TECHNICAL SERIES 31

ENERGY GROWS ON TREES

Report of the International Conference of Wood-based Bioenergy
Hanover, Germany

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ITTO

INTERNATIONAL TROPICAL TIMBER ORGANIZATION

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Hannover, Germany 17–19 May 2007

ITTO Technical Series #31

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The International Tropical Timber Organization (ITTO) is an intergovernmental organization promoting the conservation and sustainable management, use and trade of tropical forest resources. Its 60 members represent about 80% of the world's tropical forests and 90% of the global tropical timber trade. ITTO develops internationally agreed policy documents to promote sustainable forest management and forest conservation and assists tropical member countries to adapt such policies to local circumstances and to implement them in the field through projects. In addition, ITTO collects, analyzes and disseminates data on the production and trade of tropical timber and funds projects and other actions aimed at developing industries at both community and industrial scales. All projects are funded by voluntary contributions, mostly from consumer member countries. Since it became operational in 1987, ITTO has funded more than 750 projects, pre-projects and activities valued at more than US$300 million. The major donors are the governments of Japan, Switzerland and the USA. ITTO contact details are given on the back cover.

Cover photos
Front: Tetra Yanuariadi (ITTO)
Back: Eva Mueller

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FOREWORD

The world is searching for sources of energy that are carbon neutral, safe and cost-efficient. Wood-based bioenergy offers all these qualities.

Trees grow quickly in the tropics, and wood-based bioenergy already plays a strong role there. But, in general, it does so with low efficiency. Much wood and much energy are wasted. The timber sector has often treated wood off-cuts and sawdust as annoying waste products. This attitude must change. Today's wood waste is tomorrow's clean energy.

The wood-based bioenergy sector will do more than find a role for wood waste. New technologies are increasing the efficiency with which trees can be converted into energy. Given the high growth rates and relatively cheap land, dedicated energy tree plantations have plenty of scope in the tropics. The spread of such plantations will have huge implications for the forestry and energy sectors, as well as for the allocation of land.

ITTO and its member countries are keenly interested in the role of bioenergy in the forestry sector. For this reason, the International Tropical Timber Council, ITTO's governing body, decided to convene, in cooperation with the Food and Agriculture Organization of the United Nations (FAO) and the German Federal Ministry of Economics and Technology, an international conference on wood-based bioenergy.

The conference, which took place in May 2007, was attended by about 90 people from 33 countries. It reviewed the current status of wood-based bioenergy, explored the use of wood residues, wood waste and dedicated bioenergy tree plantations, and made nine clear recommendations. It focused particularly on the needs of developing countries in the tropics but drew on experiences elsewhere, particularly Europe. It highlighted the rapid development of technologies that is helping wood-based bioenergy become the fuel of choice in an increasing number of places.

On its own, wood-based bioenergy is not the solution to the coming energy crunch or the perils of climate change, but it is part of one. Many developing countries have the potential to develop an efficient and effective bioenergy sector that will help them meet their energy needs while protecting the environment. It is my hope that this conference will be the start of a great deal of activity within our Organization to promote bioenergy as a wood product in the tropics.

Emmanuel Ze Meka
Executive Director
International Tropical Timber Organization

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INTRODUCTION

People have used wood for energy since they lit the first campfires. In modern times, oil, coal, gas and uranium may have come to dominate the world energy economy, but wood has remained popular, particularly in many rural communities. Now, as climate change looms and oil prices soar, it is enjoying a resurgence. With new technologies and good management, wood-based bioenergy could play a large and perhaps critical role in meeting the world's future energy needs.

The conference

In May 2007, the International Tropical Timber Organization joined forces with the Food and Agriculture Organization of the United Nations and the German Federal Ministry of Economics and Technology to convene an international conference on wood-based bioenergy. It was held in Hannover, Germany, as part of LIGNA 2007, the world's premier exhibition of wood industry technologies.

The International Conference on Wood-based Bioenergy was attended by about 90 people from 33 countries. It reviewed the current status of wood-based bioenergy, explored the use of wood residues, wood waste and dedicated bioenergy tree plantations, drew a wide range of conclusions and made several recommendations. It was particularly concerned with the role of wood-based bioenergy in developing countries and the tropics but drew on experiences elsewhere, particularly Europe. Holding the conference in conjunction with LIGNA 2007 allowed conference participants to see, first-hand, recent technological developments in wood processing and the use of wood-based biomass for energy generation. A study visit to a site near Hannover focused on the optimized use of wood-processing residues in the application of finger-jointing technology for the assembly of off-cuts combined with wood pellet-based heat generation for drying. A second site demonstrated the integrated local use of agricultural biomass (conversion to biogas) and forest-based wood residues as fuel for joint energy generation (electricity and heat) at the village/community level.

The conference produced five key messages, which are shown in the box below.

This report summarizes the presentations made at the conference and the discussions that ensued. It also includes Powerpoint slides presented by speakers and the conclusions drawn and recommendations made by conference participants. It constitutes the proceedings of the conference.

Key messages

- Wood-based bioenergy offers countries, including developing countries in the tropics, an opportunity to improve their energy security
- Wood industries can use wood residues for the co-generation of energy, thereby increasing the cost-effectiveness of their operations and improving energy efficiency
- The use of wood-based bioenergy, both in the wood industry and generally, can help reduce greenhouse gas emissions
- The wood-based bioenergy sector needs to be developed on the basis of sustainable forest management
- The international community should support the development of efficient and cost-effective wood-based bioenergy in tropical countries, including by facilitating the transfer of appropriate technology and investment

WELCOME ADDRESS

Manoel Sobral Filho
Executive Director
ITTO

It is a great pleasure to address you today at the opening of this International Conference on Wood-based Bioenergy.

The International Tropical Timber Organization (ITTO) and its member countries are keenly interested in the role of bioenergy in the forestry sector. It is my hope that this conference will be the start of a great deal of activity within our Organization to promote bioenergy as a wood product in the tropics.

ITTO has organized this conference in partnership with the Food and Agriculture Organization of the United Nations (FAO) through my old (well, not so old) friend Wulf Killmann and his team in the Division of Forest Products and Industry. Thank you, Wulf, and I look forward to hearing your presentation in a short while.

I would also like to convey our gratitude to the German Federal Ministry of Economics and Technology for hosting the conference in this beautiful city of Hannover. I am particularly pleased that we have been able to convene during LIGNA 2007. LIGNA is, of course, an event of global fame and importance and it has always been an ambition of mine to attend it. That I can do so in conjunction with this important conference is a genuine pleasure for me.

I wish also to put on record ITTO's appreciation of the Governments of Japan, Switzerland, USA and others for raising, through ITTO's Bali Partnership Fund, the funds needed to make this conference possible.

ITTO is an intergovernmental organization comprising 60 member states which promotes the conservation and sustainable management, use and trade of tropical forest resources. ITTO operates under a treaty called the International Tropical Timber Agreement, which was re-negotiated by countries only last year. ITTO's charter is to promote the sustainable development of the tropical timber sector, including that part of it used for bioenergy.

Bioenergy is already popular in the tropics. In Brazil, my home country, we have been running our cars for decades on ethanol extracted mainly from sugar cane. More basically, wood and charcoal are the dominant forms of domestic energy in many rural economies. But the role of forestry in the organized bioenergy sector has, for the large part, been minimal in the tropics. There has been much waste and many lost opportunities. That makes this conference, which will look at the issue at the global level as well as from the point of view of the tropics, of particular importance; we are breaking new ground here.

That is not to say nothing has happened in the past. Plenty has. Today we will hear about developments in several tropical countries, as well as here in Europe and elsewhere. For its part, ITTO has been promoting the efficient use of wood-processing residues in the tropics for many years. We recognize these residues as a potentially valuable resource for energy production which can make timber industries more economically viable. Through our project program, we have been helping industry to introduce new technologies to capture this potential.

The wood-based bioenergy sector will do more than find a role for wood waste. Specialized energy trees such as hybrid poplar, now under research in the USA and other countries, can be introduced to degraded or vacant lands to produce wood cellulosic ethanol, a very high-energy-yielding product compared to corn and sugar-based ethanol. Given high growth rates and relatively cheap land, dedicated energy tree plantations have a great deal of potential in the tropics.

The widespread uptake of bioenergy technologies in the tropics is hindered, however, by many factors. These include a lack of national policies, strategies and institutional arrangements for wood-based bioenergy production, a lack of technologies that can be commercialized easily in the tropics, and a lack of finance for small and medium-sized bioenergy initiatives.

It is therefore clear that the establishment of a viable and sustainable wood-based bioenergy sector in the tropics will need an improved policy environment, a greater availability of bioenergy generation technologies, and significant investment.

I am pleased to note that one of the aims of this conference is to raise the awareness of policy-makers about the economic and technical potential of wood-based bioenergy. I look forward to hearing about experiences in developed countries, particularly in Europe, where the sector is developing rapidly.

ITTO members are also looking forward to learning about the outcomes of this conference. They hope that the Hannover conference will help them to understand the challenges facing the wood-based bioenergy sector and to take advantages of its opportunities.

I expect this conference to do just that. I hope that the presentations we receive, the discussions we have, the networking we do and the information that, ultimately, we disseminate will help stimulate the development of a sustainable wood-based bioenergy sector in the tropics.

Thank you.

SUMMARY OF PRESENTATIONS

The global wood energy sector: an overview

Wulf Killmann
Director, Forest Products and Industry Division
FAO
Rome, Italy

Wood is the oldest fuel and remains an important source of energy in many countries. However, its use is often inefficient and unhealthy and can lead to the degradation of forests and woodlands. The increased interest in wood-based bioenergy has been stimulated by two main concerns: energy security and climate change. The price of fossil fuels, particularly oil, has climbed dramatically in recent years. A significant part of the remaining oil resource is in politically unstable regions and many countries are looking to reduce their reliance on it. Coupled with this is concern about climate change. The Intergovernmental Panel on Climate Change recently issued its strongest statement yet, expressing its strong belief that high emissions of greenhouse gases such as carbon dioxide (CO_2) are causing long-term changes in the global climate. The burning of fossil fuels such as oil and coal is responsible for a large part of these emissions.

Theoretically at least, the use of biomass to generate energy is carbon-neutral: the biomass stores carbon while it grows and releases it when burnt, so the net change in carbon gases in the atmosphere is unaffected. In many parts of the world, biomass is available in significant quantities and the technology to use this biomass to produce energy is increasing in efficiency and decreasing in price.

Combustible renewables and renewable wastes currently contribute about 10.6% of current total world primary energy supply. Countries with high total industrial biofuel consumption include the United States of America, Brazil and India, while China has the highest total residential biofuel consumption. Removals of wood for fuel have grown considerably in most regions of Africa since 1990. But they have declined in Southeast and East Asia and remained relatively constant in South Asia as these regions increasingly turn to fossil fuels for their energy needs.

Wood consumption declined in the USA, South America, the Russian Federation and among Caribbean countries between 1990 and 2005 but increased somewhat in Europe, Central America and Canada. Among developed countries, Finland relies most on wood-based bioenergy – for more than 18% of its total energy supply – followed by Sweden, Austria and Lithuania.

The role of wood-based bioenergy is likely to increase, for a number of reasons. New technologies are emerging which make the conversion of wood to electricity and other usable forms increasingly efficient. Moreover, the area of plantations dedicated to fuel production, or which could be used for fuelwood, is increasing worldwide. Moreover, the policy environment is increasingly conducive to wood-based biofuels. But challenges remain, including how to ensure that wood-based biofuel resources are managed sustainably, the pricing of wood-based biofuels in the light of competition with other forest resource users, and the potential for increased destruction of natural forest because of competition for land.

Wood-based bioenergy is very important in developing countries; in many, wood is still the most widely used fuel. Many countries can and should make more use of their waste wood and improve the management of the resource. There is a chance to learn from past failures here.

Challenges for a sustainable tropical timber industry: the utilization of wood residues and waste

Hwan Ok Ma
Project Manager
ITTO Secretariat
Yokohama, Japan

The overall proportion of the permanent forest estate in the tropics under sustainable management is low – less than 5% of the total, although it is increasing. Encouraging the sustainable development of the tropical timber industry is an extremely important part of efforts to achieve sustainable forest management. A healthy, value-adding industry will maximize the economic return received by countries for the use of their forests, and it will also use the resource with greater efficiency than at present.

The tropical timber industry generates wood waste at various points in the production chain. An ITTO study estimated that the timber industry in the Amazon generated 49.7 million m^3 of waste per year, including 28 million m^3 (57%) of logging residues and 20 million m^3 (40%) in sawmills. In Malaysia, there is considerable potential for increasing wood-use efficiency, particularly in the forests and in sawmills: in 2002 the industry there was recovering 20% of logging residues, 36% of sawmilling wastes, 60% of residues generated in rubberwood harvesting, and 85% of waste generated in plywood manufacture.

Increasing the recovery of waste and its use in the bioenergy sector is constrained by several factors, including limited economic returns, the remoteness of many forests and mills from bioenergy markets, a lack of incentives for wood waste utilization, a lack of know-how on efficient waste utilization, and inadequate enforcement of environmental regulations. Nevertheless, there are some positive signs. In Brazil, the use of wood residues in generating thermal energy and electricity is increasing in medium-sized and large mills, and there is greater use of wood waste by independent electricity producers for sale to the grid.

Corn-based ethanol requires more energy to produce than it provides when burnt. Ethanol made from sugar produces more energy than is needed to grow it, but cellulosic ethanol – ethanol made from cellulose – is even more energy-efficient.

The international community could take several steps to encourage wood-based bioenergy. These include assisting in the formulation and implementation of policies to support a sustainable wood-based bioenergy sector, supporting the transfer of appropriate technologies to developing countries, identifying carbon financing opportunities for the tropical timber industry by replacing fossil fuels with wood under the Clean Development Mechanism of the Kyoto Protocol, and supporting research, development and information-sharing.

Mobilization of wood resources for wood products and energy: challenges for sustainable forest management

Ed Pepke and Sebastian Hetsch
FAO/UNECE
Geneva, Switzerland

Policies towards bioenergy are evolving quickly in Europe, driven by increasing fossil fuel prices and concern about energy security. Instability in the Middle East, uncertainties regarding oil supplies from Russia and questions over the safety of nuclear energy are all part of the mix in Europe. Coupled to these is growing concern about climate change and the need to reduce carbon emissions. The European Union (EU) has adopted a target of 20% renewable energy sources by 2020, up from 6.5% in 2005. Some countries, particularly Nordic, Baltic and some Central European countries, are ahead of others in the development of renewables. Latvia leads the way, with 40% of its energy needs met by renewables in 2005, followed by Sweden (30%), Finland (23%) and Austria (21%). Of the renewables employed in the EU, two-thirds are biomass-based. In the USA, the federal government's energy policies are less advanced, but many individual states there have policies to increase the use of renewables.

The rise of the wood-based energy sector in Europe poses a challenge to the wood industries. Demand for wood by the conventional industries is rising and so are the prices of the raw material. Thus, there is likely to be a shortage of wood in Europe in the short term. Alternative sources could include trees outside forests – such as in hedgerows – and increased recovery of demolition wood and pallets.

In October 2006, an international seminar was convened in Rome on energy and the forest products industry. This built on the findings of a technical workshop that looked at new technologies and systems leading to greater energy efficiency and reduced CO_2 emissions in the pulp and paper industry. The seminar concluded that integrated and balanced energy and forest policies are needed to mitigate climate change. The forest products industry can help combat climate change by optimizing raw material use, increasing efficiency, producing bioenergy, expanding into biofuel production, and improving sector competitiveness. But the forest products industry suffers an image problem – tainted by the fact that deforestation is still going on, although not in Europe.

A second workshop was held in January 2007 in Geneva to examine the question of whether Europe's forests can satisfy the increasing demand for raw material and energy under sustainable forest management. It concluded that there is potential to increase the wood supply and opportunities for increasing the mobilization of wood. The area of forest has increased in Europe by 7% since 1990, while it remained constant in North America and declined slightly in Russia. In all three regions, the volume of wood is increasing because harvesting is less than growth. Thus, wood production could be increased. This represents a big opportunity for the wood industry in these regions. The conference recommended coherency between policies for the wood-processing and wood-based bioenergy sectors, the integration of the supply chain in biomass strategies, the empowerment of forest owners to form 'clusters', the improvement of harvesting and processing infrastructure and logistics, the development of a qualified workforce, and the provision of comprehensive and reliable data.

Policies to enhance the utilization of forest biomass and wood residues for energy generation in the EU

Jeremy Wall
European Commission
Brussels, Belgium

The 25 countries of the EU have 165 million hectares of forests. They grow 574 million m^3 wood each year, but industry uses only 55% (315 million m^3) of this. Thus, standing volume is increasing by 290 million m^3 per year, while the area of forest is also increasing by 400,000 hectares per year or more. The inclusion of Bulgaria and Romania in the EU adds another 10 million hectares or more of forest. EU forests could be used to a greater degree – perhaps by up to 200 million m^3 per year – without negative ecological impacts.

EU forest-based industries provide 2.5 million jobs and €340 billion of turnover, which is 8% of EU manufactured value added. It is a significant sector and it is important that it maintains its competitiveness. It can also play an important role in mitigating climate change and increasing the EU's energy security.

A complex framework for renewable energy sources is already in place. Wood was providing more than 50 million tonnes of oil equivalent (MTOE) energy in 2004. The EU's Biomass Action Plan and Biofuels Strategy envisage a dramatic increase in the use of biomass for energy to 2010, from 380 million m^3 in 2003 to 820 million m^3, an increase of 440 million m^3. If all this additional biomass was to be wood, the target would be impossible to achieve.

The new demand for wood poses both opportunities and challenges. The data presented for Europe as a whole masks huge regional variations, which present logistical and other challenges. Forest owners will have more markets for their wood, including residues. This could mean more revenue for forest management. Sawmills will benefit from increased demand for their by-products, such as wood chips and sawdust, especially for pellets. Also, wood is an energy-efficient building material in manufacturing and use, which could give it a competitive advantage over other materials. But there are risks: policy changes require (better and more) wood mobilization, but existing market, institutional and fiscal frameworks may inhibit it. Unfocused demand for wood, unmatched by supply, can create bottlenecks and high prices to the detriment of both the energy and forest-based industries.

There are also some strategic considerations. How much more wood could/should be used and how can it best be managed? Which points in the forest/wood flow system should be addressed? Logistics and harvesting costs are crucial. How can such costs be overcome without unduly distorting markets?

What has happened recently in the wood biomass market? Roundwood prices have risen sharply, and supply remains tight in many regions, especially Central Europe. Supply difficulties and high costs have reduced the competitiveness of wood-processing industries, especially panels and pulp.

The new EU policies are facing up to new and renewed challenges: high and volatile prices for oil and gas will stay; global energy demand will increase by 60% over the next 30 years; EU energy dependency could rise from 50% to 70%; and climate change is likely to be more rapid that previously thought.

A new energy package was affirmed recently by member states. It has three goals: increased security for energy supply, ensuring the competitiveness of European economies and the availability of affordable energy, and promoting environmental sustainability and combating climate change. The EU's Energy Action Plan includes a binding target of meeting 20% of energy needs with renewable energy sources by 2020, of which half (10% of total energy needs) will be biofuels. For wood, this might mean a biofuel demand by 2020 of 140–190 million m^3 per year.

Technologies and economics of energy generation from logging residues and wood processing wastes

Arno Frühwald
University of Hamburg and Federal Research Center for Forest Products
Hamburg, Germany

There are big differences in renewable energies between countries in the EU. For example, Austria uses renewables for 64% of electricity (mostly biomass and hydro), while the UK uses only 4%. In 2020, wind will be most important source of electricity generation in the EU, generating 35% of demand compared to 9% by biomass and 6% by solar. The total renewable share of the energy budget could increase from 5% to 50%.

The annual wood harvest has increased in some countries since 2000. In Germany, forest covers 30% (11 million hectares) of the land area, with an annual growth increment of 80 million m^3. The current harvest is 70 million m^3, of which 20 million m^3 is already burned for energy. There is a potential to produce more logs (10 million m^3 per year) and 10–15 million m^3 of forest residues. The main barrier to such an increase is getting the wood out of the forest; much of the potential increase in is privately owned forests, but owners are often not interested in selling their wood.

Within the wood industry, fiberboard mills produce 90% of their heat demand and 40% of their electricity needs using wood residues. Under the Renewable Energy Act, electricity generated from renewable sources (wind, solar and biomass) receives a premium market price (~€0.10 per kilowatt hour – kWh) which is granted for 20 years: this has changed the market very much.

For example, a mill generating 240,000 m^3 per year of waste wood can burn this in a cogeneration facility for steam and electricity, sell the electricity for the fixed price (9 cents per kWh) and, at the same time, buy electricity from the grid for 4–6 cents.

Heat generation with wood pellets made from sawdust and other wood waste is also booming – it is environmentally friendly, easy to maintain and requires only a small investment. A silo for pellets containing 5–8 tonnes is sufficient to heat one family home for one year; the price is competitive with oil and gas systems.

Wood-fuel prices are generally competitive and technologies for wood-energy generation exist in all capacities, from 3 kW up to 200 megawatts (MW). Small (20 kW) and mid-size installations are economically competitive with other (fossil) fuels.

Discussion 1

Comment 1 (from Togo): The use of biomass for energy in Togo has a great future – wood is readily available and not expensive. The technology needed to cut wood is not expensive –so our population has access to wood as a resource. All the issues surrounding the use of wood are linked to poverty: as long as we have poverty we will see wood used as fuel. But it is not always used efficiently: sometimes you see it used as fertilizer and to increase agricultural production or repair roads. That wood could be used a lot better and tomorrow we will see some technologies that will really help my country.

Comment 2 (from Indonesia): It is hard to believe that cellulosic ethanol is more efficient than sugar ethanol. Wood cells contain complex materials and have to be degraded to simple sugars – so the route to production is longer. I can't believe that it would be efficient to grow wood for bioenergy – it would be better to only use wood wastes for this purpose.

Comment 3 (from Nigeria): In sub-Saharan Africa there is no information to plan to develop a bioenergy sector. How can we develop the database that we need to plan? We need a concerted way to assess the resources that are available.

Comment 3 (from Germany): Killmann and Pepke compared EU countries with respect to the use of biomass. Sweden was in first or second place, Austria third, and Germany at the bottom. These three countries have similar available biomass; what makes the difference is support by government. In Austria, the government supports up to 70% of the costs of pellet-burner installation, while support in Germany has gone down in recent years. More wood could be made available by traditional owners, but did you consider that a lot of this wood is in regions, such as the Alps, where it is not efficient to use the wood? Does it also include national parks? When the wood inventory was done a couple of years ago, those two points were not considered. We think that only 70% of wood is actually available.

Frühwald: On this last question, yes, we know the yield increment from two forest inventories. Then we made a prediction of the volume available, excluding national parks, of 80–85 million m^3. Small forest owners are often not interested in cutting the wood. The share of wood on private forest lands in difficult regions is not that high (20–30%).

Yes, the high rate of installation of small heating systems in Austria was due to government support. In Finland it is very different. They use a lot of wood, but the majority of wood bioenergy is black liquor from the pulp industry. Is using wood for energy wasteful? Our philosophy is to use the wood first as a material for as long and as often (i.e. through recycling) as possible. If you cut logs in the forest, 80% will end up in a house – but if you use the other 20% for energy you can use the energy to build the house.

Ma: In Togo, much of the wood-based energy is in the form of charcoal and the next stage is to move to pellets. Fertilizer is one way of promoting waste utilization; more attention will be given to organic fertilizers in the future. The technology on the use of wood-based cellulosic bioenergy is changing.

Wall: The point that some of the forest resources considered to be available are in more remote regions underlines one of my points that there are great regional variations. The fact that they don't have ready markets may mean that it makes sense to use them for serious energy production. In Austria, there have been huge investments in biomass, but it is a question of what is suitable for particular regions. Some new members of the EU, and some states in West Africa, may have resource for which there are no real markets at the moment. Eastern Europe faces similar problems to other developing countries – lots of wood residues that are not being used. It all starts with government support – you have to have the policy framework to encourage the adoption of new technologies.

Sobral: My colleague from Indonesia refers to the hydrolysis process for converting cellulose to ethanol that might not be all that efficient. However, new technologies are making conversion more efficient, both by hydrolysis but also by gasification, and some of these technologies are likely to be available commercially soon. As for growing wood for energy – I see no problem with that. Wood can be grown as a crop – we will hear today from Dr Carvalho that in Minas Gerais several million hectares of forest are being grown and used in steel production – it is much better environmentally to use charcoal than coal. If you look at the issue from all angles there is no doubt about the social, environmental and economic advantages of growing wood as an energy crop. Some developing countries have been very slow to deregulate their electricity sectors and allow biomass industries to sell electricity to the grid – it is happening at a slow pace in developing countries and that has to change.

Comment 5 (from Ghana): Ghana faces a serious energy crisis. We use hydro power and it's drying up as a result of drought. Talking about cogeneration: is it possible to use tropical wood to generate energy through cogeneration? We know the heterogeneity of our forests – can we use all kinds of wood or do we need to separate them, and how economic would it be?

Comment 6 (from Brazil *to Wall*): Is any fee paid to the industry that converts energy to biomass? *To Frühwald*: In what form could wood residues be exported to Europe from our countries? Pellets? Charcoal briquettes? What is the economic distance of that? *To all*: What is Europe doing to work with tropical countries because you are very far ahead of us technologically?

Frühwald: Is there a possibility for exporting wood fuels to the EU? At the moment, the heating value per cubic meter transported is very low. Ideally, the wood will be densified as pellets or briquettes, which can almost triple heat value per unit volume. At the moment, this is the only way I see. There are exports from British Columbia (Canada) of pellets to Europe over quite large distances; this has grown tremendously in the last two years. I can't give a figure for economic distance. But I can see opportunities for container transport of pellets from Brazil. On the question from Ghana, hydropower is the cheapest in the long run; investment costs are relatively high but the infrastructure can be used for decades.

Comparing wood energy with other fuels depends on the size of installation and fuel costs. Electricity costs at the moment are in the order of 5–8 cents per kWh for installations 2–20 MW. Nuclear-generated electricity costs 5 cents per kWh, but this doesn't factor in the decommissioning of the plant at the end of the life. It depends also on the subsidies and incentives.

Sobral: On the question from Ghana: are all tropical woods usable for energy? Yes, but they have differing energy values because of wood and moisture content. All can be used but with varying levels of efficiency.

Increasing the efficiency in the tropical timber conversion and utilization of residues from sustainable sources in Brazil

Joesio Siqueira

Coordinator, ITTO project PD 61/99 Rev 4 (I)
Federal University of Paraná Foundation for the Development of Science, Technology and Culture
Brazil

The overall objective of my project was to contribute to development of sustainable forest management in the Amazon and the specific objective as to demonstrate that the forest product industry and non-traditional consumers can contribute to forest management. It looked at forestry operations in four places in the Amazon and their potential for energy generation: Alto Solimões and Itacoatiara in Amazonas state, at Rio Branco in Acre state, and Rio Jari in the eastern Amazon.

The problem in the Amazon is increasing forest conversion to other land uses; sustainable forest management struggles to compete economically. One reason for this is an absence of markets for forest harvest residues – 600 million tonnes per year. If Brazilians want to use that potential for generating energy we could turn this into 36,000 MW of electricity, the equivalent of three large hydropower stations. We have a lot of residues that are cut from the tree and left in the forest. Large sections of the log could be used by the industry for energy production, but there are also other species that don't have much market value but produce a lot of residues. There is a large availability of biomass.

In Rio Branco, Acre's capital, the cost of investment in a 2 MW biomass-based electricity plant would be recouped in 8.6 years if the electricity was sold into the grid. A 10 MW plant would pay off in 15 years.

Existing subsidies for oil-based energy generation to the tune of R$3 billion/year in Rio Branco limit the ability of biomass-based energy to compete. Another issue is the supply of raw material, which is highly variable depending on the season and requires authorization from IBAMA [Brazil's Institute of Environment and Renewable Resources] and local agencies. The creation of national and state forests will ease up the availability of biomass. Improvements in the transport infrastructure are essential for increasing competitiveness.

Discussion 2

Comment 1 (from Switzerland): Do your costings take carbon credits into account? **Sequeira**: No. Carbon credits are still hypothetical in the Amazon. *Follow-up question*: Wouldn't carbon credits be an option to overcoming financial hurdles, rather than public subsidies? **Sequeira**: So far nothing concrete has been agreed on carbon credits – more time is needed.

Comment 2: You mentioned that half of the wood you use is derived from waste wood and the other half from industrial waste wood. As far as forestry residues are concerned, you said it may be uneconomical to use it in conversion because of the cost of transportation. That makes me wonder. You know that Brazil is behind other Latin American countries in the use of lesser known species. In Bolivia, Ecuador and Colombia, such species are being exported to China and elsewhere but Brazil lags behind. Would you consider using lesser known species as a commercial wood and to sell them accordingly? Acre's governor is present here and the main objective of his government is to increase the value of wood products. Unfortunately, that is an exception in Brazil.
The Governor's policy makes a lot of sense; his policies are sensible and the objective of his government is to protect the forests and to put them to use. In Brazil, 50% of wood extracted from the forest is lost. If we can't replicate Acre's policies in other states then we will continue to lose the opportunities presented by these resources. We're talking about millions of hectares a year. Research institutes and IBAMA aim to increase the number of exportable species for better economic results. Ten years ago, 16 tree species were sold and used; today this has gone up to about 40 tradable species. Yes, there is increasing knowledge of those species, better technologies. We have several large companies active in this area in Brazil.

Sobral: There have been further developments in the locations where Dr Siqueira's studies were carried out. There are now energy companies generating electricity from biomass. In the Jari project, a company there is generating steam and electricity. And the other is in Itacoatiara, where they are selling electricity to the grid. There have been no developments in Rio Branco because of the state subsidies for oil. It's a paradox: Europeans have incentives and subsidies for biomass production but in the Amazon the government is subsidizing the use of diesel, making biomass uncompetitive. Regarding lesser known species, 40 species are in use now but in the early 80s we did a survey and found that 300 species were being used locally and nationally. Nevertheless, Brazil is still a leader of timber exports from natural forest – US$500–600 million dollars per year, which is much more than in neighboring countries but still nothing compared to the country's plantation-based industry.

Wood waste to energy: from waste to wealth with a special reference to Malaysia

Hoi Why Kong
Forest Research Institute Malaysia
Kuala Lumpur, Malaysia

In Malaysia, forestry generates about 9.83 million m^3 of wood residues, comprising 5.1 million m^3 of logging residues, 2.2 million m^3 of primary manufacturing residues, 0.91 million m^3 of plywood residues and 0.9 million m^3 of secondary residues such as sawdust. The cost of wood is low compared to diesel, coal or charcoal.

The objectives of the national energy policy include providing adequate and secure energy supplies, promoting and encouraging efficient utilization, and ensuring minimum environmental impacts. Under the new fuel policy, conventional sources of energy will be supplemented by new sources such as renewable energy. In this regard, the fuel diversification policy, which currently covers oil, gas, hydro and coal, will be extended to include renewable energy as the fifth fuel, particularly biomass, biogas, municipal waste, solar and mini hydro. Of these, biomass resources, such as oil palm, wood wastes and rice husks, will be used on a wider basis, mainly for electricity generation.

Other potential sources of energy include palm diesel and hydrogen fuel. Several initiatives and incentives were launched in the 2002 national budget to encourage such renewables, including tax exemptions, tax allowances and exemptions from import duty and sales tax on imported machinery and equipment. This is creating a new window of opportunity for small-scale renewable energy producers. The number of renewable energy power plants is expected to increase – although problems with logistics, an insecure and uncertain supply, competition for the resource, and a lack of information and awareness about biomass energy need to be overcome.

Carbon credits from CDM fuel-switch projects replacing coal in power generation with biomass from the forest sector – a case study from Anhui, China

Gerald Kapp
GFA Consulting Group GmbH and GFA ENVEST GmbH
Hamburg

Using fossil fuels adds CO_2 to the atmosphere. The use of renewable wood energy does not: CO_2 is taken from the atmosphere by trees and then released when burned. Replacing fossil fuels with renewable energy reduces greenhouse gas emissions and thus might be eligible for carbon credits, which can then be sold.

Anhui Province is in western China along the Yangtze River. The project described here involves replacing a 75 MW, coal-fired boiler with a wood-based boiler. The boiler is used for 4,400 full-workload hours – 110 gigawatts per year. About 99,100 tons of woodchips are needed to replace 62,300 tons of coal; emissions of some 114,200 tonnes of CO_2 per year would be avoided.

China has a major reforestation program of 4 million hectares per year. The Forestry Administration is looking for ways to use pre-commercial thinnings – more than 1 million tonnes per year.

An investment of €11 million is required to build the biomass boiler. Woodchips are more expensive delivered than coal and have less energy per ton.

The supplemental costs of fuel = €1.8 million. In china, a new decree establishes a subsidy for biomass power of about €0.025 per kWh.

We calculated the internal rate of return for an 11-year period with and without carbon credits. Without carbon credits, the internal rate of return was negative (-3%). However, at the current price of carbon credits of €7/ton of CO_2, the internal rate of return becomes positive (+9%).

A second case was also investigated. The Wuhu Textile factory, which uses coal to generate heat and electricity. Replacing two coal boilers (25 MW, of which 3 MW is electricity) with sawdust-fired biomass boilers would result in avoided emissions of 55,000 tons per year. The cost of the new fuel is much cheaper than coal: even without carbon credits, the internal rate of return would be 23%. With credits, the internal rate of return increases to 30%.

This might be a problem: the additionality of such a project might come into question. It could argued that the fuel switch is so profitable it would happen without carbon credits.

Discussion 3

Comment 1: The term 'waste' is redundant. Wood residue is no longer waste but a highly priced commodity. In the past, the industry had to pay to get rid of it. Now, there is such competition for it that some countries are importing it. But the term waste creates a problem – if materials are classified as waste, they may be regarded as an environmental hazard, which can cause problems for importers. I would caution against using the term 'waste'.

Comment 2: Dr Sequeira's analysis is very good but the sensitivity analysis only talked about actual prices. You could also look at the effect of possible subsidies and the effect of raising the price of other fuels.

Comment 3: is the scheme described by Dr Kapp working in China or is it planned? Is it a difficult process and does it need specialized people?

Kapp: What I described was a pre-feasibility study. We hope it can be developed into a full Clean Development Mechanism project. Yes, it is complicated because the stipulations under the United Nations Framework Convention on Climate Change are tricky – projects have to observe certain parameters and meet some technical and logistical challenges.

Hoi: regarding the definition of waste/residue – yes, it is very important to define this carefully. Residue is a better term. FAO has a bibliography on wood, which could be used as a starting point.

The potential of using wood residues for energy generation in Ghana

Daniel Sekyere
Forest Research Institute of Ghana
Kumasi, Ghana

In Ghana's forest industry, residue comprises nearly half the total wood volume. The industry does not make efficient use of this residue. Options to improve efficiency include briquette production, cogeneration, and better fuelwood management.

If Ghanaians continue to increase their consumption of firewood, total annual consumption is likely to exceed 25 million tons by 2020. Ninety percent of the wood fuel supply in Ghana is obtained directly from the natural forest, and wood fuel accounts for about 71% of total energy demand. Wood fuel is consumed in three main forms: firewood, charcoal (termed fuelwood) and briquettes.

Much of Ghana's electricity is from hydro schemes, but there has been a curtailment of output and rationing due to drought situations that have affected water levels. Electricity tariffs have gone up considerably. Cogeneration at wood production facilities could be used to produce steam for steaming peeler blocks for plywood manufacture, the drying of lumber and electrical power – which would reduce the mills' dependency on the national grid. Cogeneration is more attractive than conventional power and heat generating options due to: its relatively lower capital investment; reduced fuel consumption; and reduced environmental pollution. Currently, Ghana's total energy generating capacity is about 65% of the national peak demand, which is growing at a rate of 15% per annum.

Bakers and brick and tile factories in Ghana like wood briquettes; using briquettes for household energy could substantially reduce the volume of firewood harvested from the forest. However, the widespread introduction of briquettes has been hampered by suspicion, a lack of confidence, and unfair comparisons with fuelwood (charcoal and firewood) in price and charcoal in quality.

Most charcoal producers use the earth kiln method. Wood residues are converted to charcoal in the vicinity of mills (rural areas). Charcoal is easy to transport; it is used mostly for domestic purposes in urban and wood-deficient areas.

There are a number of considerations in the development of wood fuel policy in Ghana. These include: support for the forestry sector to ensure the sustainable management of the country's natural forests and woodlands; ensure the design and implementation of a regulatory framework for commercial transportation and marketing of wood fuel; regulate charcoal exports to ensure that only charcoal from wood waste and planted forests are exported; establish the needed institutional framework to ensure and coordinate wood fuel-related activities as an integral part of national energy development; promote improved technologies and higher levels of efficiency in the production of charcoal and use of wood fuels; and support the development, promotion and introduction of alternative fuels for the substitution of wood fuels.

Wood energy from afforestation and reforestation: a case study from the pig iron and steel industry in the State of Minas Gerais, Brazil

Jose Carlos Carvalho

State Secretary for Environment and Sustainable Development
Belo Horisonte, Brazil

Minas Gerais, a state in Brazil, is about 589,000 sq km, which is slightly larger than Germany. We have natural grasslands and meadows and large prairies or savannahs. The state also has a lot of forests, which have specificities and peculiarities. Forty-five percent of energy comes from renewable sources – hydro, firewood and derivatives – which is higher than crude oil and natural gas.

We have the second-largest cellulose industry in Brazil. In 2004, 600,000 tons of oil equivalent were derived from sugarcane bagasse and residue wood. There are about 1.3 million hectares of *Eucalyptus* plantations, which play a very important role in the state; they are expanding by 130,000 hectares per year and are grown specifically for use in the steel and pig iron industry. Some 730,000 jobs are directly or indirectly related to the utilization of wood in Minas Gerais.

Efficient co-generation of energy products in pulp industry

Leif Gustavsson
Mid Sweden University
Östersund, Sweden

Pulp and paper mills account for about one-third of roundwood consumption in Europe and about 50% in Sweden. Replacing fossil fuels with renewables is particularly difficult in the transport sector. The aim of our recent study was to compare the potential production of electricity and motor fuels in pulp mills using conventional recovery boilers, a black liquor gasification combined cycle, and black liquor gasification for motor fuels (BLGMF).

We studied CO_2 emissions, oil use, biomass use, total primary energy use and monetary costs over a lifetime of 25 years for energy plant and pulp mill investments at a discount rate of 6%. We found that BLGMF implementation for all bleached sulphate pulp in Sweden could replace about 65 petajoules of diesel annually, or about 47% of current Swedish use of diesel.

Co-generation of energy from wood: a case study from a medium-sized wood-based bioenergy plant in Piesteritz, Germany

Andreas Jahn
Endico-Stadtwerke
Leipzig, Germany

We have two plants in the region that are 100% wood fuel-based. Someone has to finance innovative technology, someone has to take the financial risk, and someone has to run the power station. Stadt Leipzig is a public utility, owned 100% by the Government of the City of Leipzig (500,000 people). In 1999 the company's board of directors decided to go into renewable energy. It invested €50 million in the Bischofferode bioenergy plant, the first one off the blocks. The station is 100 km from Hannover in a rural area. About 4.5 months supply of wood is weighed and stored at the plant.

There were many technical difficulties at the beginning. One maintenance period is required each year, when the entire power plant stops. The maximum size of woodchips is 70 mm. The fuel consists entirely of uncontaminated (virgin) wood from state-owned forest, which is supplied under a 10-year contract. The power plant produces 25 MW of electricity at a gross electrical efficiency of 37%, which is quite high for a power station. It has proved economically viable, producing electricity for 8 cents per kWh. A new wood-based cogeneration power station is under construction at Piesteritz, 200 km from Hannover, and is expected to come on-stream in 2009. The main variable is transportation of wood to the power station – importing or transporting wood from areas further than 70 km from the plant is not viable.

Discussion 4

Comment 1 (from Togo *to Carvalho*): Congratulations on the work being done in your state. I have five years of experience in my country and I know it's not easy to plant even 1 hectare of new crops. I would like to ask: how do you get hold of the land for reforestation? Do you buy it? I didn't see any indication of how biomass will be used in households. I got the impression it is used only in industry. Can you confirm it? *To Sekyere:* You said that the utilization of briquettes is something households distrust. Why is this? If we want to disseminate briquette technology in Togo we want to address this.

Comment 2 (from Indonesia): This is a very important conference to my country. Under a presidential decree in 2006, Indonesians should use bioenergy to generate at least 5% of total energy supply by 2025. We generate about 7.8 million m^3 of industrial wood waste per year and logging waste of about 29.7 million m^3 per year. So far our problems arise in the cost of harvesting and transportation and a lack of knowledge and technology for energy generation and also harvesting wood waste in terms of illegal logging. This conference will show my country the way to obtain returns for wood waste and to achieve the President's target. We hope for a similar seminar in Indonesia financed by my government, co-financed by ITTO and FAO.

Killmann: ITTO and FAO look forward to working with Indonesia towards such a workshop.

Comment 3 (from Cameroon): This conference is something we follow with great interest. It is an important topic for us in Cameroon. It is important that the population understands that wood residues are very important and can be used for energy. When we think of local capacities we also need to think of the technologies that are required and technology transfer and logistical issues, and we need to promote cooperation at the local and national levels. Research and development need to be supported at the local level, including into social and economic factors.

Comment 4 (from Indonesia *to Jahn*): Wood plantations need at least 5–7 years to grow enough to start supplying a power plant and a large area is required. If this plantation also has to fulfill other purposes, such as ecosystem services and to meet other wood-based needs, is it financially competitive or not? If you compare it with a gasification process, which one is more financially competitive?

Carvalho: My colleague from Togo raises an important question. In Brazil and in Minas Gerais there is a tendency towards private landownership – most land is in private ownership and the state only owns about 200,000 hectares. There are more than 400,000 private owners in Minas Gerais. We cooperate closely with them when it comes to reforestation –farmers are becoming increasingly involved in these projects. Small and medium-sized farms make important efforts towards reforestation. We talk at the same time of wood consumption. Part of the forest biomass goes to private households – there is a long tradition in Minas Gerais of using firewood in households.

Sekyere: Whenever a new product is introduced, people view it with suspicion. So we have to teach people that the product, the briquette, is better than charcoal. They also thought that the government would impose taxes on it.

Jahn: Our power station is designed to be fed from a radius of 50 km. A second power station within that radius would be inefficient. There is unlikely to be competition because there simply is not enough wood for two power stations. Plantations have not been established specifically for the power station – it is only using wood that is in production anyhow and only residues.

Gustavssen: In Sweden, we have a city that is heated by a 130 MW thermal capacity cogeneration plant. It is situated in the north of the country and the forest there grows slowly. We obtain logging residues from up to 150 km using new technologies – you can reduce the cost of shipping using new technologies to compress the wood into composite logs, etc.

These technologies could be further developed to reduce cost and the energy used in transport. Transportation problems are sometimes over-estimated. We have been importing pellets from Canada for more than a decade and from our own forests to Stockholm from over 800 km away. Normally you don't want to refine the fuel too much because it costs energy and money. As for gasification: who will take the risk to build the first plant? There are lots of plans in Sweden to build gas technology plants.

Comment 5 (from Gabon): I represent the Ministry of Forestry in Gabon. This conference is very important because it puts the issue at the forefront of the agenda. My country and Central Africa generally isn't yet concerned so much about using wood residues for energy generation. However, we have plenty of residue from different processes. We as a ministry are very concerned about how best to use this residue because we want to become more efficient. The presentation we heard this afternoon from Dr Carvalho was of significant interest to us because this is a step we can take, too. We will watch how the project develops.

Comment 6 (from Mexico): I am from the Ministry of Energy. I would like information on the water needs that might result from these new technologies, particularly if talking about maize as a bioenergy crop. We need fields for these crops, but what about the water that those crops will need?

Comment 7 (from Brazil, *to Carvalho*): Are you using any specific technology in the steel industry in Minas Gerais? *To Sekyere*: Is the briquetting technology suitable for small communities? I am wondering if it is applicable to Brazil.

Comment 8 (from Mexico): There is a cogeneration plant in Monterrey using gas from landfill sites. There is also a particleboard plant using organic/wood waste from the city. I don't see why we should limit wood use to wood from forests. Why not go for some hybrid technologies?

Comment 9: Sustainable forestry: that's a term I've only heard once this afternoon. I have a report here called *Making SFM Work*, which says that ITTO plays an important role in promoting SFM, which is also important for bioenergy as well.

Comment 10 (from Ecuador): How sustainable is it for a forest or plantation to use residues from felling in energy production? We are doing something fairly similar. We are using wood residues from logging in industry to generate power and steam; now we are told that we can run into problems because we are removing this material from the natural system.

Comment 11 (from Peru): I represent the Peruvian timber industry. In my country we have no experience concerning electricity generation from biomass. We use oil, but this is something we want to change. What possibilities might be provided by ITTO and the German Government to assist in this process? We have a strong desire to be successful in the future, we want to be competitive with our products in the future. You can't enter into competition if you're not producing economically. My company employs 440 people but we are establishing no further plants at present because the costs are prohibitive and prices are so unstable. I'm interested to get more ideas on how we can make the change away from fossil fuels towards biofuels.

Carvalho: In Minas Gerais we recognize that we need to deal with three issues. 1) Environmental security: increased use of renewable energies means increased pressures on the land. If we're not careful we can degrade the soils. 2) Food security: we can't have energy security at the expense of food production. We can't have one at the cost of the other, so we need models for integration to ensure that these are balanced. 3) Technological process of carbonization – this is pretty advanced in Brazil but more research is needed in Minas Gerais. We do have companies engaged in recuperating gases that are generated during that process and some initiatives have been undertaken to use those gases, with mixed results.

Gustavvsen: On black liquor technology, it might be easiest to go to the company that has the patent for the technology; the technical director will be able to describe the technology in detail. There are large demonstration projects – up to €30 million – in the pulp and paper industry. In Sweden we are building three pellet plants; the idea is to export to Europe. The Swedish Government has set up an oil commission, with a vision of quickly removing oil dependency. This was probably over-enthusiastic, but certainly biomass will expand, perhaps double. On recovered wood: it is good to use recovered wood, but sometimes there are environmental and health problems – residual gases need to be well cleaned. How much residue can be removed from a clearcut without affecting productivity? Research for Nordic conditions shows that you can take out about 70% and you should also redistribute ash and nutrients. It depends on environmental load: some parts of Sweden have high inputs of nitrogen from the air. Fertilization is also needed in some forests.

Jahn: The Bischofferode bioenergy plant uses virgin wood exclusively. If we were to use contaminated wood, the size of the plant would have to be about one-third larger and would cost about 30% more in initial investment; there would also be additional operational costs. So the decision was made to use exclusively virgin wood. There is one plant in southern Germany that uses almost exclusively contaminated wood.

On support to Peru, it's not only price, although this is important. But there must also be a long-term contract and physically available wood. You have to be in the region and you have to run the station for 20 years so that requires very secure supply, including long-term agreements on price. The cost of construction of a power plant the size of Bischofferode is about €50 million. But it is the price for wood that in the long run is the determining factor for this kind of power station.

Modern technology for processing wood residues to produce pellets and other forms of combustible products for energy generation

Dennis Werner
Amandus Kahl
Reinbek, Germany

Pelleting is a way of turning waste wood into a usable energy product. The Kahl Group is a medium-sized company that has been producing pelletizing machinery for 70 years, originally for animal feed but increasingly for fuel. We have installed more than 250 plants worldwide just for biomass applications; most of these produce pellets and ship them to power plants here in Europe.

Wood pellets are cylindrical compacted bodies with a diameter of 6–8 mm, a length of 8–30 mm, a bulk density of 650, water content less than 10% and ash content less than 0.5%. They are made from wood-industry byproducts such as woodchips, woodshavings and sawdust and are 100% wood. Why pellets? Pellets form a standardized fuel. They are highly marketable and have a thermal value 18MJ/kg, meaning that two kilograms of pellets will produce the same energy as one liter of oil. Pellets save a huge amount of space during transport and storage, taking up 4–5 times less space than sawdust.

Equipment for power generation from forest biomass, residues from wood industry and other bio-gen waste

D. Simon
Standardkessel GmbH
Guisburg,
Germany

Our company makes equipment for power generation from forest biomass, residues from wood-industry and other bio wastes and has just started to sell equipment outside Germany. The company is a mid-sized company with just over 200 employees and an annual turnover of €146 million. We build boilers and power plants for generating electricity, process heat, hot water or steam from biomass, waste materials, heat recovery and primary fuels (coal, gas, oil).

CONCLUSIONS

From the papers presented and the discussion they generated, the following conclusions emerged:

- a well-planned wood-based bioenergy sector can generate alternative or even additional revenue with which to finance sustainable forest management, improve resource-use efficiency, reduce energy costs in industry, improve energy efficiency, offset greenhouse gas emissions from the burning of fossil fuels, and provide local employment;
- the raw material supply for the wood-based bioenergy sector can be augmented by:
  - the use of residues that are currently uncollected from forest-based operations and the wood-processing industry and by the use of post-consumer waste
  - expansion of the harvested forest area in keeping with the principles of SFM
  - in the tropics, the increased use of lesser used and lesser known species
  - the greater use of woody biomass from outside the forest
  - the development of short-rotation wood-biomass crops including on marginal agricultural sites
  - the increased productivity of the resource using silvicultural and genetic innovations;
- the volume and composition of the sustainable wood resource available globally for bioenergy is not well known, in particular because a large part is harvested and used through the informal sector. There is an urgent need for reliable information on the potential for future wood mobilization for bioenergy, globally and on a country-by-country and regional basis;
- the availability of wood resources for bioenergy depends on many factors, including:
  - the awareness of resource owners and their willingness to harvest and sell their wood
  - the price that resource owners receive for their wood
  - the availability and accessibility of the resource, its proximity to appropriate infrastructure, other logistical concerns and the energy required to harvest, transport and process the wood
  - the development of transparent markets based on reliable and up-to-date information
  - the effectiveness, efficiency and economics of harvesting, marketing and energy conversion;
- one of the most sensitive economic factors in wood-based bioenergy is the distance between wood source and the site of energy generation. The use of pelleting and similar technologies can increase energy efficiency and cost-effectiveness in the transport system;
- wood production for bioenergy generation should take environmental constraints and concerns into account. Without SFM, intensified forest management could lead to the loss or degradation of natural forests and other ecosystems;
- for long-term success it is essential that the wood-based bioenergy sector is developed sustainably. It should not be an agent for the replacement of natural forests or peatlands by other land-uses and it should contribute to the sustainable management of its resource base;

- when based on assessed resource potential, wood-based bioenergy is well-suited to small- and community-scale projects and can increase farm and forest income, make productive use of marginal lands and bolster rural economies;
- wood residues are a valuable co-product in forest harvesting and wood processing. Their use for energy generation, coupled with energy savings in the industry, can improve the economic viability of forest and wood-processing operations and help finance sustainable forest management. It is evident, however, that not all forest industries, particularly in developing countries, currently use wood residues efficiently for energy;
- a greater understanding of the economic and social benefits that could be created by developing sustainable wood-residue-based bioenergy generation, combined with energy-saving measures, is needed in developing countries in the tropics;
- to help the organized wood-based bioenergy sector grow in the tropics and to maximize its contribution to sustainable development and SFM, a number of supporting mechanisms should be put in place by governments, the private sector, research and development agencies and other stakeholders; and
- north-south and south-south exchange of information and technology, and investments to foster the development of the bioenergy sector in tropical countries, are essential

RECOMMENDATIONS

Principles

- Wood-based bioenergy is a rapidly developing sector. Detailed investigation into its potential and the policy and other measures needed to stimulate it at the country level is warranted
- Measures to increase the use of wood based bioenergy must always be within the limits of SFM
- Policies affecting wood-based bioenergy, and their implementation, should not create undue market distortions
- The transfer to developing countries of energy- and resource-efficient technologies for wood-based bioenergy must be a priority

Specific recommendations

The conference made nine recommendations for international organizations, national-level policy-makers, and the wood-based bioenergy sector:

1. Assist countries in strengthening their capacity to assess, monitor and report on forest- and wood-energy-related information;
2. Convene regional fora for government, the private sector and civil society and support demonstration projects to increase awareness about the potential of efficient wood-based bioenergy and support the exchange of best practices in this field;
3. Commission regional and global studies to assess the extent to which wood-based bioenergy can substitute for fossil fuels in the energy economy;
4. Encourage and assist governments, in partnership with the private sector and other stakeholders, to formulate and implement policies and strategies to develop efficient, cost-effective and sustainable bioenergy as an alternative to fossil fuels;
5. Develop measures to increase the participation of the tropical wood-based bioenergy sector in international carbon markets and the Clean Development Mechanism of the Kyoto Protocol;
6. Investigate the creation of small-grants' schemes to stimulate local- and community-level development of wood-based bioenergy, especially in tropical countries;
7. Work with producers to identify suitable markets for wood-energy products such as charcoal, wood and charcoal pellets, briquettes and other biofuels and to ensure they meet any standards that may be required for export;
8. Support research and development, including through pre-projects and projects, into wood-based bioenergy technologies and the marketing of bioenergy, and make efficient wood-based bioenergy generation technologies available to developing countries in the tropics; and
9. Support, through projects, investment and other means, the development of integrated wood-processing industries that use wood residues to efficiently and cost-effectively generate thermal energy and electricity for both their operational needs and those of local communities.

CONFERENCE PROGRAMME

Programme

International Conference on Wood-based Bioenergy
Hannover, Germany
17 – 19 May 2007

Hosted by the Federal Ministry of Economics and Technology, Germany
Organized by ITTO in collaboration with FAO

Time	Theme	Speaker
Thursday, 17 May Venue: Room 3A, Convention Center, Hannover Exhibition Ground		
10:00	Welcome address	Mr. Hartmut Schauerte, Parliamentary State Secretary in the Federal Ministry of Economics and Technology, Germany Dr. Manoel Sobral Filho, Executive Director ITTO, Yokohama
Theme 1: Overview of the current status of wood-based bioenergy Co-Chairs:Prof. Dr. Arno Frühwald (Univ of Hamburg), & Dr. Wulf Killmann (FAO)		
10:20 –12:30	The global wood energy sector: an overview	Dr Wulf Killmann, FAO, Rome
	Challenges for sustainable tropical timber industry: utilization of wood residues and waste	Dr Hwan Ok Ma, ITTO, Yokohama
	Mobilization of wood resources for wood products and energy: challenges for sustainable forest management – outcomes of UNECE/FAO and FAO meetings	Dr. Ed Pepke and Mr. Sebastian Hetsch, FAO/UNECE, Geneva
	Policies to enhance utilization of forest biomass and wood residues for energy-generation in the EU	Jeremy Wall, European Commission, Brussels
	Technologies and economics of energy generation from logging residues and wood processing wastes	Prof. Dr. Arno Frühwald, University of Hamburg and Fed. Research Center for Forest Products (BFH), Hamburg, Germany

Conference programme continued...

Time	**Theme**	**Speaker**
	Thursday, 17 May **Theme 2: Bioenergy from wood residues, wood waste, afforestation and reforestation** **Co-Chairs: Dr. Hwan Ok Ma (ITTO), & Dr. Wulf Killmann (FAO)**	
14:00 –16:00	Increasing the efficiency in the tropical timber conversion and utilization of residues from sustainable sources in Brazil	Mr. Joesio Siqueira, Federal University of Paraná Foundation for the Development of Science, Technology & Culture, Brazil
	The potential of using wood residues for energy generation in Ghana	Dr. Daniel Sekyere, Forestry Research Institute of Ghana (FORIG)
	Wood waste to energy – from waste to wealth with a special reference to Malaysia	Dr. Hoi Why Kong, Forest Research Institute Malaysia (FRIM)
	Carbon credits from CDM fuel-switch projects replacing coal in power generation with biomass from the forest sector: a case study from Anhui, China	Prof. Dr. Gerald Kapp, GFA Consulting Group GmbH and GFA ENVEST GmbH, Hamburg
16:00 –18:10	Wood energy from afforestation and reforestation: a case study from the Pig Iron and steel industry in the State of Minas Gerais, Brazil	Mr. Jose Carlos Carvalho, State Secretary for Environment and Sustainable Development, State of Minas Gerais, Brazil
	Efficient co-generation of energy products in pulp industry	Prof Leif Gustavsson, Mid Sweden University, Östersund, Sweden
	Co-generation of energy from wood working industry: a case study from a medium wood-based bioenergy plant (20 MW) in Piesteritz, Germany	Mr. Andreas Jahn, Endico - Stadtwerke, Leipzig, Germany
	Theme 3: Conclusions and recommendations **Moderator: Mr. Alastair Sarre (ITTO)**	
18:10 –18:30	Conclusions and recommendations of the Conference Closing remarks	Mr. Alastair Sarre (ITTO), Dr. Wulf Killmann (FAO)
	Cocktail reception	Offered by the Federal Ministry of Economics and Technology, Germany

Conference programme continued...

Time	Theme	Speaker
Friday, 18 May **Technology in bioenergy production from wood residues** **Venue: Room 3A, Convention Center, Hannover Exhibition Ground** **Moderators: Dr. Peter Schröder (Germany) & Mr. Dominik Wolfschütz (VDMA)**		
9:30 –12:00	**Presentations from selected exhibitors at LIGNA+ 2007**	
	Generating heat and other forms of energy from wood with modern combustion technology	Mr. Carsten Brüggemann, (Agricultural Association, LWK Niedersachsen), 30002 Hannover
	Recent technology for finger jointing for value-added processing of wood residues; use of wood pellets and wood chips for generation of energy	Mr. Uwe Schiemann, GreCon-Dimter-Weiing, Alfeld
	Modern technology for processing of wood residues to produce pellets and other forms of combustible products for generation of energy	Mr. Dennis Werner, Amandus Kahl GmbH&Co.KG 21465 Reinbek
	Equipment for power generation from forest biomass, residues from wood-industry and other bio-gen waste (2-25 MW)	Mr. D. Simon Standardkessel GmbH, 47138 Duisburg
Guided visit to LIGNA+ 2007 focusing on technology in bioenergy production from wood residues **Moderators: Dr. Peter Schröder (Germany) & Mr. D. Wolfschütz (VDMA)**		
13:30 –16:00	Visit to selected exhibitors and displays at LIGNA+ 2007	
	Presentation "energy from wood" at "Freigelände" of LIGNA	Mr Brüggemann (Agricultural Association-Hannover)
	Demonstration Center for renewable energies -IDEE- Olsberg, NRW)	Mr. Schwarz, IDEE
	- Amandus Kahl GmbH - Standardkessel GmbH - Maxxtec - Fagus-GreCon	Hall 13 E02 Hall 13 D68 Hall 13 F32 Hall 12 B/48/K48/D48/E48

Time	Theme	Speaker
Saturday, 19 May **Optional study visit to selected bioenergy related projects near Hannover** **Moderator: Dr. Peter Schröder (Germany)**		
9:30 –11:00	Visit of FAGUS-GreCon Plant (Weinig-Group)at Alfeld/Leine	Mr. Jürgen Bartels Fagus-GreCon Website: www.fagus-gropius.com
11:50 –15:10	Visit of "Bio-energy village Jühnde" 37127 Jühnde, Germany	Mr. Paffenholz (05502-300053); Mr. Fangmeier (Eckhard.Fangmeier@ bioenergiedorf.de) Bioenergy Village Jühnde Co-op Website: www.bioenergiedorf.dea

LIST OF PARTICIPANTS

International Conference on Wood-Based Bioenergy

Hannover, Germany, 17-19 May 2007

1. ABDULLAH, Hamidah
Malaysian Timber Council, Kuala Lumpur, Malaysia
hamidah@mtc.com.my

2. ADOBO, Ernesto
Department of Environment and Natural Resources, Zamboanga City, Philippines
Ernesto_dadobojr@yahoo.com.ph

3. ALVES, Marcus
Brazilian Institute of Environment and Renewable Resources, Brasilia, Brazil
marcus.alves@ibama.gov.br

4. AMENDOEIRA, Pedro Santos
Portugal
pamendoeira@grupo-catarino.pt

5. ANTELO, Pablo
Cámara Forestal de Bolivia, Santa Cruz, Bolivia
pantelo@lachonta.com

6. BAHNE, Thorsten
WestLB Trust, Duesseldorf, Germany
thorsten.bahne@westlbtrust.com

7. BATTISTELLA, Gilberto
Brazilian Association for Mechanically Processed Timber, Curitiba, Brazil
abimci@abimci.com.br

8. BONNY, Douadio
Eugene Ministère de l'Environnement et Eaux et Forêts, Abidjan, Côte d'Ivoire
gustapata@yahoo.fr

9. BOONTHAMRONGKIT, Khomwit S
BP Timber Group, Pratumtani, Thailand
kboontha@hotmail.com

10. BRÜGGEMANN, Carsten
Agricultural Association, LWK Niedersachsen, Hannover, Germany

11. BÜCHEL, Karl
Forest and certification, Hannover, Germany
karl.buechel@gmx.net

12. BUHOLZER, Christoph
Precious Woods, Zurich, Switzerland
christoph.buholzer@preciouswoods.com

13. CARRASCO, Jorge
Aglomerados Cotopaxi, S.A., Quito, Ecuador
jcarrasco@cotopaxi.com.ec

14. CARVALHO, Jose
Carlos State Secretariat of Environment and Sustainable Development, Belo Horizonte, Brazil
jcc@semad.mg.gov.br

15. CATARINO, Jorge
Grupo Catarino, Febres, Portugal
jcatarino@grupo-catarino.pt

16. CHANDRA, Jimmy
ITTO Project PD 286/04 Rev.1 (I) – " Strengthening the Capacity to Promote Efficient Wood Processing Technologies in Indonesia", Jakarta, Indonesia
inteak@cbn.net.id

17. CHOI, Don-Ha
Korea Forest Research Institute, Seoul, Rep. of Korea
cdonha@foa.go.kr

18. EISENSTADT, Keith
'Keegan' CO2OL, Missoula, Montana, U.S.A.
keegan@co2ol-usa.com

19. EKE, Andreas
Futuro Forestal, Panama City, Panama
ae@futuroforestal.com

20. ELIZONDO, Rodrigo
Forestal La Reforma, S.A., Monterrey, Mexico
relizondo@grupolareforma.com

21. FISCHBEIN, Nils
Martin German Development Service (DED), Bonn, Germany
nils.fischbein@web.de

22. FRÜHWALD, Arno
University of Hamburg, Hamburg, Germany
fruhwald@holz.uni-hamburg.de

23. **GONZALES MORA, Héctor Enrique**
Universidad Nacional Agraria La Molina,
Lima, Peru
egonzales@lamolina.edu.pe

24. **GUSTAVSOON, Leif**
Mid Sweden University, Östersund, Sweden
leif.gustavsson@miun.se

25. **HETSCH, Sebastian**
UNECE/FAO Timber Section,
Geneva, Switzerland
Sebastian.hetsch@unece.org

26. **HESS, Jürgen**
GTZ- German Agency for Technical
Development, Germany

27. **HOI, Why Kong**
Forest Research Institute Malaysia,
Kuala Lumpur, Malaysia
hoiwhykong@yahoo.com, hoiwk@frim.gov.my

28. **JAHN, Andreas**
Stadtwerke Leipzig GmbH (SWL),
Leipizg, Germany
ajahn@t-online.de

29. **JAUCH, Dieter**
Eurowood, Oberndorf, Germany
redaktion@eurowood.info

30. **JETTER, Inga**
AS Solar GmbH, Hannover, Germany

31. **KAPP, Gerald**
GFA-ENVEST, Hamburg, Germany
geraldkapp@gfa-envest.com

32. **KEHR, Karl Consultant,**
The World Bank, Washington, D.C., U.S.A.
cmfkehr@aol.com

33. **KILLMANN, Wulf**
FAO-Forest Products and Industry Division,
Rome
Wulf.Killmann@fao.org

34. **KINGUE SOBGOUM, Joseph**
SFID Groupe Rougier, Mbang, Cameroon
jskingue@yahoo.fr

35. **KOH, Mok-Poh**
Forest Research Institute Malaysia,
Kuala Lumpur, Malaysia
kohmp@frim.gov.my

36. **KOLJONEN, Katja**
Newspaper Maaseudun Tulevalsuus,
Helsinki, Finland
katja.koljonen@maaseuduntulevalsuus.fi

37. **KOLK, Jan-Peter**
Carl Kliem Corporate Finance GmbH,
Kronberg, Germany
jpkolk@kliem.de

38. **KUDLICH, Wolfram**
Wald21, Mainz, Germany
kudlich@wald21.com

39. **KÜRSTEN, Ernst**
Wood Report GmbH, Hannover, Germany
e.kuersten@t-online.de

40. **KUWAHARA, Masato**
Fuso Ltd., Sakurai City, Nara Prefecture, Japan
mastao@fuso.ltd

41. **LAUZON, David**
Lauzon Distinctive Hardwood Flooring,
Quebec, Canada
david.lauzon@lauzonltd.com

42. **LEE, Hua Seng**
Sarawak Timber Association, Kuching,
Sarawak, Malaysia
hslee@sta.org.my

43. **LEHRINGER, Christian**
Universität Hamburg, Hamburg, Germany
christianlehringer@gmx.de

44. **LIESE, Walter**
Universität Hamburg, Hamburg, Germany
Wliese@aol.com

45. **MAGEL, Elisabeth**
University of Hamburg, Hamburg, Germany
elisabeth.magel@uni-hamburg.de

46. **MASSANO, Paolo**
R.D.3, Fossano, Italy
paolomassano@hotmail.com

47. **MÜLLER, Mirjam**
Greenpeace, Hamburg, Germany
mirjam.mueller@greenpeace.de

48. NAKAU, Charles
Appropriate Technology & Community Development Institute, Lae, Papua New Guinea
cnakau@atcdi.unitech.ac.pg

49. NAMBAÏ, Rubens
Ministère des Eaux et Forêts, Environnement, Bangui, Central African Republic
nambairubens@yahoo.fr

50. NIETO, Dolores
Forum de Desenvolvimento Sustentavel do Acre, Rio Branco, Acre, Brazil
nieto.dolores@gmail.com

51. NTSAME-OKWO, Célestine
Ministère de l'Economie Forestière, des Eaux de la Pêche et des Parcs, Libreville, Gabon
nocmc@yahoo.fr

52. OLIVEIRA, Rogério
ICED – International Company for Eucalyptus, Florianópolis, Brazil
rocrissa@terra.com.br

53. OONJITTICHAU, Woratham
Royal Forest Department, Bangkok, Thailand
woratham@yahoo.com

54. OURO-DJERI, Essowe
Ministère de l'Environnement et des Ressources Forestières, Lomé, Togo
ouroadam@yahoo.fr

55. PASTORE, Floriano Jr.
University of Brasilia, Brasilia, Brazil
fpastorej@gmail.com, pastore@unb.br

56. PEPKE, Ed
Food and Agriculture Organization of the United Nations (FAO), UN Economic Commission for Europe, Geneva, Switzerland
ed.pepke@unece.org

57. PESCE, Fabio
Fortea Studio Associato, Torino, Italy
fortea.bureau@fortea.eu

58. POPOOLA, Labode
University of Ibadan, Ibadan, Nigeria
labopopoola@yahoo.com

59. POUNA, Emmanuel
Ministry of Forestry and Wildlife, Yaoundé, Cameroon
epouna@yahoo.fr

60. REICHERT, Joachim
Federal Ministry of Economics and Technology, Berlin, Germany
joachim.reichert@bmwi.bund.de

61. RODRIGUEZ COMBELLER, Carlos
Comisión Nacional Forestal, Zapopan, Jalisco, Mexico
ccombeller@conafor.gob.mx

62. ROTTER, Richard
Pilones de Antigua, S.A., Antigua, Guatemala
rotterrichard@yahoo.com

63. SCHAUERTE, Hartmut
Parliamentary Secretary of State in the Federal Ministry of Economics and Technology, Germany

64. SCHIEMANN, Uwe
GreCon-Dimter-Weinig, Alfeld, Germany

65. SEEPERSAD, John
Ministry of Public Utilities and the Environment, Port of Spain, Trinidad y Tobago
forestry@tstt.net.tt

66. SEKYERE, Daniel
Forestry Research Institute of Ghana, Kumasi, Ghana
dsekyere@forig.org

67. SERRANO, Olman
Food and Agriculture Organization of the United Nations (FAO), Rome, Italy
Olman.Serrano@fao.org

68. SHERRARD, Alan
Elmia AB, Jönköping, Sweden
alan.sherrard@elmia.se

69. SIMON, Detlef
Standardkessel, Duisburg, Germany
dsimon@standardkessel.de

70. SIQUEIRA, Joésio
STCP Engenharia de Projetos Ltda., Curitiba, Brazil
joesio@stcp.com.br

71. STENMANNS, Frank
GFA Consulting Gmbh, Hamburg, Germany
fstenmanns@compuserve.com

72. SUDRADJAT
Centre for Forest Products Research, Bogor, West Java, Indonesia
prof_sudradjat@yahoo.com

73. SUKIMAN
ITTO Project PD 286/04 Rev.1 (I) – "Strengthening the Capacity to Promote Efficient Wood Processing Technologies in Indonesia", Jakarta, Indonesia
namuindah@hanmail.net

74. SUN TRA, Hang
Forest Industry and Trade Development Office, Forestry Administration, Phnom Penh, Cambodia
hsuntra@yahoo.com

75. TANGKETASIK, Jansen
Forest Products & Wood Resource Control, Ministry of Forestry, Jakarta, Indonesia
jansen_57@yahoo.com

76. TANGSIRICHIT, Yongyutt
Phoenix Pulp & Paper Plc. Khon Kaen, Thailand
yongyutt@phoenixpulp.com

77. TOLEDO, Enrique
Fondo de Promoción del Desarrollo Forestal, Lima, Peru
etoledo@fondebosque.org.pe

78. TORRES ENRIQUEZ, Ramón Carlos
Secretaría de Energía, Mexico City, Mexico
ctorres@energia.gob.mx

79. UNCOVSKY, Stepan
GTZ – Gesellschaft für Technische Zusammenarbeit GmbH, Eschborn, Germany
stepan.uncovsky@gtz.de

80. VASQUEZ, Mary Anne
Philippine Wood Producers Association, Makati City, Philippines
mailav@netscape.net, pwpa@greendot.com.ph

81. VIANA, Jorge
Forum de Desenvolvimento Sustentavel do Acre, Rio Branco, Brazil
jviana.ac@uol.com.br

82. WALL, Jeremy
European Commission, Brussels, Belgium
jeremy.wall@ec.europa.eu

83. WALTI, Gérald
Precious Woods, Zurich, Switzerland
gerald.walti@preciouswoods.com

84. WERNER, Dennis
Amandus Kahl GmbH, Hamburg, Germany
werner@amandus-kahl-group.de

85. WIDMER, Bruno
SGS, Geneva, Switzerland
bruno.widmer@sgs.com

86. WONG, Tuck Meng
Malaysian Timber Council, Cheras, Malaysia
wong@mtc.com.my

ITTO SECRETARIAT

SOBRAL FILHO, Manoel
Executive Director

MAYURA, Charas
Finance/Administrative Officer, Management Services

MA, Hwan-Ok
Projects Manager, Forest Industry

HANASHIRO, Patricia
Programme Officer, Office of the Executive Director

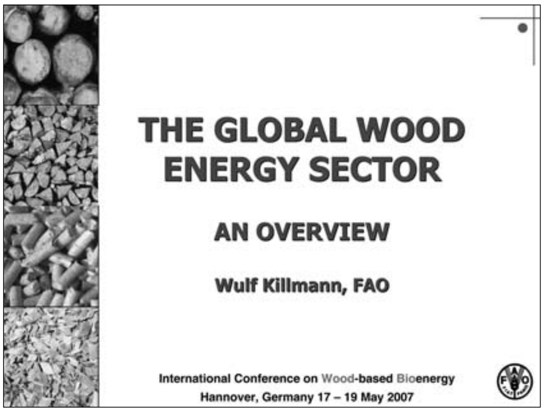
SARRE, Alastair
Consultant

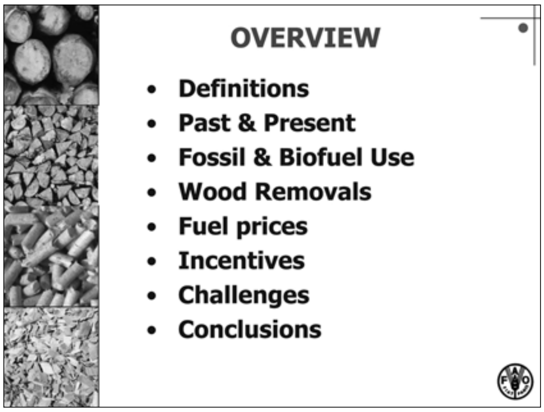
SCHROEDER, Peter
Consultant

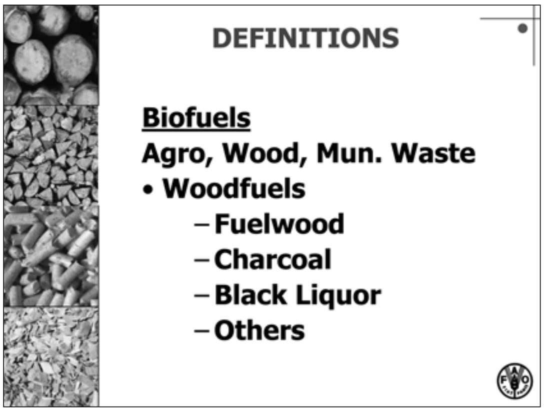
PRESENTATION SLIDES

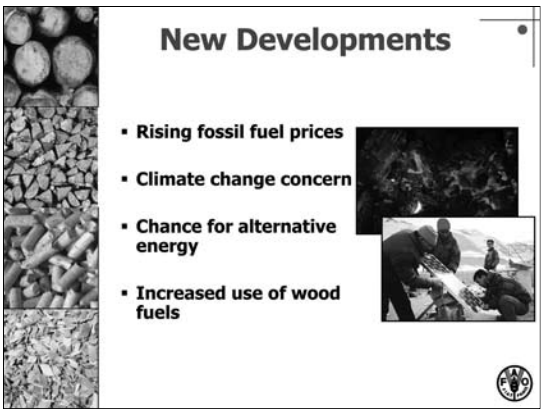
The Global Wood Energy Sector: An Overview

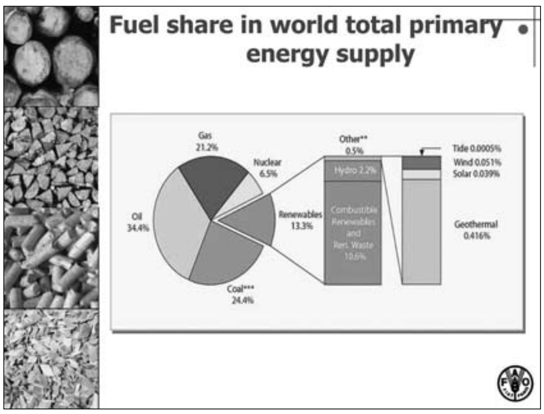
Dr Wulf Killmann, FAO, Rome



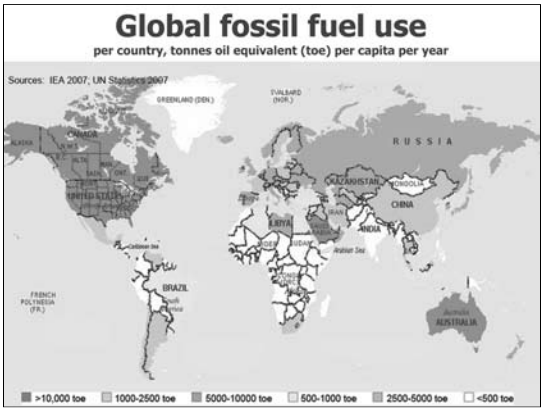


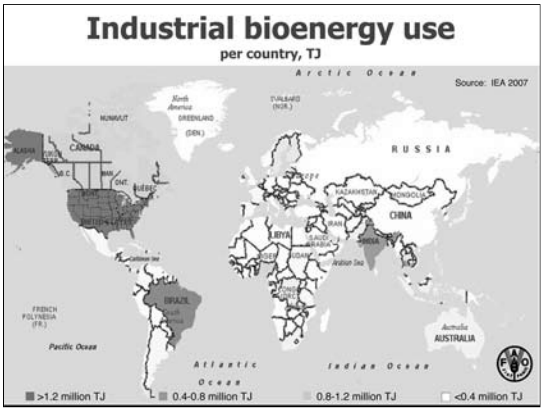


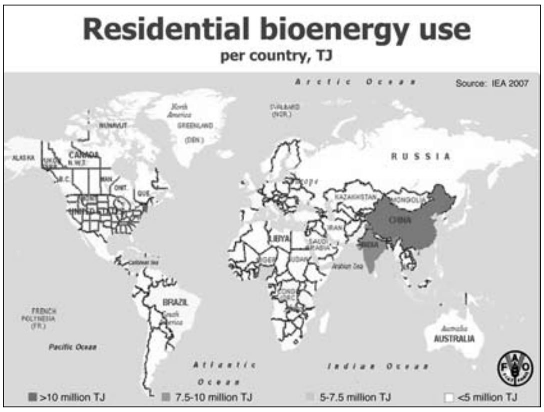


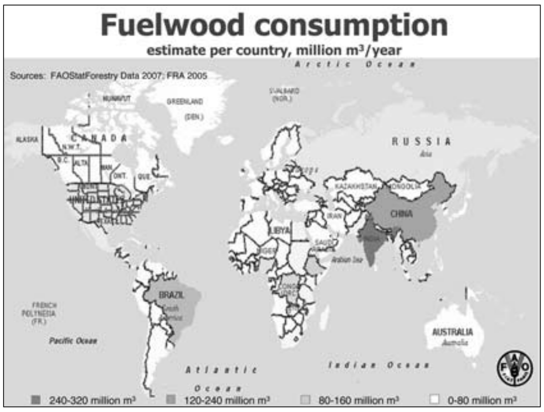


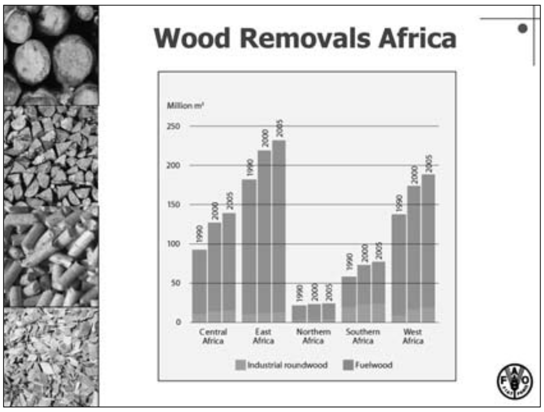
The Global Wood Energy Sector: An Overview (continued)



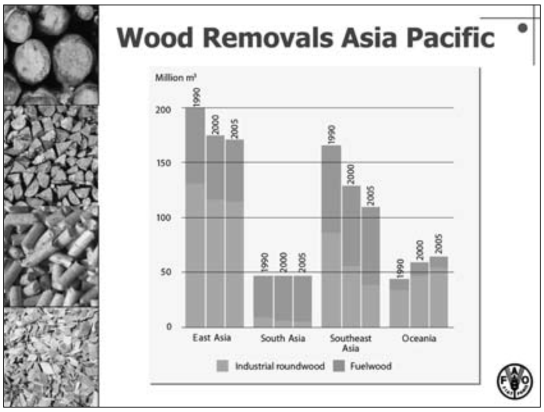


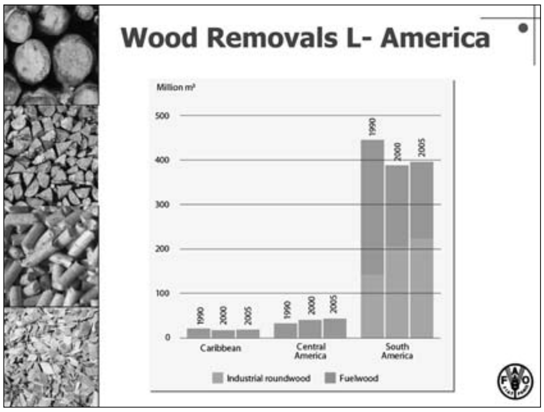


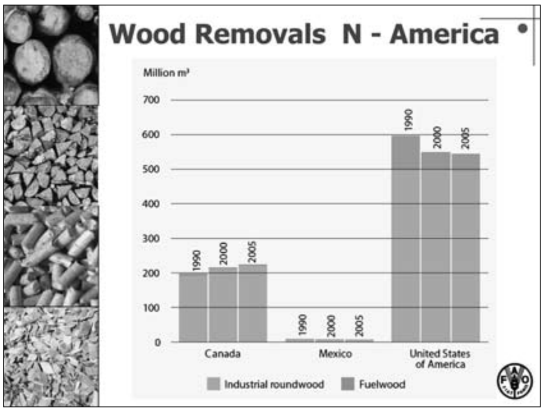


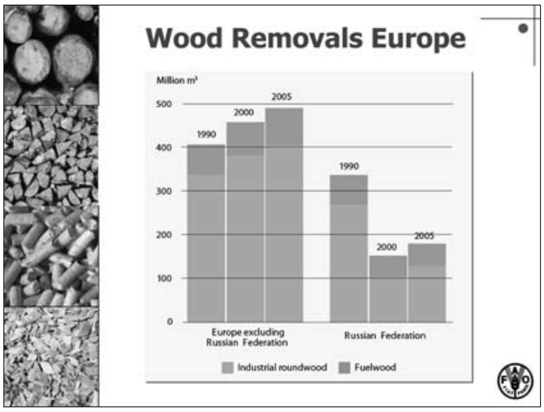


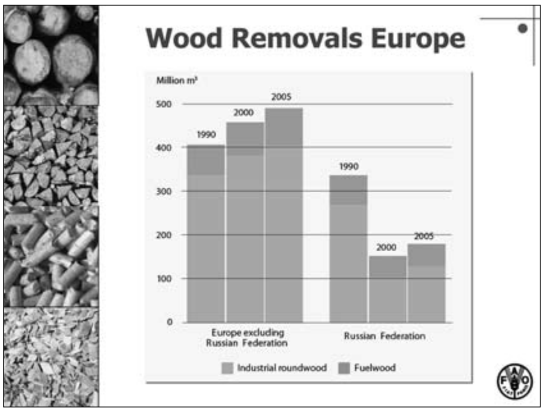
The Global Wood Energy Sector: An Overview (continued)

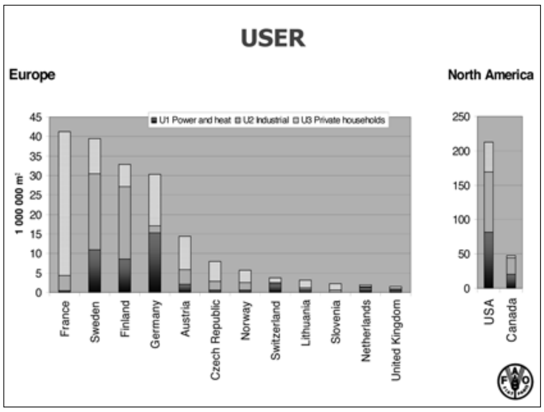




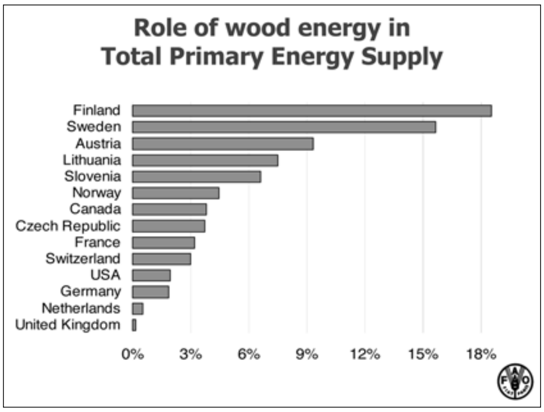


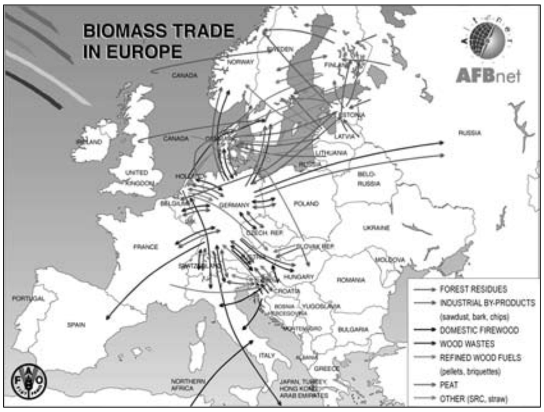


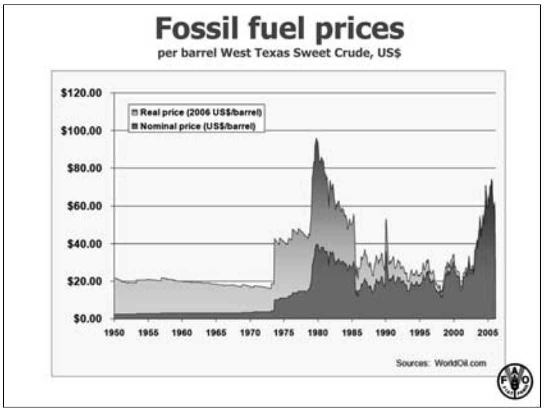


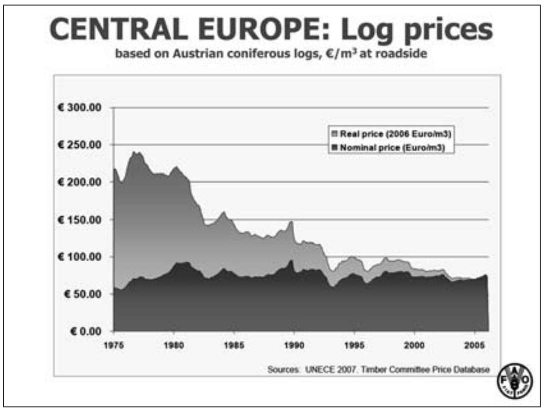


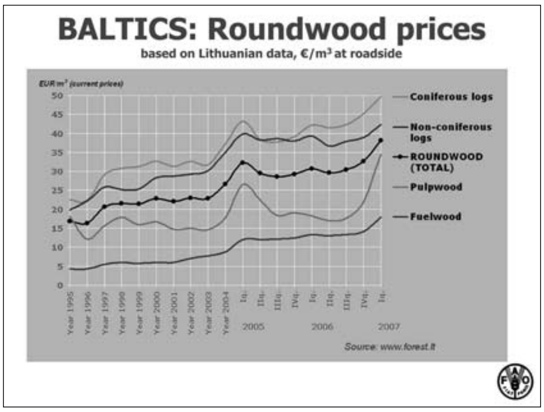
The Global Wood Energy Sector: An Overview (continued)

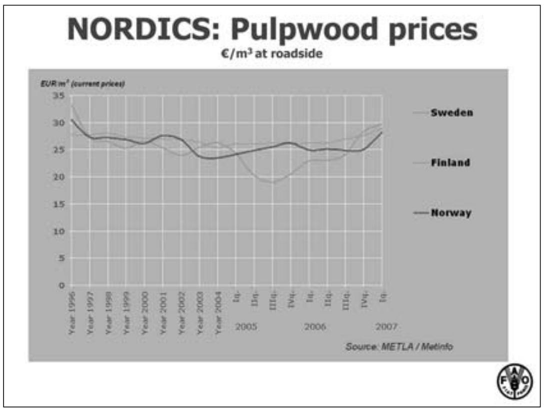




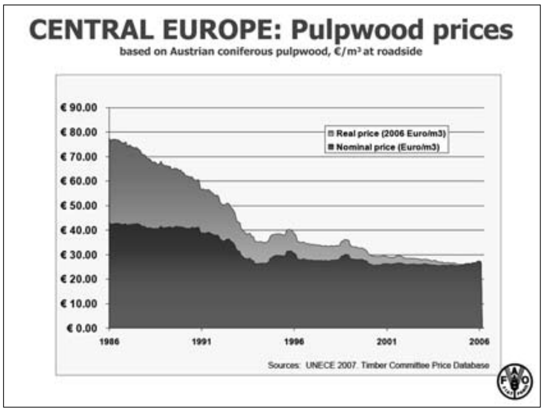


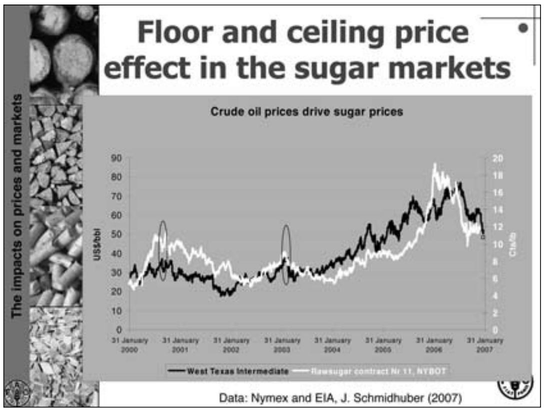


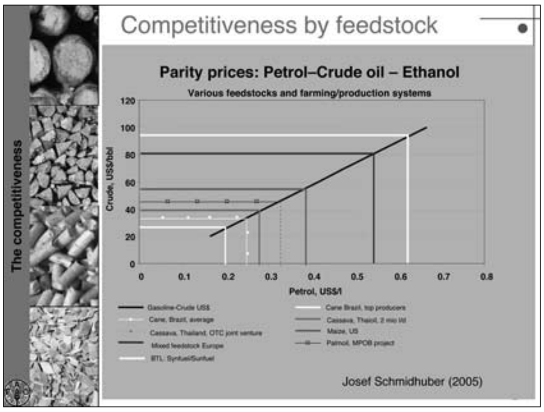


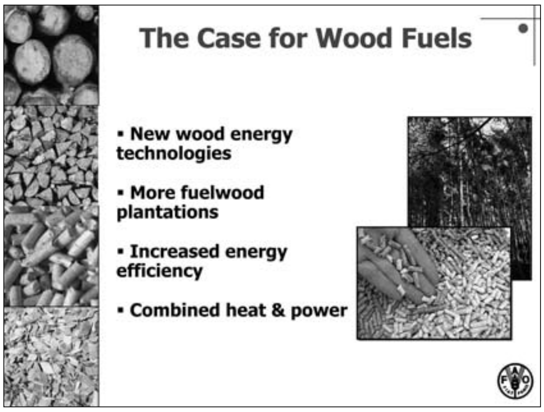


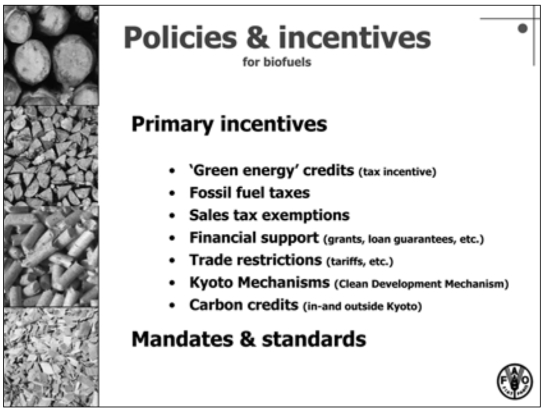
The Global Wood Energy Sector: An Overview (continued)

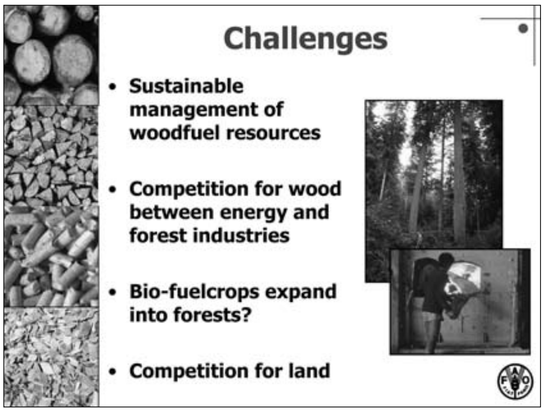




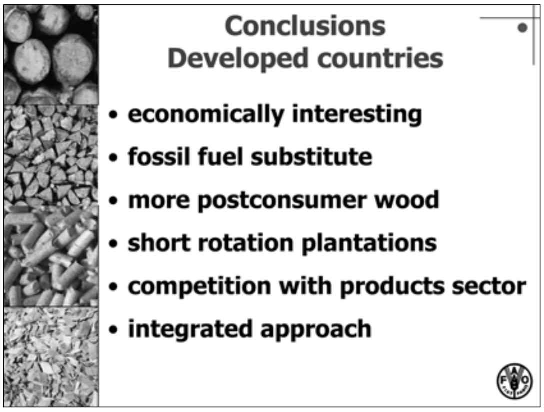






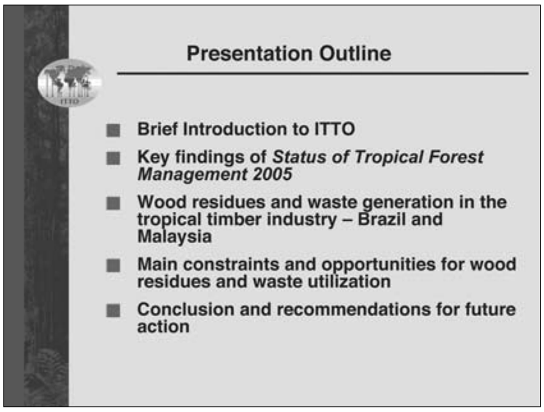


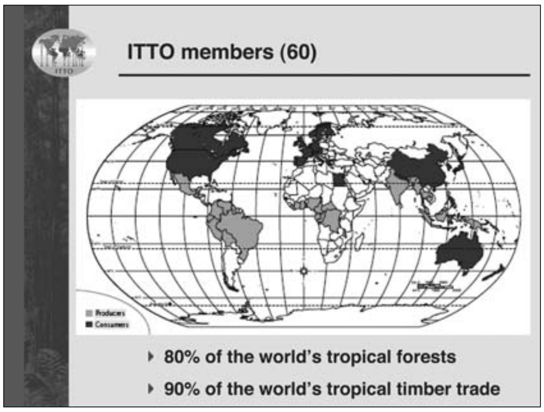
The Global Wood Energy Sector: An Overview (continued)

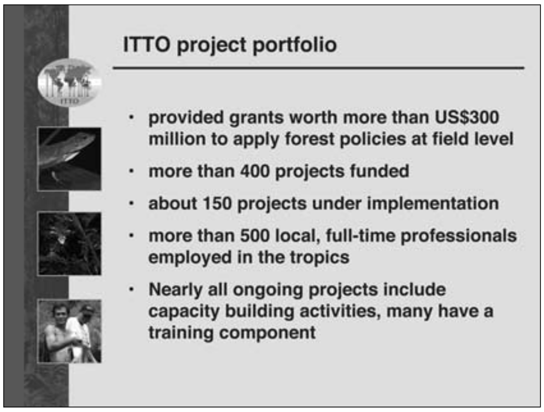


Challenges for Sustainable Tropical Timber Industry: Utilization of Wood Residues and Waste

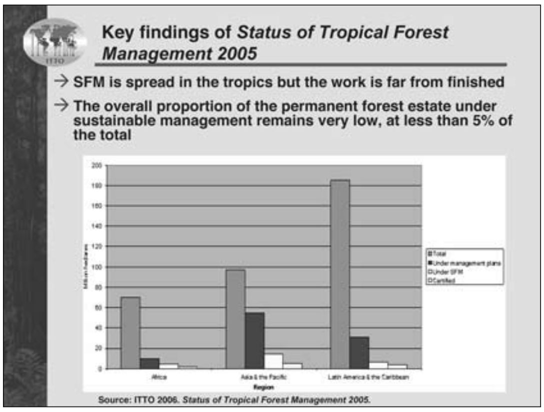
Dr Hwan Ok Ma, ITTO, Yokohama

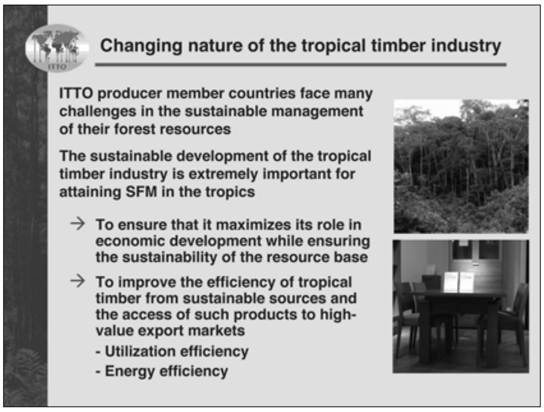


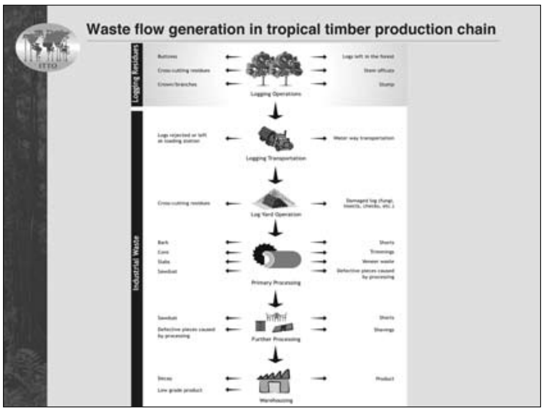


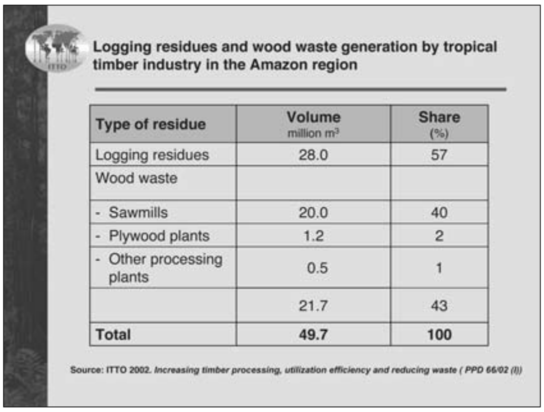


Challenges for Sustainable Tropical Timber Industry: Utilization of Wood Residues and Waste (continued)



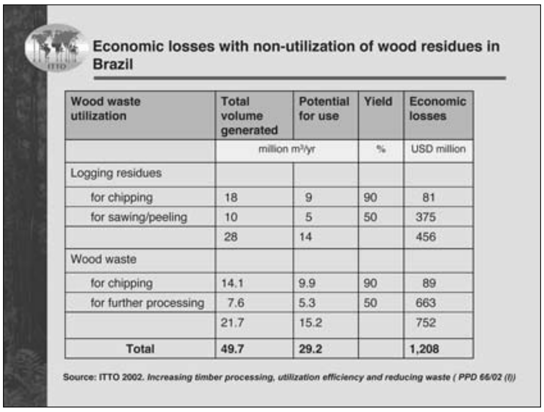





Logging residues and wood waste generation by tropical timber industry in the Amazon region

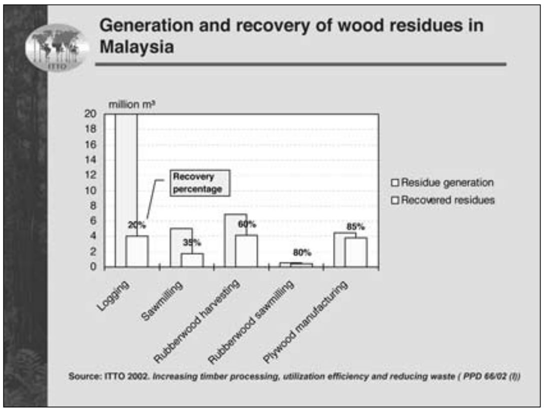
Type of residue	Volume million m³	Share (%)
Logging residues	28.0	57
Wood waste		
- Sawmills	20.0	40
- Plywood plants	1.2	2
- Other processing plants	0.5	1
	21.7	43
Total	**49.7**	**100**

Source: ITTO 2002. *Increasing timber processing, utilization efficiency and reducing waste (PPD 66/02 (I))*


Economic losses with non-utilization of wood residues in Brazil

Wood waste utilization	Total volume generated	Potential for use	Yield	Economic losses
	million m³/yr		%	USD million
Logging residues				
for chipping	18	9	90	81
for sawing/peeling	10	5	50	375
	28	14		456
Wood waste				
for chipping	14.1	9.9	90	89
for further processing	7.6	5.3	50	663
	21.7	15.2		752
Total	**49.7**	**29.2**		**1,208**

Source: ITTO 2002. *Increasing timber processing, utilization efficiency and reducing waste (PPD 66/02 (I))*



Challenges for Sustainable Tropical Timber Industry: Utilization of Wood Residues and Waste (continued)

Generation and recovery of wood residues in Malaysia in 2002

Sector	Total residues	Un-utilized	Un-utilized residues	Share
	million m³	%	million m³	%
Logging	20	80	16	70
Sawmilling	5	65	3.3	14
Rubberwood harvesting	6.9	60	2.7	12
Rubberwood sawmilling	0.6	20	0.1	1
Plywood making	4.5	15	0.7	3
Total	**37**	**62**	**22.8**	**100**

Source: ITTO 2002. *Increasing timber processing, utilization efficiency and reducing waste (PPD 66/02 (I))*

Main constraints limiting wood residues and waste utilization

- The economic returns
- Production sites far from possible markets
- Lack of incentives for wood-waste utilization
- Lack of know-how on residue and waste utilization knowledge and technologies
- Inadequate enforcement of environmental regulations
- Lack of vertical and horizontal integration in business strategies
- Lack of adoption of sustainable forest management practices

Energy production from wood residues and waste

Conversion of wood to different types of bioenergy through direct combustion, pyrolysis, densification, gasification and ethanol production

→ Charcoal
→ Pellets and briquettes
→ Energy production at sawmills
→ Energy production in co-generation plants
→ Biofuels

A Warming Trend for Putting Wood Waste to Work as Fuel

Climate Concerns Spur New Interest In 'Bio-Oil' Efforts

Washington Post
Friday, April 20, 2007; Page A25

http://www.washingtonpost.com/wp-dyn/content/article/2007/04/19/AR2007041902519.html

Utilization of wood waste in Brazil

Most wood residues and waste generated at the tropical timber industry in Brazil is burnt or accumulated at mill sites.

Improvements on waste utilization:

- generating thermal energy is increasing at medium and large-sized mills
- independent power producers using wood waste are increasing to produce and sell electricity South-South cooperation
- many timber industries are using wood waste for their own electricity - replacement of diesel (small diesel generators) by wood waste
  - costs of electricity (around USD 0.11 per kWh-diesel, USD0.04 per kWh-wood waste)
  - carbon credits under the Kyoto Protocol

→ Energy generation not only makes electricity but also contributes to improving environmental conditions – smoke reduction, avoiding rivers and soil pollution

Opportunities for production of celluosic ethanol in the tropics?

Bad, good and best ethanol

Corn-based ethanol is neither cheap nor green. Needs much energy to produce

Sugar ethanol is good. It produces far more energy than is needed to grow it.

→ There is a brighter prospect: cellulosic ethanol. It is made from feedstocks rich in cellulose such as wood, …..

→ Cellulosic ethanol would be more energy-efficient to produce than sugar ethanol

The Economist: April 7th 2007; Page12

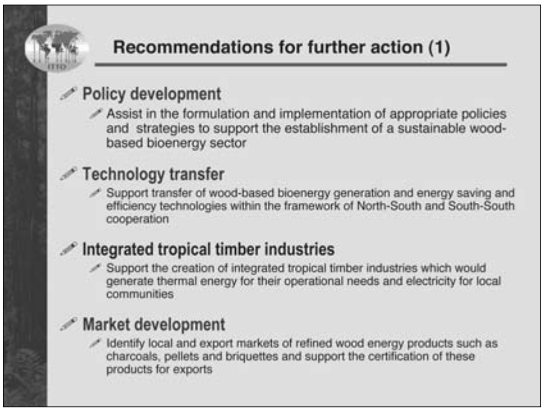
http://www.ornl.gov/info/ornlreview/v40_1_07/cover_story.shtml

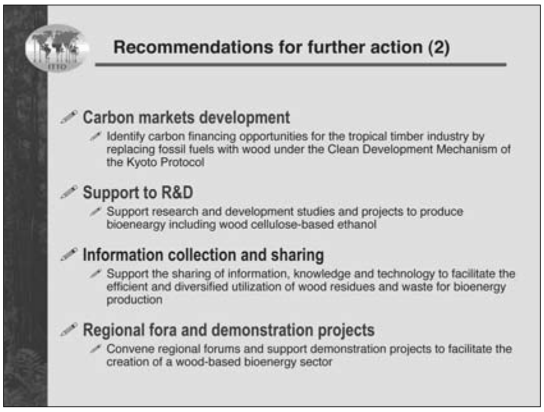
Conclusion

→ Bioenergy offers a number of opportunities to the tropical timber industry sector

→ Wood residues and waste should be considered valuable by-products to capture the environmental and financial benefits of bioenergy

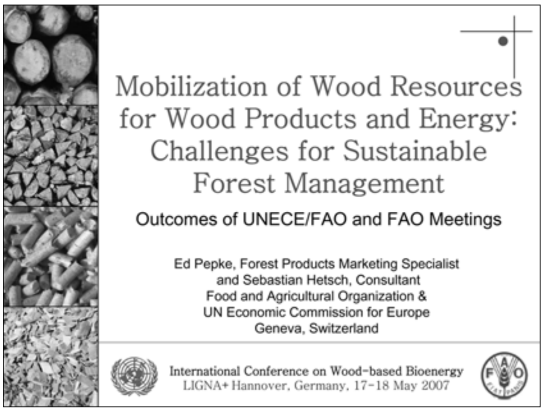
Challenges for Sustainable Tropical Timber Industry: Utilization of Wood Residues and Waste (continued)

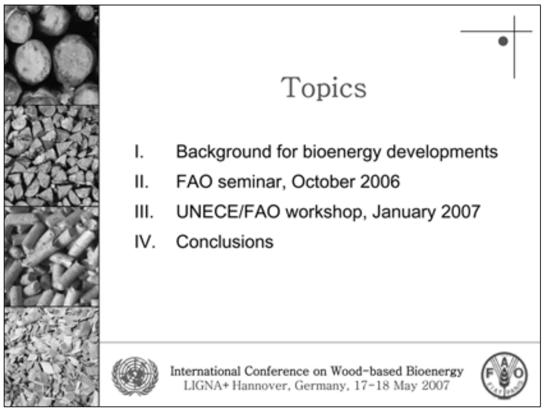


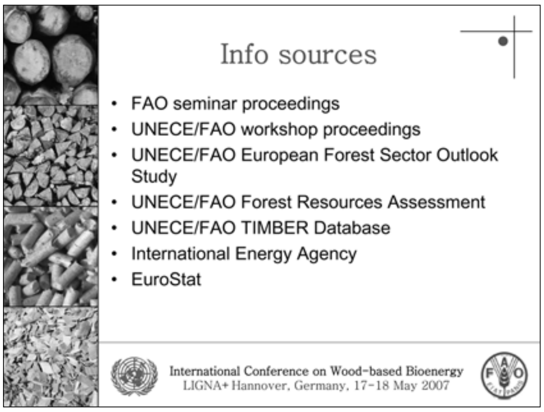


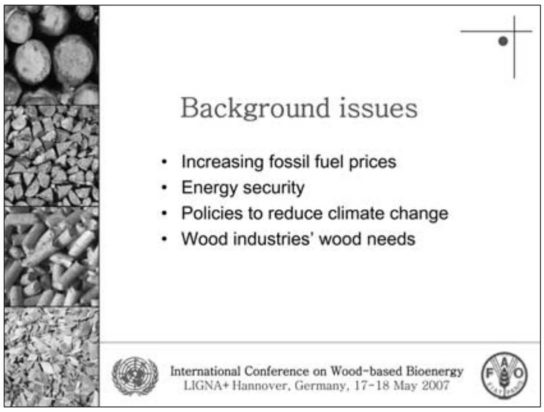
Mobilization of Wood Resources for Wood Products and Energy: Challenges for Sustainable Forest Management

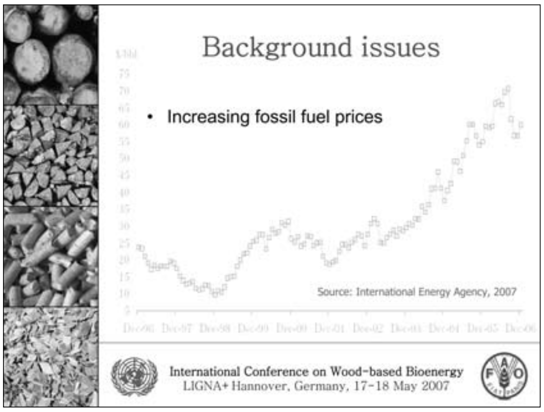
Dr. Ed Pepke and Mr. Sebastian Hetsch, FAO/UNECE, Geneva

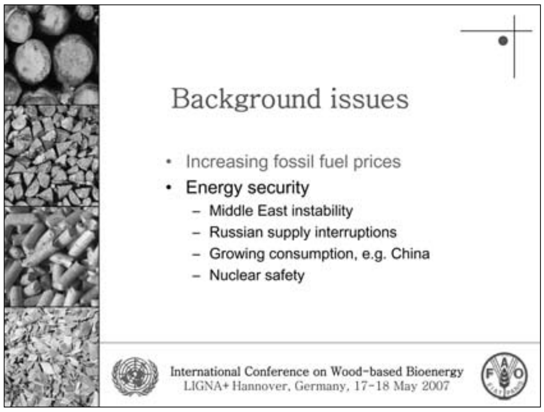




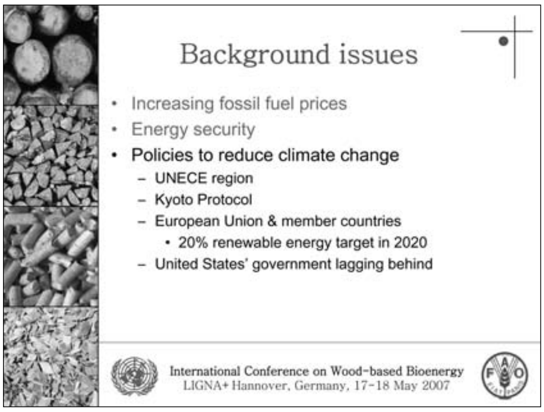


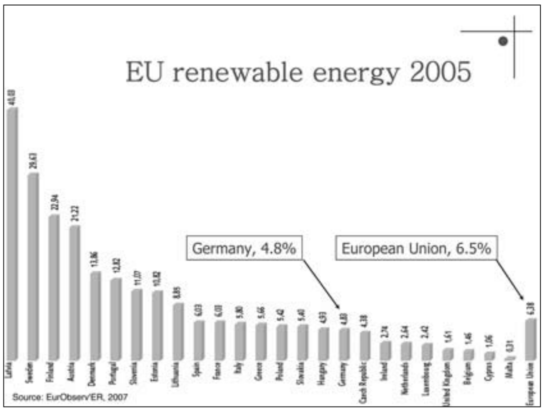


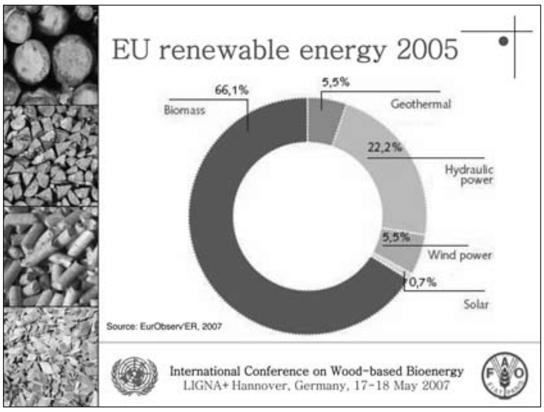


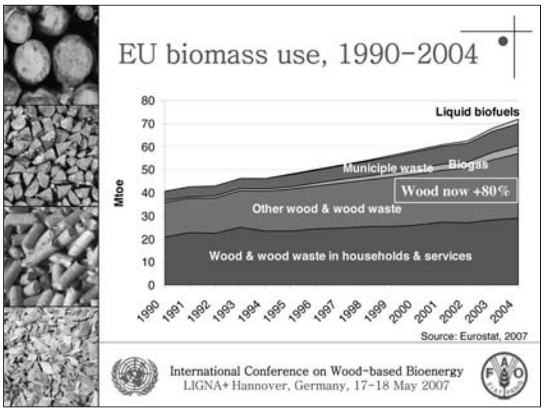


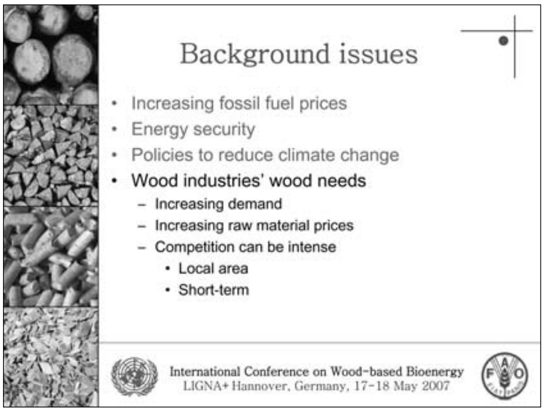
Mobilization of Wood Resources for Wood Products and Energy: Challenges for Sustainable Forest Management (continued)

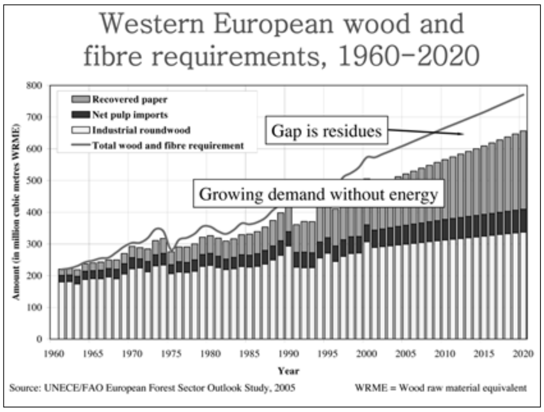












Mobilization of Wood Resources for Wood Products and Energy: Challenges for Sustainable Forest Management (continued)

Supply and demand dilemma in *western* Europe in 2010

- Wood and paper industry – 312 million m³ (wood raw material equivalent)
- Energy sector – 210 million m³ (based on EU targets)
- Forests' annual growth – 505 million m³ (net annual increment on forests available for wood supply)

International Conference on Wood-based Bioenergy
LIGNA+ Hannover, Germany, 17–18 May 2007

Supply and demand dilemma in Europe in 2010

	Western Europe[2]		Eastern Europe[2]	
	2000	2010	2000	2010
Industrial roundwood consumption	271	312	81	107
Energy targets (direct wood energy only)	139	210	114	?
Total direct wood supply for industry and energy	411	522	195	?
Net annual increment on forest available for wood supply (NB NOT directly comparable!)	515	505	230	219

[1][million m³WRME/year]
[2]EFSOS country groups (new EU members are i
[3]Very rough estimation on basis of EU25 Biomas

NAI not only source. Wood outside forests. Recovered wood too, e.g. 12 MM m³ in Germany

Source: UNECE/FAO European Forest Sector Outlook Study, 2005 and EU, 2007

International Conference on Wood-based Bioenergy
LIGNA+ Hannover, Germany, 17–18 May 2007

International Seminar on Energy and the Forest Products Industry

October 2006, Rome

FAO, IEA, ICFPA, UNECE, ITTO, WBCSD

International Conference on Wood-based Bioenergy
LIGNA+ Hannover, Germany, 17–18 May 2007

Energy and the Forest Products Industry Seminar

- Themes
  - Energy policies and trends
  - Role of wood as an energy source
  - Energy and material efficiency in the forest products industry
- Building on results of technical workshop on new technologies and systems leading to energy efficiency and CO_2 emissions reduction in pulp and paper industry

International Conference on Wood-based Bioenergy
LIGNA+ Hannover, Germany, 17–18 May 2007

Energy & industry seminar conclusions

- Integrated and balanced energy and forest policies mitigate climate change
- Local actions with global vision
- Stable, sustainable regulatory frameworks needed for level playing field

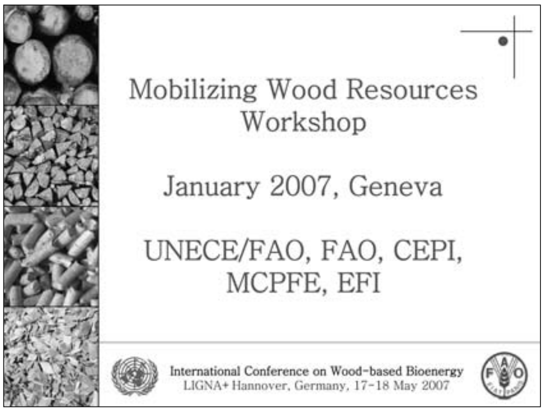
International Conference on Wood-based Bioenergy
LIGNA+ Hannover, Germany, 17–18 May 2007

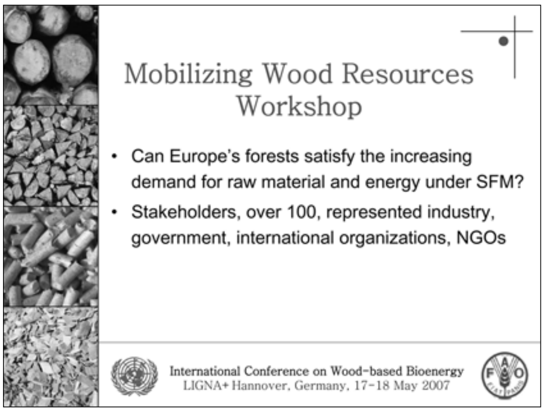
Energy & industry seminar conclusions

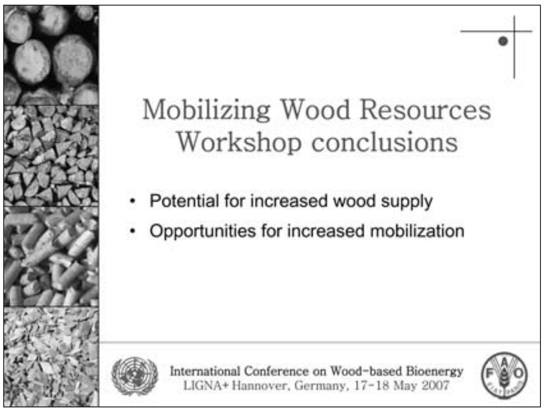
- Forest products industry combats climate change by
  - Optimizing raw material usage
  - Increasing efficiency
  - Producing bioenergy
  - Expanding into biofuel production
  - Improving sector competitiveness
- Forest products industry could be a net supplier of energy

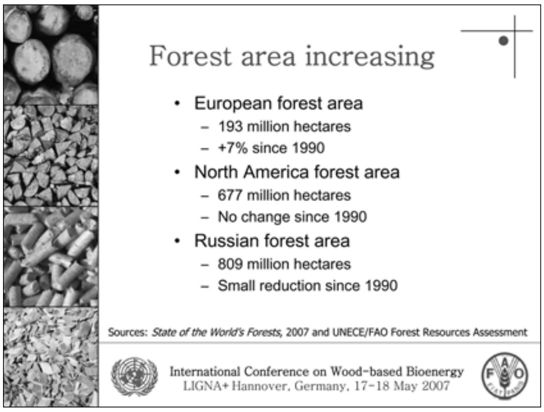
International Conference on Wood-based Bioenergy
LIGNA+ Hannover, Germany, 17–18 May 2007

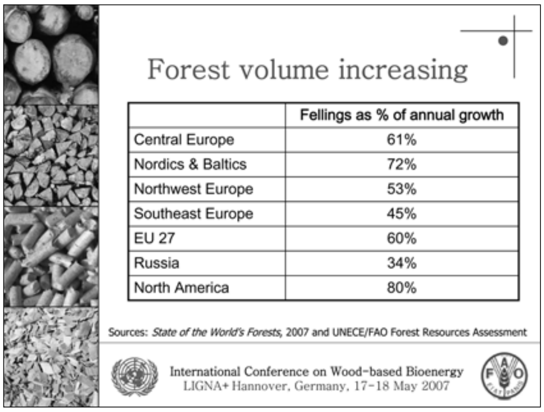
Mobilization of Wood Resources for Wood Products and Energy: Challenges for Sustainable Forest Management (continued)





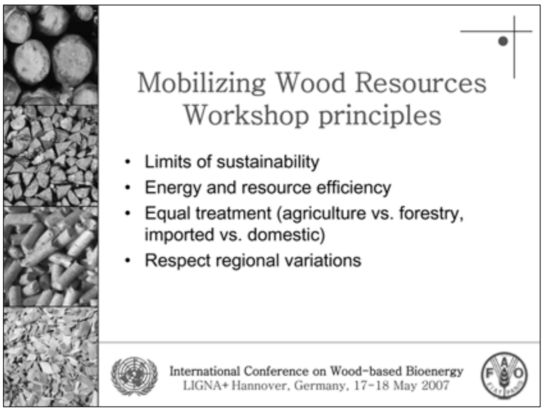


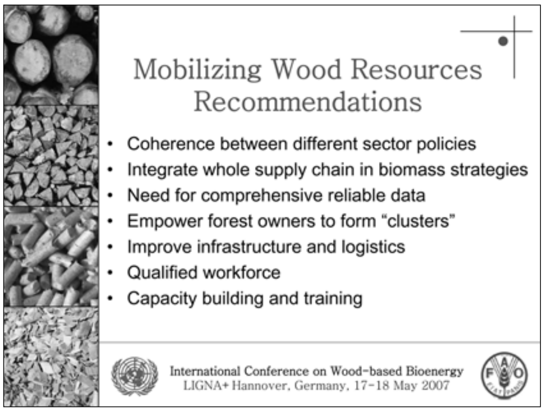


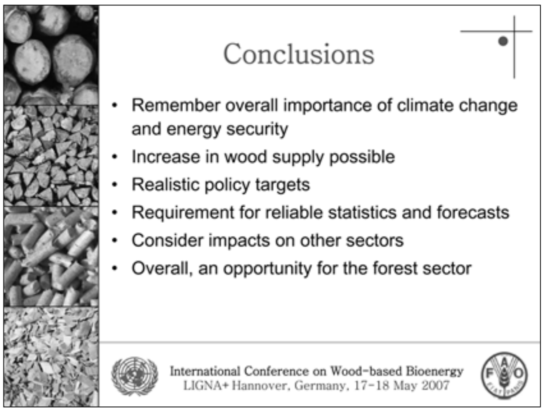


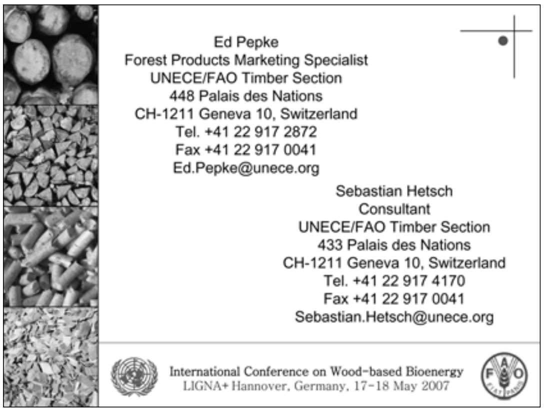
	Fellings as % of annual growth
Central Europe	61%
Nordics & Baltics	72%
Northwest Europe	53%
Southeast Europe	45%
EU 27	60%
Russia	34%
North America	80%

Mobilization of Wood Resources for Wood Products and Energy: Challenges for Sustainable Forest Management (continued)









Policies & Activities to Enhance the use of Forest Biomass in the EU, Including for Energy

Jeremy Wall, European Commission, Brussel

European Commission

International Conference on Wood-based Bio-energy, Hannover, 17/05/2007

Policies & activities to enhance the use of forest biomass in the EU, including for energy.

Jeremy Wall
European Commission, Brussels,
DG Enterprise & Industry,
(Textiles, Fashions & Forest-based Industries Unit).
Jeremy.wall@ec.europa.eu

Summary of presentation:

1. overview of EU (EC + MS) policies wrt wood
2. forest resources, wood supply, industries
3. challenges: climate change, energy security
4. EU policy responses – implications for wood
5. conflict zone? – wood products v. energy?
6. renewed EU policies, including actions to accommodate uses of wood
7. other initiatives needed

1. Overview of EU (EC + MS) policies affecting use of forest biomass

Activities	Sectorial policies	Horizontal policies
Wood procurement from forests and other wooded land	National forest policies EU Forest Action Plan - FAP (CAP) Rural Development	Regional Environmental Research & Technological Development + Innovation
Wood utilisation		
as raw material for processing into forest-based materials & products	Industrial policies	Finance
as building material	MS building regulations + Const. Prod. Dir.	Competition
as (in-)direct energy source	Energy Policies	Internal Market Trade

2. EU forest resources:

- EU-25 has 160 M ha. forests (5 % global FOWL), mostly small, private lots (16 M owners), yielding 315 M m³ (o.b.) of wood annually (55% NAI)
- EU-25 forests grow 574 M m³ wood each year (o.b. NAI)
- EU forest-based industries use only 55% (315 M m³)
- so, the EU forest standing wood volume is constantly increasing (+ 290 M m³/yr) and so is the area (+ 400 000 ha/yr)
- since 01/01/2007 EU enlargement to include Bulgaria and Romania adds 10.5 M ha forest and significant wood production and use

Wood supply - why not all available wood is used:

- logically, EU forest resources can be more intensively used (85 % NAI fellings + 173 Mm³?) no negative ecological impacts (EEA study: + 40 Mtoe = 200 Mm3)
- large national, regional and local variations in supply & use
- not all wood of right species, age, dimension, quality at a distance, price & time suitable for markets (wood ≠ wood)
- forest & other infrastructures & logistics inadequate
- private forest owners not always "market" actors (UFOs)
- hence, EU is importing about 10 % (+/- 30 M m³) of the supply of wood for industries (in Finland +/- 25 % wood raw material is imported, currently most from Russia)

EU forest-based industries (woodworking, pulp & paper; printing):

- 340 Bn € turnover p.a. (8% of EU manufacturing added value),
- 2. 5 M jobs (9 % of EU manufacturing jobs)
- growing export markets for paper and structural timbers
- 90 % of wood from sustainably managed EU forests (SFM)

NB roles of forest-based industries as:
- raw material operator and "co-ordinator" (i.e. « mobiliser »)
- as a large energy user of electricity & heat
- as producer of electricity & heat for "export"to grids
- as innovator and developer of new product and process technologies

BUT: mostly SMEs, so: low investment in R&D & education; high costs; risk of relocation outside EU & limited scope to singly improve wood supply

Therefore the competitiveness of the EU forest-based industries must be maintained and enhanced for: products > jobs > wealth > growth

Policies & Activities to Enhance the use of Forest Biomass in the EU, Including for Energy (continued)

3. Challenges:
- **mitigate climate change:** by reducing GHG emissions, CO_2 capture
- **increase EU energy security:** by diversifying energy types & sources

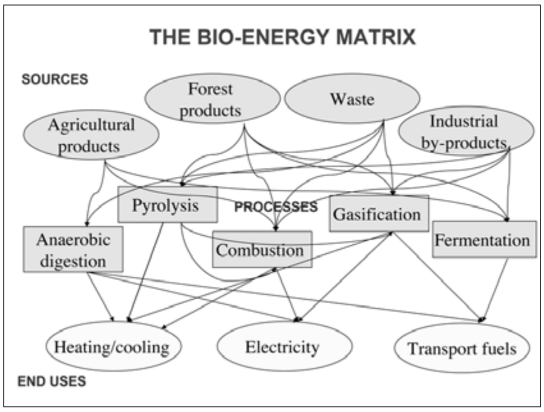
4. EU (EC + MS) response: energy policies **especially for new & renewable energy sources** (RES)

a) 1997 « White Paper » 12 % energy from renewable energy sources (RES) by 2010 (1997 = 6 % for EU-15):

Wind
Hydro
Geo-thermal
Photo-voltaic
Solar thermal
Biomass = agri + urban + wood (no « target », est. 27 Mtoe)

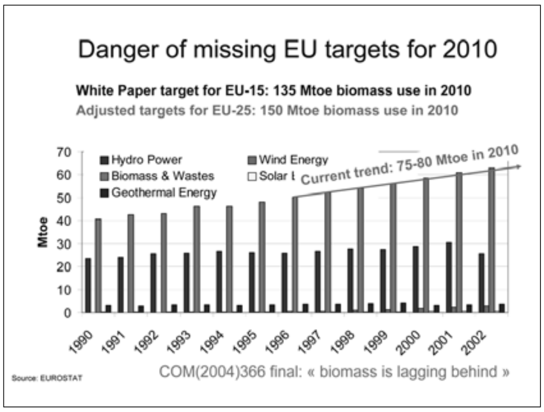
b) Papers on Energy Security: NB other technologies becoming available: hydrogen & fuel cells; zero-emission fossil fuel plants; smart grids

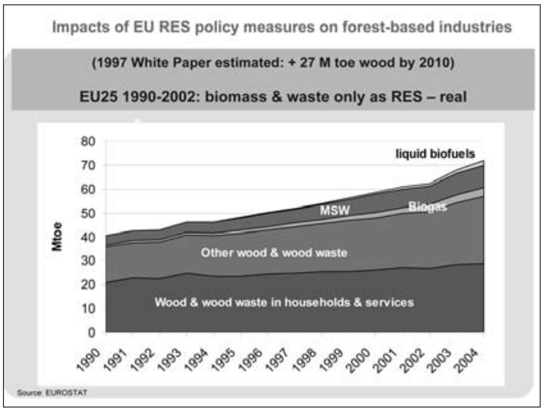
Member States obliged to fulfil indicative « targets » at national level



A comprehensive but complex framework for RES and EE (energy efficiency) is already in place

	Political and legislative instruments:	Sector: RES	Sector: EE	Supply	Demand: Building	Demand: Transport	Demand: Industry
1997	White Paper on RES	X		X	X		X
	Green Paper on Security of Energy Supply	X	X		X	X	X
	Directive on RES-electricity	X		X	X		X
	Directive on Energy Performance of Buildings	X	X		X		
	Directive on Biofuels	X		X		X	
	Directive on a Scheme for GHG Allowance Trading	X	X	X			X
	Directive on the Taxation of Energy Products	X	X	X	X	X	X
	Directive on Co-generation	X	X	X	X		X
	Green Paper on Energy Efficiency		X		X	X	X
	Green Paper on Energy	X	X	X	X	X	X
2007	Energy & Climate Pkg (To be continued….)	X	X	X	X	X	X





2010 "targets" for EU BAP & Bio-fuels Strategy: scale of biomass energy use scenario "if all biomass = wood" (NB not all will biomass foreseen to come from wood, but also agri-residues, waste and liquid bio-fuels should play a significant role).

(M toe)/Mm³	(2003)	(2010)	Difference
Green Electricity	110 Mm³	303 Mm³	(35 Mtoe) **+193 Mm3**
Heating & cooling	264 Mm³	413 Mm³	(27 M toe) **+149 Mm3**
Transport Bio-fuels	6 Mm³	105 Mm³	(18 M toe) **+99 Mm3**
TOTAL	380 Mm³	820 Mm³	**+440 Mm3**

Ex. "The share of renewable energy" COM 366/2004 (For EU-25)

Policies & Activities to Enhance the use of Forest Biomass in the EU, Including for Energy (continued)

5. Conflict zone? Wood for products v. energy?

Sectorial issues: forests & forest-based industries (F-BI):

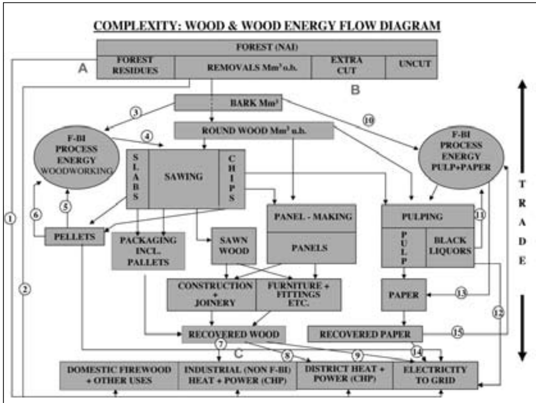
1. There are both **opportunities and risks**, especially for the forest-based industries
2. EU-level figures hide: **complex market structures; national & regional variations** in: extent, intensity & location of forest resources, population density, financial & fiscal régimes giving rise to several identifiable regions within Europe (NB cross-border effects in central Europe)
3. Need to safeguard ("urban") forest **resources and access** to them at competitive prices for both industry and energy production, whilst respecting ecological and social amenity functions of forests
4. **Scale and costs** need to be assessed, especially in context of **national planning**

Opportunities:

- forest owners can have more markets for using more wood, incl. residues. (More revenue available for forest management?);
- sawmills benefit from increased demand for their by-products like wood chips and sawdust, especially for e.g. pellets;
- pulp industry can use e.g. black liquors not only for CHP, but as "bio-refineries", using current & new technologies, also new opportunities (bio-fuels: (m)ethanol from black liquors or directly from cellulose)
- wood is an energy-efficient building material in mfg. and use

Risks:

- policy changes require (better and more) wood mobilisation, but existing market, institutional and fiscal frameworks may inhibit it
- unfocused demand for wood, unmatched by supply, can create bottlenecks and high prices to the detriment of both the energy & forest-based industries
- end-use subsidies, e.g. the use of high feed-in tariffs for the production of "green electricity", may not pull previously unused biomass from the forests or gather post-consumer residues, but compete with F-BI
- energy efficiency may not be optimised and/or
- optimal use/full added value may not be derived from wood
- Wood-based products may be priced out of market by less sustainable



STRATEGIC CONSIDERATIONS FOR MOBILISING MORE WOOD

1. How much (more) wood could/should be used and how can that best be managed? i.e. at national, regional & local (+ company) levels
2. Which points in the forest/wood flow system should be addressed? (A? B? C? Others?)
3. Logistics and harvesting costs are crucial. How can such costs be overcome without unduly distorting markets?
4. Which specific (new) measures are needed?
5. Added value of F-BI value chain is substantially higher than that of energy sector and wood products can be recycled. But what about F-BI profitability, capital intensity and returns on investments?
6. How to get better statistical and other information?
7. How can EU policies & actions mobilise wood?

What has happened recently in the wood biomass market?

- roundwood prices have risen sharply, in some cases eased, (e.g. wooden pellets), but:
- supply remains tight in many regions, esp. Central Europe
- supply difficulties and costs have reduced competitiveness of wood-processing industries, esp. panels and pulp (closures)
- heightened concern by EU forest-based industries (F-BI) that trend will continue

6. Renewed EU policies facing up to new & renewed challenges :

- **High and volatile prices** for oil and gas will stay
- **Global energy demand** is predicted to increase by 60% over the next 30 years (So, CO2 emissions will also rise)
- By 2030 the **EU energy dependency** could rise from 50% to 70%, mostly from regions threatened by insecurity
- According to the **Kyoto Protocol**, EU has to reduce its GHG emissions from 1990 until 2008/2012 by 8 %
- Stern Report (Climate Change more rapid)
- Thus, January 2007: **"Energy Package"**, including Renewable Energy Road Map 20% RES by 2020
- EU Council conclusions 09/03/2007 (- 20 % CO_2, etc.)

Policies & Activities to Enhance the use of Forest Biomass in the EU, Including for Energy (continued)

Integrated & mutually supportive approach to climate and energy policy

Three goals:

- increasing security of energy supply
- ensuring the competitiveness of European economies and the availability of affordable energy
- promoting environmental sustainability and combating climate change

Energy Policy for Europe, incl. Energy Action Plan (2007-9)

In addition to RES, the EAP seeks to complete EU internal energy market and develop a European Strategic Energy Technology Plan, including safe carbon capture.

EAP will be target of Strategic Energy Review in 2009

European Energy action Plan includes, inter alia:

- review of state-aid guidelines for environment
- energy efficiency: reduce consumption 20 % by 2020

For RES:

- binding 20 % target RES by 2020 (burden sharing)
- comprehensive "implementing" directive on use of all RES (electricity, heating & cooling, bio-fuels), including:

- member states' overall national targets
- national action plans with sectorial targets and measures
- sustainability criteria for bi-energy
- provisions to avoid conflicts between diff. uses of biomass

RES "targets" and progress

	2006	2010	2020
All renewables:	7%	12% (indicative)	20% (binding)
Bio-fuels:	1%	5.75%	10%
Green electricity:	15%	21%	(MS sectoral
Heating/ cooling:	9%	none	targets)
Biomass:		150 Mtoe	195 Mtoe
Wood "share" (?27→35? Mtoe)		108-149 Mm3 →	140-194Mm3

Renewables Directive 2007

Energy from biomass (incl. organic waste) is expected to make a significant contribution to a future sustainable energy system in Europe in all 3 sectors: electricity, transport, heating and cooling

A predictable, long-term policy framework needed: National Biomass Action Plans to feed into national RES action Plans! Biomass supply and use to be assessed at national level across three sectors

Supplementary action on national, regional and local levels with close involvement of all relevant stakeholders is essential and equally important

Challenges exist: competition for raw material and increasing imports to ensure sustainability criteria met for the production of biomass/ biofuels

Bio-fuel increase: sustainability? Second generation support?

Natioal Biomass Plans (nBAPs)

Council June 2006 endorsed EU Biomass Action Plan & « invited MS to develop or up-date nBAPs, concentrating on national bottlenecks »

- Follow-up: nBAPs WG set up in July 2006 (EC + MS)
- nBAPS Information Matrix established
- By 2nd meeting (13/03/2007):
- - only 6 matrices completed, but significant N° of MS preparing nBAP or biomass part of national energy plan (linked to their draft Operational Programmes for Structural & Cohesion Funds).
- - biomass supply is key element of nBAPs, but still
- - no uniform MS understanding of nBAPs
- - MS requests to exchange information & experiences
- - possibility of « guidelines » from Commission?
- Follow-up: web-site established:

http://ec.europa.eu/energy/res/biomass_action_plan/nationa_bap_en.htm

- - matrix questionnaire launched - due 15/05/07

BAP State of Play

Other on-going actions:

- Review buildings directive to incentivise use of RES
- Study on performance of household biomass boilers and possibly set eco-design requirements
- Review the impact of the energy use of wood and wood residues on forest-based industries
- CEN standards on quality of biomass fuels
- Development and trade policies to promote sustainable biomass/ bio-fuels production (NB major international bio-fuels conferences)

Policies & Activities to Enhance the use of Forest Biomass in the EU, Including for Energy (continued)

EU Forest Action Plan (FAP) – DG AGRI

The overall objective of the Action Plan is to enhance sustainable forest management and the multi-functional role of forests. Its four operational objectives are to:

- **improve long-term competitiveness of the forest sector**
- **maintain & enhance biodiversity, carbon sequestration, integrity, health and resilience of forest ecosystems**
- **contribute to life quality by preserving and improving the social & cultural dimensions of forests & forestry**
- **To improve coherence, co-operation and communication in forest related matters**

This is to be achieved through four groups of « Key Actions »:
Competitiveness
Environment
Quality of life
Co-ordination and communication

EU Forest Action Plan - Key Action 4

Promote forest biomass use for energy generation through:

- Assessment of the availability and possibilities for increased mobilisation of small/low-value timber and harvesting residues for energy; disseminate good practices
- Assessment of the feasibility of using forest residues and tree biomass for energy in the context of sustainable forest management; examination of environmental limits
- Examination of possibilities for co-operation between forest owners in energy projects
- Support for R&D for heating and cooling, green electricity and fuels from forest resources
- **NB Working group set up (06/03/2007) to examine mobilisation of wood resources fro energy use.**

Support from Common Agricultural Policy

CAP reform (2003)

- De-coupled income support
- Non-food (energy) crops on set-aside areas
- Energy crop premium
- Reduced scope for steering production

Rural Development Policy (2007-2013)

- Menu of measures in support of renewable energy, e.g. biomass supply chains, processing capacity, bio-energy installations, including energy use of forest material)

What has DG Enterprise done?

- **major contribution to developing the « Lisbon Agenda »**
- **contributed to inter-service co-operation, incl. Energy & Climate Package, and with Member States**
- **developed new communication on innovative and sustainable forest-based industries**
- **reconvened RES Working Group of the EU F-BI Advisory Committee: working document**
- **co-operated with international organisations (FAO/IEA/UNECE)**

The Lisbon Agenda - matching sustainability with competitiveness

The **Lisbon Agenda**: was re-launched Feb 2005. Recalling the three components of sustainability (environmental, social, economic), as well as competitiveness, it seeks:

« To preserve the EU sustainable development model for the future, the Union's competitiveness must be strengthened; its economy dynamised »:

Other EU policies: Internal Mkt., Industry, Employment, R&D (EC + MS)
- EU + attractive for investment & work (Single Mkt., less & better regulation)
- 2010: R&D 3% GDP - knowledge & innovation for sustainable growth
- 2010 create 6 M new and better jobs

(**Essentially: growth & jobs)**

EU Forest-based industries:
New communication document foreseen mid 2007):
« Innovative & sustainable forest-based industries in the EU »

(This is in follow-up to the 1999 communication: « The State of the Competitiveness of the EU Forest-based & Related Industries »)

The new communication will address sectorial challenges:

- Increased Global Competition
- Wood Raw Material
- Secondary Raw Material
- Energy
- Demand for wood and paper products
- Structural Change

NB three of these relate to wood mobilisation

Policies & Activities to Enhance the use of Forest Biomass in the EU, Including for Energy (continued)

F-BI communication - principles & objectives

→To enhance the competitiveness by taking care of the advanced know-how and competences that the EU forest-based industries possess while also taking into consideration related competences in the chemical industry and the machinery industry.

→To recognise the forest-based industries strategic role in mitigating climate change, enhancing a sustainable energy supply, promoting sustainable forest management and in supporting generally a sustainable development.

→To support an enhanced level of innovation and research and technological development.

→To facilitate the forest-based industries' access to a sufficient raw material supply, both new fibres and recovered, at reasonable costs.

→To facilitate an energy supply at competitive prices.

NB challenges will be addressed through 24 action areas

Conclusions of report by RES WG (DG ENTR) identified:

- **factors influencing the availability of wood and its increased use for energy**
- **more woody biomass can be mobilised**
- **economic instruments**
- **forest and agri-energy resources can better be developed by using a package of co-ordinated measures**

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7. Other initiatives needed:

Opinion of the European Economic & Social Committee:
Wood as an energy source in the enlarging Europe » (Kallio)
http://eesc.europa.eu/activities/press/registry/index_en.asp
Co-operation with international organisations:

a) Joint (EC/IEA/UNECE) Wood-energy Enquiry (07-10/2006)
- based on recent co-operation, esp. with the FAO/UNECE JWPFES, the three agencies drew up a survey sent to both forestry statistics and energy use correspondents in the network countries (26 IEA + 56 UNECE (EU))

- only 19 replies, but from key wood-producing & –using countries;

- results surpsingly showed a much higher level of energy-wood production and use than had even been estimated
- much production and use not officially recorded
- how to follow up? Meeting Geneva 19/03/2007, experts will refer to:
- Joint FAO/UNECE Working Party on Forest Economics & Statistics

Further info: http://www.unece.org/trade/timber/Welcome.html

b) International Seminar on Energy and the Forest Products Industry, Rome, 30 – 31/10/2006 in collaboration with UNECE, ITTO and WBCSD (http://www.fao.org/forestry/site/34867/en/)

c) Mobilising wood resources » Geneva 11-12/01/2007 (FAO/UNECE/MCPFE/EFI/CEPI)
http://www.unece.org/trade/timber/workshops/2007/wmw/mobilisingwood.htm
Follow-up meetings: **Task Force** (Geneva, 19/03/2007; Rome 25/05/2007)

Wood Availability & Mobilisation Potentials (WAMPs)

1. Need for common understanding of challenge, scope & issues

2. Backed up by empirical research to enhance data and reporting (coefficients, deductions, conversion factors etc.)

3. Dynamics & qualitative issues / conditions

4. Input to key fora (EU, FAO/UNECE, MCPFE, etc.)

5. Need for active involvement by all partners (governments, industry, others)

6. McKinsey study – CEPI (May) present to UNECE TC/ISCPolicy Forum (October)

7. MCPFE (Declaration on energy)

8. EU national Biomass Action Plans (nBAPs)

9. Other projects?

Energy policy & finance
EC, DG TREN: EU Biomass Action Plan
- **http://ec.europa.eu/energy/res/biomass_action_plan/green_electricity_en.htm**
- nBAPs: http://ec.europa.eu/energy/res/biomass_action_plan/nationa_bap_en.htm

EC, REGIO: Structural and Cohesion funds
- **http://ec.europa.eu/regional_policy/index_en.htm**

EC, DG AGRI: EAFRD
- **http://ec.europa.eu/agriculture/rurdev/index_en.htm**

European Investment Bank (EIB)
- http://www.eib.org/

European Sustainable Energy Week 29/01- 02/02
- http://www.eusew.eu/

General information on FP7 **EU research**
- *http://ec.europa.eu/comm/research*
- **Seventh Framework Programme** *http://ec.europa.eu/comm/research/future/index_en.cfm*
- **Information on research programmes and projects** *http://cordis.europa.eu/*
- **RTD *info* magazine** *http://ec.europa.eu/comm/research/rtdinfo/*
- **Information requests** *research@ec.europa.eu*
- DG Enterprise & Industry - Forest-based Industries: http://ec.europa.eu/comm/enterprise/forest_based/index_en.html

Technologies and Economics of Energy Generation from Logging Residues and Wood Processing Waste

Prof. Dr. Arno Frühwald, University of Hamburg and Fed. Research Center for Forest Products (BFH), Hamburg, Germany

Technologies and Economics of Energy Generation from Logging Residues and Wood Processing Waste

Prof. Dr. Arno Frühwald
University of Hamburg and
Federal Research Centre for Forestry and Forest Products
Hamburg, Germany

ITTO
International Conference on Wood-Based Bioenergy
Hannover, Germany 17 – 19 May 2007

Outline of the presentation

- Vision for renewable energy in Europe
- Potential for wood-energy, example Germany
- Wood-energy in the timber industry
- Use of wood for energy in households
- Pellets: technology and economics
- Medium sized heat/heat + power plants: Technology and Economics
- Logging residues: harvesting and costs
- Ecological aspects
- Summary

Selected countries in the EU: Electricity Generation from Biomass (all biomass: wood + agric. biomass) in GWh

	Electricity Share of renewables %	Solar	Wind	Biomass	Hydro-energy
Austria	64	86	79	3452	3132
Denmark	27	9	566	2154	2
Finland	27	1	10	7556	1296
France	12	19	49	12007	5179
Germany	11	269	2173	9367	1812
Great Britain	4	25	166	2863	424
Italy	14	19	159	3145	3671
Sweden	56	5	73	8883	5170
Spain	16	62	1341	4853	2713

European Union: Renewable Energy for Electricity Generation 2006 compared to 2020 (source: EC DG JRC, 2007)

in Terrawatt-hours (TWh)	2006	2020	increase per year	contribution to el-generation 2020
Wind	95	856	17 %	35 %
Biomass	55	209	10 %	9 %
Solar	2,5	150	34 %	6 %
Total	152,5	1250	15 %	
pred. consumption	3040,0	2432 (!)		
Share of renewables	5 %	50 %		

Example Europe

Net annnual increment > fellings

EU 15 (mill m³):
483 ⇔ 302

Additional 10 EU states (mill m³):
125 ⇔ 81

Source: UNECE/FAO, 2000; no data for Greece, Luxembourg and Malta)

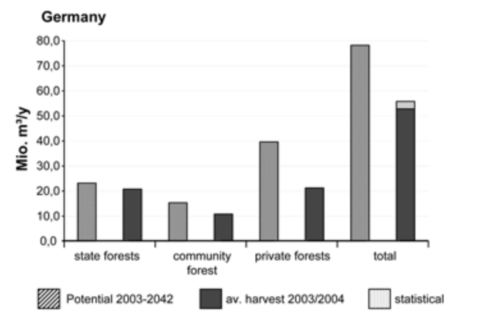
Germany: Forest, Wood Utilization, Potentials

Forest area ~ 11 Mio ha (~ 30 % of land area)
annual increment (long term)
logs ~ 80 Mio m³
residues ~ 20 Mio m³ (solid volume)
harvests and uses (m³/y)[1)]
logs ~ 70 Mio m³
of which ~ 36 Mio m³ saw logs
~ 15 Mio m³ firewood (priv. households)
~ 8 Mio m³ wood bases panels
~ 6 Mio m³ pulp and paper
~ 5 Mio m³ energy (incl. CHP)
Potentials ~ 10 Mio m³ logs more
~ 10 – 15 Mio m³ forest residues
(actually 3 – 5 Mio m³ used)
Main problem: private forest owners!

[1)] Source: Mantau 2007

Technologies and Economics of Energy Generation from Logging Residues and Wood Processing Waste (continued)

Potential and Harvest



Wood prices in Germany in Euro/ton (dry)

logs: softwood	80 - 120 +
hardwood	70 – 150 +
forest residues wet, chipped	60 – 80
industrial residues	
chips	70 – 90
sawdust	50 – 70
others	40 – 60
recycled wood	50 – 70 (less if contaminated)
pellets	160 – 220
oil equivalent	230 – 250

1 Euro = 1.35 US$

Germany: Wood Industry, Use of Wood-Energy

% wood energy of total energy

		1994	2004
Sawmills	heat	75	80
	power	20	40
Plywood mills	heat	86	90
	power	10	20
Particle- and Fiberboard mills	heat	75	90
	power	5	40
Furniture mills	heat	60	80
	power	5	10

Germanys system to generate more "renewable electricity"

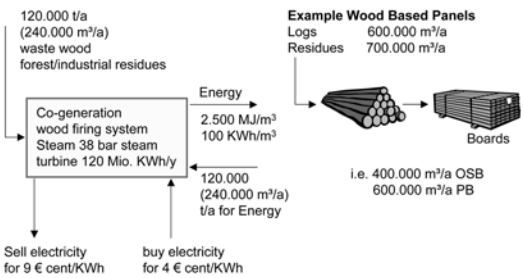
"Renewable Energy Act"

Electricity generated from Renewable sources

- Wind
- Solar
- Biomass
- .
- .
- .

receives a premium market price (~ 0,10 €/KWh) which is granted for 20 years

Energy Generation in the Timber Industry



turn over 120 Mio. KWh 0,09 € = 10.800.000 € → 12 €/m³ of board
Invest 50 Mio. €, annual running costs 2 Mio. → total costs 6 Mio €/y

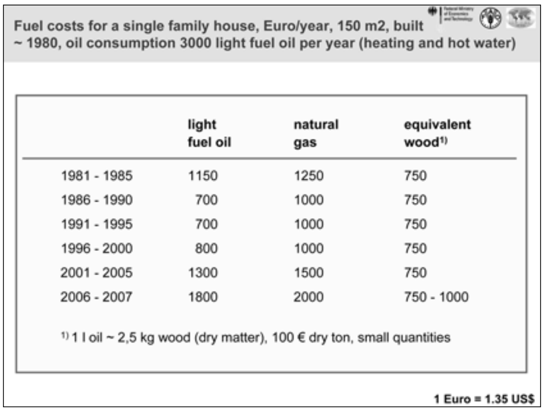
1 Euro = 1.35 US$

Energy from Wood in Households

- fire place (open, closed), efficiency 10-50 %
- simple oven (with heat storage) efficiency 50-70 %

- pellet heating-system (single/double family houses efficiency 80-90 %
- woodchip heating system (dry or wet chips)
  - multi-family houses (small installations)
  - living quarter (up to i.e. 500 houses)
  - or community buildings

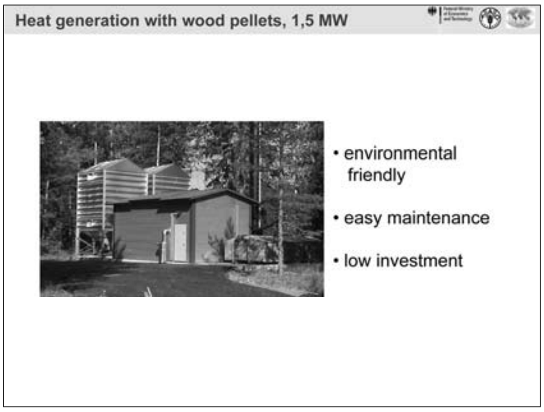
Technologies and Economics of Energy Generation from Logging Residues and Wood Processing Waste (continued)

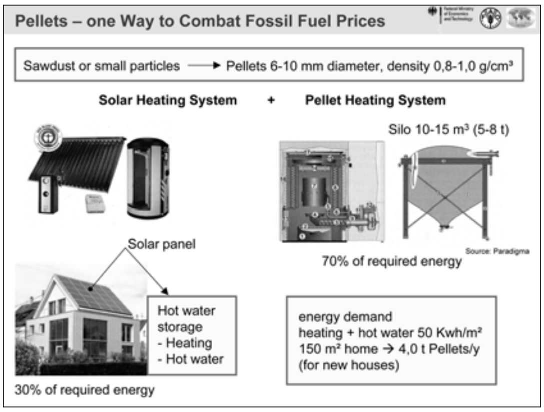

Fuel costs for a single family house, Euro/year, 150 m2, built ~ 1980, oil consumption 3000 light fuel oil per year (heating and hot water)

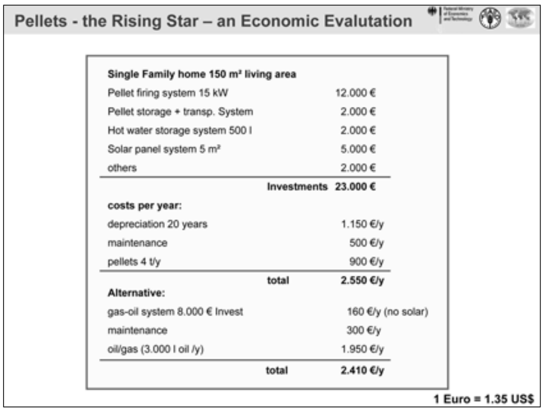
	light fuel oil	natural gas	equivalent wood[1]
1981 - 1985	1150	1250	750
1986 - 1990	700	1000	750
1991 - 1995	700	1000	750
1996 - 2000	800	1000	750
2001 - 2005	1300	1500	750
2006 - 2007	1800	2000	750 - 1000

[1] 1 l oil ~ 2,5 kg wood (dry matter), 100 € dry ton, small quantities

1 Euro = 1.35 US$

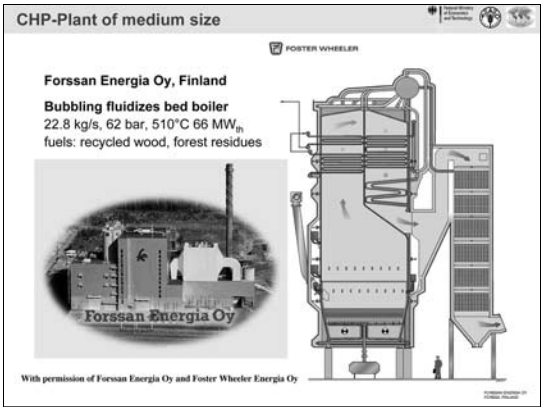




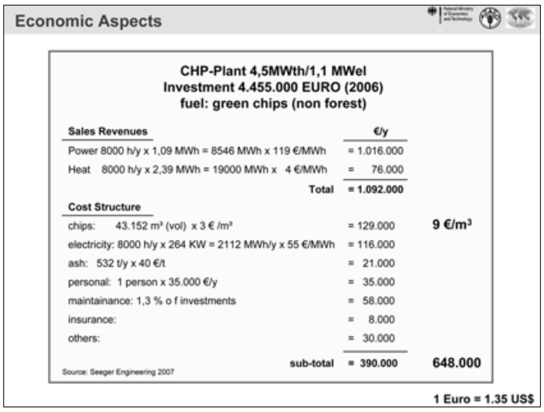

Pellets - the Rising Star – an Economic Evalutation

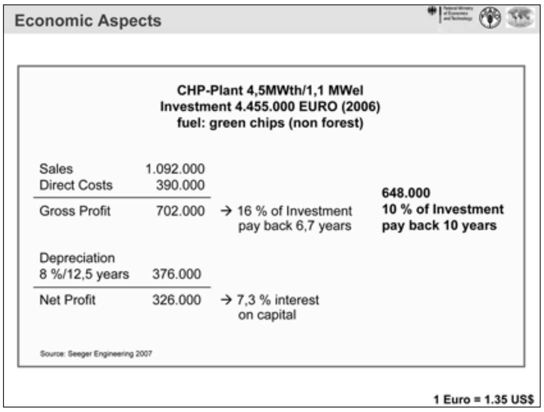
Single Family home 150 m² living area		
Pellet firing system 15 kW		12.000 €
Pellet storage + transp. System		2.000 €
Hot water storage system 500 l		2.000 €
Solar panel system 5 m²		5.000 €
others		2.000 €
	Investments	23.000 €
costs per year:		
depreciation 20 years		1.150 €/y
maintenance		500 €/y
pellets 4 t/y		900 €/y
	total	2.550 €/y
Alternative:		
gas-oil system 8.000 € Invest		160 €/y (no solar)
maintenance		300 €/y
oil/gas (3.000 l oil /y)		1.950 €/y
	total	2.410 €/y

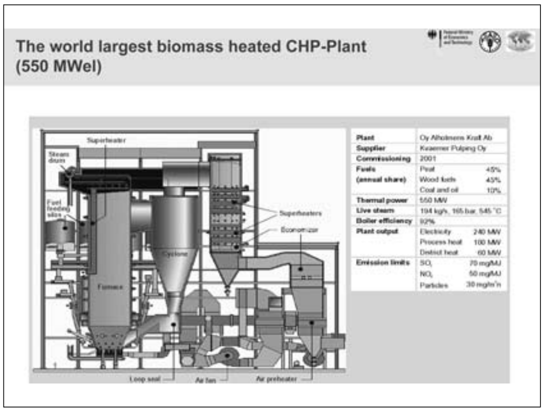
1 Euro = 1.35 US$



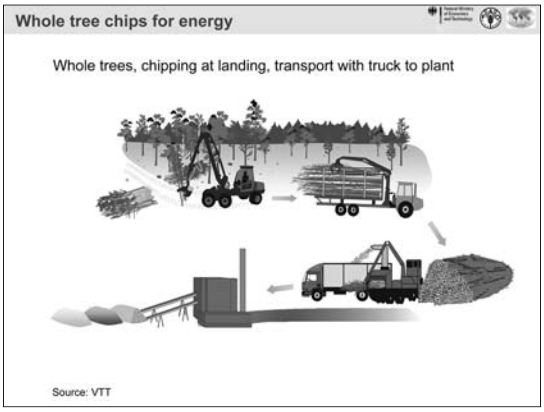
Technologies and Economics of Energy Generation from Logging Residues and Wood Processing Waste (continued)

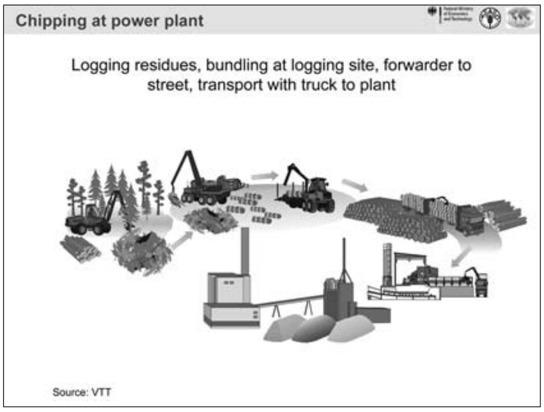


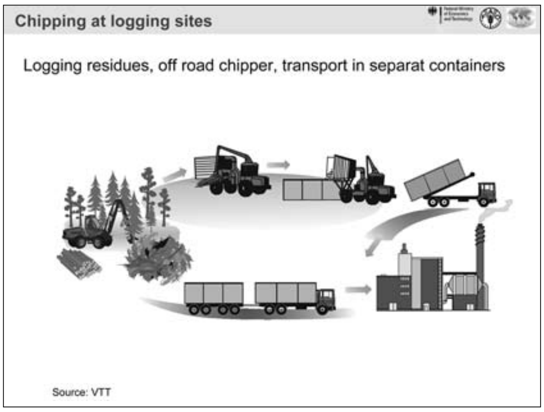


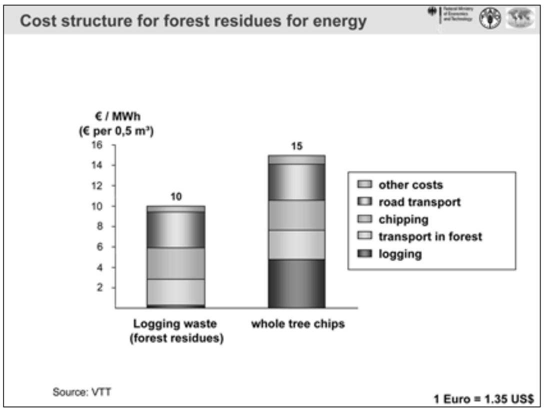


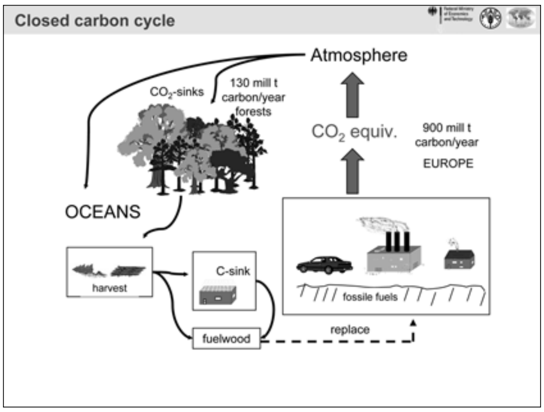
Technologies and Economics of Energy Generation from Logging Residues and Wood Processing Waste (continued)

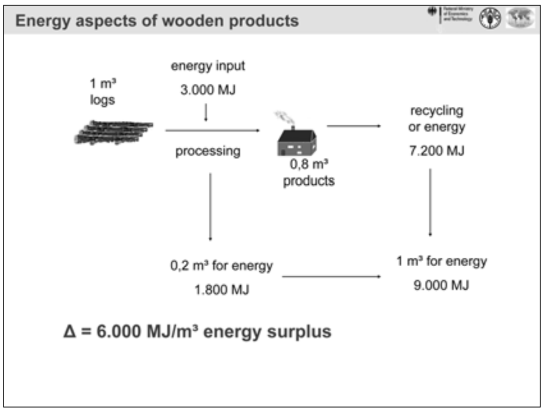




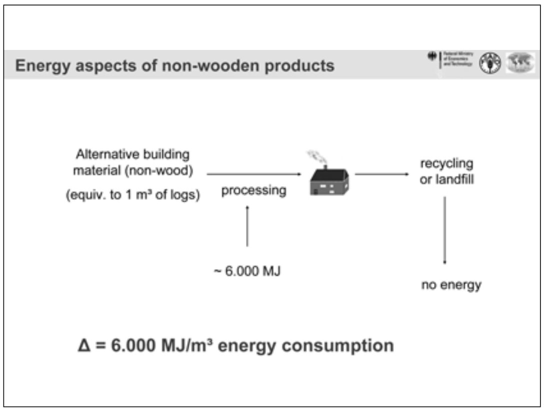


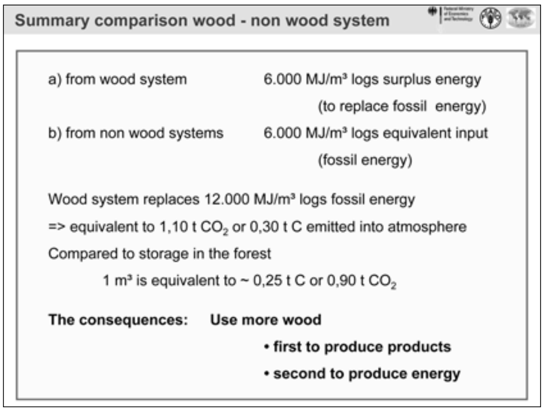


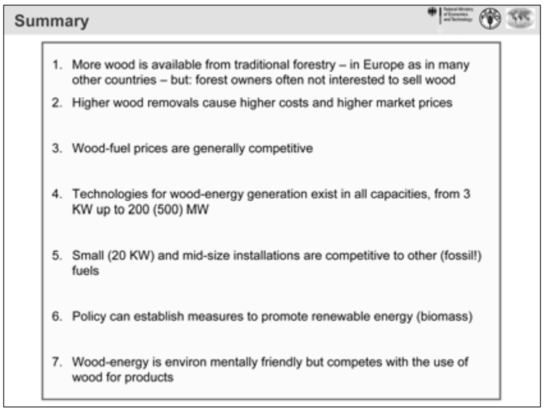


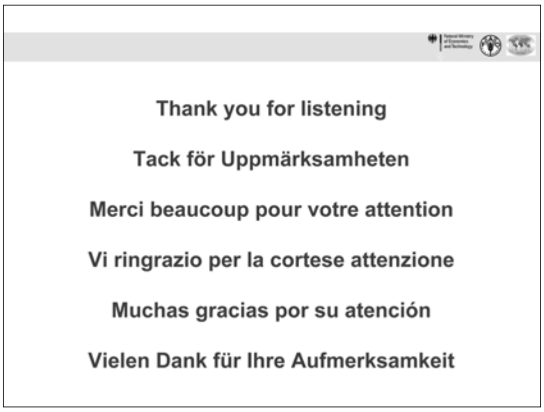


Technologies and Economics of Energy Generation from Logging Residues and Wood Processing Waste (continued)



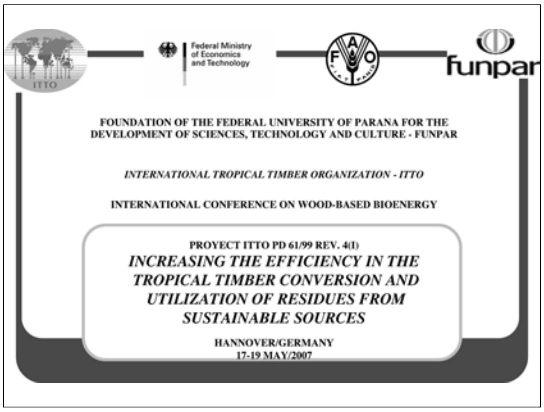


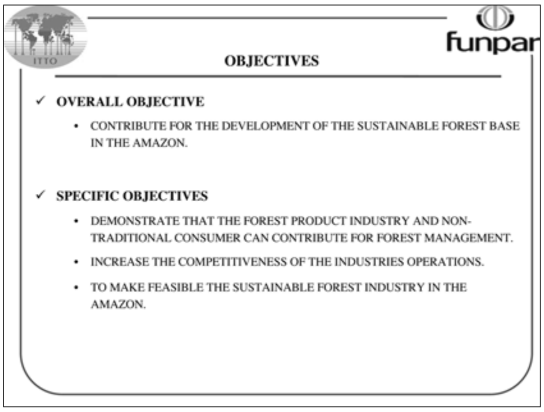


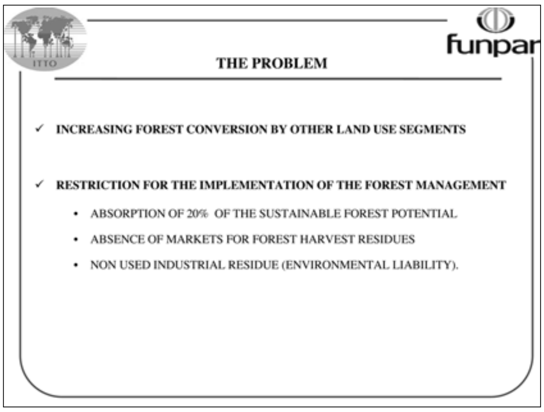


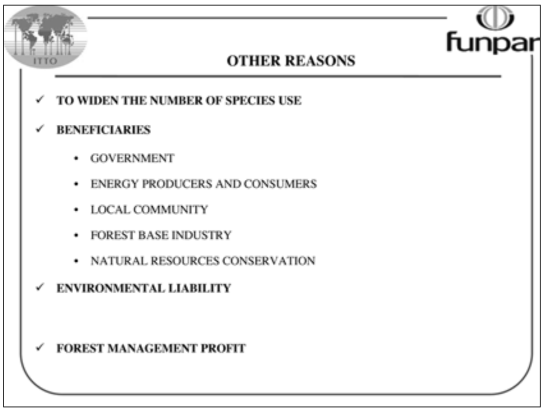
Increasing the Efficiency in the Tropical Timber Conservation and Utilization of Residues from Sustainable Sources

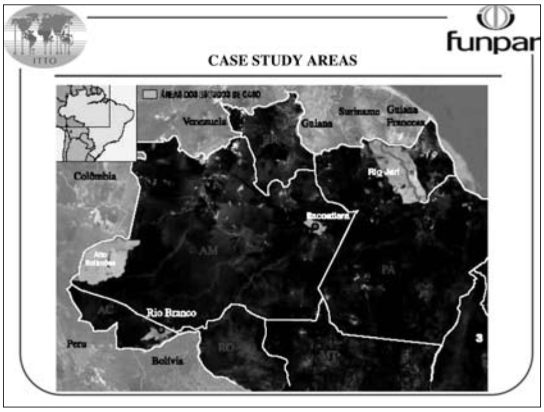
Mr. Joesio Siqueira, Federal University of Paraná Foundation for the Development of Science, Technology & Culture, Brazil

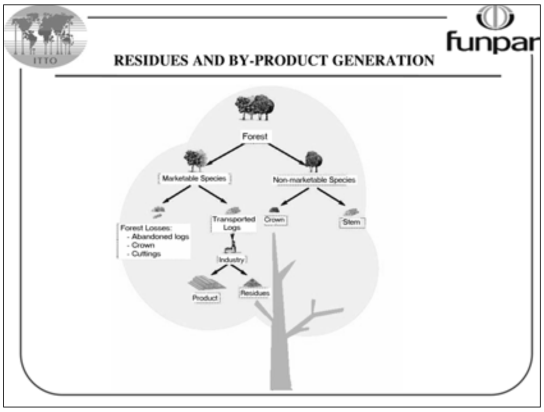












Increasing the Efficiency in the Tropical Timber Conservation and Utilization of Residues from Sustainable Sources (continued)

BIOMASS AVAILABILITY

✓ COMPOSITION OF STEM VOLUME

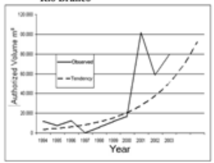
COMPONENT	%
LOG (COMMERCIAL VOLUME)	**48.1**
RESIDUE	51.9
Stem residue	17.7
Crown residue	34.2
Ø < 35 cm	20.5
Ø ≥ 35 cm	13.7
TOTAL	**100**

Source: Higuchi et al, 1998

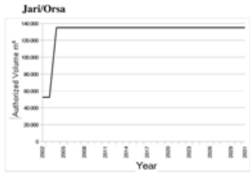
BIOMASS AVAILABILITY

✓ FOREST

Rio Branco



Jari/Orsa



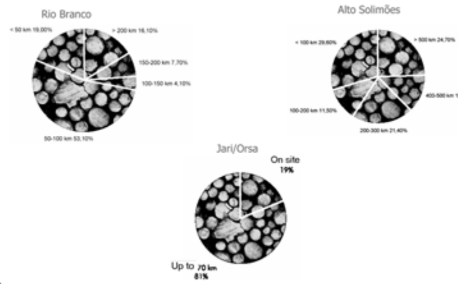
✓ Alto Solimões:
19,000 m³/year

BIOMASS AVAILABILITY

✓ VOLUME (M³/YEAR)

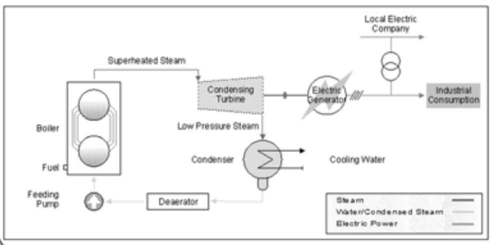
TYPE	Rio Branco	Alto Solimões	Jari
Forest Harvest Residue	**86,287**	**20,845**	**145,665**
Stem	29,428	7,109	49,678
Crown	56,859	13,736	95,987
Non-Marketable Species	**153,679**	**43,538**	**256,153**
Stem	101,121	28,648	168,549
Crown	52,558	14,890	87,604
Industrial Residue	**96,808**	**10,625**	**94,500**
TOTAL	**336,774**	**75,008**	**496,318**

BIOMASS DISTRIBUTION BY DISTANCE CLASSES



ALTERNATIVE SELECTED

✓ BASIC SYSTEM FLOWCHART USING A CONDENSATION TURBINE



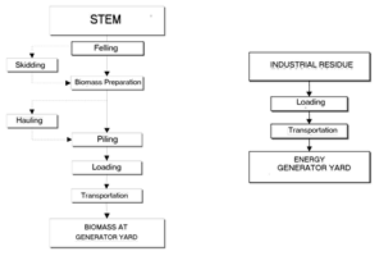
DESIGN CONCEPTION

REGION	RIO BRANCO	ALTO SOLIMÕES	JARI/ORSA
ASSUMPTIONS			
CATEGORY	Independent Producer	Independent Producer	Self-producer
RAW MATERIAL	Market purchases	Market purchases	Own procurement
TYPE	Energy Generation	Energy Generation	Co-generation (energy and steam)
REVENUE	Energy Sale	Energy Sale	Own consumption and sale of excess
CHARACTERIZATION			
TECHNOLOGY	Multistage condensation turbine, one of the more recommended as it has a larger thermal efficiency in relation to the others	Multistage condensation turbine, one of the more recommended as it has a larger thermal efficiency in relation to the others	Controlled extraction turbine, the most recommended for cogeneration plants
POWER MWH	2.0 MWH 10.0 MWH	2.0 MWH 10.0 MWH	3.5 MWH 5.6 MWH
BIOMASS CONSUMPTION (t/year)	36,300 t/year 132,200 t/year	36,300 t/year 132,200 t/year	79,500 t/year 121,000 t/year
LOCATION	Rio Branco	Benjamim Constant	Monte Dourado

Increasing the Efficiency in the Tropical Timber Conservation and Utilization of Residues from Sustainable Sources (continued)

DESIGN CONCEPTION

✓ PROCUREMENT LOGISTICS



FEASIBILITY STUDY

✓ CASH FLOW – RIO BRANCO (R$)

ITEM	2.0 MWH MARKET	2.0 MWH SUBSTITUTION	10,0 MWH MARKET	10,0 MWH SUBSTITUTION
CASH INFLOW	32,805,002	89,357,022	154,598,426	444,176,005
Energy Sales Revenue	25,946,250	25,926,250	129,729,600	129,729,600
CCC or Fuel Savings	5,655,980	62,208,000	21,462,421	311,040,000
Residual Value	1,202,772	1,202,772	3,406,405	3,406,405
CASH OUTFLOW	34,484,347	34,484,347	176,180,120	176,180,120
Fixed Asset Investment	7,541,306	7,541,306	28,616,561	28,616,561
Working Capital Investment	90,716	90,716	439,944	439,944
Production Cost	22,036,725	22,036,725	123,045,915	123,045,915
Revenues Taxes	4,815,600	4,815,600	24,077,700	24,077,700
Income Taxes	-	-	-	-
NET CASH FLOW	-1,679,345	54,872,675	-21,581,694	267,995,885

FEASIBILITY STUDY

✓ CASH FLOW – ALTO SOLIMÕES (R$)

ITEM	3.0 MWH MARKET	2.0 MWH SUBSTITUTION
CASH INFLOW	32,857,470	89,409,490
Energy and Steam Sales	25,946,250	25,946,250
CCC	5,655,980	62,208,000
Residual Value	1,255,240	1,255,240
CASH OUTFLOW	52,485,185	52,485,185
Fixed Asset Investment	7,541,306	7,541,306
Working Capital Investment	143,184	143,184
Production Costs	39,985,095	39,985,095
Revenues Taxes	4,815,600	4,815,600
Income Taxes	-	-
NET CASH FLOW	-19,627,715	36,924,305

FEASIBILITY STUDY

✓ CASH FLOW – ORSA/JARI (R$)

ITEM	2.0 MWH MARKET	2.0 MWH SUBSTITUTION	10,0 MWH MARKET	10,0 MWH SUBSTITUTION
CASH INFLOW	76,431,781	120,406,921	111,427,554	252,625,202
Energy Sales	65,059,200	19,440,000	92,145,600	92,145,600
CCC	9,954,139	99,532,800	17,428,537	158,630,400
Residual Value	1,418,442	1,434,121	1,853,417	1,849,202
CASH OUTFLOW	64,959,812	55,019,456	124,348,927	126,620,797
Fixed Asset Investment	13,272,185	13,272,185	23,238,049	23,238,049
Working Capital Investment	162,647	178,326	341,418	337,203
Production Costs	37,960,890	37,960,890	83,667,315	83,667,315
Revenues Taxes	12,074,925	3,608,055	17,102,145	19,378,230
Income Taxes	1,489,165	-	-	-
NET CASH FLOW	11,471,969	65,387,465	-12,921,373	126,004,405

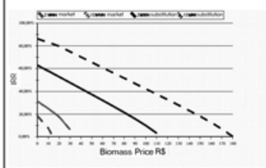
FEASIBILITY STUDY

✓ ECONOMIC AND FINANCIAL INDICES

REGION/ ALTERNATIVE	POWER MWH	NPV (R$) (MDR 12%)	IRR %	INVESTMENT RECUPERATION (years)
RIO BRANCO				
Market	2.0	-2,840,301	-	8.6
	10.0	-17,550,577	-	15.0
Substitutioon	2.0	20,432,046	53.7	1.8
	10.0	104,945,170	67.8	1.4
ALTO SOLIMÕES				
Market	2.0	-11,167,087	-	-
Substitution	2.0	12,245,191	37.5	2.4
JARI/ORSA				
Market	3.5	1,824,220	16.6	1.9
	5.6	-12,315,574	-	10.9
Substitution	3.5	38,512,790	57.0	1.9
	5.6	43,876,860	41.7	2.3

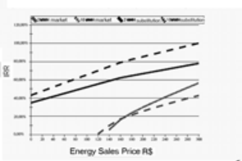
FEASIBILITY STUDY

✓ RIO BRANCO – IRR SENSITIVITY TO:

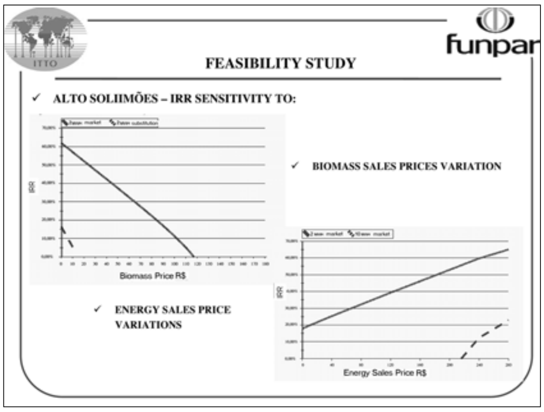


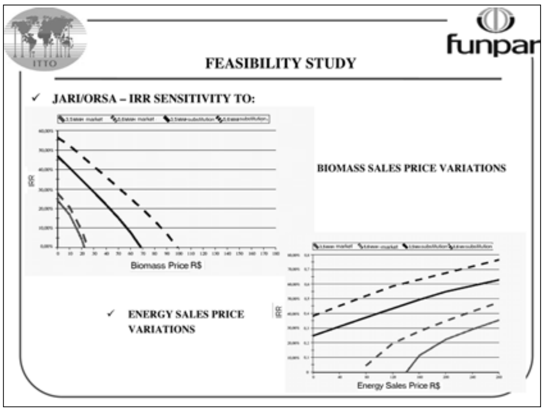
✓ BIOMASS SALES PRICES VARIATION

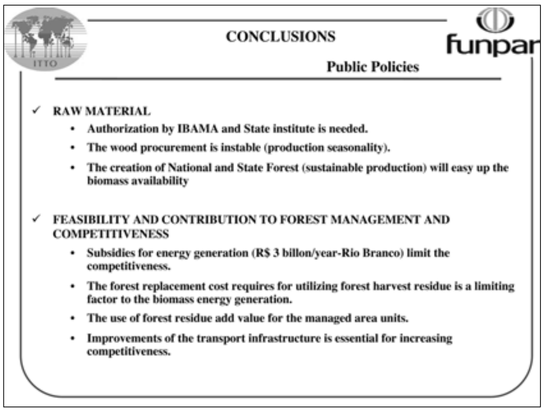
✓ ENERGY SALES PRICE VARIATIONS

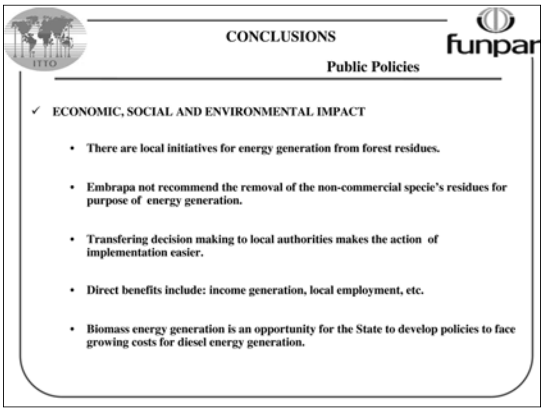


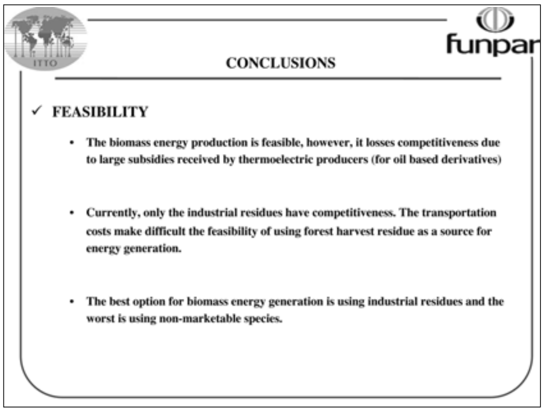
Increasing the Efficiency in the Tropical Timber Conservation and Utilization of Residues from Sustainable Sources (continued)

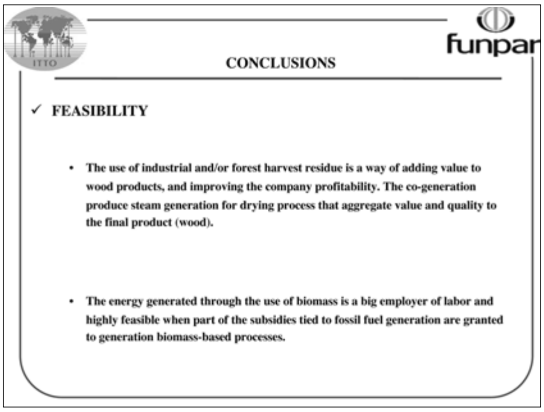






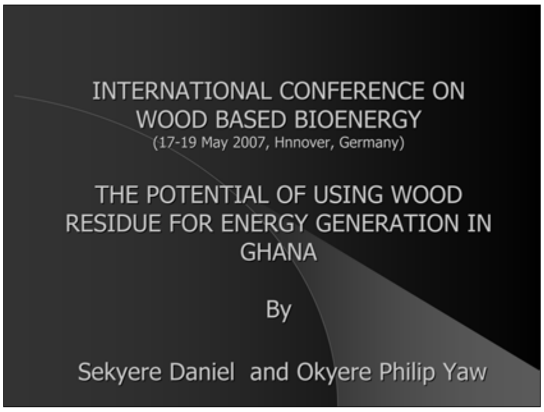


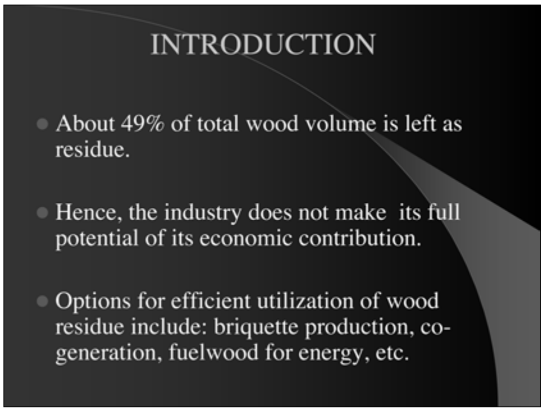


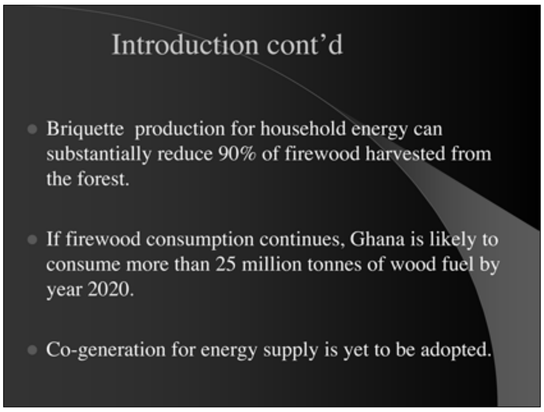


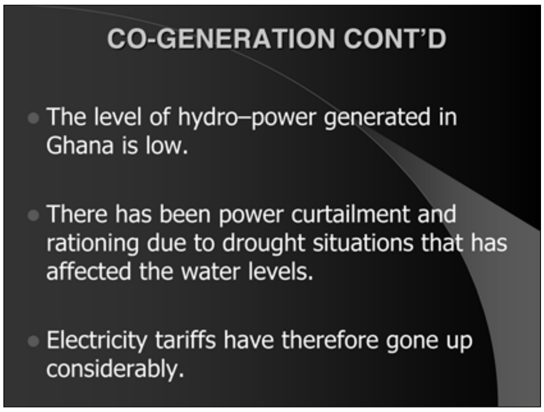
The Potential of Uusing Wood Residue for Energy Generation in Ghana

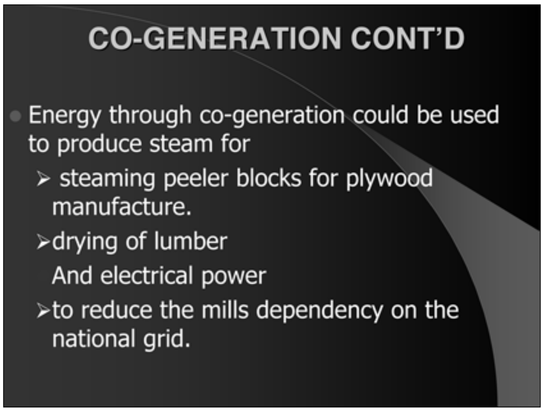
Dr. Daniel Sekyere, Forestry Research Institute of Ghana (FORIG)

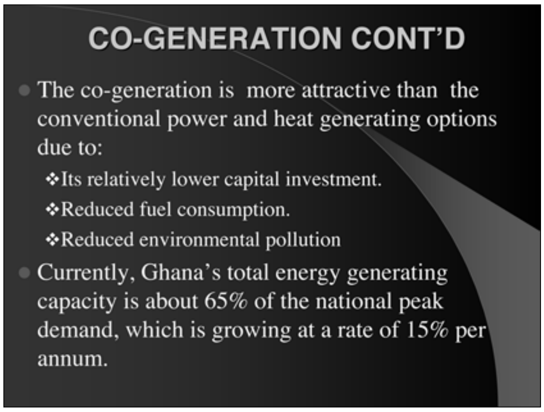












The Potential of Uusing Wood Residue for Energy Generation in Ghana (continued)

WOODFUEL

- It exists in three main forms: firewood, charcoal (termed fuelwood) and briquette.
- Gross national woodfuel consumption is estimated at 18 million tonnes per annum.
- 90% of the woodfuel supply in Ghana is obtained directly from the natural forest.
- Woodfuel accounts for about 71% of total energy demand.
- Petroleum accounts for about 20% and electricity accounts for about 9%.

A. Briquette

- Briquette is the preferred fuel by bakers and brick and tile factories in Ghana.
- Its introduction was characterized by suspicion, lack of confidence and unfair comparison with fuelwood (charcoal and firewood) in price and charcoal in quality.
- However, the product is not in the market.
- Demand in the capital city by the bakery industry is high.
- There is a need for a pilot plant.

B. Firewood

- This is the cheapest of the three (Firewood, Charcoal and briquette).
- It is used mostly in the rural and peri-urban areas where income levels are low.
- It is bulky to transport over long distance which makes delivery cost very high.
- Not convenient to use due to the smoke and sparks.

C. Charcoal cont'd

- Most of the charcoal producers use earth kiln method.
- Wood residues are converted to charcoal in the vicinity of mills (rural areas).
- Charcoal is easy to transport.
- It is used mostly for domestic purposes in the urban and wood deficient areas.
- It is also used in boarding institutions, hospitals, restaurants, chop bars, in forges by blacksmiths, gold-and silversmiths, etc.

Policy considerations on woodfuel use in Ghana

- Support for the forestry sector to ensure sustainable management of the country's natural forests and woodlands.
- Ensure the design and implementation of a regulatory framework for commercial transportation and marketing of woodfuel.
- Regulate charcoal exports to ensure that only charcoal from wood waste and planted forest are exported.

Policy considerations cont'd

- Establish the needed institutional framework to ensure and co-ordinate woodfuel related activities as an integral part of national energy development.
- Promote improved technologies and higher levels of efficiency in the production of charcoal and use of woodfuels.
- Support the development , promotion and introduction of alternative fuels for the substitution of woodfuels.

The Potential of Uusing Wood Residue for Energy Generation in Ghana (continued)

Characteristics of different types of wood processing residues

Table 1: Moisture content (Wet basis) of some selected wood species sawdust and bark

Species	Mean Moisture content (%) (Wet basis)	
	Sawdust	***Bark***
Triplochiton scleroxylon	43.90	53.39
Antiaris toxicaria	41.76	59.19
Ceiba pentandra	60.00	40.02
Pterygota macrocarpa	42.72	40.30
Guibourtia ehie	48.76	32.04
Pycnanthus angolensis	47.75	56.83

Table 2: Ash content of some selected wood species.

Species	Ash content (%)	
	wood	Bark
Triplochiton scleroxylon (ts)	4.00	8.00
Antiaris toxicaria (at)	2.00	14.00
Ceiba pentandra (cp)	4.00	6.00
Cordia alliodora (ca)	2.26	2.54
Pterygota macrocarpa (pm)	3.98	10.12
Guibourtia ehie (ge)	1.35	9.58
Pycnanthus angolensis (pa)	2.93	10.00

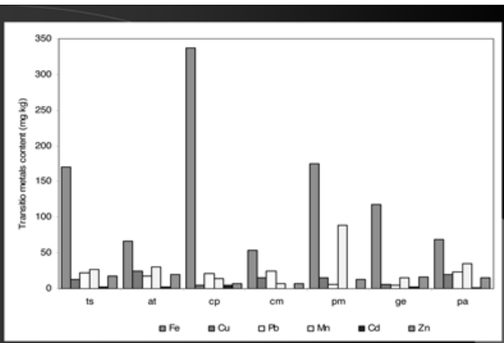


Fig. 2: Transition metals content of ash (wood) of some selected wood species

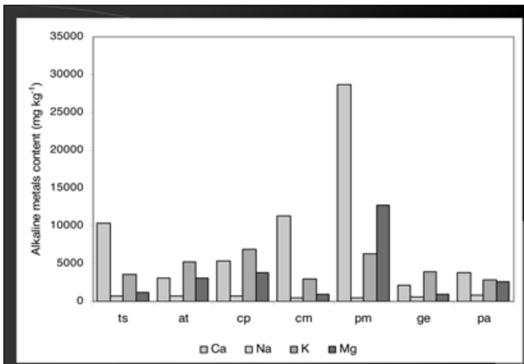


Fig. 4: Alkaline metals content of ash (wood) of some selected wood species

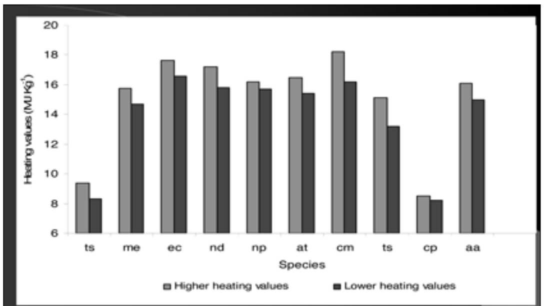


Figure 6: Higher and lower heating values for 10 hardwood species at oven-dried and at 12% moisture content

ts-Triplochiton scleroxylon, me-Milicia excelsa, ec-*Entandrophragma cylindricum*, nd-*Nauclea diderrichii*, np-*Nesogordonia papaverifera*, ti-*Terminalia ivorensis*, cm-*Celtis mildbraedii*, ts-*Terminalia superba*, pa-*Pycanthus angolensis*, cz-*Celtis zenkeri* cp-*Ceiba pentandra*, aa-*Afzelia africana*, at-*Antiaris toxicaria*

AVAILABILITY OF WOOD RESIDUE FROM THREE TIMBER MILLS

Production lines of the Timber mills

1. Asuo Bomosadu Timbers and Sawmills Ltd (ABTS)
   - ***Sawmill & Moulding***
   - ***Plymill***
2. Logs and Lumber Ltd (LLL)
   - ***Silcer Veneer***
   - ***Rotary veneer and Plywood***
   - ***Sawmill***
3. Omega Wood Processing Mill Ltd (OWPL)
   - Plymill
   - Sawmill

The Potential of Uusing Wood Residue for Energy Generation in Ghana (continued)

A) Asuo Bomosadu Timbers and Sawmills Ltd (ABTS

- Ply mill section
- Rotary cutting veneer core = 20%
- Defective sheets total = 20% of the log input.
- Sawdust = 12%.
- 20% of the residues (solids) ☞ secondary processing of which 10% comes off as sawdust.
- Residues that are not re-processed include slabs, bark, sapwood edgings and defective material.
- Altogether these constitute 38% of the initial log input

B) Logs and Lumber Ltd

Ply mill section

- One month total logs for sliced veneer production yielded the volume of 1,933.353 m^3
- The residues generated from the slicer veneer section are:
- The off-cuts were 20.2%
- Slabs and edgings were 7.2%.
- Slicer rejects (defective veneer) were 55.9% during processing.

Omega Wood Processing Co. Ltd

Ply mill section

- The total volume of wood residue from the total log input was 2586.708m^3 (64.54%).
- The total monthly average volume of bark, sawdust and off-cuts were 966.730m^3 (24.12%).
- The total monthly average volume of residue (veneer core, trimmings and defective veneer and plywood) was 1617.979m^3 (40.37%)

Plate 1: Mixed residue being burnt in the open air

Plate 2: Veneer core at dumping site

Table 6: Daily input & output volumes and % wood residue generation

Species	Input vol. (m^3/)	Export vol. (m^3)	Lumber rejects	Offcuts, slabs & Sawdust (%)	Recovery (%export)
Pterygota macrocarpa	77.984	23.736	9.544	57.34%	30.43%
Entandrophragma angolense	35.832	11.507	11.451	35.93%	32.11%
Triplochiton scleroxylon	76.916	27.673	3.602	59.34%	35.97%
Milicia excelsa	39.062	6.907	7.653	53.15%	27.26%

The Potential of Uusing Wood Residue for Energy Generation in Ghana (continued)

Table:9 the monthly log input for veneer and plywood production and residue generation for 7 months

Month	Total log vol. m^3	Total vol. of bolts and flitches from log inputs	Total vol. Of veneer and plywood	Total vol. of residue from production line	Total vol. of bark, Offcuts and sawdust	Vol. of wood residue from total input	% of total residue of log input
Jan	5198.97	2838.97	1745.95	2150.53	1302.31	3453.03	66.54
Feb	4056.28	3028.08	1442.64	1562.11	1052.21	2613.64	64.43
March	3307.03	3896.48	1138.98	1415.84	752.22	2168.05	65.61
April	3925.09	3004.72	1557.21	1452.53	915.45	2367.88	60.33
May	4623.17	2554.82	1630.91	1921.24	1071.41	2992.27	64.72
June	3204.67	3009.72	1024.42	1417.32	762.90	2180.25	68.01
July	3708.48	3552.14	1364.14	1474.83	869.51	2344.33	63.20

Plate 3: Mixture of wood residues

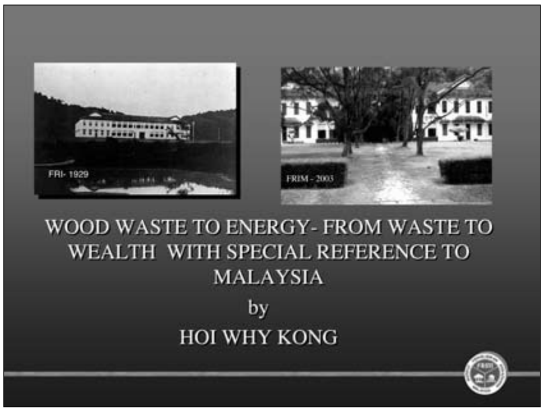
Conclusions

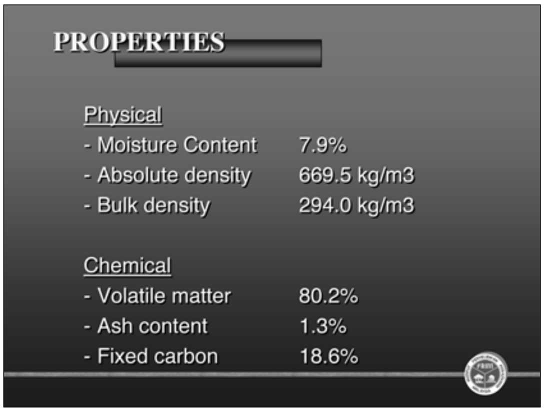
1. The wood residues generated from mills include sawdust, shavings, trimmings, slabs, veneer core, defective veneer, edgings, Offcuts and barks.
2. Recoveries of export products are still very low.
3. Most mills in Ghana generate an average annual wood residue of 33.3%.
4. Wood is still the largest and the dominant source of energy and it will remain the largest single resource for the foreseeable future.
5. There is the trend towards the increased use of sawdust as a boiler feed for energy generation.
6. Wood residue is suitable for energy generation.

Thank you for your attention

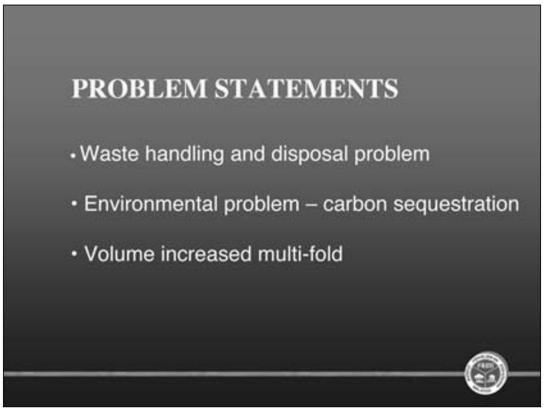
Wood Waste to Energy – From Waste to Wealth with Special Reference to Malaysia

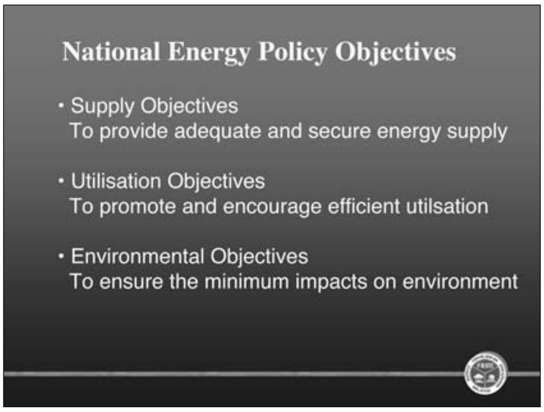
Dr. Hoi Why Kong, Forest Research Institute Malaysia (FRIM)

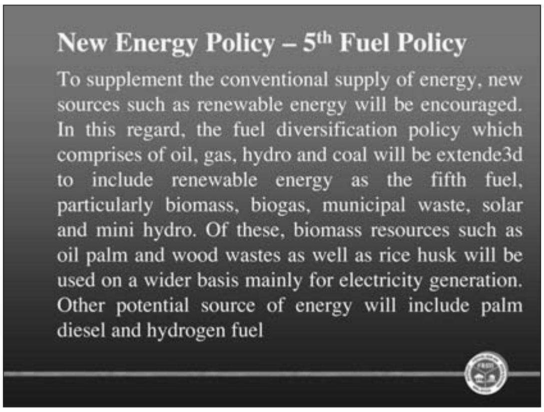


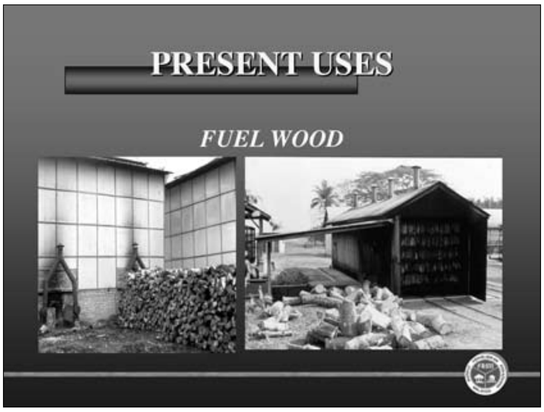


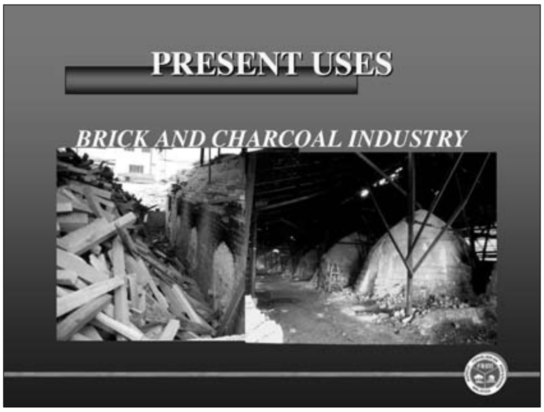
Wood Waste to Energy – From Waste to Wealth with Special Reference to Malaysia (continued)



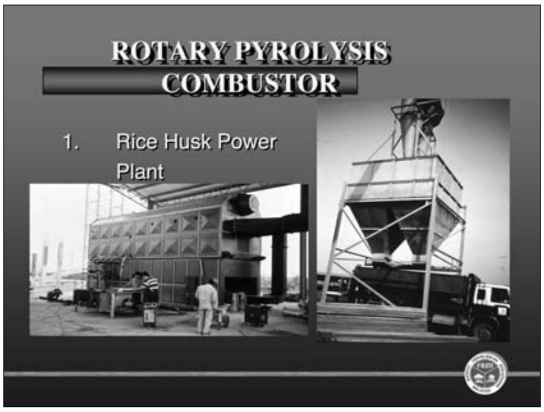


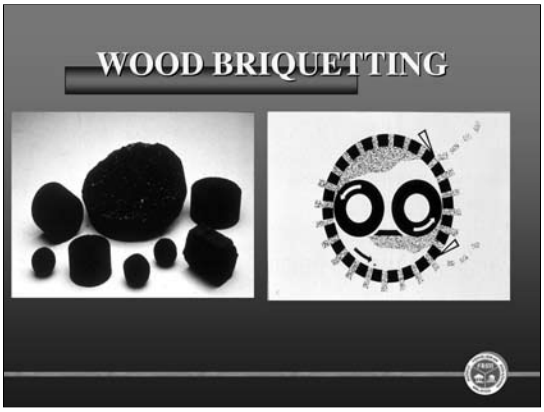


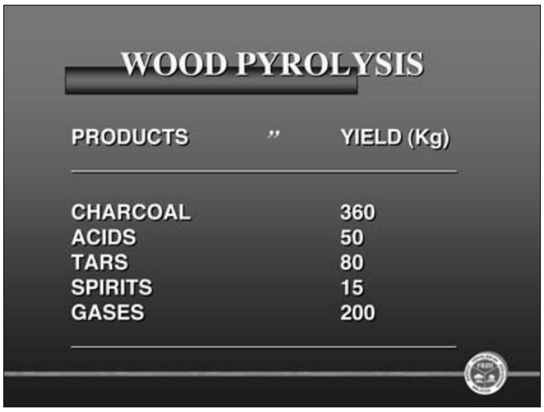


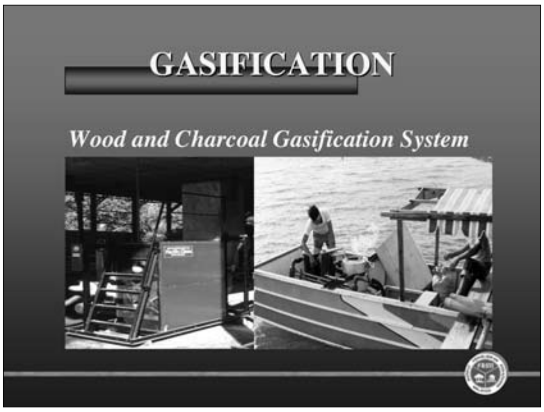


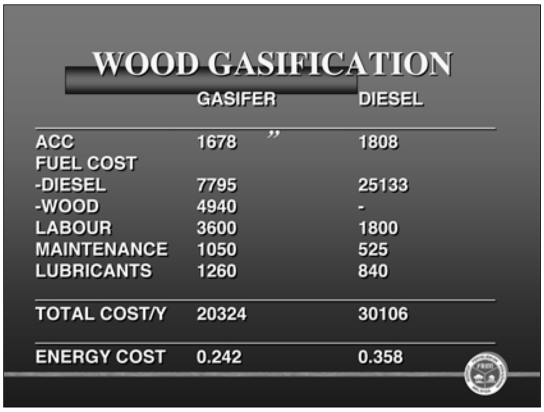
Wood Waste to Energy – From Waste to Wealth with Special Reference to Malaysia (continued)

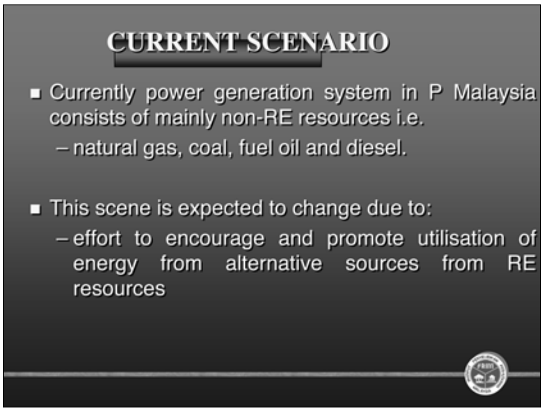












Wood Waste to Energy – From Waste to Wealth with Special Reference to Malaysia (continued)

CURRENT SCENARIO

– several initiatives and incentives were launched in the 2002 Budget; tax exemption, tax allowance and exemption of import duty and sales tax on imported machinery and equipment

– Create a new window of opportunity for small-scale RE power producers (SREP) in electricity generation

CURRENT SCENARIO

- Number of RE power plants are expected to increase in the near future as promotion to accelerate development and use of RE in electricity generation is gaining pace
- Contribution from RE sources is targeted to reach 5% of total energy generated by the year 2005 under 8th and 9th Malaysia Plan
  – about 600MW of power capacity.

CURRENT SCENARIO

- Assuming this capacity (600 MW) from RE is fully utilized, an equal amount of generation capacity from existing resources would be displaced or 'avoided' from conventional generation.

CURRENT SCENARIO

– Analysis is critical in decision of how RE resources are developed and utilized for electricity generation in P Malaysia leading to a policy on

-pricing of electricity generation from RE

-Investment subsidies for RE generators

ENERGY POTENTIAL

Type of residues	% of wood residues	Residues utilized (mil tonnes)	Generation capacity (MW)
Rubber Wood	50% of logging residues & 10% of processing residues	2.02	1,380
Forest Wood	18% of residues from forest wood industry	0.33	225

COGEN PLANT-AN EXAMPLE

Turbine Configuration	2 x 650 kW
Boiler Capacity	6.5 MW (steam)
Boiler Efficiency	75 %
Fuel Input Rate (residues)	3.1 cubic meter per hour
Plant Availability	7200 hrs per year
Estimated Project Cost	RM 7.5 million

Wood Waste to Energy – From Waste to Wealth with Special Reference to Malaysia (continued)

ECONOMIC /FINANCIAL

General Parameters and Assumptions

Installed Capacity	: 6 MW
Firm Capacity	: 5.2 MW
Commercial Operation Date	: 2004
Fuel	: 77% EFB & 23% shells
Total efficiency	: 20.1%
Capacity factor	: 90.4%
Investment cost	: RM 31.4 million
Fuel cost	: RM15/tonne *(current terms for 20 years)*
Electricity sales tariff	: 16.7 sen/kWh *(current terms for 20 years)*

FINANCIAL RESULTS

Parameter	Unit	Project Cost	
		RM 31 million	RM 27 million
FIRR	%	6.7	9.1
Payback	years	8	7

ECONOMIC RESULTS

Parameter	Unit	Project Cost	
		RM 31million	RM 27 million
EIRR	%	14.7	17.6
Econ. surplus	RM million	10.6	15
FOREX surplus	RM million	23.2	25.5

ENVIRONMENT RESULTS

Emissions	Unit	Value
CO_2	tonnes/year	- 41,764
SO_2	tonnes/year	- 42
NO_x	tonnes/year	562

CONCLUSION

- Implementation of RE power plant reduce 13,890 tonnes of coal consumption a year or fuel savings of RM 2.4 million for Malaysia
- Identified constraints:-
  - Logistic problem
  - Insecure and uncertain supply
  - Competition from other uses
  - Awareness
  - Lack of database, regular information on biomass energy

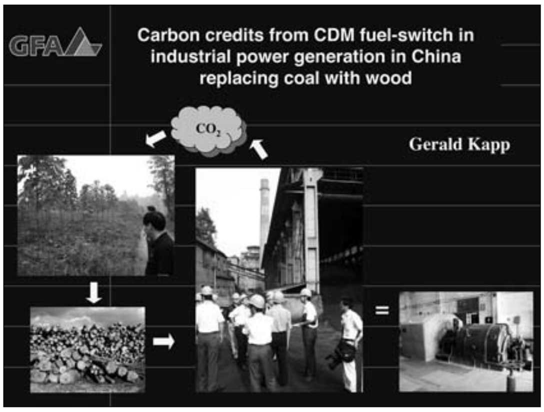
FUTURE ACTIONS

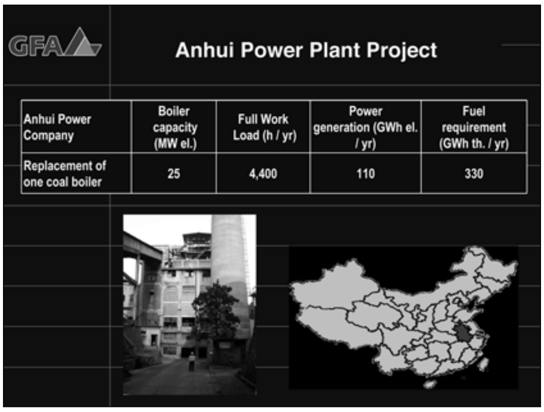
- Estimate the net availability of residues for electricity generation
- Study on the technologies for conversion of wood residues to energy
- Include additional case studies for analysis on economic and financial viability of RE power plants

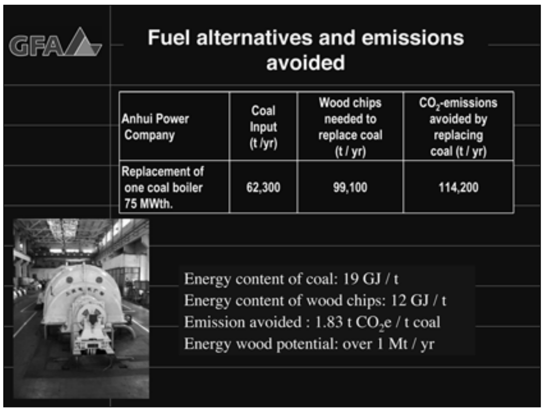
Wood Waste to Energy – From Waste to Wealth with Special Reference to Malaysia (continued)

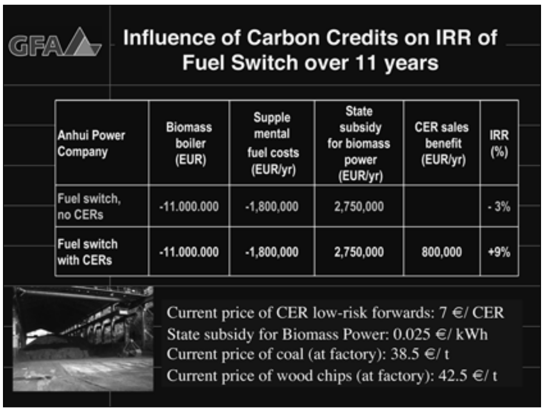
Carbon Credits from CDM Fuel-Switch in Industrial Power Generation in China Replacing Coal with Wood

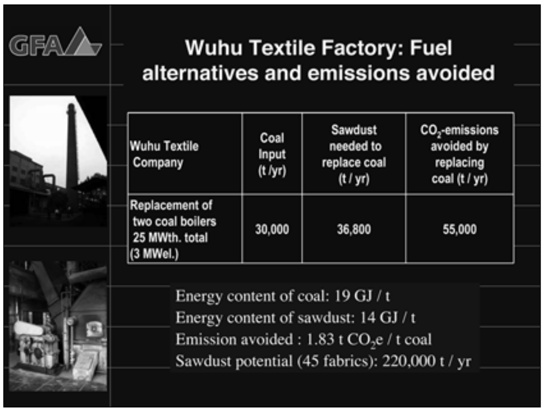
Prof. Dr. Gerald Kapp, GFA Consulting Group GmbH and GFA ENVEST GmbH, Hamburg

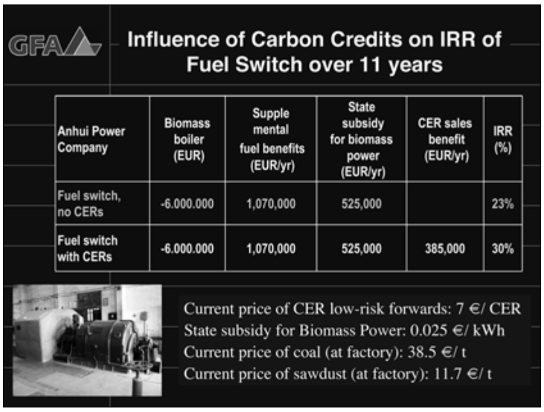






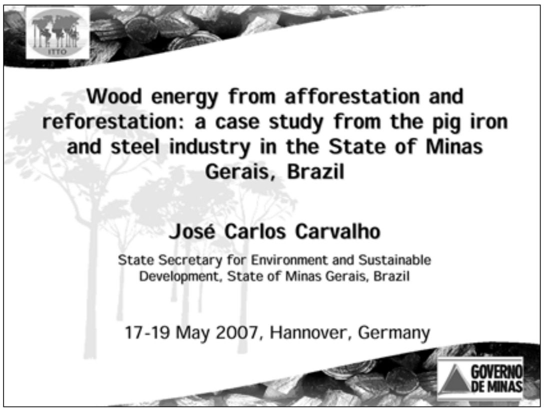


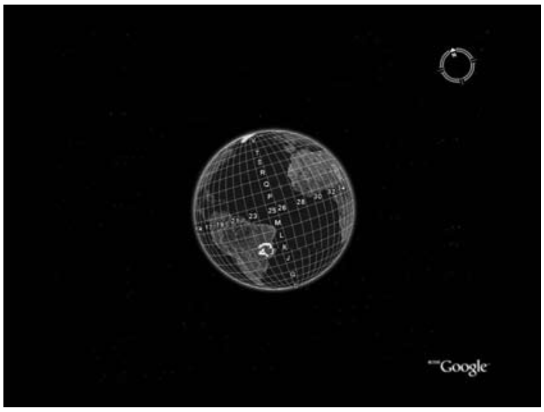


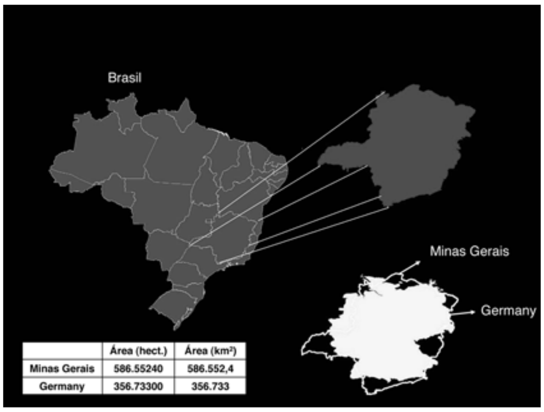


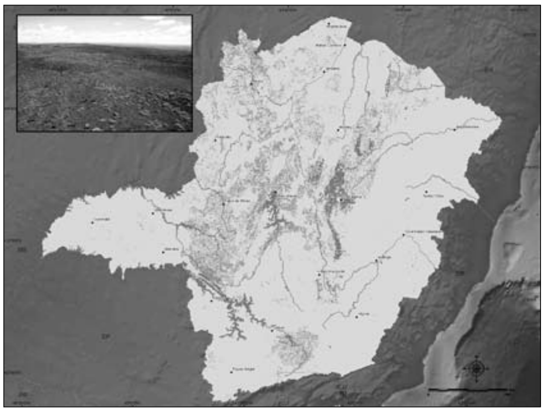
Wood Energy from Afforestation and Reforestation: A Case Study from the Pig Iron and Steel Industry in the State of Minas Gerais, Brazil

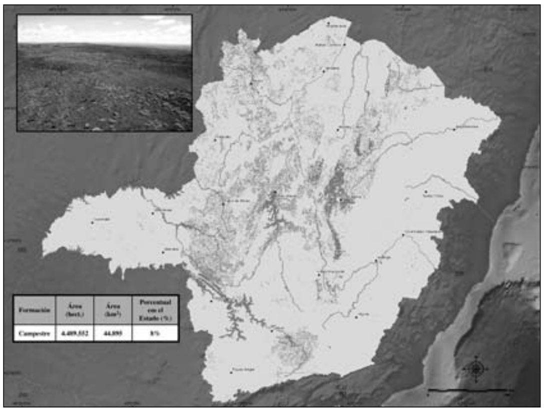
Mr. Jose Carlos Carvalho, State Secretary for Environment and Sustainable Development, State of Minas Gerais, Brazil

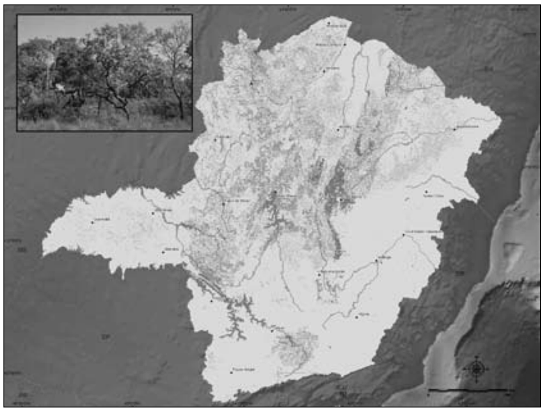




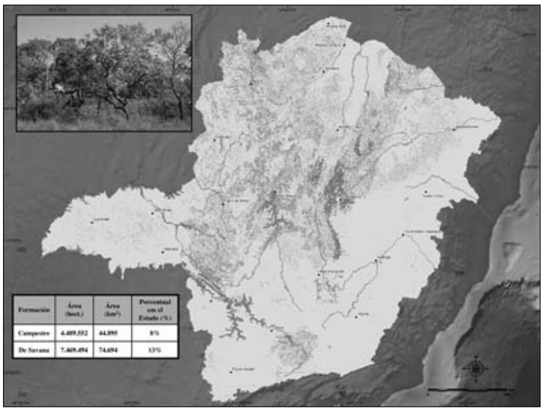


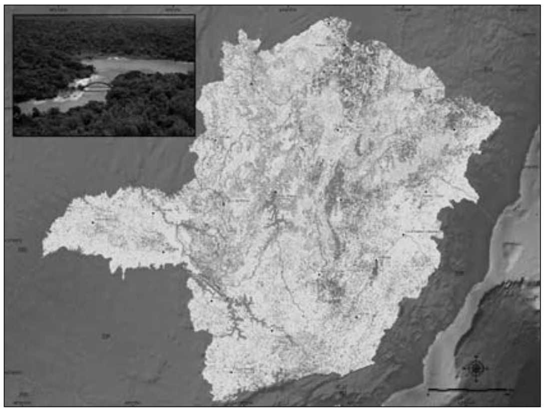


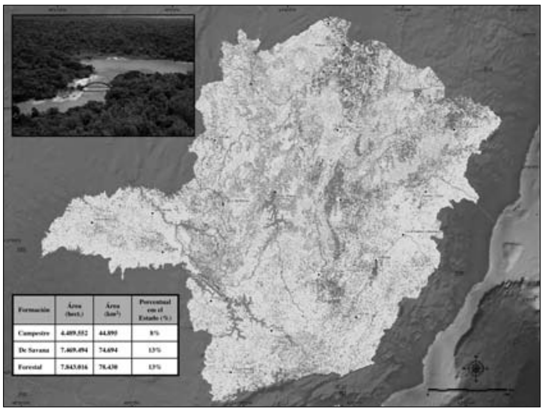


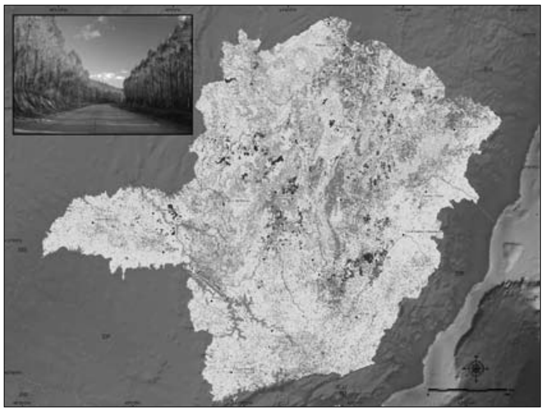


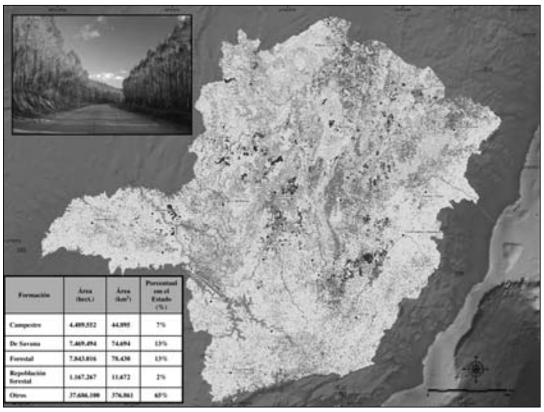
Wood Energy from Afforestation and Reforestation: A Case Study from the Pig Iron and Steel Industry in the State of Minas Gerais, Brazil (continued)

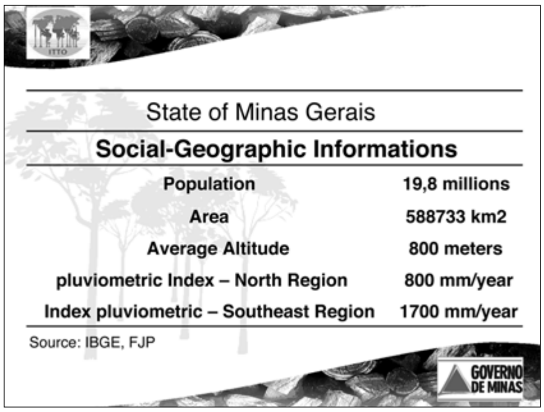




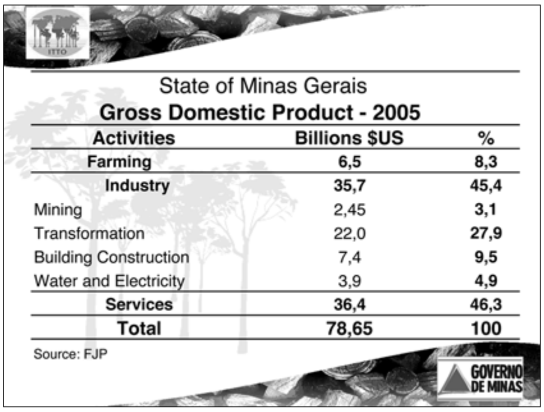








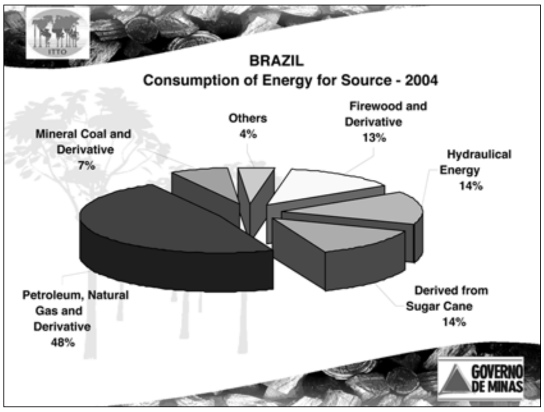
Wood Energy from Afforestation and Reforestation: A Case Study from the Pig Iron and Steel Industry in the State of Minas Gerais, Brazil (continued)

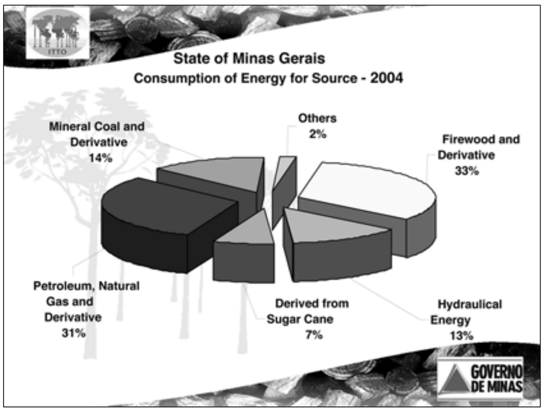


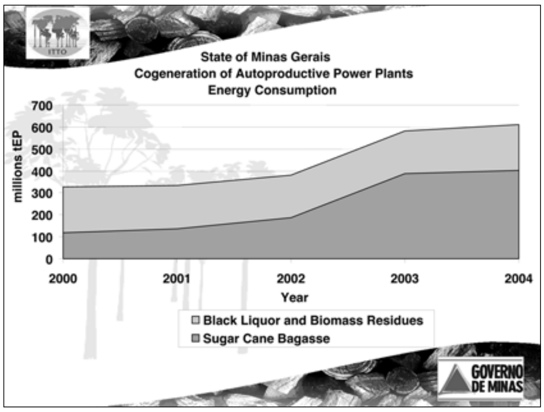
State of Minas Gerais
Gross Domestic Product - 2005

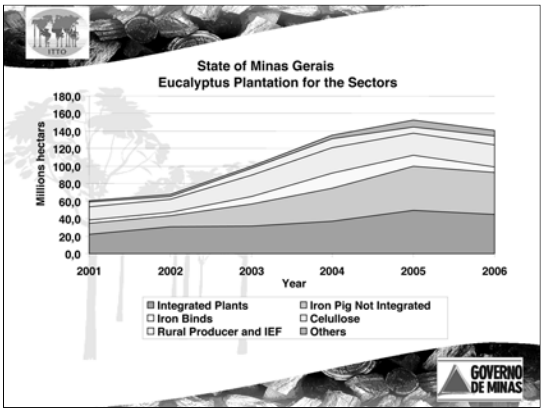
Activities	Billions $US	%
Farming	**6,5**	**8,3**
Industry	**35,7**	**45,4**
Mining	2,45	**3,1**
Transformation	22,0	**27,9**
Building Construction	7,4	**9,5**
Water and Electricity	3,9	**4,9**
Services	**36,4**	**46,3**
Total	**78,65**	**100**

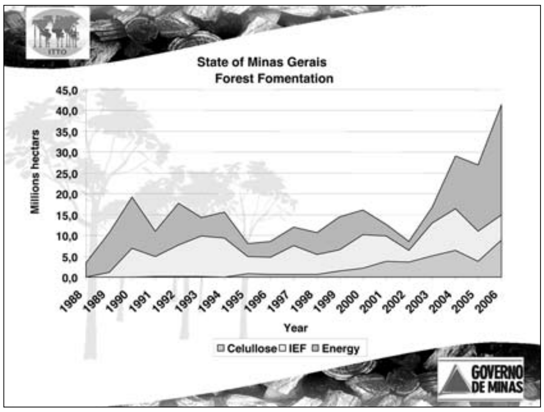
Source: FJP











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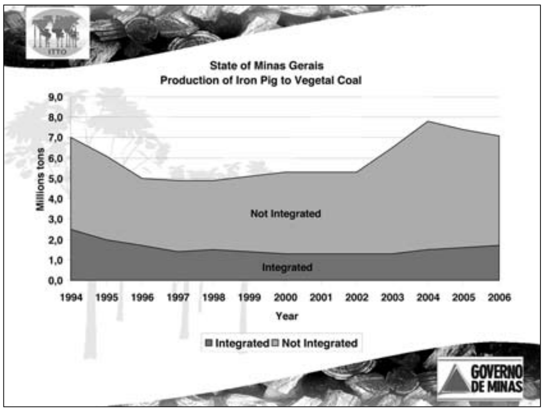
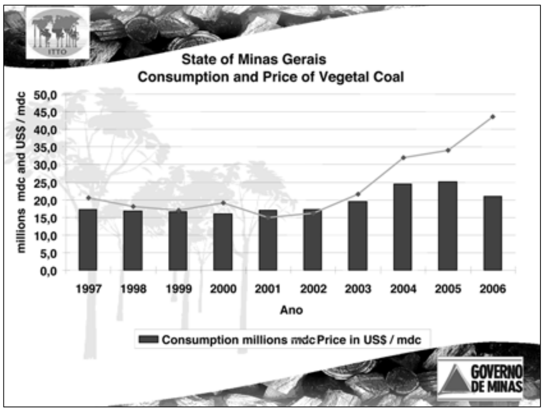


Iron Pig Producers - 2006	Minas Gerais	Brasil	MG/BR %
Independent Plants			
Number of Kilns	105	154	68,2
Installed Capacity millions tons/year	8,0	13,9	57,6
Production in millions tons	5,3	9,5	55,8
Sales in Domestic Market - millions tons	3,1	3,5	88,6
Iron Pig Exportation - millions tons	2,2	6,0	36,7
Iron Pig Exportation - billions US$ FOB	-	1,6	-
Integrated Plants			
Number of Plants	4	4	100,0
Production in millions tons	1,7	1,7	100,0

Source: Sindifer



State of Minas Gerais
Man Power used by the Forest Sector - 2006

	Number of Jobs			
	Direct	Indirect	Income Effect	Total
Forest Sector	94.100	368.000	222.170	684.270
Forest Plantations	42.300	169.200		
Timber Carbonization	47.600	190.400		
Combustible Timber	4.200	8.400		
Siderurgy	28.136	119.272	230.570	377.978
Integrated	8.068	32.272		
Iron Pig	11.100	51.200		
Iron Binds	8.970	35.800		
Celullose and Paper	10.600	42.400	46.000	99.000
Timber and Furniture	14.960	59.840	43.380	118.180
Panels	1.380	5.520		
Processed Timber	13.580	54.320		
Total	147.796	589.512	542.120	1.279.428

Source: AMS, Sindifer, Fiemg, empresas do setor.

Efficient Co-generation of Energy Products in Pulp Industry

Prof Leif Gustavsson, Mid Sweden university, Östersund, Sweden

Efficient co-generation of energy products in pulp industry

Leif Gustavsson
Ecotechnology
Mid Sweden University

International Conference of Wood-based Bioenergy
Hannover, Germany, 17-19 May 2007

Aim

To compare **potential** production of electricity and motor fuels in pulp mills using

- Conventional recovery boiler (RB) - reference
- Black liquor gasification combined cycle (BLGCC)
- Black liquor gasification for motor fuels (BLGMF)

The presentation is mainly based on: Holmberg, J.M. and Gustavsson, L., *CO_2 and oil use reduction by implementation of black liquor gasification and energy efficiency in pulp and paper industry* (journal article manuscript).

Background, drivers

- Climate change
  - Use of biomass-based energy to replace fossil-based energy
  - Better effect when carbon intensive energy is replaced, e.g. coal-based electricity
- Oil dependency
  - Specific policy targets for reduced use of oil
  - Biomass-based fuels to replace petroleum products in transportation sector
- ➢ The objective is (at least) dual
  - Not optimize for one or the other objective

Pulp and paper mills

- Accounts for about one third of the roundwood use in Europe, in Sweden about 50%.
- Already co-produce fibre products, steam and electricity from biomass
- Have infrastructure and competence for handling large amounts of biomass
- Use large transportation fleets – potential for introduction of new transportation fuels with centralized refuelling

Studied alternatives

Bleached softwood kraft pulp

RB	BLGCC	BLGMF
Conventional recovery boiler	Black liquor gasification	Black liquor gasification
• Back pressure and condensing steam turbines	• Combined Cycle gas and steam turbines	• Back pressure steam turbine • DME synthesis
Electricity Surplus	**Electricity** surplus	**Motor Fuel** surplus

Data based on Berglin et al., 2003, *Preliminary economics of black liquor gasification with motor fuels production*, Colloquium on Black liquor Combustion and gasification, Park City, Utah, May 13-16 2003.

Parameters studied

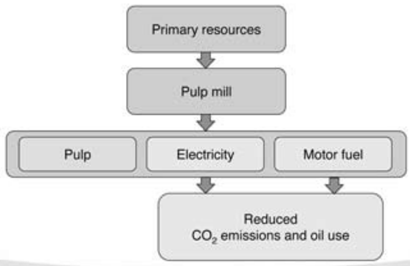
- CO_2 emission
- Oil use
- Biomass use
- Total primary energy use
- Monetary costs
  - Lifetime of 25 years for energy plant and pulp mill investments
  - Discount rate of 6%

Efficient Co-generation of Energy Products in Pulp Industry (continued)

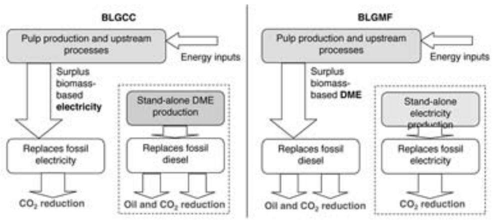
Assumptions

- Chemical pulp mills
- Bleached softwood kraft
- Based on Swedish conditions
- Data from model mills (based on KAM project)
- Energy demand in the mill is met with forest biomass

From primary resources to final products



Same CO_2 emission and oil use reduction



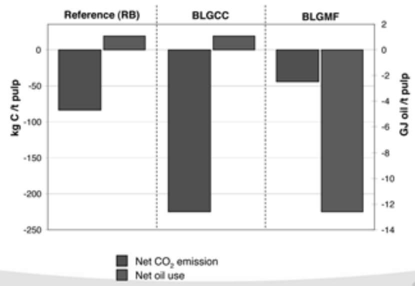
Assumptions energy supply

- Stand-alone biomass-based electricity
  - Integrated gasification with combined cycle (BIG/CC)
  - 47% conversion efficiency
- Stand-alone biomass-based DME
  - Gasification and fuel synthesis
  - 63% conversion efficiency
  - 0.11 GJ auxiliary electricity use / GJ DME
- Fossil energy replaced
  - Coal-based electricity (47% conversion efficiency)
  - Diesel as transportation fuel

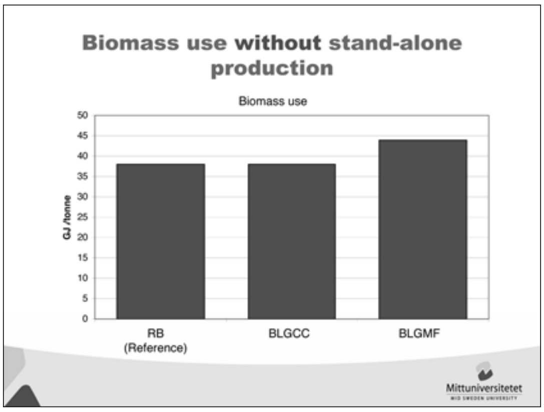
Co-generation in pulp mill and stand-alone production GJ per ton pulp

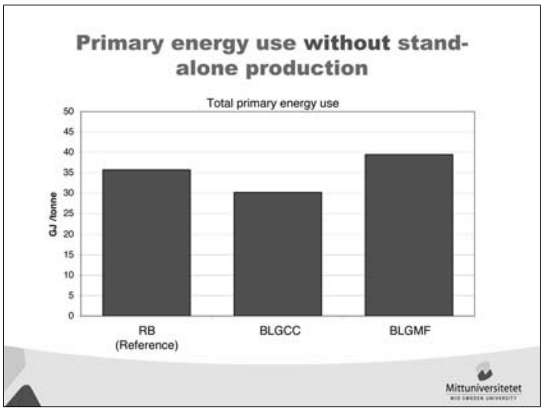
	RB		BLGCC		BLGMF	
	Electricity	Fuels	Electricity	Fuels	Electricity	Fuels
Co-generation, gross	5.4	0	8.9	0	1.4	13.5
Stand-alone generation	2,3	13.9	**0**	13.7	6.0	**0**
Process use and energy system own use	-5.2	-2.3	-6.4	-2.1	-4.9	-1.9
Net export	**2.4**	**11.6**	**2.4**	**11.6**	**2.4**	**11.6**

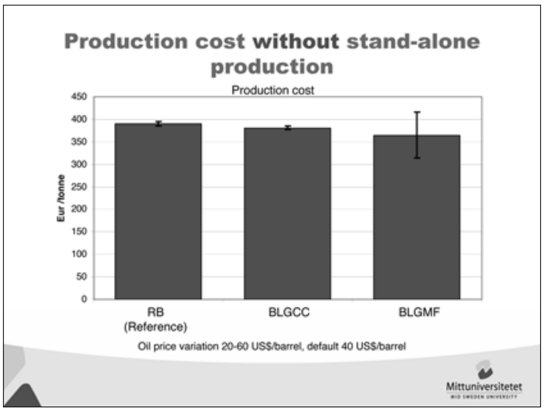
CO_2 emission and oil use balance without stand-alone production

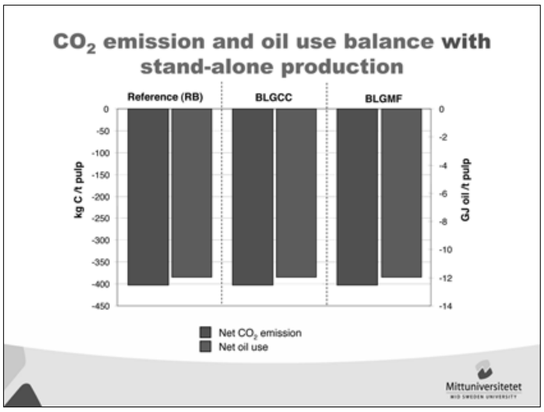


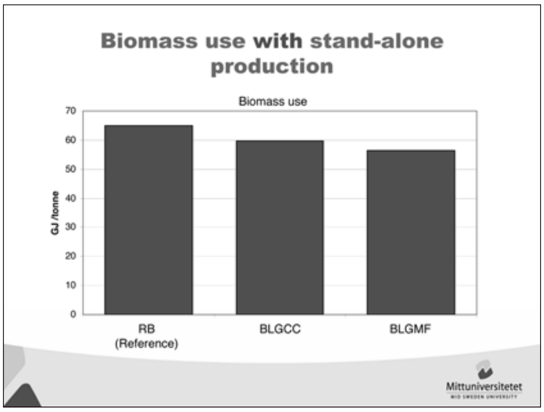
Efficient Co-generation of Energy Products in Pulp Industry (continued)

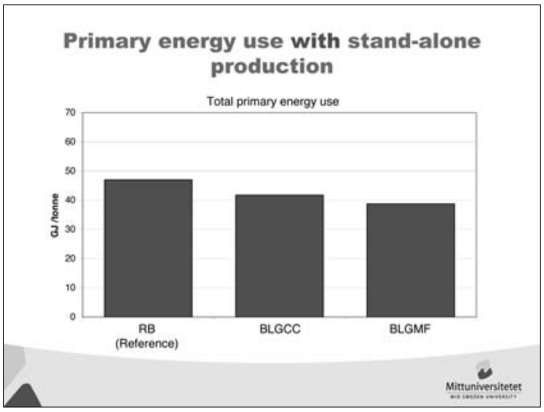






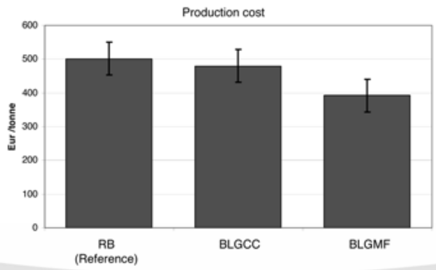






Efficient Co-generation of Energy Products in Pulp Industry (continued)

Production cost with stand-alone production



Oil price variation 20-60 US$/barrel, default 40 US$/barrel

Production of sulphate pulp

M tonne	Bleached	Unbleached	Total
Sweden	4.9	2.1	7.0
Europe	19	6.5	26
Global	79	30	109

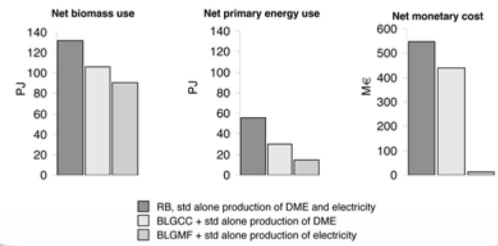
BLGMF implementation for all *bleached sulphate pulp* in Sweden could replace ~65 PJ of diesel annually, or about 47% current Swedish use of diesel.

Pulp data for 2005 from FAOSTAT. Diesel use 2003 according to statistics Sweden.

Conclusions

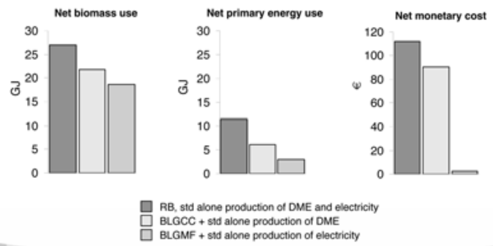
- BLG in chemical pulp mills gives lower biomass use, primary energy use and monetary costs than stand-alone production of fuels and electricity from biomass.
- BLGMF is to prefer if we want both CO_2 emission and oil use reductions
- BLGCC is to prefer if we want only CO_2 emission reduction
- The conclusion is not sensitive to changes in fuel and biomass prices or choice of discount rate or marginal electricity supply.

Costs to reduce Swedish CO_2 emissions by 1.6 Mt C and oil use by 64 PJ

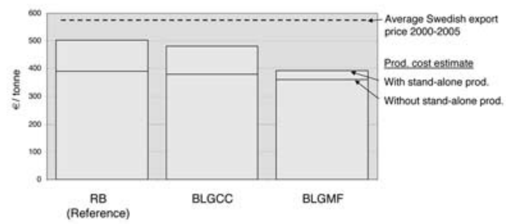


Costs to reduce CO_2 emissions by 400 kg C and oil use by 12 GJ

(reduction per tonne pulp)

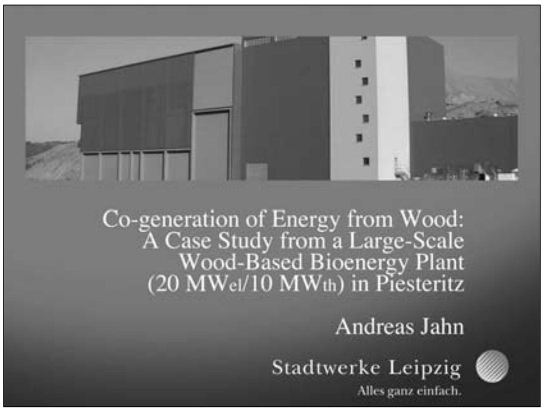


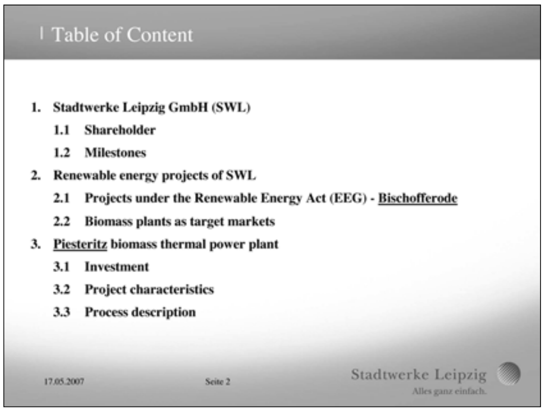
Comparison to market prices

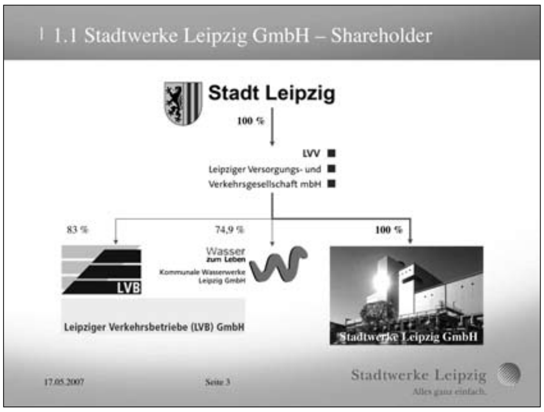


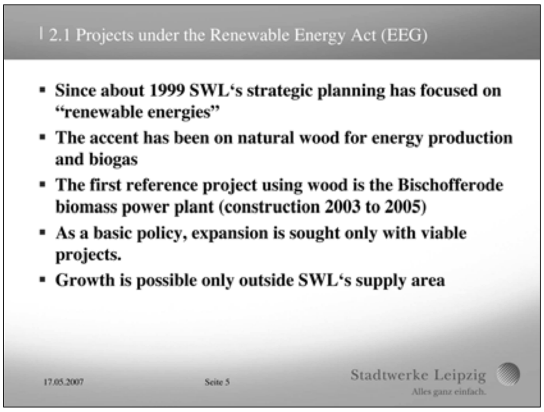
Co-generation of Energy from Wood: A Case Study from a Large-Scale Wood-Based Bioenergy Plant (20 MWel/10MWth) in Piesteritz

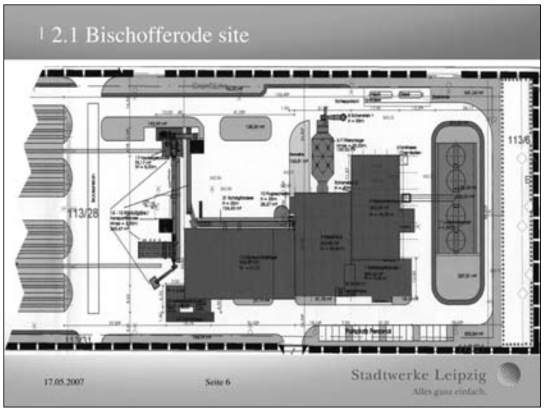
Mr. Andreas Jahn, Endico – Stadtwerke, Leipzig, Germany



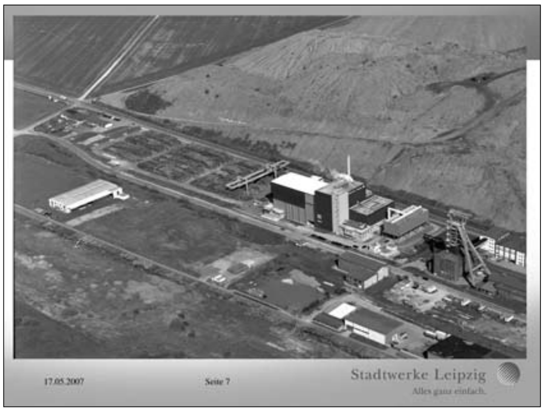


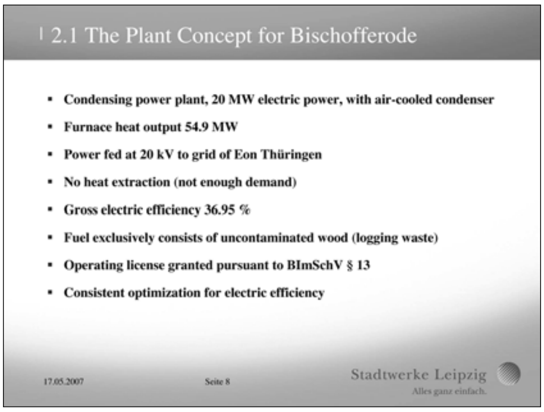


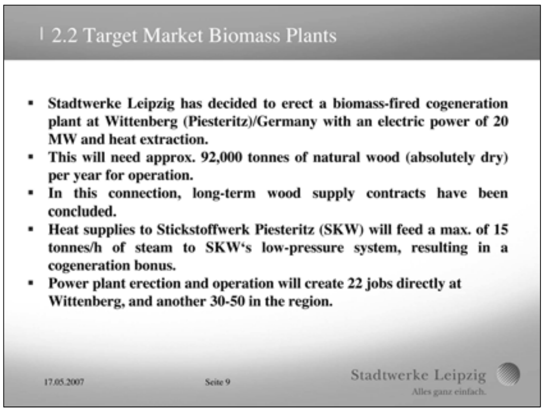


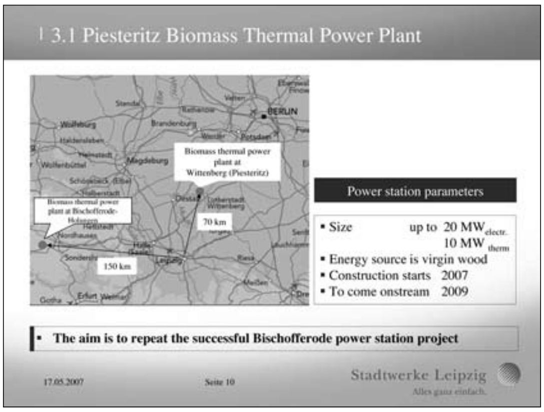


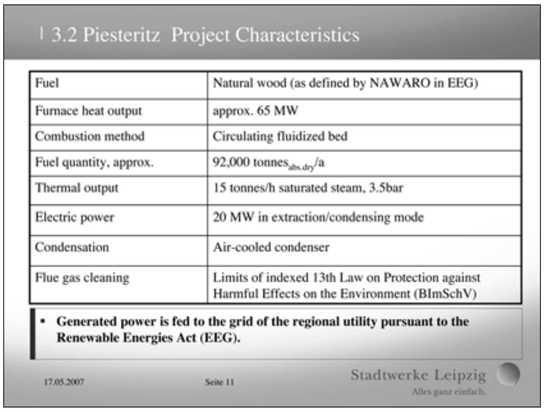
Co-generation of Energy from Wood: A Case Study from a Large-Scale Wood-Based Bioenergy Plant (20 MWel/10MWth) in Piesteritz (continued)



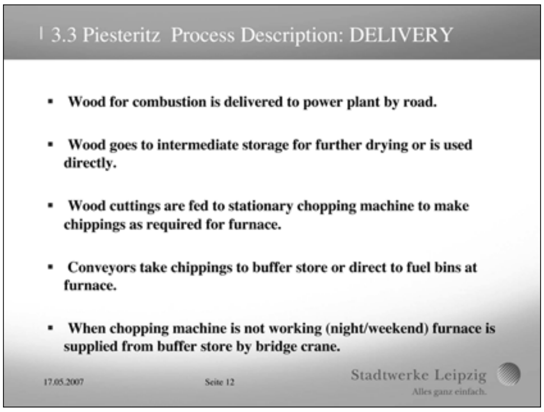




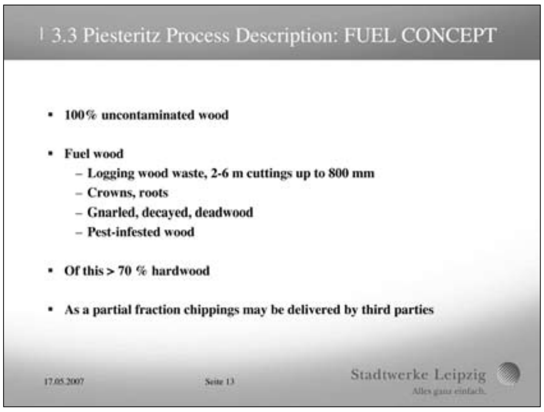


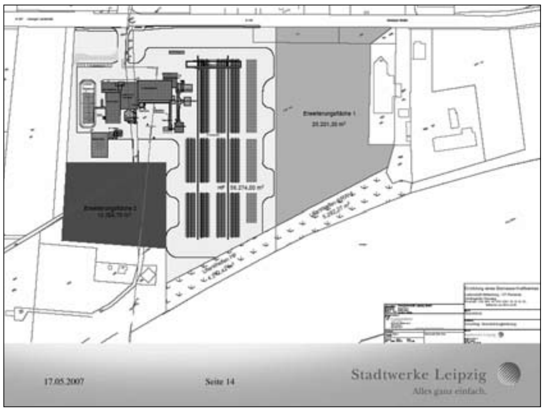


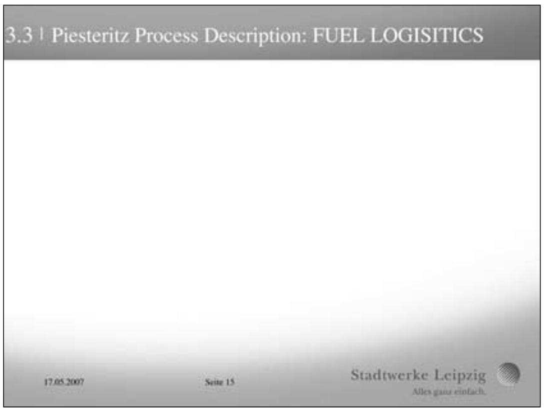
Fuel	Natural wood (as defined by NAWARO in EEG)
Furnace heat output	approx. 65 MW
Combustion method	Circulating fluidized bed
Fuel quantity, approx.	92,000 $tonnes_{abs.dry}$/a
Thermal output	15 tonnes/h saturated steam, 3.5bar
Electric power	20 MW in extraction/condensing mode
Condensation	Air-cooled condenser
Flue gas cleaning	Limits of indexed 13th Law on Protection against Harmful Effects on the Environment (BImSchV)

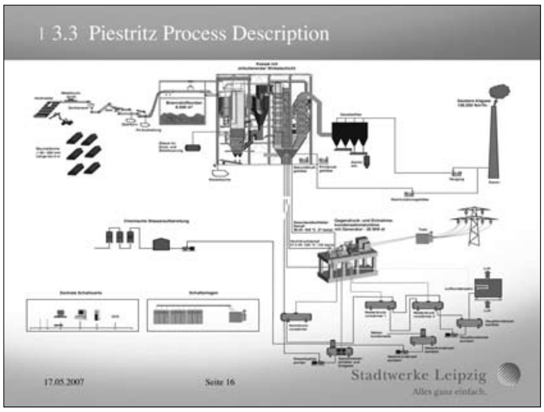


Co-generation of Energy from Wood: A Case Study from a Large-Scale Wood-Based Bioenergy Plant (20 MWel/10MWth) in Piesteritz (continued)









INTERNATIONAL TROPICAL TIMBER ORGANIZATION

International Organizations Center, 5th Floor, Pacifico-Yokohama, 1-1-1, Minato-Mirai, Nishi-ku, Yokohama, 220-0012, Japan
Tel 81-45-223-1110 Fax 81-45-223-1111 Email itto@itto.or.jp Web www.itto.or.jp