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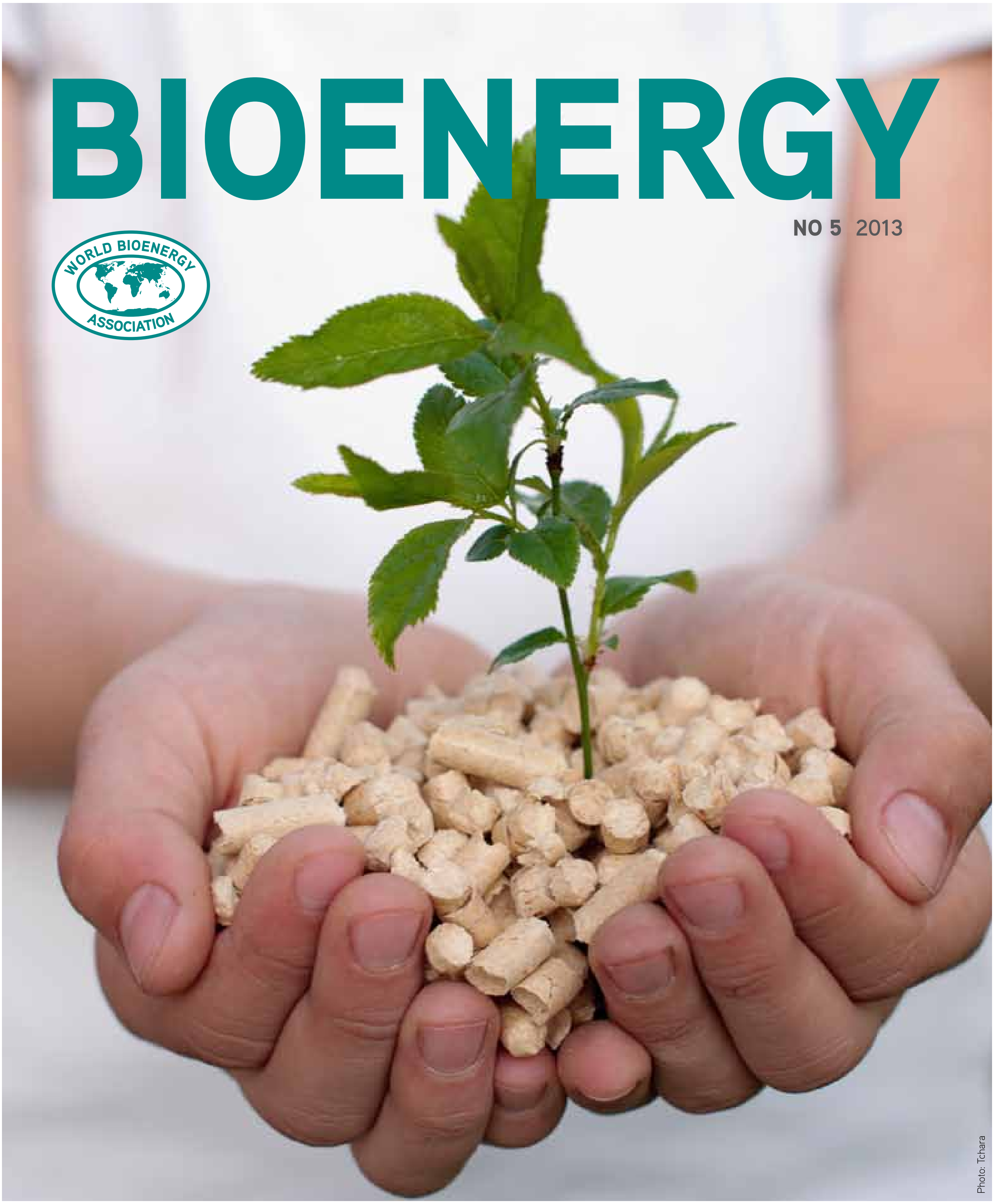

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BIOENERGY – A WORLD OF OPPORTUNITIES

Biofuels for transport

Biomass Combined Heat and Power (CHP)

BIOGAS – AN IMPORTANT RENEWABLE ENERGY SOURCE

Heinz Kopetz:

Bioenergy – a world of opportunities

FULL VERSIONS OF ARTICLES; worldbioenergy.org

SINCE THE WORLD BIOENERGY ASSOCIATION was formed in 2008 it has grown in both strength and influence on a global stage through the support of governments, scientists and private sector funding. Simultaneously we are ensuring that our work remains scientifically verifiable and most importantly, impartial to all outside influence. The WBA's mission statement has not changed since its formation; 'To promote the use of sustainable bioenergy globally.'

Today, the WBA is recognised globally by the IPCC, UN, EU, IRENA (International Renewable Energy Agency) and the REN Alliance (International Renewable Energy Alliance).

Since the industrial revolution governments' foreign policy and major industry across all sectors have dictated how time, effort and money is spent ensuring the continued extraction of fossil fuel resources in order to continue competitive international trade.

Bioenergy is (often literally) a growing sustainable energy source and a vital part of the futures sustainable energy system that has not "stolen food off the table", but in the future could actually add to international food security.

Bioenergy today is woven into society on many levels, with public perception varying tremendously from country to country.

The following articles are excerpts from a series of fact sheets, produced by the WBA, to inform its readers of modern developments in the field of bioenergy. The WBA is convinced that bioenergy is a sustainable, clean energy source that we will increasingly need, in order to one day completely rid ourselves from our dependence on unsustainable, polluting or dangerous energy sources. We are sure you will draw the same conclusions from the information we have put together within these pages and we welcome (and encourage!) you to join the discussion.

For the full versions of the articles, please visit the WBA website; www.worldbioenergy.org

Yours sincerely,

Heinz Kopetz,
President of the World Bioenergy Association

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INTRODUCTION

Recently the first part of the 5th Assessment Report of the IPCC on "Climate Change " was published in Stockholm. The WBA has summarized three important messages from this report as follows:

Human influence

The human influence on our climate now appears effectively to be proven. The report says:

"It is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century".

Fossil fuels as main cause of climate change

Burning fossil fuels is the dominant cause for the increase of CO_2 in the atmosphere. The report explains: "There is an uptake of energy in the climate system due to the positive radiative forcing. The largest contribution to total radiative forcing is caused by the increase in the atmospheric concentration of CO_2 since 1750." and further: " Annual CO_2 emissions from fossil fuel combustion and cement production were 9.5GtC in 2011, 54% above the 1990 level. Annual net CO_2 emissions from anthropogenic land use change were 0.9 GtC on average during 2002 to 2011." Hence the CO_2 emissions caused by burning fossil fuels are ten times higher than those of land use change!

The chance for mitigation

The IPCC publication also contains an optimistic message pointing out that mankind still has the choice to mitigate climate change in this century. In the report a mitigation scenario is presented within the context of rather modest climate change. In this IPCC scenario cumulative CO_2 emissions of 270GtC are assumed in the period of 2012 – 2100 as compared to 1685 GtC emissions in the high emission scenario. The report concludes: " Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions."

In the remainder of this article the WBA will present a strategy towards getting 100% of our energy from renewables in the future; a strategy that simultaneously leads to a more successful mitigation of climate change.

The WBA concept for the mitigation of climate change:

100% renewable energy is possible

THE FIRST STEP ON THE MITIGATION PATHWAY: MORE THAN 50% RENEWABLES BY 2035!

The cornerstones for the changes needed to the global energy system by 2035 are:

- A reduction in the energy consumption in the developed world,
- Globally a twentyfold increase of wind and solar energy from a relatively low level,
- A threefold increase of biomass from already relatively high levels,
- A halving in the use of fossil fuels.

The technologies and resources are available for this proposal of increased implementation of renewable energies. What is still needed is a reliable political framework and conditions that attract private capital investment for this energy revolution and clear and simple rules to drive and guide a sustainable development of biomass. This transformation has to comprise the markets for electricity, heat and transport. The WBA proposes targets for renewable electricity, heat and transport until 2035 in line with the mitigation scenario of the IPCC.

Electricity

The WBA proposes a rapid deployment of renewable electricity such as electricity from wind, solar and other technologies with an annual growth rate of 8.5%. Such a development in combination with a stable production of nuclear electricity would completely change the structure of the industry. In 2035, electricity demand will be higher than 2010, with the share of renewable electricity above 80% and the fossil fuel-based electricity reduced by more than 75%.

Table 1: Proposed electricity generation

Energy sources	2010, IEA TWh	2035, WBA TWh
Fossil sources	14 447	3 200
Nuclear	2756	2 800
Total RE*	4207	32 600
Total generation	21 408	38 600
Share of RE	20%	84%

** electricity from wind, solar geothermal, hydro and biomass.*

Heat

Paradoxically the heating sector is often overlooked in the discussion about energy strategies although for the developed world heating makes up about 50% of final energy. The main sources of renewable heat are biomass, geothermal energy and solar energy. WBA proposes a strong push for renewable heat, especially based on biomass and solar thermal technologies.

This rapid growth of the use of biomass for heat requires specific strategies for different countries. In countries north of 45 degrees latitude, biomass in the form of wood chips, other wood residues and agricultural by-products such as straw should be increasingly used in district heating plants, plus the use of heat from biomass cogeneration plants. But also the service and manufacturing sector will become an interesting market for this kind of biomass-sourced heat.

In addition, a rapidly growing pellets industry will supply pellets for residential, manufacturing and service sector, and for electricity generation sectors. White pellets and also, in future, torrified pellets, have a high energy density and can therefore be traded worldwide at low cost, as long as the main consumer is located near the coast. In developing countries with a high share of traditional biomass and charcoal, the main focus will have to be improvements in efficiency and technology used and to drive the move to sustainable production.

Table 2: Proposed heat energy production

Energy sources	2010, IEA Mtoe	2035, WBA Mtoe
Fossil sources	3 320	1 576
Bioenergy	1 132	2 684
Other RES	38	516
from geothermal	*9*	*86*
from solar thermal	*29*	*430*
Total renewable heat	1170	3 200
Total heat	4 490	4 776
Share of RE	26%	67%

Transport

In the year 2010 the share of renewables in the transport sector including road, train, ship and air transport, was low. Out of the total consumption of 2376 Mtoe (99.5EJ) 60 Mtoe (2.5 EJ) were covered by biofuels, mainly ethanol and biodiesel, and 24 Mtoe (1EJ) by electricity. As 80% of electricity was not renewable in 2010 the total amount of renewables in transport was only 64Mtoe, corresponding to 2.7%.

In the year 2035 the WBA does not expect a dominant role for renewables in the transport sector. The WBA proposes an increase of first-generation fuels, of advanced biofuels and of biomethane for transport, to 334 Mtoe in total. Electricity use will grow for trains and subways, and for shorter distance road traffic but not for long-distance road traffic, or for trucks. Biofuels used by ships and air traffic will increase in response to binding targets.

Table 3: Structure of energy use in the transport sector

Energy sources	2010, IEA Mtoe	2035, WBA Mtoe
Oil/others	2 294	2 293
Electricity	24	95
Biofuels	59	334
Total RES	83	429
Total	2 377	2 722
Share of RE	2.7%	16%

THE FINAL GOAL: 100% RENEWABLES

The first priority concerns the time period from 2010 to 2035. This is the timespan in which the transformation to a new energy system has to begin and be partly implemented in order to follow the mitigation pathway. Yet, the described energy concept for 2035 is only an intermediate target on the way to an energy system based completely on renewables. Such an an energy system can be reached in the period between 2035 and 2050.

The following Table 4 presents a vision for the sustainable energy system of the future. It should be noted that in such a sustainable system a negligible quantity of fossil fuels might still be needed for specific purposes, for example remote industrial processes.

The main characteristics of the path beyond 2035 to a 100% RE world will be:

- A reduction of the total primary energy demand due to energy savings and a higher efficiency of the total system.
- Phase-out of nuclear energy.
- Phase-out of fossil fuels except for a small quantity for transport and special uses in industry.
- Strong further growth of solar electricity, solar heat and wind electricity supported by additional energy from geothermal resources.
- Small further growth of hydropower and of biomass mainly for transport fuels
- Decentralised energy supply.

The lion's share of the energy supply in a 100% RE world would come from solar and wind, the rest from bioenergy, geothermal and hydro. Such a system would have dramatic advantages as compared to the present system.

Cheap energy in the future

One main difference concerns the fuel cost. Fossil energy and biomass have feedstock costs whereas wind, solar, hydro and geothermal don't have feedstock costs but only operating and capital costs.

The proposed transformation of the energy system would mean that the share of energies without costs for the feedstock increases from 3% now to 25% in 2035 and more than 60% in the future. This means energy could become really cheap.

Table 5: Changing share of energies without feedstock cost, %

	2010	2035	2050
Energy carriers without feedstock cost	3	24	63

Reduction of the CO_2 emissions, no nuclear risks, no wars for energy resources!

The biggest advantages of the new RE system lies in the avoidance of CO2 emissions, the various risks associated with nuclear power plants and reduced risk of future conflicts arising from dwindling fossil resources. 100% RE is the way towards an environmental-friendly, peaceful and sustainable energy future.

New employment

In addition the transformation to such a system would create millions of jobs as a big part of the total energy system has to be renewed.

Table 4: The transformation to 100% renewable energy sources (RE)

Energy sources	2010, IEA, Mtoe	2035, WBA, Mtoe	Vision towards 2050, Mtoe
Fossil	10 327	5 153	238 (2.1 %)
Nuclear	719	740	0
Hydro	295	593	715 (6.3%)
Bioenergy	1 277	3 650	4 055 (35.4 %)
Other RE	112	2 504	6 441 (56.2 %)
TOTAL	12 730	12 640	11 449
Share of RE in %	13.3	53.4	97.1

Photo: Roman Milert

Future innovations facilitate switch to 100% renewables

In the next 20 years many innovations in the energy field will again take place – just as many innovations were observed over the last 20 years. These innovations will facilitate the transformation to a 100% renewable energy system.

The main challenge until 2035 should be the transformation of the electricity and heating sector to renewables; renewable transport should not be the main concern as long as far bigger quantities of fossil fuels are used for heat or electricity generation. The transformation of the transport sector should follow later, based on new experiences to be gained over the next two decades. It also can be expected that the demand for heating/cooling will go down in the longer run due to the better energy efficiencies of buildings – then a larger share of biomass would be available to be used for the generation of transport fuels after 2035.

WBA is convinced: the best answer to the new IPCC report on climate change is an accelerated transition to an energy system without reliance on fossil and nuclear energy. Government policies and investment decisions should be directed towards this goal. A delay in the transformation of the energy system deepens the problem. It leads to additional global warming and would require even bigger adjustment efforts in the future. 100% renewable energy is possible within less than 40 years! The faster we take this road, the better for the future! ■

LITERATURE:

IEA, World Energy Outlook. 2012. Paris.

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SUMMARY

'Biogas' is a gas produced by anaerobic fermentation of different forms of organic matter and is composed mainly of methane (CH_4) and carbon dioxide (CO_2). The global potential of biogas is large enough to provide a substantial share of future gas demand; estimations show that biogas could cover around 6% of the global primary energy supply, or one quarter of the present consumption of natural gas (fossil methane gas).

Typical feedstocks for biogas production are manure and sewage, residues of crop production (i.e., straw), the organic fraction of the waste from households and industry, as well as energy crops including maize and grass silage.

Biogas – an important renewable energy source

INTRODUCTION

Worldwide, biomass (including putrescible waste and bio-wastes) accounts for more than two thirds of all renewable energy supplied. Among biomass sources, biogas is an interesting option with a large potential that offers many exciting possibilities to supplant and therefore reduce our dependence on fossil fuels.

Currently the modern biogas production industry is just at the beginning of wider implementation. With the exception of a few countries, like Germany (which are already demonstrating its real potential) only a tiny part of this global potential has been realized. Reasons for the slow deployment of biogas include: a lack of information about the possibilities of biogas, a lack of a trained labor force, high capital cost for the setting up of commercial plants, generally inadequate and un-reliable government support policies and the competition of natural gas as a cheaper alternative in many parts of the world.

A specific advantage of biogas technology is in the utilisation of organic wastes and other organic byproducts for energy production, as opposed to disposal via landfills, which inevitably leads to further emissions of greenhouse gases by the process of slow decomposition.

Photo: Bernd Wittelsbach

Biogas energy plant in Germany. Biogas already provides more than 3% of the whole of Germany's electricity consumption, as well as significant amounts of industrial heat, transport fuels, and volume injected into the natural gas grid.

FEEDSTOCK

Biogas can be produced from most biomass and waste materials regardless of their composition and over a large range of moisture contents (although very high moisture content material of under 5% dry matter reduces biogas yield) with limited feedstock preparation.

Organic fraction in landfills

By extracting and processing the landfill gas so it can be used for energy purposes – usually as a fuel for gas engine-driven generators. Moreover, landfill gas utilisation reduces green house gas (GHG) emissions.

Sewage sludge

Sewage sludge refers to the residual, semi-solid material left from wastewater treatment. It can be used as a feedstock for biogas. This is done in many wastewater treatment plants. The residues from digestion can be used as soil conditioner.

Manure

Manure is produced by intensively housed livestock and in some countries it is stored on farms for several months in both liquid or solid form for use as fertilizer. During storage, anaerobic digestion can take place in the bottom layers of the manure, producing methane that might be released to the atmosphere if it were not used for energy or flared. Blending manure with energy crops or other waste streams for anaerobic digestion is an attractive option to increase biogas production. In developing countries, manure is often used in small family-scale anaerobic digesters and the gas is mostly used for cooking, with other applications being domestic lighting or running spark ignition engines.

Energy crops

Energy crops (in the context of biogas production) are agricultural plants grown specifically for feedstock in biogas plants. Typical energy crops in Europe and North America are maize and sweet sorghum. Sugar beet is also gaining importance in northern Europe. The mix of manure and maize is a common feedstock for biogas plants on farms in Europe.

Other agricultural feedstocks

Other agricultural feedstocks that can be used for biogas are catch crops that are planted after the harvest of the main crop; which allows a second harvest on the same piece of land within one year. Ley crops (crops planted on land resting between commercial crop cycles) also have some potential and are already used in some places. Also green cuttings and other fresh leafy materials coming from the maintenance of the landscape, such as from trimming of trees, bushes and grass, can be used for biogas plants as well.

Waste streams for biogas

Different by-products or residues of the food processing and prepared food production industries – breweries, sugar plants, fruit processing, slaughter houses, etc., but also food waste, used kitchen oil, the organic fraction of municipal solid waste (MSW) can all be used as biogas feedstock.

USE AND APPLICATION

Biogas covers a variety of markets, including electricity, heat and transportation fuels. Whereas using the gas for direct combustion in household stoves and gas lamps is common in some countries, producing electricity from biogas is still relatively rare in most developing countries. In industrialized countries, power generation is the main purpose of biogas plants; conversion of biogas to electricity has become a standard technology.

After fermentation the biogas is normally cooled, dried of water vapour and cleaned of hydrogen sulfide to produce a good combustion gas for gas engines.

Upgrading

Biogas produced from anaerobic digestion cannot be used directly as vehicle fuel or injected into a gas grid; it must be upgraded to biomethane first. The gas is cleaned of particles, water and hydrogen sulfide to reduce the risk of corrosion. The gas is upgraded by removing carbon dioxide to raise the energy content and create a gas with constant quality consisting of about 98% methane.

Several techniques for removing carbon dioxide from biogas exist today and they are continually being improved. These methods include water scrubbing, pressure swing absorption (PSA), organic physical scrubbing, chemical scrubbing and upgrading using membrane technology.

Emerging biogas concepts for infrastructure and supply

Different requirements for biogas use, such as heat generation or upgrading for injection into a gas grid, requires different configurations of the biogas plants' locations and size. Early on, when biogas was beginning to be used to produce energy, CHP units were often placed at the same location. More recently new concepts have emerged involving the production of the biogas in one place and the subsequent transportation of the biogas to a central CHP plant, or upgrading station, located near a gas pipeline for injection into the regional gas grid.

Support policies

It is true that modern biogas production is only developing rapidly in regions with a consistent and effective government support policy. The main elements of a typically successful support policy are: Guaranteed access to the electricity and gas grids, reasonable feed-in tariffs for electricity and biomethane, investment grants, education and training of the labor force, support policies to include the use of heat, some variation of a carbon tax on equivalent fossil fuels, support for methane fuelled vehicles.

As with natural gas, biogas (particularly in its upgraded form) is a high quality energy carrier. It should therefore primarily be used for energy services that demand high quality energy such as combined heat and power generation, or transport.

THE GLOBAL POTENTIAL

The feedstock is diverse and the potential and classification can be illustrated briefly as in Table 5 below.

The potential is reported in units of biomethane (1 m³ biomethane = 1.67 Nm³ biogas) to make it readily comparable with natural gas.

For the EU27 the potential, excluding energy crops, was estimated as 50.7 billion m³ biomethane with 31.7 billion m³ coming from agriculture and 19.0 billion m³ from the waste sources. The total potential, including energy crops on 5% of the arable land, was estimated to be 77.9 billion m³ (2804 PJ). This corresponds to 15% of the present consumption of natural (fossil) gas in the European Union.

Several studies in Europe show that the potential for biogas without using energy crops is of the order of 3,6 PJ per 1 Million inhabitants.

Table 5: Potential for biogas in PJ (Billion m³ biomethane), CH_4: EU 27, China, World

Type of resource	EU 27 PJ	EU 27 Billion m³ CH_4	China PJ	China Billion m³ CH_4	World PJ	World Billion m³ CH_4
Manure	738	20.5	2 591	72		
Residues (straw from grain, corn, rice, landscape cleaning)	407	11.3	1152	32		
Energy crops	978	27,2	1 799	50		
Total from agriculture	2 123	59	5 542	154	22 674	630
Urban waste (organic fraction of MSW)	360	10	2591	72		
Agro-industry waste (organic fraction)	108	3	1152	32		
Sewage sludge	216	6	576	16		
Total waste, billion m³ CH_4	684	19	4 319	120	13 316	370
Total (agriculture and waste)	2 807	78	9 861	274	35 990	1 000
Total in EJ	2.8		9.9		35,9	

BIOGAS AROUND THE WORLD

Experience with domestic biogas technology in Developing Countries

Around the world, the implementation of domestic biogas technology has occurred in countries where governments have been involved in the subsidy, planning, design, construction, operation and maintenance of biogas plants. The giant biogas countries China and India (April 2010 to March 2011) produced 2.8 million and 150,000 biogas plants respectively in 2011, arriving at impressive cumulative numbers of 42.8 million and 4.5 million units installed of all sizes from a few m³ in volume upwards.

The Netherlands Development Organization, SNV, supports national programs on domestic biogas that aim to establish commercially viable domestic biogas sectors in which local companies market, install and service biogas plants for households in developing countries. The countries supported by SNV have installed a total of more than 475,000 plants by the first half of 2012. Financial support was provided by a wide spectrum of national and international organisations.

The United States

The U.S. has over 2,200 sites producing biogas: 191 anaerobic digesters on farms, approximately 1,500 anaerobic digesters at wastewater treatment plants (only 250 currently use the biogas they produce) and 576 landfill gas projects. By comparison, Europe has over 10,000 operating digesters; some communities are essentially fossil fuel free because of them.

Europe

In order to reach the EU member state targets for renewable energies for 2020 and to fulfill European waste management directive requirements, anaerobic digestion is seen to be one of the key technologies.

In total, 21.1 billion m³ of biogas, corresponding to 12.7 billion m³ biomethane, was produced in 2010 in the European Union. The electricity production from biogas in 2011, with a growth rate of 18.2% reached 35.9 TWh, while over the same period biogas heat sales to factories or heating networks increased by 16%.

Germany: Industrial scale

Germany is Europe's biggest biogas producer and the market leader in biogas technology. In 2012, the number of biogas plants reached 7470, including 80 units producing biomethane.

The total electric output produced by biogas in 2012 was 20 TWh, equating to the supply of 5.7 million houses with electricity. Biogas already provides more than 3% of the whole of Germany's electricity consumption, as well as significant amounts of industrial heat, transport fuels, and volumes injected into the natural gas grid.

Sweden: World leader in the use of biogas for transport

Sweden is a world leader in upgrading and use of biomethane for transport, and has many 'biogas vehicles', including private cars, buses, and even a biogas train and a biogas touring car team. At the end of 2012, there were nearly 44,000 gas vehicles in Sweden: 1 800 buses, nearly 600 trucks and the rest being cars and light transport vehicles (often part of municipal fleets). Compared to the end of 2011 (one year earlier), the number of gas vehicles increased by about 14 percent. Over a similar period of time the number of upgrading plants has reached 47 plants, representing a 22% growth in numbers since 2008.

China: Leader in household biogas plants

In China the renewable energy policy is driving the steady development and implementation of biogas. As of 2013, China has nearly 42 million small biogas digesters in operation, producing biogas for households, for cooking, and a further 60,000 small, medium and large scale installations producing biogas for industrial purposes. Total biogas output in 2010 is estimated at 15 billion m3 biogas, equivalent to 9 billion m^3 biomethane. China also has ambitious targets for 2020.

- 10,000 new agricultural biogas projects
- 6,000 new industrial biogas projects
- Installed biogas generator capacity; 3,000 MW
- Total biogas output: 50 billion m^3 biogas, equivalent to 30 billion m^3 of biomethane.

In China it is envisaged that in the future a percentage of the biogas produced will be upgraded and subsequently injected into the gas grid network for use as transport fuel, CHP or industry.

Global production

Exact global data on the energy supply by biogas is not available. It can be roughly calculated that globally biogas delivers 30 – 40 billion m^3 biomethane equivalent, corresponding to 1080 – 1440 PJ, thus, only a very small fraction of the potential of biogas for energy has been realized so far.

THE BENEFITS OF BIOGAS TECHNOLOGY

Biogas plants provide multiple benefits at the household, local, national, and international level. These benefits are appreciated differently in different countries and can be classified according to their impact on energy security, employment, environment and poverty.

Environmental benefits

Anaerobic digestion of wastes results in reduced contamination of groundwater, surface water, and other resources. Anaerobic digestion effectively destroys such harmful pathogens such as E.coli and M. avium paratuburculosis. Effluent from biogas digesters can serve as high quality organic fertilizer, displacing import or production of synthetic nitrogenous fertilisers. Finally, anaerobic digestion serves to reduce the volume of wastes and the associated problem of their disposal.

The impact on the greenhouse effect

Biogas produced on a sustainable basis can significantly reduce greenhouse gas (GHG) emissions. Of the 30 million tons of methane emitted worldwide per year (generated from the different animal waste management systems like solid storage, anaerobic lagoon, liquid/slurry storage, pasture etc), about half could be avoided through anaerobic treatment. It is estimated that through anaerobic treatment of animal waste and subsequent use of the methane produced for energy, about 13,24 million tons of CH_4 emission can be avoided worldwide per year.

Economic and social benefits

Increased employment:
Promoting biogas production from organic wastes and sustainably produced feedstocks results in creation of permanent jobs and regional development. The involvement of many interested parties in planning, construction, cost estimation, production, control and distribution is needed to ensure the successful development of biogas technology.

Sustainable energy resource:
The development of biogas represents a strategically important step away from dependence on fossil fuels whilst contributing to the development of a sustainable energy supply and enhanced energy security in the long-term.

Decentralized energy generation:
One of the advantages of biogas technology is that it can be established locally, without the need for long-distance transportation or import of raw materials. Small or medium-sized companies and local authorities can establish biogas plants anywhere.

Sustainable waste management:
Utilising organic waste for biogas reduces the amount that must be otherwise taken care of in some other way, for example by combustion, or transport to landfills.

Clean fuel for industry:
Methane is a fuel in demand by industry; partly because it is a gas that delivers a high quality combustion that can be precisely controlled. Methane burns with a clean and pure flame which means that boilers and other equipment are not clogged by soot and cinders. The result is a cleaner workplace environment and often a reduced maintenance costs for the plant. ■

POSITION OF WBA

WBA advocates that biogas production should be an important part of the strategy to reduce greenhouse gas (GHG) emissions and improve energy security everywhere. Biogas production uses feedstock that would otherwise be left to decay and emit GHGs resulting in a number of environmental problems. Biogas also replaces fossil fuels which further reduces emissions of GHG.

The deployment of biogas technology requires a decentralized approach involving many new entrepreneurs. The construction and successful operation of biogas plants needs an integrated support policy by governments, comprising the following elements:

- Training and education of the labor force.
- Monitoring and continuous improvements in the plants operation.
- Access to the electricity and gas grids.

Reliable long-lasting financial support in the form of tariffs for the electricity or biomethane sold to the grid and to vehicle fuels.

WBA advocates that each country set up a biogas development plan with the target to use at least 30% of the biogas potential by 2030. Such a plan should not only contain quantitative targets but also an array of measures and a system of monitoring to reach the targets. This should be valid for countries in the developing world as well as the developed world.

The global institutions such as the organization of the UN with its affiliates, the World Bank, and the coming Green Climate Fund, should offer financing instruments that support small and medium sized biogas plants and not just large-scale applications.

WBA is convinced that such an integrated approach to the development of biogas would enhance the national energy security, generate employment (especially in rural areas) and contribute positively to climate change mitigation. ■

SUMMARY

Biofuels for transport are part of important strategies to improve fuel security, mitigate climate change and support rural development. In 2010 some 84 millions tonnes of conventional biofuels based on crops containing starch, sugar or vegetable oil were delivered, which represents some 104 billion litres of fuels that address 2.7% of the global demand for transportation fuels.

Many studies have shown there is enough land available to produce more food, more feed and more biofuels. However, the available land has to be used in a better way. In recent years more than 200 Mha land has been set aside around the globe and not used at all! Therefore a priority for all governments and international organizations must be to improve agricultural and forestry production methods worldwide in a sustainable and socially acceptable way.

In addition, conventional biofuel production could become part of a global strategy to compensate for the strong variations of harvests that comes with climate change.

Biofuels for transport

INTRODUCTION

In recent years, several major challenges have become a focus of public interest. Key issues in this context are: worries about energy security, the need to mitigate climate change, efforts to stimulate economic development including the creation of jobs in agriculture and the renewable energy industry. As a consequence biofuels as renewable fuels for transport became part of a new energy strategy in many countries.

BIOFUELS IN THE PUBLIC DISCUSSION

The global context

In 2010 global biofuel production reached 104 bn litre and protein feed production for the market related to biofuels reached 79.1Mt protein feed. The net use of arable land for biofuels in 2010 was 1,4%.Several global developments influence the discussion on biofuels:

- The world population is growing annually by 70 million people;
- In 2011 CO_2 emissions reached a maximum of 34 billion tonnes; far above the limit to comply with the 2°C target!
- Global warming and the growing frequency of extreme weather events are becoming a threat for a secure food production in the future.
- A reduction of GHG emissions can only be achieved, if the transport sector reduces its emissions.

These facts demonstrate some of the challenges the global society is facing.

Commodity prices, malnutrition and biofuels

It is regrettable that still hundreds of millions of the world's people don't get enough to eat. This problem has existed for many decades but thankfully the situation is slowly improving. 40 years ago one quarter of mankind suffered hunger, in 2012 it was less than 15%, while these levels of hunger and malnutrition are unacceptable, the improvement continues. Agricultural commodity prices have been fluctuating over the past decade and were particularly high in 2007/08. A number of different factors are influencing them such as: increasing fossil oil prices, bad harvests (as a consequence of extreme weather situations), growing demand of food for an increasing population with changing eating habits, slower improvements in productivity gains due to low investments in agriculture and finally the production of biofuels.

According to several studies, among these different factors biofuels have a minor impact on the level of global food prices. Importantly these studies have also shown that the higher commodity prices have many positive effects in the global agricultural commodities market. They provide strong incentives for increased returns for farmers for example in developing countries, thus offering important development benefits.

ILUC discussion and biofuels

The discussion of indirect land use change (ILUC) caused by biofuels started a few years ago.

Globally the use of land is changing permanently: the population grows, deserts are expanding due to the loss of protection for fertile land, forests are expanding in one part of the world and declining in other parts, urban settlements are getting bigger, more land is used for roads and other infrastructure, and large tracts of potentially productive agricultural land is just left idle due to market failure, poor incentives, or lack of technology or capacity. Furhermore, a growing consumption of meat requires more land.

Just to develop this example: The increased demand for meat over the last 15 years has required more additional land for feed production for animals than was used for any expansion of biofuel production. If in one part of the world such as in Europe, biofuel production is reduced on the basis of ILUC calculations and the other trends continue unchanged, the shift of carbon to the atmosphere cannot be prevented. To the contrary CO_2 emissions will increase due to higher consumption of fossil fuels.

Advanced biofuels

The volumes of possible feedstock for the production of advanced biofuels are vast: by-products from agriculture such as straw, bagasse, rice husks, oil palm empty fruit bunches, MSW, by-products of the forest-and-wood industry, woody harvest residues, dedicated cellulosic energy crops like grasses, short rotation woody coppices and algal biomass.

One big advantage of these fuels is there is no direct competition with the food market.

As a result different technologies are under development and several pilot and an increasing number of demonstration plants are under construction or entering production.

Now the time is ripe to start commercial plants to gain experience in large-scale operation. The production cost will be high due to a combination of the very high capital investment requirements for plants, a lack of experience, the complexity of the conversion technology and the need to build up logistic chains that can supply sufficient feed stock volumes for large capacity plants at reasonable costs. Only commercial plants can bring the needed experience for further development and a quantity of fuel production that will make significant impacts on the market.

Conventional biofuels and food security

Climate change is more and more becoming a threat to global food security, largely because more extreme weather events, and shifting rainfall patterns are predicted to cause bad harvests more frequently.

The difference in global crop harvests between good and bad years typically oscillates around 10 per cent. More extreme weather poses a risk that these 'oscillations' can become larger. In this context conventional biofuels can be seen as an insurance; in years with good or normal harvests the biofuel production capacity can be fully used whereas in years with bad global harvests fuel production is reduced.

The feedstock is used for food and feed and more fossil fuels are temporarily used instead for transport. Such a concept, including remuneration payments for plants shut down for a period of time, would better secure the food supply than set-aside programs. These set-aside programs imply no production on the concerned land and it might take one or two years to get a crop harvest from this land, whereas a global food shortage might be urgent immediately. Hence it makes sense to use several percent of the cropland for biofuels also from the standpoint of food security.

Global trade, land grabbing and biofuels

The expansion of biofuels has to be supported within a global policy to decrease the dependence on fossil fuels and mitigate climate change – not only in Europe but worldwide. The build up of a biofuel production for export while continuing the use of fossil fuels at home is not a sustainable concept, it only favours trade. In countries with no adequate land policy it might increase the demand for land that, due to other factors, is already in high demand leading to land grabbing at the detriment of the indigenous or rural population.

Only those countries should export feedstock for biofuels that already have a successful national and genuinely sustainable biofuels policy that prevents land grabbing within its boundaries. ■

POSITION OF WBA

WBA sees that the main driver for an accelerated transformation of the global energy system is the struggle for better fuel security. A second driver is the threat of accelerated climate change in this century resulting in negative consequences regarding temperature, sea level and frequency of extreme weather globally. According to WBA calculations the CO_2 emissions from fossil fuels need to be reduced by 50% by 2035 to keep on track towards the “under 2°C temperature rise” target.

Improved fuel security: 40 years ago, during the winter 1973/74 an oil crisis severely hampered the supply of transport fuels. The transport sector and agriculture were severely affected. In some regions even the planting of new crops in spring 1974 was compromised. Nobody can rule out the development of a similar situation within the next two decades.

Therefore, WBA supports a consistent, far sighted further deployment of biofuels for transport as an important strategy to improve fuel security worldwide.

Conventional biofuels can grow: Conventional biofuel production can grow to cover 5-7% of the global transport demand by 2035 without compromising social, economic and environmental conditions and in many instances improving them. It is important that the public recognize these crops as being an important basis for the global protein supply as well as for transport fuel.

Advanced biofuels are vital but need commercialisation: Advanced biofuels are vital for the future but they are yet to enter the market on the basis of commercial production units. As production costs are currently higher than the market price this can only happen if governments set up reliable and long-lasting framework conditions for investors to offset the initial higher cost. If these commercial plants develop successfully, advanced biofuels could cover 5-10% of the transport sector by 2035, with biomethane for transport included.

On agriculture: Much more emphasis is needed to improve the agricultural productivity worldwide by a set of measures such as education, training, supply with modern inputs, improved facilities for the storage of the harvests to avoid losses, improved access to markets, better extension services, more research to increase the production per hectare and also to increase surface of arable land by a new land policy such as fighting desertification and regaining degraded land for production.

On land availability: There is enough land available to feed a growing population and for the production of biofuels. We advocate the use of several per cent of the agricultural land for the production of biomass for fuels. Not only is better use of the available land an imperative for all countries, this will also help to improve the security of food supply of the local population, stimulate endogenous economic growth and reduce poverty in many regions.

On the European discussion: The European discussion on biofuels and ILUC factors appears exaggerated. It only can be understood under the assumption that one;

1. Ignores the issue of energy security and rural development.
2. Takes for granted that fossil fuels are always available.
3. Believes that economic models completely portray the complex relationships between land use, socio-economic development, protein supply, meat production, elasticity of commodity markets etc.

ILUC models are a blunt tool and don’t portray the complex reality. WBA is against the application of ILUC factors and favours targeted regional strategies to minimize emissions by land use change. In addition the CO_2 emissions by land use changes are declining and are not the big cause of a growing CO_2 concentration in the atmosphere; this increase of the CO_2 concentration is mainly caused by the use of fossil fuels.

The proposed change of the rules for biofuels only a few years after they have been decided upon by the European Authorities undermines the confidence of investors, reduces jobs and will hamper future investments. The limitation of first-generation biofuels to 6% will serve the fossil fuel industry, increase CO_2 emissions and diminish protein production in Europe when compared to the 10% target. WBA sees a pragmatic solution of the present discussion in sticking to the 10% target but adding subtargets for 10% ethanol, 7% biodiesel and the rest to 10% using other renewable transport technologies such as advanced biofuels, biomethane, electricity but without referring to a higher counting of specific technologies.

On CO_2 emission and biofuels: Conventional biofuels such as ethanol, biodiesel and biogas are the only commercially available low emission option to replace fossil fuels at present. For many years these will be needed – bedding the path for advanced biofuels. Biofuels are only one portion of the suite of transportation solutions required, other renewable technologies for transport must be promoted as well.

Finally, the use of land for energy is nothing new. Before entering the fossil age mankind used 20 – 30% of the land to produce feed for animals used for traction and transport. Leaving the fossil age means that again a few percent of the land will be needed to produce energy for transport and traction! ■

SUMMARY

The carbon released by the burning of fossil fuels is not part of the 'natural' carbon cycle and is rapidly increasing the CO_2 content of the world's atmosphere. In 2011 about 90% of total CO_2 emissions were a result of burning fossil fuels. The continued use of fossil fuels is creating an increase of carbon dioxide in the atmosphere that will be a huge burden for future generations.

Alternatively the use of forest biomass for energy is carbon neutral, on the basis that the carbon is absorbed from the atmosphere to form biomass by forest ecosystems and carbon is released back to the atmosphere by biomass decay or by combustion. The absorption process can be alleviated by proper forest management e.g. by harvesting trees/stands with low absorption capacity and replace them (over time) with more effective trees/stands.

It is a fundamental requirement of sustainable forestry that the carbon absorption capability in forests remains stable or increases over time. Permanent deforestation and unsustainable forest management lead to a decline of the carbon absorption capability of the forest which must be avoided. The forests are part of the global carbon pool atmosphere - biospheres within which the carbon moves as part of the natural carbon cycle.

Replacing fossil fuels with renewable energy has to be the core strategy with regards to future climate policies. Utilising biomass from sustainably managed forests can play an important role in this strategy. Several countries have demonstrated that both a build-up of carbon in forests and an increase of forest biomass for energy is simultaneously achievable through good forest management practice.

Claims are being made, that trees should rather be left to grow to stock further CO_2 and not be harvested. However this cannot be a solution because forests will stop growing as soon as the trees are mature. It would also mean not utilising the sustainable products from forests: timber, paper, energy and to replace them by fossil fuel based products.

The carbon neutrality of biomass from forests

FORESTS AND THE CARBON CYCLE

On the earth a natural carbon cycle exists between the atmosphere, the oceans and land. The plants sequester carbon from the atmospheric CO_2 through the process of photosynthesis which is powered by the energy provided directly from the sun.

This carbon is later released to the atmosphere by the decay of the organic matter, by its use as food or as biomass for energy.

In contrast to the biological carbon cycle, the combustion of fossil fuels injects additional carbon stored over millions of years deep beneath the earth's surface into the atmosphere and thus unbalances the global carbon cycle.

In some circumstances the use of forest biomass can increase the CO_2 content of the atmosphere. This can happen, when net release of the forest-stored carbon occurs as a consequence of deforestation, of the over use of forests or of the transformation of overage forests to young productive forests and these shifts in a specific area are not compensated for by a net growth of forest biomass. These changes do not add additional carbon in to the land-ocean-atmosphere cycle, they only redistribute it; they should be avoided as they are harmful for the climate.

Figure 4. In a sustainable managed forest trees of different age grow side by side. The photo shows a sustainable managed forest in Sierra Nevada, USA, certified by the Forest Stewardship Council (FSC). Source: ppcnet.org

THE NATURAL LIFE CYCLE OF A TREE AND THE DIFFERENT FOREST ECOSYSTEMS

The unmanaged forest

In a forest ecosystem undisturbed by human influences, normally trees of all phases exist together and over a longer period of time they absorb about the same amount of CO_2 from the atmosphere as they release via decomposition and breathing. These forests are considered to be in equilibrium and serve as carbon storage, not as a carbon sink.

Newly planted forests are absorbing more CO_2 than they release – they are considered to be carbon sinks and are building up additional carbon storage, however as soon as they reach their phase of maturity they are no longer carbon sinks but serve as carbon storage, and will eventually turn into a carbon source (if they are transformed into younger productive forests without utilisation of the wood or stored carbon).

The sustainably managed forest

Sustainable forest management means that the average annual wood output can be kept stable for hundreds of years without decreasing the stored carbon content of the forest. A sustainably managed forest can be described as follows:

The fertility of the soil is safeguarded and the quantity of wood harvested and removed is equal or less than the quantity produced. Trees are harvested before reaching their stage of maturity or natural death. These forests have a net growth of biomass that can be harvested.

The harvested volume may change from period to period. If less wood is harvested than produced the total wood stock and thus carbon stock increases. This form of forest management can go on for hundreds of years; it combines the storage of carbon with the net production of biomass to become materials for buildings or for energy production.

In these forests the quantity of carbon sequestered also grows but does not reach the level of mature forests. Typically these forests are comprised of trees that have varying ages.

Regarding forestry policy, additional criteria for sustainable forestry management are in use. The most important being; maintaining biodiversity, avalanche or watershed protection, social services and recreation. Although these are important, they are of no relevance concerning the carbon cycle.

The opposite of sustainable forestry management is the overuse of forests resulting in more carbon being released than is sequestered by growing trees. Deforestation is the extreme case of such disequilibrium.

HOW TOO NARROW ANALYTICAL BOUNDARIES CONTRIBUTES TO MISLEADING RESULTS

Any forest ecosystem has a lifetime of centuries and covers many hectares. If an analysis of the carbon cycle of a forest is limited to a short time period or a single stand, the interaction over time and space might be overlooked resulting in misleading conclusions as a consequence.

Misleading conclusion 1: carbon debt

The first misleading result of a narrow or limited analysis is the myth of 'carbon debt' of forest biomass. There is no carbon debt in using forest biomass because all the carbon released by using the biomass was previously absorbed from the atmosphere. It is impossible to burn a tree that has not already grown from absorption of atmospheric carbon. The majority of assumptions in the theories on carbon debt and payback time of biomass are wrong, because they assume that first you burn the tree and then you grow it!

In addition, in a sustainably managed forest the young growing trees absorb all the carbon that is released by any burning of biomass from old trees. This fact might be overlooked if one studies only an individual tree or a defined area instead of considering the ecosystem of the forest as a whole.

In regions with an unsustainable forest management there is a net shift of carbon release from the forest biomass to the atmosphere. But also in this case the carbon stems from the atmosphere and no additional carbon is injected from the earth crust to the natural carbon cycle.

Misleading conclusion 2: leave the trees in the forests

Another misleading result of too narrow analysis is the conclusion that it is better for the climate to leave trees in the forests and use fossil fuels instead rather than sustainably harvesting the trees and use part, or all of them for energy.

One argument behind this position says that the burning of wood releases more CO_2 per unit energy than combustion of oil or gas and therefore the CO_2 content of the atmosphere remains lower if the trees continue to grow and absorb CO_2 and fossil fuels are used instead. This argument may have some validity as long as the trees are growing vigorously but it is not valid any more if trees are reaching maturity.

As soon as this phase is reached, no net carbon is being absorbed while the emissions of burning fossil fuels continue to increase the carbon content of the atmosphere directly.

Alternative suggestions infer that burning old trees releases CO_2 immediately, whereas the decomposition of old trees to CO_2 and other green house gases in nature takes many years, so there is a time lag in favor of less emissions now by not burning trees. This analysis ignores that mature trees occupy the space that could otherwise be utilized by young trees. These old trees are no longer a carbon sink but a slow carbon emitter. If fossil fuels are used instead of this biomass two sources of emissions exist: the burning of fossil fuels and the decomposition of biomass. The fact is, by comparison, the impact on the climate will be worse.

Misleading conclusion 3: the build up of over-aged forest is sustainable

Finally, it is sometimes argued that using forests solely as carbon storage and not as productive ecosystem might help to comply with politically defined climate targets within limited time frames and that ultimately there is no need to care about the situation afterwards. This argument completely ignores the principle of sustainability as it was defined in the UN report *Our common future:*

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

Sustainability cannot be reduced to a concept of a few years defined by political targets; it is a principle that includes the responsibility of the present generation for the well-being of the generations to come!

The transformation of productive growing forests to unproductive mature forests and using fossil fuels instead is unsustainable in many respects:

- The capacity of forests to store carbon is used up by the present generation,
- The fossil fuel resources are depleted,
- Climate change will be accelerated as soon as the forests don't absorb additional carbon

Misleading results of an analysis with narrow criteria about the role of forests in the carbon cycle might cause decision makers to postpone the transformation of the energy systems to the next generation. But there is no time left for this kind of procrastination.

THE GLOBAL ROLE OF FORESTS IN THE CARBON CYCLE

The global forest area in 2010 was 4,032 billion hectares, with 30% of these forests being used for wood production. The growing wood stock on this area is estimated at about 527 billion m^3 wood, and the annual removal is 3.4 billion m^3!

Over the last 10 years the forest area was increasing in Asia (mainly China), in North America and Europe and decreasing in Africa, South America and Australia. The global net loss in forest area annually was 5.2 million ha.

In the boreal forest zone, (Northern Russia, Northern Canada and Northern Scandinavia), the regeneration of these forests takes place after fires, massive insect attacks, wind throw, etc., resulting in more or less even-aged stands. Very large areas of these forests in Canada and Russia are overmature and so are already at the point, or close to the stage, of being a carbon source.

The forests store a huge amount of carbon in the growing wood stock, in litter and dead biomass and in the soils. In 2010 the total carbon stock of forests is estimated at 652 gigatonnes (Gt) carbon, of which about 289 Gt is in the growing biomass. The loss of carbon stored in forest biomass due to deforestation and overuse is estimated at about 0.5 Gt per year (1.8 Gt CO_2).

The carbon stored in forests can be increased if deforestation is strongly limited and new forests are created by natural expansion or afforestation. A net increase of the global forest area by at least 100 million ha would lead to an additional carbon uptake of 0.27 Gt carbon (1.0 Gt CO_2) annually. (This assumes biomass production of 5,4 t biomass dry matter/ha annually)

These figures have to be set in relation to the global carbon emissions caused by fossil fuels. In 2011 these emissions reached 9.26 Gt carbon (34 Gt CO_2), 34 times more than the additional 100 million ha of forests could absorb annually. During the last years fossil fuels have become the dominating cause for the increasing CO_2 content in the atmosphere as the following carbon balance for the year 2010 shows.

Table 1: Global carbon balance for 2010:

Carbon sources in Gt		Carbon sinks in Gt	
Fossil fuels	9,1	Biosphere	2,6
Land Use Change	0,9	Oceans	2,4
		Atmosphere	5,0
Total	10,0	Total	10,0

Source: www.globalcarbonproject.org

As Table 1 shows, 90% of the CO_2 emissions come from burning fossil fuels and the cement industry and 10% from land use changes. Within this 0,9 Gt related to land use 0,5 Gt, which corresponds to 5% of total emissions, are due to deforestation and overuse of forests. On the other hand, it can be seen that the biosphere in total absorbs more CO_2 than land use related sources emit.

These relations changed dramatically over the last 50 years. Whereas around 1950 the emissions from fossil fuels and land use were almost equal, at present the emissions from fossil fuels are 10 times higher and these emissions are increasingly stored in the atmosphere.

Therefore the reduction in the use of fossil fuels is the central challenge of climate policy. Better management of currently used forests by the transformation of 10 – 15% of unused forests to sustainably managed forests and the use of the increment of 100 million ha new forests for energy could contribute to the energy system with an additional 30 EJ, replacing 8% of the fossil fuels.

EUROPE AS A POSITIVE EXAMPLE

In Europe, the forest area increased over the last 10 years by 676,000 hectares, and the carbon stock is also increasing. Even in countries with a high share of biomass in the energy system such as Sweden – where biomass provides over 30% of the primary energy demand - the carbon stock in the forests today is much higher than decades ago. This example shows that an increase of forest biomass and build up of carbon in the forest can be reached simultaneously by applying sustainable forest practice. ■

POSITION OF WBA

Biomass is a carbon-neutral energy source, because the plants absorb CO_2 from the atmosphere via photosynthesis and this carbon is eventually released to the atmosphere via the decay of biomass or by using it. Biomass in forests can be harvested while at the same time the carbon stock in the forest is increased, ensuring a carbon-neutral source of renewable energy.

- WBA favors a further limitation of deforestation and a well-financed global afforestation program of 10-20 million ha annually for the next ten years in all continents, especially in Africa and South America, in order to reach a net increase of the global forest area by at least 100 million ha by 2025.
- To meet the growing demand of forest biomass for energy it is recommended to use bigger share of the existing forests as sustainably managed forests and to improve forest management worldwide.
- WBA considers the transformation of productive forests to over-aged forests for the sake of carbon storage (without net biomass production) as a mistake, and supports instead replacing fossil fuels by biomass sourced from sustainably managed forests.
- WBA rejects the concept of ‘carbon debt’ of biomass and emphasizes the carbon debt caused by continued use of fossil fuels is a huge liability for future generations.
- The growing demand for solid biomass might lead to a reduction of carbon sequestered in forests in some parts of the world. This should be avoided. Therefore WBA urges governments to enforce a forest management policy in their countries based on the principle of sustainability, and proposes to introduce sustainability criteria as developed by WBA in combination with a Biomass Certification system, to apply to companies using or trading in large quantities of solid biomass. On the way to a low carbon economy, biomass from forests will have to play an important role in replacing fossil fuels, especially in the heating and transportation sector. ■

SUMMARY

Combined heat and power (CHP) means the simultaneous production and utilization of heat and electricity. Combined heat and power production uses a series of proven, reliable and cost effective technologies that are already making an important contribution to meeting global heat and electricity demand.

CHP, particularly together with district heating and cooling (DHC), is an important part of greenhouse gas (GHG) emission reduction strategies, due to higher efficiency and hence, a reduced need for fuels. The construction of new DHC grids is in many cases a prerequisite for an increased CHP application.

Biomass Combined Heat and Power (CHP)

INTRODUCTION

Stand-alone power plants

Stand-alone power plants, also named condensation plants, only deliver electricity meaning that any heat generated during the process is lost in the flue gases and the cooling water.

At the very high steam temperature and pressure used in these plants, it is possible to reach over 40% electricity efficiency. With an advanced (and expensive) gas combined cycle process, it is possible to increase the electricity efficiency up to 50-55%.

Combined Heat and Power plants

Unlike a stand-alone power plant, CHP plants deliver borth electricity and usable heat and are therefore much more efficient in terms of usable energy output. When planning for a CHP plant the investigation of the demand of heating and cooling in the surrounding area is crucial, whether this be for industry or residential use.

Using the CHP model with a modern combustion steam cycle and a relatively large CHP unit (>50 MWe) could produce approximately 35% electricity and 55% useful heating and/or cooling energy. The energy loss within this unit is only 10%.

With different advanced technologies including Integrated Gasification Combined-Cycle (IGCC) it is possible to increase the electricity output to about 50%, based on a fixed heating demand. Smaller (under 10 MWe) biomass-fuelled CHP plants using steam turbines, depending on the fuel and the technology implemented, can achieve an overall efficiency of 85-90%, and electricity efficiency of 12-25%, or in the case of biogas fuelling a gas motor, up to 38% as electricity.

District Heating and Cooling (DHC) – infrastructure

DHC systems distribute hot water, steam or chilled water generated at a central plant (either DHC or CHP plant) through separate systems of insulated pipes to residential and commercial buildings connected to the DHC system. Once the (hot or cold) water is used in customer buildings, it is returned to the central plant to be reheated or re-cooled and then circulated through the closed-loop DHC piping system.

Before

After

The city of Sundsvall in middle Sweden is located between two mountain ranges. Before district heating was introduced, smoke from hundreds of chimneys and smoke stacks caused serious air pollution, particularly on cold winter days. Today almost all of the houses are connected to the district heating grid, supplying 80,000 people with heat. And the air quality has improved accordingly.
Pictures supplied by Sundsvall Energi. Photo: Torbjörn Berhkvist

In regions where there is no adequate present demand for heat, there may be an opportunity to have cooling provided for houses and offices, institutions and industries. In this case an absorption heat pump can utilize the heat from the CHP plant. Heat pumps in general use electricity to move heat from a cool space into warm space, making the cool space warmer and the warm space cooler. Absorption heat pumps use a small amount of electricity but get most of their energy from a heat source.

In the case of a CHP plant, the absorption heat pump is driven by the heat from the condensed steam having passed by the turbine. The cool water is then distributed in a district cooling pipe system to provide cooling in warmer months to many of the same buildings as the DHC grid services heat in colder months.

In DHC grids, sustainable energy sources and new types of production technologies are adopted, and existing ones significantly extended. Various biofuels and waste resources are increasingly replacing fossil fuels in existing and new CHP facilities. Other renewables like (deep) geothermal and solar from large thermal plants are also being increasingly integrated.

Table 1: Bioenergy power plant fuel conversion efficiencies and cost components			
Capacity	Typical Power Generation Efficiency	Capital Costs (USD/kW)	Operating Costs (% of Capital Cost)
10 MW	14-18	6 000-9 800	5.5-6.5
10-50 MW	18-33	3 900-5 800	5.0-6.0
50 MW	28-40	2 400-4 200	3.0-5.0
Co-firing*	35-39	300-700	2.5-3.5

**Co-firing costs relate only to the investment in additional systems needed for handling the biomass fuels, with no contribution to the costs of the coal-fired plant itself. Efficiencies refer to a plant without Carbon Capture and Storage (CCS).*

AN EXAMPLE DEMONSTRATING BIOMASS FOR CHP

A modern 5 MW electrical capacity biomass fuelled combined heat and power (CHP) plant generates around 30,000 MWhe of electricity and 50,000 MWh of heat energy annually. This plant would require about 40,000 green tons (35% moisture) woody biomass (roughly 120 thousand MWh fuel energy value).

CHP is designed to capture this 'excess' heat and use it for productive purposes. The heat is distributed to customers via insulated pipes. After the heat energy is drawn off via a heat exchanger the water returns in another pipe to the boiler. By using a far higher percentage of the energy in the fuel, CHP technology should result in energy cost savings, waste heat reduction and lower CO_2 emissions.

The key to an economically viable CHP plant is that there must be a demand for the heat that is captured from the electricity generating process. In Europe, small and large scale district heating plants are increasingly using CHP technology and these plants have proven to be very efficient.

Using biomass solely for electricity generation is seen as an inefficient use of biomass. Modern commercially viable heating, cooling and cogeneration technologies can reach efficiency levels of up to 80-90%, whereas production of electricity alone from biomass may only have an efficiency of around 25-30%.

DIFFERENT ASPECTS OF BIOMASS-FUELLED CHP

Finance

The IEA's Technology Roadmap "Bioenergy for Heat and Power" 2012 shows an overview of biomass-fuelled plant fuel conversion efficiencies and cost breakdowns. See table 1 above.

According to Table 1, the bigger the plant, the lower the specific cost of investment per MW capacity. Yet, this relationship is only one part of the picture. Normally, the bigger the plant the more difficult it is to find a heat demand big enough to use the heat by-product of the electricity production, and also the longer the distances to haul the biomass to the plant. Efficient CHP plants can only be built if the plants thermal output matches the local demand for heat.

In many cases a necessary scale of heat demand might depend on the existence of a DHC system. A district heating grid is part of the infrastructure of a town or city. Energy utilities specializing in producing electricity (there are some exceptions like Scandinavian countries) are normally not interested in building DHC systems. Therefore public policy at municipal, state or federal level may have to require the construction of DHC systems as a prerequisite for the development of CHP plants in those places where there is no industrial heat consumer.

Environment

The IEA's Technology Roadmap "Bioenergy for Heat and Power", 2012, indicates: "Bioenergy for heat and power can provide considerable emission reductions compared to coal, oil and natural gas-generated heat and power, when no additional GHG emissions from changes in land use occur.

The lowest life-cycle GHG emissions can be achieved through use of residues and wastes on site, for instance in pulp and paper mills. When using waste and residues, methane (CH4) emissions that occur through decay of organic waste is avoided. Emission savings of more than 100% compared to fossil fuels can be achieved."

Biomass to electricity on a global scale

Global installed biomass-fuelled electricity generating capacity in 2010 was estimated at 62 GW, corresponding to 280 TWh of electricity produced and requiring about 106 million tons of oil-equivalent (Mtoe) of biomass. The electricity is mostly generated in stand-alone power plants. An important task is to convert them to CHP.

This figure of 280 TWh corresponds to 1.5% of the global power production. Power generation from biomass is still concentrated in OECD countries, but China and Brazil are also becoming increasingly important producers thanks to support programmes for biomass electricity generation, in particular from agricultural residues.

Solid biomass (by-products of the forest industry, straw, bagasse, pellets) is the main material for bioelectricity production. It is used in CHP plants, in dedicated electricity plants, or for co-firing (biomass used together with coal, for example). Co-firing is the source of about 10% of total biopower. The share of CHP plants using biomass is relatively low but detailed figures are not available. A remarkable increase in production of biopower can be expected in many countries, increasingly based on pellets, and this will be strongly dependent on government policies. ■

POSITION OF WBA

WBA favors the sustainable, cost-competitive and efficient use of biomass for energy. The production of electricity from biomass without utilisation of the heat is not efficient. Therefore WBA supports the adoption of CHP technology in using biomass for electricity production.

It is recommended that governments create economic frameworks and conditions favouring CHP development. For example: feed-in tariffs or green electricity certificates for biomass to electricity applications only if the overall efficiency of the plant is higher than 60%. Other examples of the frameworks are planning authorisation of biomass co-firing installation only if the efficiency is above 60%, support programs for the construction of DHC grids and a CO_2 tax on coal, heating oil and natural gas to make heat from CHP plants more competitive.

Exemptions (in terms of electricity production without the use of heat) are justified if the biomass to electricity plant uses residues or by-products that are not easily transported over long distances and that are produced in regions without a big demand for heat; for example, straw in the vast rural regions of the world. It is better to use straw in an electricity only plant than to just burn it on the field.

Some companies are interested in continuing the operation of fossil-fuelled electricity production plants without heat use but to reduce the plants CO_2 emissions by co-firing with biomass. This is not the solution for the future because it requires the continuation of an inefficient energy system and waste of the limited biomass resource. The long-term solution is in utilising the heat, by conversion of the current plant or construction of a new CHP plant. ■

SUMMARY

Worldwide more than 75% of all biomass is used for cooking and in small-scale heating devices (for space and water heating). This article has been produced to give an overview of various biomass heating systems below 100 kW, and their potential beneficial applications.

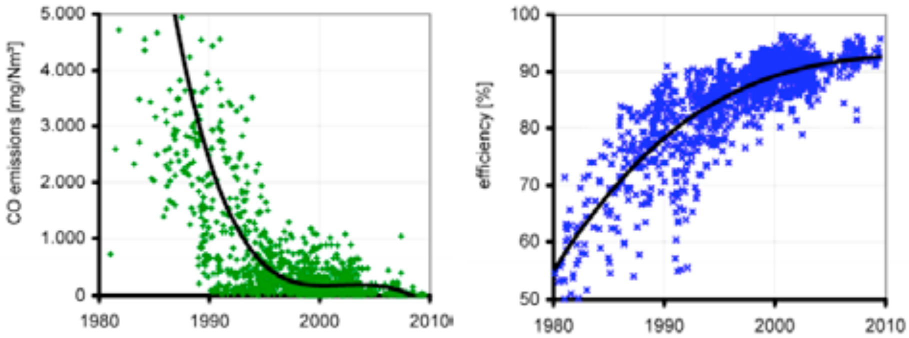
In many regions globally people are using old or outdated equipment with low energy conversion efficiency that can result in relatively high emissions. Yet, in the last decade, significant improvements in the technology of small-scale biomass combustion have been achieved. These improvements concern the preparation of the biomass fuel as well as the combustion technology, resulting in high efficiencies and a reduction of emissions by more than 90% when compared to older equipment.

Small-Scale Biomass Heating

INTRODUCTION

In the northern hemisphere about 50% of the final energy requirement is heat energy. At present, district heating is uncommon globally, with a few exceptions in parts of Europe, meaning that residential heating is mainly provided by burning fossil fuels in small-scale or by using electricity from the national grid. Among the renewable sources of heat generation, biomass is the most significant source, responsible for over 90% of all renewable heat. Wood is by far the most dominant fuel source for biomass heat generation.

Figure 1: Efficiency and CO emissions of small-scale wood boilers



This figure shows how small-scale wood boilers efficiency have been increased and CO emissions decreased in the last 30 years of technological improvements.

THE HEATING VALUE OF BIOMASS

The energy content of biomass depends primarily on the moisture content of the biomass and the dry weight with the heating content of 1kg absolute dry biomass being 5kWh (18MJ). The higher the moisture content, the lower the useful available heat. Part of the energy content of wet biomass is needed to evaporate the water present in the biomass. Also some water is formed during combustion by the combination of hydrogen and oxygen that are part of the dry matter of wood. The evaporation of 1 kg water requires 0.68 kWh (2.44 MJ).

WOOD FUELS FOR SMALL-SCALE HEATING

Firewood

Firewood is the dominant biomass fuel for traditional use but is also popular in modern small boilers. The moisture content of firewood determines how well it burns and how much heat is released per kilogram of wood, for example firewood that has been dried well has a moisture content of approximately 20% and a heating potential of 4kWh (14,4MJ) per kg.

Wood chips

Wood chips are a typical biomass fuel for bigger installations of capacity above 100 kW. There are exceptions in use for small-scale heating on farms or forest estates. To equal the energy of 1,000 liters heating oil (1 m³) a storage volume of 12 to 15 m³ chips is needed. This high storage volume is considered the biggest problem when using chips in small-scale heating.

Wood pellets

Wood pellets can be seen as a major heating fuel for the 21st century. Pellets are small, standardized, cylindrical and densified wood pieces with moisture content below 10%, that can be transported economically, burned completely and suit an automated feeding process. Due to these pellets' high density, the storage volume is significantly reduced when compared to firewood or wood chips. For example, to store the energy equivalent of 1 m³ heating oil, only 3 m³ (2 tons) of pellets are required. Today pellets are also becoming more increasingly available with more than 600 pellet plants in operation worldwide. In 2010 global wood pellet production reached 14.3 million tons.

THE IMPROVED COMBUSTION TECHNOLOGY OF WOOD FUELS

The perfect and complete combustion of wood should only produce CO_2, H_2O, some ashes and most importantly, heat energy. Under real conditions the combustion of wood, especially in older stoves and boilers, is far from perfect since harmful particulates and gases are emitted due to incomplete combustion.

Combustion of a piece of solid biomass fuel proceeds in three stages. It starts with heating and drying, followed by the formation and combustion of volatile gases and finally the combustion of charcoal. Modern research into the process of wood combustion has led to the construction of new types of wood boilers. These new boilers supply metered air to various combustion areas and employ sophisticated flue gas treatments. Whereas traditional wood boilers may reach an efficiency of 30% to 40%, and produce a lot of smoke and other emissions, modern high-tech boilers reach efficiencies above 90% and result in a tremendous reduction of emissions.

AVAILABLE EQUIPMENT FOR SMALL-SCALE HEATING WITH WOOD FUELS

Firewood stoves

These stoves can be used to heat single rooms or small houses and are available with outputs from 3.5 kW to 20 kW. Stoves can be found in widely varying designs, such as doors with or without viewing glass or with casings of tiles or soap-stone. The thermal efficiency of modern fire wood stoves can be as high as 80%.

Firewood boilers

Firewood boilers are more suitable for houses and are popular in rural areas. Firewood boilers are designed to burn larger pieces of wood than a wood stove. Wood is manually loaded into the appliance, and their capac-

"Modern high-tech wood boilers reach efficiencies above 90%."

Illustration: KWB, TP Easyfire 2

Figure 2.
A wood pellet boiler with automatic pellet feed and automatic ignition.

ity range is between 15 kW to 70 kW. The technology has been improved dramatically; Two-stage combustion with automatic ignition, blower fan and reduced heat losses are examples of these improvements. Modern firewood boilers can achieve efficiencies of more than 90%.

Wood chip-fuelled boilers

Wood chip-fuelled boilers may be used to provide heat in larger houses, for farm buildings, or for industrial furnaces. Automatic operation and lower emissions because of continuous combustion are the advantages of wood chip heating systems when compared to firewood boilers. Wood chip-fuelled boiler capacity ranges from between 15 kW to 100 MW.

Wood pellet stoves

Pellet stoves are more sophisticated than firewood stoves. Pellet stoves usually have a small fuel pellet storage, from which the pellets are conveyed by a small auger to a shaft from where they fall into the combustion chamber. A fan provides the air needed for combustion.

When compared to firewood stoves, the advantages include: fully automatic operation, higher efficiency, cleaner burning and easier to use.

The capacity range of domestic pellet stoves are between 1.5 kW to 12 kW.

Wood pellet boilers

Wood pellet boilers are used for capacities in the range 15 - 300 kW. These boilers are usually installed in a basement or in a separate container outside the house; fuel storage should be located close to or next to the boiler room. Wood pellet boilers operate fully automatically, whether they are top feed, horizontal or underfeed burners. Ash removal is generally automated and the exterior ash box requires emptying once or twice a year.

Retrofit of oil boilers

External pellet burners can also be used when converting fossil-fuelled boiler facilities to using pellets. This way of retrofitting old systems can be a fast and cost-efficient way to convert to pellets for fuel.

Combination of wood and solar heating

The combinations of a pellet, chip or firewood-fuelled boiler or stove with a solar heating system can easily provide space heating and hot water all year round. A 'buffered' heat storage system for solar and biomass heat means that the efficiency of this kind of combined system can be very high.

SMALL-SCALE BIOMASS HEAT, MARKET PERSPECTIVES AND ECONOMIC ISSUES

The competitiveness of small-scale biomass heating differs from continent to continent. For example, in some regions in Japan with pellet prices of 400 €/t, small-scale heating is not very competitive. This is also the case in parts of North America because of very low gas prices. By comparison, in Central Europe pellet prices for the final consumer are between 220 and 270€/t which means that the cost in 2012 was about 50% lower than for fossil fuels.

A hindrance for the faster development of small-scale heating systems is the higher investment cost when compared to fossil fuelled alternatives. In several countries this obstacle is overcome by a CO2 taxation of fossil fuels to improve the competitiveness of biomass (e.g. Italy, Sweden) or by government grants to private households or support to companies manufacturing small-scale biomass heating systems (e.g. Austria and UK).

The justification for a pro-active government policy in favor of small-scale biomass heating installations is obvious, as the final energy output for a given quantity of wood is three times higher than using the same quantity of biomass for the production of electricity, unless the electricity is produced in combined heat and power plants (CHP). In addition, the promotion of small-scale renewable heat is one of the cheapest strategies to reduce CO_2 emissions.

At present, in the northern hemisphere, hundreds of millions of homes use fossil fuels or national grid electricity for low temperature heating. Small-scale biomass heating offers an important renewable alternative for them. ■

POSITION OF WBA

WBA urges public authorities to re-evaluate the importance of biomass for production of heat energy, especially for the small-scale heat market and set up programs to promote this energy sector, including the supply side, the training of installers, financial support for the installation costs and raising the awareness amongst the public about this cost competitive, CO_2-neutral energy option. ■

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