

# **Recent Advances in Biomass Energy Technology in Europe and Applications for SE Asia**

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## **Introduction**

The aim of this paper is to highlight the state of relevant developments on biomass energy technology in Europe and to point to the areas of application for SE Asia.

Policy issues that have applied in Europe to promote biomass energy technology are briefly outlined. Heat and power systems are described and some system selection is proposed for potential power application to Sri Lanka and similar countries. Comparison of available technologies for power generation is made for scales of output loosely classified as: around 100 kW, around 2 MW, and above 2MW. Developments in Europe on co-firing of biomass in coal-fired power stations are considered. Issues of CHP and decentralized production of electricity are presented due to their particular relevance for biomass energy resources.

The historical background and continued use of biomass energy in SE Asia particularly in plantation industries is outlined. Consideration is given to energy efficiency measures since these offer great scope for increasing the energy value of existing biomass resources. Industrial training and technical educational measures are important requirements to achieve this since realization of such savings requires a replication of measures over the large and dispersed number of small-scale agro-industrial manufacturing operations that typify this region.

Some summary conclusions are drawn of work carried out under the EC COGEN3 project. This project looked systematically at the cogeneration (or CHP) capacity in various industries with biomass fueling potential within the ASEAN group of countries over the past 10 years.

## **Biomass Energy Technology in Europe**

Various strategic policy statements that have underpinned the development of biomass energy technology in the past decade in the EU. Notably these include:

- EC 'White Paper' 1997 with the overall target of 12% renewable energy by 2010.
- 'Campaign for Take Off', 1998 documents and the CTO itself which ran from 2000 to 2003, setting some intermediary targets for different renewable energy sectors.
- A directive on renewable electricity generation (Directive 2001/77/EC) in 2001 requiring an increase in electricity from renewable sources from 14% in 2000 to 22.1% in the EU-15 (21% in EU-25) by 2010.
- A directive (Directive 2003/30 EC) with a target for liquid biofuels of 2% by 2005 and 5.75% by 2010.

- More recently the ‘EU Biomass Action Plan’<sup>1</sup>, 2005 has proposed that the total biomass energy contribution of 51 Mtoe in 2001 should rise to 130 Mtoe by 2010. This would come from additional contributions in: electricity 32 Mtoe, heat 24 Mtoe, and biofuels 18 Mtoe.(1)

Although the biomass energy sector targets in the CTO were not fully met, the EU Biomass Action Plan has broadly retained the original White Paper biomass energy targets for 2010. Earlier this year an extensive consultation exercise was carried out in support of this latest plan.

There has been a strong emphasis in policy for technological advanced biomass energy power systems. More recently has there been growing recognition that this focus on advanced technology power systems was diminishing the potential uptake of biomass for heat and CHP. However in some countries, such as Austria, a high growth rate in biomass energy is already being achieved.

Issues of resource availability in terms of biomass supply and land potential for production of biofuel are both important related matters though beyond the scope of this paper. In overall terms they have not been considered as constraints to the EC targets. Demand for large quantities of biomass at specific locations as discussed later for co-firing of biomass on large capacity coal fired stations is however creating local shortages. In the longer-term, extension of the EU membership will further increase the resource base. In a study by an NRI co-ordinated project these countries were identified to have existing resources from forestry, wood industry wastes and agricultural residues at around 1000PJ which could enable an increase in bioenergy from 2% to 9% of their current total energy<sup>2</sup>. They also have good potential for production of dedicated fuel crops, particularly SRC.

## **Technologies**

### **BIOMASS FOR HEAT**

The market uptake and use of biomass as heating fuel in Europe varies greatly between different countries, due to various, climate, cultural, historical and infrastructure issues. Heat-only application of biomass is more suited to rural areas without gas grid supplies. Certain countries, notably Austria and the Scandinavia states, have far above the average use of biomass and it is considered that there is an undeveloped potential for biomass fuelled heating systems in other countries. In UK there is a growing lobby for effective governmental support of biomass derived or ‘green’ heat.

In Europe commercial activities in this technology are largely for domestic or institutional heating purposes that do not apply for Sri Lanka and neighbouring countries, so it is not easy to match types of equipment. Traditional European equipment suppliers to the plantation industries have now largely vanished and equipment needs are increasingly met from within the region. Any equipment sourced from the EU-15 is likely to be of higher cost, although this may not be the case for suppliers in the new accession

countries some of which have extensive forestry related industries with related equipment suppliers.

## **BIOMASS FOR POWER**

### **Specification and Selection of Dedicated Systems**

There are a large number of different routes for dedicated power generation from biomass at various scales of power output. These scales of output may be loosely classified as: around 100 kW, around 2 MW, and above 2MW. NRI coordinated an EC JOULE Project<sup>3</sup> about ten years ago that made a detailed examination of available commercial systems for European application.

One major way the picture has altered in the past decade is that now co-firing of biomass on existing coal-fired power stations is being applied. This development and its consequences are discussed later. The following section reviews the status of dedicated biomass-fired systems drawing upon the basic conclusions of the earlier NRI work with update as necessary:

#### ***Power Systems 100 kW Range***

*Small steam engine* - This technology is technically robust and reliable but more suited to about the 100 kW scale. However an efficiency of only 6% would be typical. Cost was high but a complete steam engine system manufactured in a developing country could be very much cheaper to one manufactured in Europe.

*Small-scale gasification with an IC engine* - Downdraft gasifiers are available for use at the 100 kW scale or smaller and this is a technology that has essentially been available commercially since the 19<sup>th</sup> century and pre-dates the widespread use of liquid fossil fuels. There has been resurgent interest in times of fuel shortage and more recently as a viable alternative form of renewable energy. For improved maintenance and operation, a dual-fuel compression ignition engine using 10% diesel may be preferred but spark-ignition engines will operate without auxiliary fuel. Diesel engines are more tolerant of the tars and alkali metals deposition in the combustion chamber that can markedly reduce engine reliability. With either engine type, the gas must be cleaned to attain reliable operation and long engine life. Using such gasifier systems at this scale offers an energy conversion efficiency of around 20%. Maintenance requirements are more demanding than for steam systems.

Essentially the choice for smaller scale systems at around 100kW until recently has been either

- (i) low efficiency steam systems coupled to either steam turbine or for smaller scale to steam engines, with high reliability and low maintenance or

- (ii) for higher efficiency, gasifier based systems using producer gas for fuelling of internal combustion engines but with lower availability and higher operational and maintenance requirements.

In order to expand and develop the options for power from biomass at this scale there has been a significant range of continuing development work underway. Other options that may now be considered include:

*Pyrolysis with an IC engine* - Various processes exist for pyrolysis of wood to produce bio-oil and, after suitable treatment, this can be burnt in a compression- ignition engine. In the flash pyrolysis process, yields of bio-oil as high as 80% can be achieved. For a 300 kW system, the capital cost is very high. However it has a good energy conversion efficiency at about 28%, and there may be substantial economies of scale. This technology is still under development.

*Indirectly-fired gas turbine under development* – Use of indirectly-fired gas turbines eliminates problems of corrosion and erosion of the turbine blades encountered with gasifier systems. It offers a potentially high availability and reliability. In the basic system wood-fuel is burnt in a furnace and the hot combustion gases pass through a heat exchanger to provide clean hot air. This clean hot air from the heat exchanger takes the place of the combustion chamber in a directly-fired gas turbine. Benefits are expected through use of automotive technology for the turbine unit. A system examined by NRI and others had an efficiency of 20% but was not fully developed<sup>4</sup>.

*Biodiesel and ethanol* – direct replacement of liquid fuels by biomass derived alternatives, particularly for transportation applications should be mentioned in the context of 100kW systems. These fuels can be biodiesel, derived through esterification of vegetable oils such as rapeseed oil, or bioethanol, derived through fermentation of cane sugar or other crops. In terms energy yield/ha, the energy efficiency of such fuels is low compared to other energy crops, such as SRC wood. However where large land areas are available for cultivation of such crops they have been adopted to a considerable extent. These liquid biofuels can be directly and easily used as replacement fuel on existing engines. Unavailability of surplus agricultural land in SE Asia probably makes them less appropriate to this region. Thus in Europe, biodiesel is an industrial crop that is now being extensively grown on land surplus to food crops. In Brazil loss of markets for sugar from sugar cane has encouraged the replacement production of bioethanol. Under historic fossil fuel prices such products have needed large subsidies.

*Stirling Engine*- Stirling engine systems have been the subject of some impressive development work over the past 5-10 years by the Danish Technical University in association with Bios Energiesysteme GMBH, Austria on biomass fuelled stirling engines<sup>5</sup>. This has resulted in trial operation of a 35kW power output system for over 7,000 hours. Also a pilot plant with a 75 kWel Stirling engine has been put into operation in autumn 2003 and has been operated for more than 2,000 hours (until March 2004)<sup>6</sup>. These Stirling engines are modern technology versions of an old engine design that involves externally fired reciprocating engines. They and have the potential for high

availability with good conversion efficiency and can be used in small-scale CHP applications. Considerable cost disadvantages exist for such one-off constructed engines compared to mass produced internal combustion engines. Small series manufacture of such engines is now underway and is expected to considerably reduce engine cost.

*Process selection at 100kW range.* On the basis of previous practical experience and in the interest of sustainable operation with small scale gasification systems, the selected power plant should be a down-draught system with a dual-fuel diesel engine operating at around 10% diesel level. A variety of gasifier and diesel engine suppliers exist. A high level of labour inputs in operation and maintenance of such technology is required for high availability compared to running similar engines on liquid fossil fuels. Developments with Stirling Engines offer the best potential alternative and should be closely monitored.

### ***Power Systems for 2 MW range***

*2 MW Steam Turbine* - These systems represent the most readily available technology at this scale and this technology is well established with proven reliability. The boiler systems use various types of horizontal grate or fluidized beds in more advanced designs for larger scale. Fuel to power energy conversion efficiencies at this scale are maximum 18%.

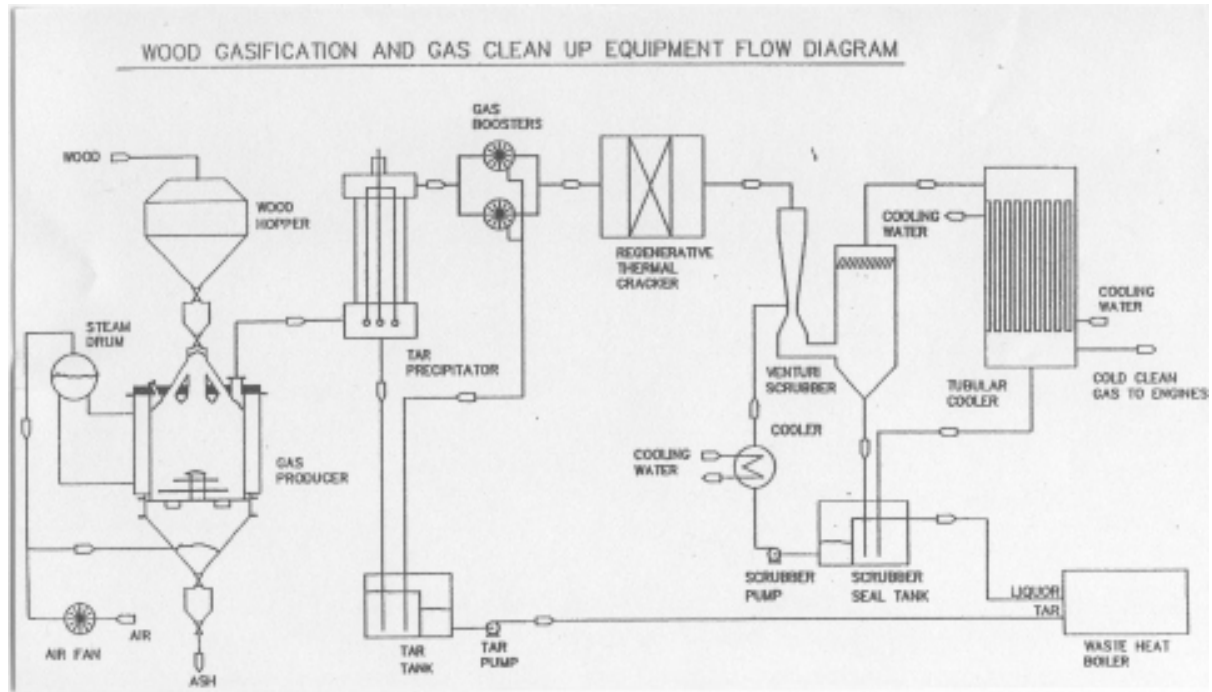
*2 MW Updraft gasifier with an IC engine* - This technology has scope for gains in efficiency and lower capital costs compared to steam technology at this scale. Complex gas clean-up trains are required and are subject to further development, but essentially this is old and proven technology. It could use large marine type diesel engines operating in dual fuel mode or large modified spark ignition natural gas engines. Manufacturers have quoted power energy conversion efficiencies of around 28%. Maintenance and operational labour requirements will probably be more demanding than for steam systems. At 2 MW, a technical choice of the gasification process system could be made between either updraft fixed bed gasification or fluid bed gasifiers. However, at this output, cost considerations favour the choice of updraft fixed bed gasification.

An economic analysis of these systems at 2MW concluded that the price of electricity generated by the steam boiler/steam turbine and updraft gasifier/ IC engine systems is similar. The steam technology is well established with little scope for cost reduction and process improvement. Gasifier power systems using fixed bed updraft gasifier technology were selected as they have more potential for improvement, particularly in terms of capital cost and efficiency. The equipment flow diagram for such a system is shown in figure 1.

*Organic Rankine Cycle (ORC)*- It is relevant to mention here recent commercial developments of Austrian technology with the Organic Rankine Cycle (ORC) system<sup>6</sup>. This is the same engine cycle as used by conventional steam turbines but with a closed system organic fluid instead of water as the working fluid. It is presently being run for a CHP application with a net electric conversion efficiency of 18% on a 1 MW electricity

power output. This available commercially in ranges of 0.4 to 1.5 MW electricity output and has good power-turndown characteristics that are important for flexible operation in CHP applications.

Figure 1 – Flow sheet for 2MW UpDraft Gasifier



*Process Selection at 2MW range:* At the 2 MW output the relative simplicity of the updraft gasifier makes it more cost effective and for this reason, it should be selected. Technical success of this route for power application was amply demonstrated in the past. More recently it has been updated through (i) a CHP application supplying district heating and 1.4 MW power plant at Harboore, Denmark using Volund gasification technology<sup>7</sup>, and (ii) monitored trials undertaken by Wellman in UK on a prototype present-day system<sup>7</sup>. Most of the tars will be removed by electrostatic precipitation and then burnt in a waste heat boiler. Further gas clean-up is achieved with a regenerative hot gas cracker and a venturi scrubber. Cold clean gas is then provided for fuelling of reciprocating engine/generator sets.

### ***Power Systems for > 2MW***

Above 2 MW the choice of systems is essentially between steam boilers coupled to steam turbines, or gasifiers coupled to gas turbines. As the scale increases, more advanced combustion and gasifier technology is appropriate and fluid bed systems are utilized. This would apply for around 5MW and above.

### ***Fluid Bed Gasifiers***

Fluid bed systems offer larger unit capacity and economies of scale compared to conventional grate boilers and fixed bed updraft gasifiers. Fluid bed combustion has become widely used over the past 20-30 years and is now standard technology from such companies as Foster Wheeler, Lurgi and others. For power applications these are normally linked to steam turbines. Potentially more efficient systems result from coupling gasifiers to direct fired gas turbines as will be described below.

### *Steam Boiler and Steam Turbine Technology*

Steam boiler and steam turbine technology has always been recognized as offering low maintenance and high availability. A number of systems have been implemented in Europe for combustion of biomass feedstocks. In UK there are now five such plants operating on agricultural wastes such as chicken litter and straw and ranging in capacity from 10 MW to 38.5 MW and with total capacity of 110 MW<sup>8</sup>. Recently plans were announced by SemCorp Utilities for a wood-burning 30MW capacity plant costing £60 million to be installed as part of a energy supply complex providing CHP for industrial activities at Wilton, Teeside<sup>9</sup>.

However it has been considered less appropriate for government policies to promote this steam boiler and steam turbine technology since it is classified as commercially mature. Consequently grants and subsidies have been directed towards new technologies such as fluid bed gasification and gas turbines.

### *Fluid Bed Gasification and Gas Turbines*

Fluid bed gasification and gas turbine technology has the potential for higher conversion efficiencies and better economics especially for the relatively low capacity power systems that are envisaged for biomass at below around 50 MW. This gasifier/gas turbine technology has been proposed with variations including combinations with waste heat boilers and integrated steam turbines – known as biomass integrated gasification combined cycle (BIG/CC). These come with higher capital investment but offer high overall theoretical efficiencies (30%+?) and potentially better economics. Technical demonstrations of BIG/CC systems were provided in the late 1990s by the Varnamo plant in Sweden<sup>7</sup>.

As described, there has been a particular focus in Europe on advanced and capital intensive technology for biomass-derived energy. The EC and various national renewable energy promotion schemes have supported this. These policies have also placed a much greater emphasis on power generation from biomass, rather than thermal energy or CHP systems. Thus, in the UK promotion schemes for use of biomass were only available through subsidies from payment of higher tariffs for green electricity.

The imbalance in the promotional strategies for biomass derived power in Europe was highlighted by the process selection and subsequent commercial failure of a prestige THERMIE demonstration project in UK. This was known as the ARBRE project and it

collapsed in the later stages of commissioning in 2002. It was a state of art BIG/CC plant that cost around £30 million and was built to provide a total of 8MW power output. It involved use of Swedish TPS fluid bed gasification technology and direct firing of a Typoon 4.5 MW gas turbine. Fuel was agricultural residues and SRC willow chips. A detailed analysis of the various reasons for the failure has been given in the IEA Report ‘Status of Biomass Gasification in Countries participating in the IEA and GasNet activity- August 2204’<sup>7</sup>. There were various problems over finance, project management and in technical performance – but none that seemingly should have resulted in the project collapse. It is evident that same level of public money investment for use of biomass in conventional technology such as: steam boiler/steam turbine for power, thermal plant or CHP could have provided much more renewable energy. Promotion of technology seemed to have been the goal in itself, rather than the promotion of renewable energy from biomass. It appears that a much more pragmatic approach is now being followed as evident from the initiatives for co-firing of biomass on existing coal burning power stations that are described elsewhere.

### *Process Selection*

Any choice of biomass fueled power plant will depend upon the scale of operation and the feedstock characteristics. Information on the COGEN3 website that is to be retained until 2006 is a useful information resource for European equipment with examples of demonstration projects<sup>14</sup>. At larger capacities, there are scale factors that will favour the choice of newer fluid bed combustion or gasification plant<sup>11</sup> as compared to the more traditional fixed or moving grate furnaces. There are operational benefits from adopting gasification systems where the applications are retrofits to existing fossil fuel burning plant or in co-firing installations. Some key issues are summarised in table 1.

**Table 1 Typical capacity/efficiency/resource data for biomass power systems**

| <b>System</b>                                 | <b>Power kW<br/>(note a)</b> | <b>Energy efficiency %</b> | <b>Biomass dm tonnes/yr<br/>(note b)</b> | <b>Comments</b>   |
|---|------------------------------|----------------------------|--|---|
| Small down draft gasifer/IC engine            | 10                           | 15                         | 74                                       | High operation & maintenance, and/or low availability, low cost |
| Large down draft gasifer/IC engine            | 100                          | 25                         | 442                                      | High operation & maintenance, and/or low availability, low cost |
| Stirling Engine                               | 35                           | 20                         | 177                                      | Potential good availability, under development, high cost       |
| Steam Engine                                  | 100                          | 6                          | 1840                                     | Good reliability, high cost                                     |
| Indirect-fired gas turbine                    | 200                          | 20                         | 1104                                     | Not available commercially                                      |
| Pyrolysis/IC engine                           | 300                          | 28                         | 1183                                     | Under development   |
| Rankine Organic Cycle                         | 1000                         | 18                         | 6133                                     | Commercial  |
| Updraft gasifier/IC engine                    | 2000                         | 28                         | 7886                                     | Commercial  |
| Fixed grate or fluid bed boiler/steam turbine | 2000                         | 18                         | 12270                                    | Commercial  |
| Fluid bed (BIG/CC) –                          | 8,000 +                      | 28                         | 29710                                    | Demonstrated  |

|                               |         |    |       |            |
|-------------------------------|---------|----|-------|------------|
| dedicated biomass             |         |    |       |            |
| Fluid bed gasifier - co-fired | 10,000+ | 35 | 31500 | Commercial |

Notes

- a Indicative of range for application
- b. Assumes: availability at 70%, fuel net calorific value 20 Mjoule/kg

### Co-Firing of Existing Coal.

Over the past five years there has been a major shift with energy policy to promote use of biomass as fuel with the realization that co-firing of biomass on existing coal-fired power stations is a technically viable option. Earlier trials had given inconclusive evidence about the impact on ash formation, in-plant depositions, etc and also there was a general reluctance from in the power generators to go in this direction since it created additional operational problems. The attraction of this approach was that it gives high conversion efficiency at around 35% through benefiting from use of advanced high pressure steam turbine technology in these stations. However in UK, for example, there was little financial incentive until the introduction of Renewable Obligations Certificates (ROCs). With this and other such schemes making it financially attractive, power generators became serious about trials and commissioning of co-firing.

The high level of interest in UK is evident from table 2 below from a DTI commissioned report that gives the position in 2003<sup>10</sup>. With this high level of interest, questions of availability and cost of biomass materials have become important. Delivered energy costs of biomass materials are at least 50% higher than the cost of coal at £1.2 per Gigajoule but nevertheless extra income through meeting ROC obligations is possible. In the short-term it has been considered financially viable to import some available materials such as palm and olive residues long distances. Over time, restrictions on use of non-indigenous materials will limit their use and, in anticipation of this there now are agricultural and forestry based commercial energy supply operations developing for contract supply to these power stations. Levels of co-firing of 5-10% are being considered and for large stations this is equivalent to biomass fueling at 100 MW levels or more.

**Table 2 Status of co-firing activities at coal fired power stations in Britain, July 2003<sup>10</sup>**

| Power Station  | Capacity (MW) | Status     | Biomass Fuels                           |
|----------------|---------------|------------|---|
| Cottham        | 2,000         | trial      | forestry/sawmill wastes                 |
| Didcot A       | 2,100         | trial      | wood                                    |
| Drax           | 4,000         | trial      | milled palm shells                      |
| Ferrybridge C  | 2,035         | commercial | olive residues, palm nuts, citrus, wood |
| Fiddlers Ferry | 1,995         | commercial | olive residues, palm nuts, citrus, wood |
| Ironbridge     | 970           | trial      | wood                                    |
| Kingsnorth     | 2,034         | trial      | cereal residues                         |
| Longannet      | 2,400         | commercial | sewage sludge                           |
| Rugeley        | 1,000         | trial      | wood, olive residues, cereal            |
| Tilbury        | 1,085         | trial      | wood                                    |

The level of technology being applied varies. Some simply make addition of the biomass feedstock to the pre-milled coal for subsequent injection to the boiler in the pulverized fuel burners. Other systems use separate biomass fuel preparation and additional burners, and in other applications a biomass gasification system is installed and the resulting producer gas fed into the co-fired boiler.

One of the longest running schemes for biomass co-firing is the Lahti, Finland CHP plant<sup>11</sup> which is rated for outputs of 216 MW electricity and 240 MW heat. Standard fuelling is a mixture of gas and coal-fired, but locally available biofuels and refuse fuels substitute about 15% of the fossil fuels burned in the main boiler. This process using Foster Wheeler biomass gasification demonstrates on a commercial scale the direct gasification of wet biofuel and the use of hot, raw and very low calorific gas directly in the existing design coal-fired boiler.

### **Issues with CHP and Decentralization**

Emphasis on CHP technology for applications in Europe is increasing and in particular for biomass fueling. Within the EC-supported promotion agencies this is covered by the Cogen Programme, and this programme has had a dedicated component described as COGEN3<sup>12</sup> which has been identifying and supporting biomass fueled CHP applications in the ASEAN countries. This work is very relevant to this paper and is described in more detail later. In CHP applications high overall energy conversion potential is attainable with less focus needed on implementing costly technology for obtaining high electricity conversion efficiency.

Another growing movement in the EU and elsewhere is one towards decentralized production of electricity. Various arguments underlie this move such as, higher CHP potential and lower grid system power losses. In any event decentralization is better suited to biomass fuel resources since by its very nature biomass is often created over dispersed areas and transport costs are relatively high due to the low energy density compared to fossil fuels. The vision for the EU is to increase decentralised electricity production from the current level of 9% to 20% by 2020. This concept is also described as 'distributed generation' and is addressed by the DG-FER project<sup>12</sup> funded by the EC Cogen organization. This project is based on a model from the World Alliance for Decentralization of Energy (WADE)<sup>13</sup>.

### **Applications for biomass energy in SE Asia**

#### **Historical**

Many examples of earlier-designs of European biomass-fuelled systems for thermal applications still are operated to this day in the plantation industries of SE Asia. Typical of these are the wood-burning furnaces for supply of process heat as hot air for tea and desiccated coconut drying. These furnaces are generally made up from cast iron elements that are assembled on site with appropriate furnace brickwork. This modular style of

design was adopted due to the transport difficulties to remote locations and for ease of repair and maintenance of equipment on site. The fuel efficiency of these dryers is relatively low, and very sensitive to operation and management. NRI found that with better designs and trained operators there is potential to make large savings in fuelwood use in these industries. In many cases these systems have been adapted to burn fuel oil, again with poor efficiency.

Biomass-fuelled power systems using both internal and external combustion producer gas engines were also used in these industries. Some such examples of slow speed, single cylinder, internal combustion gas engines dating back to early 20<sup>th</sup> century may still yet be found operating in factories with traditional belt and shaft power, but now running on liquid fossil fuel rather than producer gas. However, the use of biomass for power effectively ceased with the advent of grid electricity and regular fossil fuel availability.

There is now a renewed interest for promotion of 'advanced' technology to enable use of biomass for energy in Europe. A review of the history of biomass fuelling shows that it is important to qualify the term 'advanced' since we find many of these are re-introductions of old technologies, some of which were previously applied in SE Asia.

For example there is a well-documented application of a large scale biomass feedstock chemical engineering project that was operated in 1940s at Cochin, India. This was built by the Power-Gas Corporation and described to a London meeting of the IChE in October 1949<sup>15</sup>. The system produced ammonia, using 300-400 tons wood/day. The wood supply came from felling of 2000 acres/year of natural forest with a linked re-forestation scheme that was intended to give a 15 year rotation over 110 square miles. The technology applied was updraught gasification of wood on six air blown gasifiers to provide producer gas followed by steam reforming in ten hydrogen generators. Carbon dioxide was removed in gas scrubbers to obtain a synthesis gas mix of hydrogen and nitrogen. The ammonia synthesis reaction was carried out at 350 bar pressure. The system took around 2-years to fully commission but the paper describes the operation for March 1949 when 4500 tons of wood (dry weight) was used, which was close to the design capacity. The discussion on the paper was an interesting mixture of admiration for the technological achievement and apprehension at the environmental consequence of the venture. A wood supply at this level could have provided for about a 5MW power plant, which would have been technologically a far simpler activity!

## **Current**

The BEASL and TERI contributors to this conference will describe the current situation on biomass energy technology and utilization for Sri Lanka and India in more detail. It is important to note that in all countries in the region, biomass makes a far greater proportional contribution to national energy than arises in any individual European country, with the possible exception of Austria. Nevertheless there is considerable potential in the region for greater use of biomass for power generation, CHP, and in thermal applications. The report 'Options for Dendropower in Asia' issued by the FAO RWDEP covered the power aspect comprehensively<sup>16</sup>. The COGEN 3 project addressed

potential for biomass CHP for ASEAN countries; and a new GEF regional project entitled "Reducing GHG emissions by promoting bioenergy technologies for heat applications" is addressing thermal applications for Sri Lanka and four other South Asian countries (Bangladesh, Bhutan and Nepal).

An important aspect of any review of technology for the region is to address the potential for more energy efficient use of biomass in existing applications. Through various projects NRI has identified and demonstrated potential for significant fuel savings in the plantation industries in Sri Lanka. Provision of appropriate technical training to managers and operators in these industries is an important feature. Also there is a large potential for well-engineered modification or re-design of equipment.

In another recently completed NRI project in Bangladesh, the potential for saving 49% of the use of rice husk fuel with improved rice husk furnaces for rice milling was identified and demonstrated on prototype equipment<sup>17</sup>. This simple technology, if widely implemented, could result in large increase in availability of a key energy resource that already provides 22% of national energy. In this, as with many other examples, realization of such savings requires a replication of measures over a large and dispersed number of small-scale manufacturing operations.

### **COGEN3**

COGEN3<sup>12</sup> has looked systematically at the cogeneration (or CHP) capacity in various industries with biomass fueling potential within the ASEAN group of countries. In total it is estimated that these countries generate 120 million tonnes/year of biomass residues and that these represent a power capacity of 10 GW. The programme ran over 10 years and formally was completed in December 2004 though the COGEN3 website remains and provides a valuable information resource. It is essentially an initiative for providing market potential for European technologies, and which has supported installation of more than 70 cogeneration projects ranging from 0.5 to 100MW.

In particular this CHP potential lies within the sugar, palm oil, rice milling and wood industries. Broadly the conclusions on the existing practice and potential for change are as summarized in table 3 below. This shows that there is scope for a far more effective use on generation both heat and power from the available biomass wastes that arise in all these industries.

### **Conclusion**

When making comparisons between Europe and SE Asia in the applications of biomass energy technology we need to recognize that there are particular differences. These occur in terms of appropriate policy, engineering infrastructure, social and historical background and general economy. In many respects there are influences favouring the use of biomass due to amongst other things: high existing levels of biomass use for

energy, existence of traditional plantation industries, relatively low labour charges, lack of fossil fuel resources, need to minimize trade balance, etc.

Any technology will need to show high availability, moderate cost and efficient use of biomass. These criteria have been applied to indicate selection of potentially new systems. Energy efficiency in existing systems needs continuing attention.

**Table 3 – Existing and Potential CHP technology for biomass residue use as fuel in Agro-Industries in ASEAN**

| <b>Industry</b> | <b>Existing Heat/Power</b>  | <b>Potential Heat/Power Efficiency</b>  |
|-----------------|---|---|
| Sugar           | Steam 20-30bar<br>Power efficiency 10%<br>Power/heat 0.1-0.2  | Multi fuel 60 bar steam<br>Power efficiency 25%<br>Power/heat 0.3-0.35  |
| Palm oil        | Steam 20-30 bar<br>power efficiency 10%<br>Power/heat 0.1-0.2   | 40 bar steam with<br>Power efficiency 18-25%%<br>Power/heat 0.35-0.4  |
| Rice Mills      | <b>Small/medium</b><br>Steam 20-30 bar<br>Power efficiency 5%<br><b>Large</b><br>Steam 40 bar<br>Power efficiency 18-20%% | <b>Small/medium</b><br>Steam 40-60 bar<br>Power efficiency 20-24%<br><b>Large</b><br>Steam 60 bar<br>Power efficiency 25%%  |
| Wood Industry   | Low pressure sat steam,<br>No power, Heat only  | <b>Small</b> -<br>Power 25-30% (gas engines)<br><b>Medium</b><br>Steam 25-40 bar<br>Power Efficiency – 15%<br><b>Large</b><br>Steam 40-60 bar<br>Power Efficiency – 20% |

## References

1. EU Biomass Action Plan  
[http://europa.eu.int/comm/energy/res/biomass\\_action\\_plan/index\\_en.htm](http://europa.eu.int/comm/energy/res/biomass_action_plan/index_en.htm)
2. Bioenergy Strategy Plan for Central and Eastern Europe, A. Hollingdale, R. Venendaal and R. Ellenbroek, Paper Presented to 1<sup>st</sup> World Conference on Biomass for Energy and Industry, June 2000.
3. ‘Decentralized Production of Electricity from Biomass’, A C Hollingdale and G R Breag, Natural Resources Institute, UK. WOOD FUEL INTO PRACTICE 3rd International Wood as Fuel Conference Glasgow, October 1995.
4. ‘Indirectly-Fired Gas Turbine for Rural Electricity Production from Biomass’, Biomass Technology Group BV EC FAIR-CT95-0291
5. ‘State-of-the-Art and Future Developments regarding Small-scale Biomass CHP Systems with Special Focus on ORC and Stirling Engine Technologies’, by I Obernberger, H Carlsen and F Biederman, International Nordic Conference, 2003
6. Biomass CHP plant Oberlech based on Stirling engine technology (Oberlech, Austria)  
<http://www.bios-bioenergy.at/bios01/projects/en/oberlech.html>

7. 'Status of Biomass Gasification in Countries Participating in the IEA and GasNet Activity', ed K W Kwant and H Kknoeff, August 2004
8. Biomass as a Renewable Energy Source, Royal Commission on Environmental Pollution, [www.rcep.org.uk](http://www.rcep.org.uk), May 2004
9. SembCorp Utilities UK - Press Release March 2005
10. 'Development of Low Cost Systems for Co-Utilisation of Biomass in Large Power Stations' DTI Report B/U/007/26/00/00, W R Livingston, Mitsui Babcock Technology and Engineering, 2003
11. Biomass CFB Gasifier--Demonstration Project: Kymijärvi Power Station at Lahti, Finland, [www.fwc.com](http://www.fwc.com)
12. DG-FER Project Presentation to IEA, Feb 2004, [www.cogen.org](http://www.cogen.org)
13. World Alliance for Decentralized Energy, [www.localpower.org](http://www.localpower.org)
14. 'EC-ASEAN Cogen Programme: Implementing Biomass Cogeneration in ASEAN', 2004 <http://www.cogen3.net>
15. 'The production of Ammonia Synthesis Gas from Wood Fuel in India', R W Rutherford and K Ruschin, Institution of Chemical Engineers, London 1949
16. 'Options for Dendro Power in Asia' Report published by FAO Regional Wood Energy Development Programme in Asia, Bangkok, April 1998
17. 'Benefits of Improved Rice Husk Combustion, Bangladesh', N Dagupta, M A Baqui, S Dhingra, P Ramen, M Ahiduzamann, VVN Kishore, DFID Project No R7659, December 2003