BIOENERGY KNOWLEDGE CENTRE

Bioenergy Update October 2007

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Current Articles and Reports

Feasibility study of forest residue use as fuel through co-firing with pellet
Granada, E. Lareo, J., Miguez, J.,Moran, J., Poteiro, J and Ortiz, L. *Biomass and Bioenergy* V 31(3) 2006 p.238-246
Co-firing is a useful technology for reclaiming waste biomass as fuel. This article studies the use of three different forest residues (Eucalyptus, pine and pine bark) with pellet based on a mixture of fuels prior to combustion. Several combustion configurations, such as the basic configuration (only preheated primary air supply) and other especially developed configurations, such as secondary air and gas recirculation, are studied and optimized. Due to feeding problems, a co-firing feeding hopper was specially developed and honed in order to assure a precise feeding rate of different fuel materials. The experimental results suggest that the pine bark has the best feed performance. Overall, a lower efficiency was achieved compared with pellet-only combustion. Co-firing of these blends is financially viable due to the lower price of the treated pine bark. High percentages of pine bark (50%) reduce efficiency significantly. This is improved with secondary air and recirculation. Pine bark of around 25% is the most suitable configuration.
(To request email library@energylibrary.org.nz and quote **Bio4Granada**)

Relationships between heating value and lignin, moisture, ash and extractive contents of biomass fuels. Dimirbas, A. *Energy Exploration & Exploitation* 2002 V 20(1) p. 105-111
(To request email library@energylibrary.org.nz and quote **Bio4Dimirbas**)

Hydrolysis of lignocellulosic materials for ethanol production: a review. Sun, Y. and Cheng, J. *Bioresource Technology* V 83(1) 2002 p1-11
Lignocellulosic biomass can be utilized to produce ethanol, a promising alternative energy source for the limited crude oil. There are mainly two processes involved in the conversion: hydrolysis of cellulose in the lignocellulosic biomass to produce reducing sugars, and fermentation of the sugars to ethanol. The cost of ethanol production from lignocellulosic materials is relatively high based on current technologies, and the main challenges are the low yield and high cost of the hydrolysis process. Considerable research efforts have been made to improve the hydrolysis of lignocellulosic materials. Pretreatment of lignocellulosic materials to remove lignin and hemicellulose can significantly enhance the hydrolysis of cellulose. Optimization of the cellulase enzymes and the enzyme loading can also improve the hydrolysis. Simultaneous saccharification and fermentation effectively removes glucose, which is an inhibitor to cellulase activity, thus increasing the yield and rate of cellulose hydrolysis.
(To request email library@energylibrary.org.nz and quote **Bio4Sun**)

Estimation of the availability and cost of supplying biomass for Bioenergy in Canterbury By Robertson, K and Manley, B *New Zealand Journal of Forestry* V51(2) 2006 p. 3-6
(To request email library@energylibrary.org.nz and quote **Bio4Robertson**)

BIGCC system for New Zealand: An overview and perspective By Pan, S. and Li, J. *New Zealand Journal of Forestry* V51(2) 2006 p.7-12
(To request email library@energylibrary.org.nz and quote **Bio4Pan**)

Co-benefits of utilizing logging residues for Bioenergy production: The case for East Texas, USA By Ban, J and Smith, C *Biomass and Bioenergy* V 31(9) 2007 p. 623-630
This study evaluated the co-benefits associated with the utilization of logging residues for electricity production in East Texas, USA. The benefits evaluated included the value of CO_2 emissions displaced due to substituting logging residues for coal in power generation, reductions in site preparation costs during forest regeneration, and creation of jobs and income in local communities. Based on the 2004 Forest Inventory Analysis data and a 70% biomass recovery rate, annual recoverable logging residues in East Texas were estimated at 1.3 Mt (dry). These residues, if used for electricity production, would displace about 2.44 Mt of CO_2, valued at some 9M$ at the current CO_2 price traded at the Chicago Climate Exchange (accounting for about 2% of the stumpage value). Removing logging residues would also save \$200–250 ha^{-1} in site preparation costs. In addition, input–output modeling revealed that logging residue procurement and electricity generation together would have a stronger ripple effect on employment than on output or value-added, with about 1340 new jobs created and 215M$ in value-added generated annually. These results offer new insights into the cost-competitiveness of forest biomass and bioenergy production.
(To request email library@energylibrary.org.nz and quote **Bio4Ban**)

Biomass gasification Dover, M. 2007 *Inwood*, Issue 76 p. 12-14
This article offers a look at the biomass gasification pilot project at the University of Canterbury in New Zealand. Wood gas is the product of thermal gasification of biomass or other carbon-containing materials. It can be used to power cars with ordinary internal combustion engines if a wood gasifier is attached. The university's Department

of Chemical and Process Engineering started a laboratory-scale 100 kilowatt biomass gasifier to investigate advanced wood-to-energy conversion technologies.
(To request email library@energylibrary.org.nz and quote **Bio4Dover**)

Turning limbs and chips into energy biomass, humus Patterson, D., Montgomery, R., and Pelkki, M. *BioCycle* 2007 V 48(8) p.56
An 80% reduction in volume was observed when a *John Deere 1490D slash bundler* forest biomass collector was tested on loblolly pine residues. This unit collects forest debris then compresses and binds them into 6-10 foot bundles.
(To request email library@energylibrary.org.nz and quote **Bio4Patterson**)

Biomass gasifier gas turbine power generating technology Williams, R. and Larson, E. *Biomass and Bioenergy* 1997 V 10(2-3) p. 149-166
Integrating gasifiers with gas turbines, aeroderivative gas turbines in particular, makes it possible to achieve high efficiencies and low unit capital costs in modest-scale biomass power generating facilities. Electricity produced with biomass-integrated gasifier/gas turbine (BIG/GT) power systems would be competitive with electricity produced from coal and nuclear energy under a wide range of circumstances. Biomass also offers major environmental benefits. Initial applications will be with biomass residues generated in agro- and forest-product industries. Eventually, biomass grown for energy purposes on dedicated energy farms will also be used to fuel these gas turbine systems. Continuing improvements in jet engine and biomass gasification technologies will lead to further gains in the performance of BIG/GT systems over the next couple of decades.
(To request email library@energylibrary.org.nz and quote **Bio4Williams**)

Energy demand in wood processing plants Li, J, McCurdy, M and Pang, S. *New Zealand Journal of Forestry* V 51(2) 2006 p13-18
(To request email library@energylibrary.org.nz and quote **Bio4Li**)

Cellulosic biorefineries – Charting a new course for wood use Koukoulas, A. *Pulp and Paper Canada* 2007 V 108(6) 2007 p.17-19
The US Department of Energy (DOE) awards target the development of three conversion technologies which include acid hydrolysis, enzymatic hydrolysis and gasification – the most well known processes for producing ethanol from cellulose. A group of agencies selected by the DOE propose a selection of approaches for the production of cellulosic ethanol made from woody plants such as agricultural wastes, forest residues and wood.
(To request email library@energylibrary.org.nz and quote **Bio4Kouloulas**)

Gasification of biomass wastes and residues for electricity production Faaij, A., van Ree, R, Waldheim, L., Olsson, E., Oudhuis, A., van Wijk, A., Daey-Ouwens, C. and Turkenburg, W. *Biomass and Bioenergy* 1997 V 12(6) p. 387-407
The technical feasibility and the economic and environmental performance of atmospheric gasification of biomass wastes and residues integrated with a combined cycle for electricity production are investigated for Dutch conditions. The system selected for study is an atmospheric circulating fluidized bed gasifier-combined cycle (ACFBCC) plant based on the General Electric LM 2500 gas turbine and atmospheric gasification technology, including flue gas drying and low-temperature gas cleaning (similar to the Termiska Processer AB process). The performance of the system is

assessed for clean wood, verge grass, organic domestic waste, demolition wood and a wood-sludge mixture as fuel input.
System calculations are performed with an ASPEN plus model. The composition of the fuel gas was derived by laboratory-scale fuel reactivity tests and subsequent model calculations. The net calculated efficiencies for electricity production are 35.4–40.3% (LHV) for the fuels studied, with potential for further improvement. Estimated investment costs, based on vendor quotes, for a fully commercial plant are 1500–2300 ECU per kWe installed.
Electricity production costs, including logistics and in some cases negative fuel price, vary between minus 6.7 and 8.5 ECUct/kWh. Negative fuel costs are obtained if current costs for waste treatment can serve as income to the facility. Environmental performance is expected to meet strict standards for waste incineration in the Netherlands. The system seems flexible enough to process a wide variety of fuels. The kWh costs are very sensitive to the system efficiency but only slightly sensitive to transport distance; this is an argument in favour of large power-scale plants. As a waste treatment option the concept seems very promising. There seem to be no fundamental technical and economic barriers that can hamper implementation of this technology.
(To request email library@energylibrary.org.nz and quote **Bio4Faaij**)

Wood residue utilization in Pennsylvania: 1988 vs. 2003 Murphy, J.A., Smith, P.M. Forest Products Journal V 57(4) p. 101-106
(To request email library@energylibrary.org.nz and quote **Bio4Murphy**)

Cost structure of and competition for forest-based biomass Lundmark, R Scandinavian Journal of Forest Research 2006 V 21(3) p 272-280
(To request email library@energylibrary.org.nz and quote **Bio4Lundmark**)

Cellulose–hemicellulose and cellulose–lignin interactions in wood pyrolysis at gasification temperature Hosoya, T., Kawamoto, H. Saka, S**.** Journal of Analytical and Applied Pyrolysis 2007 V 80(1) p. 118-125
Cellulose–hemicellulose and cellulose–lignin interactions during pyrolysis at gasification temperature (800 °C) were investigated with various cellulose samples mixed with hemicellulose (glucomannan or xylan) or milled wood lignin. Significant interactions were observed in cellulose–lignin pyrolysis; lignin inhibited the thermal polymerization of levoglucosan formed from cellulose and enhanced the formation of the low molecular weight products from cellulose with reduced yield of char fraction; cellulose reduced the secondary char formation from lignin and enhanced the formation of some lignin-derived products including guaiacol, 4-methyl-guaiacol and 4-vinyl-guaiacol. Comparatively weak interactions were also observed in cellulose–hemicellulose pyrolysis. Finally, factors influencing the wood pyrolysis at gasification temperature are discussed.
(To request email library@energylibrary.org.nz and quote **Bio4Hosoya**)

Synthesis of transportation fuels from biomass: chemistry, catalysts and engineering Huber, G., Iborra, S., and Corma, A. *Chemical Reviews* 2006 106 p. 4044-4098
(To request email library@energylibrary.org.nz and quote **Bio4Huber**)

Integrating advanced biomass gasifiers into the New Zealand wood industry Rutherford,J, and Williamson, C. *NZ Journal of Forestry* 2006 V 51(3) p. 35-41
(To request email library@energylibrary.org.nz and quote **Bio4Rutherford**)

Microbiology of synthesis gas fermentation for biofuel production Henstra, A., Sipma, J., Rinzema, A., and Stams, A. *Current Opinion in Biotechnology* 2007 V 18 (3) p. 200-206
A significant portion of biomass sources like straw and wood is poorly degradable and cannot be converted to biofuels by microorganisms. The gasification of this waste material to produce synthesis gas (or syngas) could offer a solution to this problem, as microorganisms that convert CO and H2 (the essential components of syngas) to multicarbon compounds are available. These are predominantly mesophilic microorganisms that produce short-chain fatty acids and alcohols from CO and H2. Additionally, hydrogen can be produced by carboxydotrophic hydrogenogenic bacteria that convert CO and H2O to H2 and CO2. The production of ethanol through syngas fermentation is already available as a commercial process. The use of thermophilic microorganisms for these processes could offer some advantages; however, to date, few thermophiles are known that grow well on syngas and produce organic compounds. The identification of new isolates that would broaden the product range of syngas fermentations is desirable. Metabolic engineering could be employed to broaden the variety of available products, although genetic tools for such engineering are currently unavailable. Nevertheless, syngas fermenting microorganisms possess advantageous characteristics for biofuel production and hold potential for future engineering efforts.
(To request email library@energylibrary.org.nz and quote **Bio4Henstra**)

Renewable energy generation by Full-Scale Biomass Gasification System Using Agricultural and Forestal Residues. Tong, A., Lai, K., And Ng, K., And Tsang, Tongzhou, L., Liu, J. Jing, H. Weihua, Z. and Lo, I. *Practice Periodical of Hazardous,* Toxic & *Radioactive Waste Management* 2007 V 11(3) p. 177-183
(To request email library@energylibrary.org.nz and quote **Bio4Tong**)

Pyrolysis of wood/biomass for Bio-oil: A critical review Mohan, D., Pittman C., and Steele, P. *Energy & Fuels* 2006 V 20(30) p. 848-889
(To request email library@energylibrary.org.nz and quote **Bio4Mohan**)

Integrating fuel reduction management with local bioenergy operations and businesses – A community responsibility. Iversen, K. and Van Demark, R. *Biomass and Bioenergy* V 30(4) 2006
In approximately 20,000 US wildfire "at-risk" communities, private citizen awareness and involvement is essential for the effective integration of sustainable fuel reduction programs with the establishment of local biomass/woody materials businesses and bioenergy facilities. The factors that influence local community bioenergy and wood products economic development are mostly social, political, and financial not biological, ecological, or technological. It is the private sector that is the driving force for creating and influencing sustainable forest resources and broadening access to public lands. The many years of no-wood harvesting policies in the United States have caused excessive overgrowth and eliminated local forest products markets. Now with the severe overgrowth, drought and beetle-infested conditions in many Southwestern forests, actions are necessary to reduce fire hazards, improve public safety, and promote forest health. It is the local communities that must take an active role in creating bioenergy

facilities and wood products markets to use these fuel reduction supplies. A case in point is Prescott, Arizona, which is enclosed in the south and west by the Bradshaw Mountains and Sierra Prieta range. In 1990, under companion resolution of the Mayor of the City of Prescott and the Yavapai County Supervisors, the Prescott Area Wildland/Urban Interface Commission (PAWUIC) was formed to address the continuing growth of urban population into the wildland areas surrounding the Prescott basin. This organization of private volunteers and cooperating government agencies has the objectives to provide community fire safety education, wildland/urban fire hazard removal, and to promote the local markets for materials harvested from the wildland areas.
(To request email library@energylibrary.org.nz and quote **Bio4Iverson**)

The feasibility of producing alcohol fuels from biomass in Australia Mardon, C. International journal of global energy issues 2007 V 27(2) p 138-159
(To request email library@energylibrary.org.nz and quote **Bio4Mardon**)

Decision-support program "EnerTree" for analyzing forest residue recovery options Roser, D., Pasanen, K, Asikainen, A. Biomass and Bioenergy 2006 V 30(4) p. 326-333
The extraction of residues from the harvesting processes for energy production is common practice particularly in Finland and Sweden. Furthermore, the removal is expected to increase also in Central European and the Baltic countries. The extraction of forest biomass provides an extra source of income for the forest owner and positively affects the economy of the forest operation, scenic values and reduces chances of an insect pest outbreak. At the same time, the harvesting of forest residues affects the ecological state of the forest site both in the long term and short term. For example, nutrient depletion might have a negative effect on the future growth of the stand and additionally may be detrimental for biodiversity. The impact on the stand can be manipulated by either seasoning the residues so that needles are left in the stand or through compensation fertilizing using ash.
The individual forest owner is faced with a large number of options regarding forest fuel recovery though they have only limited knowledge of the potential impact on the forest ecosystems. Consequently, they will probably have difficulties making a decision. Another aspect is that various forest owners have different preferences regarding economical or ecological factors. A computer-based decision support program is therefore developed to assist the forest owners in making a decision concerning the utilisation of wood for energy. The program deals with a large number of aspects such as revenues from sales, environmental effects and silvicultural benefits. The forest owner provides the program with the basic data of the forest site such as site classification, basal area, mean height and diameter. Thereafter, the forest owner can rank their personal preferences, for instance, how they weigh the importance of net income, nutrient loss, biodiversity, scenic value or the risk of insect pests. The results of various treatment options are then presented to the forest owner, and recommendations for further additional treatment (amount of fertilizer) will also be provided.
The decision support program is a unique tool to assist the forest owner to make a comprehensive decision on whether they should harvest forest residues on their forest site and, if they decide to do so, what fuel recovery option will be the most beneficial for them. The EnerTree decision support program also provides an excellent opportunity to convey knowledge gained in research to the forest owner by very practical and understandable means.
(To request email library@energylibrary.org.nz and quote **Bio4Roser**)

Societal values and economic return added for forest owners by linking forests to bioenergy production Vogt, K. *et al Journal of Forestry* 2005 p. 21
(To request email library@energylibrary.org.nz and quote **Bio4Vogt**)

Hydrogen production from sewage sludge via a fixed bed gasifier product gas. Midilli, A., Dogru, M., Akay,G., and Howarth, C. *International Journal of Hydrogen Energy* 2002 V 27(10) p. 1035-1041
The main objective pursued in this work is to investigate the hydrogen production potential from sewage sludge by applying downdraft gasification technique. An experimental study was conducted using a pilot scale (5 kWe) throated downdraft gasifier. During the experiments, all data were recorded with an analogue to digital (ATD) converter linked to a computer for every 15 s. The flow rates of the wet product gas, the mass flow rate and volumetric percentage of hydrogen were determined and illustrated. The effects of temperatures of oxidation zone on the production of hydrogen were discussed, and the conversion ratios of dried sewage sludge to hydrogen and ash were also designated. It was concluded that substantial amount of hydrogen gas could be produced utilizing a renewable biomass source such as dried and undigested sewage sludge pellets by applying air blown downdraft gasification technique. The product gas obtained mainly consists of H_2, N_2, CO, CO_2 and CH_4 with a maximum average gross calorific value of 4 MJ/m^3. Around 10–11%(*V*/*V*) of this product gas is hydrogen which could be utilized for fuel cells. Moreover, sewage sludge can be assumed as an alternative renewable energy source to the fossil fuels, and the environmental pollution originating from the disposal of sewage sludge can be partially reduced.
(To request email library@energylibrary.org.nz and quote **Bio4Midilli**)

Bioenergy potentials from forestry in 2050: An assessment of the drivers that determine the potentials. Smeets, E. and Faaij, A. *Climatic Change* 2007 V 81 (3-4), p. 353-390
The goal of this study was to calculate the global energy production potential of woody biomass from forestry for the year 2050 using a bottom-up analysis of key factors. Future projections were made by comparing the future demand with the future supply of wood, based on existing databases, scenarios and outlook studies.
(To request email library@energylibrary.org.nz and quote **Bio4Smeets**)

Innovation diffusion, public policy, and local initiative: The case of wood-fuelled district heating systems in Austria Madlener, R *Energy Policy* 2007 V 35(3) p. 1992-2008
This paper comprises a three-level study on wood fuel utilisation for district heating in Austria. First, we discuss the framework conditions for the diffusion in Austria of rural biomass district heating (BDH) plants, an energy conversion plant type which constituted a real innovation in the 1980s. Second, we describe the diffusion of BDH systems in the Austrian province of Vorarlberg, where a variety of biomass energy systems have been promoted by capital grants since 1993, as part of a dedicated bioenergy promotion programme. Third, the paper contains a case study of a 2 MW BDH plant put into operation in 2000 in Rankweil, a small market town located in Vorarlberg on the east side of the Rhine Valley. Analysis of the plant history reveals that an oversupply of forest residues, caused by devastating storms and forest diseases, together with the more general need to rejuvenate severely over-aged forest stands, created strong incentives to form local actor networks and initiatives to push for the adoption and diffusion of centralised biomass heating systems in rural areas. In

addition, intensive lobbying and strong political and public support were necessary to successfully combat interventions by both the natural gas industry and influential gas-supplied industrial enterprises. Finally, a capital grant of 45% of eligible investment costs as well as careful capacity expansion and other planning significantly improved and safeguarded the economic viability of the plant. These considerations, combined with a dedicated forest-restructuring programme, render the plant one of the most successful integrated forestry and BDH projects in Vorarlberg, and an important model for later adopters. Overall, the analysis sheds some light on the role of public policy, local actors, and economic and other framework conditions on the market diffusion dynamics of BDH in Austria.
(To request email library@energylibrary.org.nz and quote **Bio4-Madlener**)

The 'nice' fuel woody biomass limited without incentives Dover, M. *Inwood Magazine* Issue 75 2007 p.16-21
The article focuses on woody biomass, the by product of wood processing industries. The government of New Zealand has created the Forest Industry Development Agenda Bioenergy Programme to foster research on forest waste harvesting. But wood processing industries have long been using woody biomass as a source of fuel for process heat applications. According to industry sources, there is no surplus because wood processors consume them for energy generation for drying and heating.
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Particle emissions from combustion of single wood pellets. Johansson, L. Martinsson, L. Tullin, C and Leckner, B V1 p.21-29
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Effects of fuel ash composition on corrosion in biomass-fired boilers. Lokare. S, Anderson, M. Baxter, Tree, D. and Junker, H. V1 p.157-168
(To request email library@energylibrary.org.nz and quote **Bio4 Volume1e**)

Operating conditions in biomass waste combustion in a conical spouted bed. San Jose, M.J., Alvarez, S., Ortiz de Salazar, A., and Bilbao, J. V1 p. 228-236
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Towards biomass classification for energy applications. Jones, J. Nawaz, M, Darvell, L., Pourkashanian, M., and Williams, A p. 331-339
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Electricity and heat generation by combustion and gasification of wood residues and straw – a strategic assessment. Kalber, S., Leible, L. Kappler, G., Lange, S., Neike, E., Wintzer, D. Furniss, B. p. 1714-1726
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Energy use in the New Zealand wood processing industry Gifford, J and Anderson, C. 2003 Click here (pdf)

Breaking the biological barriers to cellulosic ethanol: A joint research agenda. 2006. US Department of Energy. This extensive report is based on material from the 2005 Biomass to Biofuels Workshop. Click here(pdf)

The US Dept of Energy Provides $30 Million to Jump Start Bioenergy Research Centers : DOE Bioenergy Research Center Investment Tops $400 Million Click here (pdf) to read article.

Wood Residue-to-Fuel *Biomass Magazine* 2007 July.
Wood residues from a plywood mill are turned into fuel to help power the milling process. Click here (pdf) to read how Tolko Industries Ltd and Nexterra transform by-product to co-product and reduce mounting energy bills from within the mill itself.

Focus on biomass gasification *FiB* 2007 Volume4(20) This online newsletter by Denmark's Energy Research Program includes brief articles such as "*the largest gasification plant in Europe", "Gasification of problematic biofuels"* and "*Remove the stench add an alga to your tank"* Click here (pdf) to read this issue or here to access a variety of material provided by the Danish Bioenergy website.

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