specified training should also be included. Any provisions for on-going training, commitments to train newly hired facility personnel, and training with respect to possible future equipment or software upgrades should also be described. Any fees associated with the client's request for training beyond what the ESCO is contractually bound to provide should also be specified.>

SCHEDULE N GENERAL CONDITIONS

<Schedule N: For State agencies and others if applicable, insert standard GENERAL CONDITIONS. Where referenced in Section 1.2, describe which of the paragraphs of the general conditions apply to this contract.>

SCHEDULE O ANNUAL INSTALLMENT PAYMENT SCHEDULE

<Schedule O: This schedule contains the amortized financing payments to be made to the financing institution for the capitalized costs (principal and interest) of the project. This schedule will indicate the frequency (monthly, quarterly semi-annually) of payment, the specific amount due. The actual lease agreement and associated documents are located in Appendix D.

EXHIBITS

EXHIBIT I

PERFORMANCE BOND ***<for State agencies, or others if applicable>***

EXHIBIT II

LABOR AND MATERIAL PAYMENT BOND ***<for State agencies, or others if applicable>***
<Since bonding requirements will vary, ensure that bonds are included as exhibits here, as necessary.>

EXHIBIT III (i) CERTIFICATE OF ACCEPTANCE—DPR ***<for State nodal agencies, or others if applicable>***

EXHIBIT III (ii) CERTIFICATE OF ACCEPTANCE—INSTALLED EQUIPMENT

APPENDICES
APPENDIX A RFP FOR ESCO SOLICITATION
APPENDIX B ESCO PROPOSAL
APPENDIX C DPR
APPENDIX D LEASE AGREEMENTS AND DOCUMENTS

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ADDITIONAL OPTIONAL SCHEDULES
<The following schedules can be included as optional and included or combined with others or may be contained in the audit report, as desired. If any of the following schedules are used, references to these schedules may need to be added to the contract body.>

PRE-EXISTING SERVICE CONTRACTS

<Information regarding the scope and cost of pre-existing equipment service contracts should be located in this schedule. This gives both the client and ESCO information about how and when the existing equipment is being serviced. As well, if the ESCO is credited with any maintenance savings or is taking over any existing service contracts, the scopes and costs of such Contracts will useful in tracking the performance of the ESCO in providing the required services and documenting any attributable cost savings.>

ENERGY SAVINGS PROJECTIONS

<This schedule should contain the projected energy savings in units for each year of the contract. Often times these projections are broken down on a measure by measure basis although some measures may be aggregated into general categories such as lighting or HVAC. If there are several buildings involved in the project, this schedule should contain projections for each facility, even though they may all be covered under a single guarantee.>

PROJECTED FINANCIAL PERFORMANCE

<This schedule should contain a spreadsheet depiction of the expected financial performance of the project for the entire contract term. It should clearly identify all of the financial components of the project including interest rates, current fuel prices, any escalation rates to be applied, the guaranteed savings figures, ESCO compensation figures, cash-flow projections and projected Net Present Value of any cumulative positive cash flow benefits to the CUSTOMER .>

FACILITY CHANGES CHECKLIST

<A "Facility Changes Checklist" or other method may be provided by the ESCO for the client to notify the ESCO of any changes in the facility that could have an impact on energy consumption (e.g. new equipment acquisition, hours of use, etc.). This checklist is generally submitted on a monthly basis or quarterly basis.>

CURRENT AND KNOWN CAPITAL PROJECTS AT FACILITY

<If there are any current or planned capital projects to be implemented in the facility, that information should be contained in this schedule. This information could prove to be very useful in the out-years of the contract to avoid potential disputes over long-term **Energy cost** ***savings performance, overall facility energy consumption and costs. Depending upon the type of financing used, an installment payment/amortization schedule may need to be included.*****>**