

Bioenergy

New Growth For Germany



 **Öko-Institut e.V.**
Institut für angewandte Ökologie
Institute for Applied Ecology

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Foreword from the Minister To reach the goal, by 2020, of covering at least 20% of our electricity and 10% of our primary energy demands with renewables, there is no way around an increased use of biomass. About 10% of the electricity, heating, and fuel for cars could be produced by 2020 from biomass alone.

On account of its high potential for energy production, biomass offers great prospects for climate protection through the reduction of greenhouse gases. At the same time, over 200,000 jobs, particularly in rural areas lacking in infrastructure, could be created. That's why we will increasingly promote the use of biomass energy in the future.

Its high variability in use and its ability to be stored are further advantages of biomass. On the other hand, it's not easy to identify, among the vast number of technologies, the most efficient alternatives with the best prospects for being developed. This brochure represents findings from a three-year study on the future prospects of various technologies with regard to jobs, costs, climate protection, and nature conservation. Its results show us the way towards a future sustainable bioenergy use in Germany.

A handwritten signature in black ink, appearing to read 'Jürgen Trittin'. The signature is fluid and cursive, with a long horizontal line extending to the right.

Jürgen Trittin
Federal Minister for the Environment, Nature Conservation, and Nuclear Safety

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A Renaissance

The Federal Government backs renewable energies. The long-term goals are: to obtain at least a 20% share of electricity generation by 2020, and 50% of the total energy supply by 2050.

Biomass is a carbon-based material. As it is burned, only so much CO₂ is formed as was absorbed from the air during plant growth.

Supported by the Federal Ministry of the Environment

Renewable energies are good for the climate – that's why the German Government wants to double their use by 2010, compared with 2000: for electricity, to 12.5%, and to 4% of its primary energy. More ambitious goals are possible in the long run – by the year 2030, renewables could cover almost one quarter of Germany's energy demands. As biomass would provide the lion's share of that even more than coal a rediscovered source of energy steps into the limelight.

Already today, energy is being produced from biomass: predominantly in heating with forest wood in fireplaces at home, and in the use of by-products in large power plants, e.g., from the wood industry. In comparison, the potentials of agriculture, forestry, and waste management have hardly been developed, and could sustainably provide much more than they do now. There are good arguments to use these available supplies: bioenergy relieves the strain on the environment, creates jobs and strengthens regional economies.

What importance will biomass have in the future supplying of our energy? Which technologies will catch on? What costs will its development have and how greatly will it effect the environment and employment?

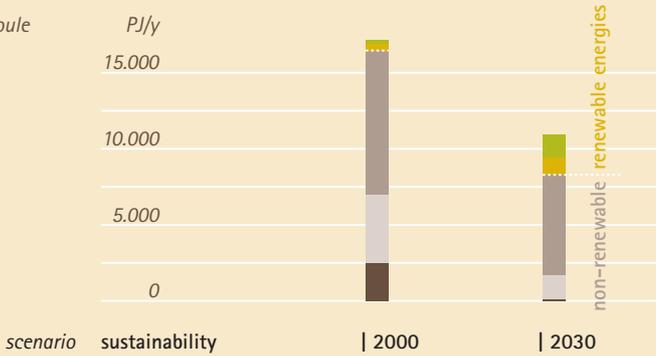
The Biomass Material-Flow Analysis (MFA) Project researchers have found answers to these questions and have looked ahead to the year 2030. This brochure describes the most important findings and provides policy recommendations.

Energy Mix Today and Tomorrow

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Petajoule (PJ) = 10^{15} Joule

- biomass
- other renewables
- oil, natural gas
- coal
- nuclear



Above:

Energy demand and share of regenerative energies in the SUSTAINABLE scenario in petajoules (PJ)

Below:

Emissions of greenhouse gases and costs (without costs of savings)

What Would It Be Like ...?

The emissions of greenhouse gases should be lowered by 21% by 2012, compared with 1990 (Kyoto goal).

The Government plans on a reduction of 40% by 2020.

In the findings of the MFA Project, even the long-term goal of minus 80% by 2050 is feasible!

In addition to the development of renewables, energy efficiency is the second pillar for a sustainable energy supply. That's why closing down old power plants is as important as their replacement with modern facilities. Here, only those possibilities for energy efficiency which are economically feasible have been considered.

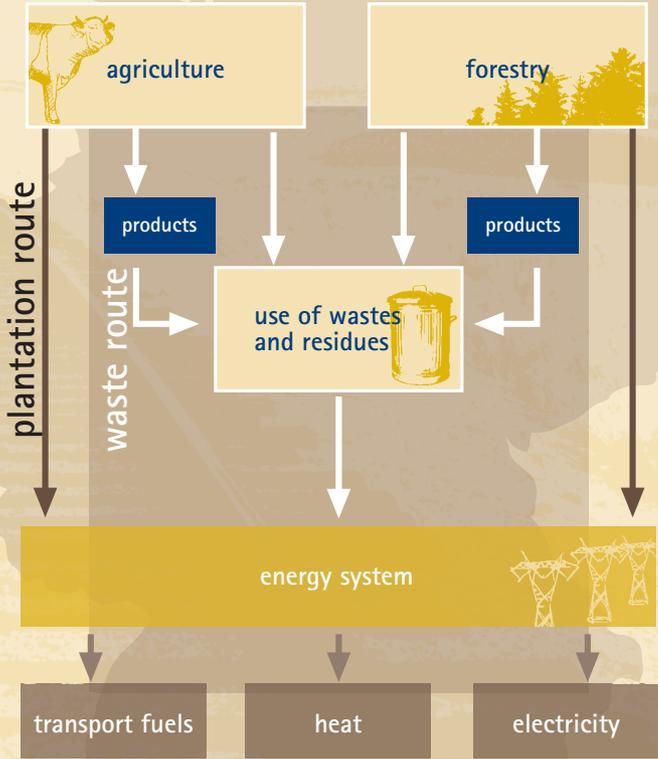
If it's *business as usual*, then we'll fall short of our goals for climate protection; in the 90s, levels of greenhouse gas emissions sunk considerably, but since then they've stagnated.

Scenarios that are serious about sustainability look very different. If Germans are persistent about saving energy and make use of the existing potential of renewable energies, future electricity will be green: by the year 2030, biomass could produce almost 16% of our electricity, in addition to around 10% of our heat and 12% of the fuel for our cars. Thus, biomass has a greater potential in the next 25 years than brown and hard coal combined. With the addition of sun, wind, water, geothermal and energy conservation, CO₂ emissions will be reduced to the extent that long-term goals for climate protection can be fulfilled. The vast majority of savings are dependent on gains in efficiency on the demand side.

With successful implementation of energy-saving measures, the future supply of energy will be not only lower in emissions, but more economical as well: in scenarios, costs lay almost 20% lower than those extrapolated from the current energy supplied by coal and atomic energy. However, the costs of energy efficiency have not been determined by the project.

System Boundaries

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▶ plantation route: use of plants dedicatedly grown for energy

▶ waste route: use of residues and bio-wastes

*Biomass comes from
agriculture and forestry.
Cultivated biomasses
as well as by-products
are used.*

Mass is Energy

Organic farming requires more land than conventional, but the competition for land for bioplants is less than it is often assumed to be.

Arable land for the cultivation of energy crops will still remain, despite the fundamental change in agricultural practices.

The amount of energy availability from biomass by-products and energy crops is, from the current standpoint, about the same. A strategy for development must, therefore, take into consideration cultivation as well as by-products.

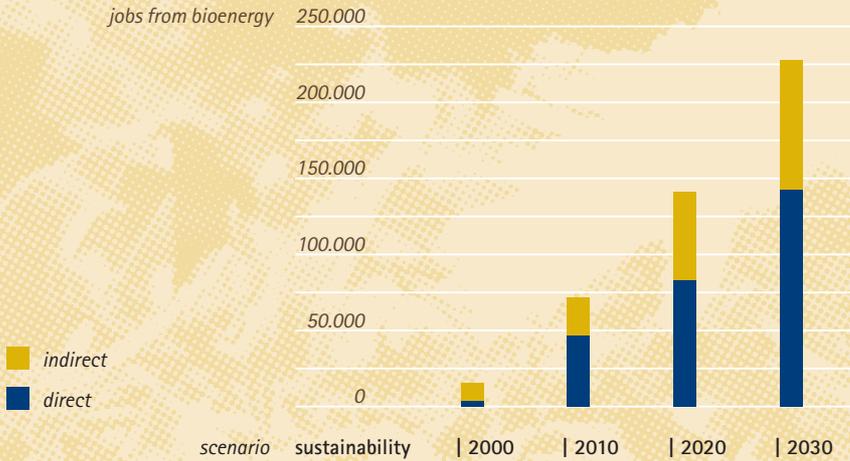
Biomass by-products accumulate anyway, but at the moment they are hardly used. In the future, a second life as a source of energy awaits these solid as well as liquid materials – they can supply 700 Peta Joules (PJ) per year. That's enough for the energy supply of ten cities as big as Munich (including business and industry).

The greatest potential is offered by wood from forest thinning, biogas from manure, straw from grains, and wood wastes like old furniture, woody construction material, or cutting by-products from industry. Until the near future, methane-rich landfill gases are also available. However, the dumping of organic wastes is being phased out.

4.4 million hectares of fields and meadows can, by the year 2030, become "free" for the cultivation of energy crops, as agriculture's increasing yields require less and less area to provide for the decreasing population – despite a fundamental change towards sustainable organic agriculture. This newly available area would yield a maximum of 1200 PJ bioenergy per year.

Jobs from Biomass

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Bioenergy creates new jobs in Germany: indirectly through the construction of power plants and directly through their operation.

Biomass Fuels Job-Engine

Biomass secures and creates employment. In fact, it also replaces jobs in the field of fossil energies, with more jobs per kilowatt hour being brought about through bioenergy than by coal, oil or natural gas.

If the development of bioenergy is financially supported, this money will no longer be available for other purposes. The so-called "budgeting effect" describes the effect of such redistribution. Here, the "budgeting effect" will not be considered, as it is dependent on many factors – e.g., if the money is otherwise saved or spent on other purposes, and how effective in creating employment the alternative uses would be.

The project scenarios give an indication of what the results of the development of biomass could look like, all in all. The replacement of fossil energy sources has already been considered in these figures.

The production of bioenergy impacts employment both directly and indirectly. Direct employment results from the actual operation, while indirect employment stems from investments in construction and infrastructure.

In the long-run, direct employment is especially important for the job market. This is most significant in energy crop cultivation and in the production of electricity by combined heat and power generation (CHP). If biomass is only used for heating or fuel, considerably fewer direct jobs will be created.

This means that, above all, work in rural areas is created. These are areas where, in the past, many people's opportunities for income have been lost.

Range of Use – The Three Scenarios

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General assumptions for all scenarios:

Demand-side

- | population decreases
- | energy mix changes
- | more renewable resources

Supply-side

- | increase in power of technology
- | collection of biomass changes
- | land-use decrease from higher efficiency & yields

Three scenarios have been considered – they define the upper and lower limits of sustainable use.

Potential Means Opportunity

Different scenarios are a part of the Biomass

MFA Project:

BIOMASS creates as much bioenergy as possible with minimum emissions of greenhouse gases.

ENVIRONMENT considers comprehensive environmental and nature conservation restrictions which inevitably decrease the potential.

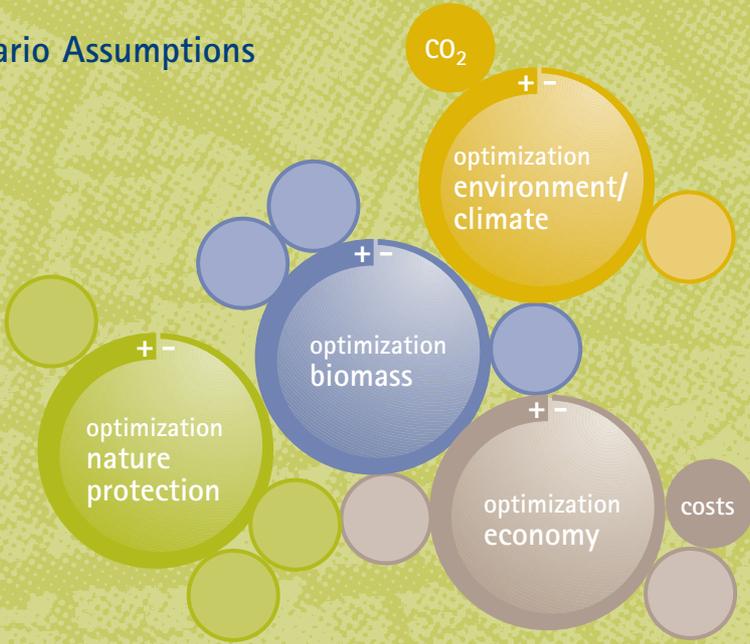
These recommendations are found in the scenario SUSTAINABILITY. Consequently, only these findings are printed here.

Potential always indicates the supply of energy based on specific assumptions within a specific timeframe. Competition for different uses limits the potential. The results presented here already consider the essential requirements of the environment and of nature conservation, as well as the land demands of housing, waste management, and transport. What would it be like if ... in the year 2010, 20% of farmers were actually farming organically? Or if ...? The project considered, by means of scenarios, ways of increased but sustainable bioenergy production and use based strictly on the following assumptions:

- Conditions for use of forests and protected areas guarantee a **sustainable forestry** for the future as well.
- Political demand for a fundamental **change towards organic agriculture** with 20% or more organic farming to be implemented – the REFERENCE scenario (business as usual) being the exception. In spite of predictions to the contrary, large areas for energy crops remain available.
- In agrarian areas, there is a lack of structural elements such as hedges or trees, as refuges for plants and animals. What the natural environment lacks must be restored; in addition, ecologically valuable grasslands may not plowed up into fields for energy crops.

Scenario Assumptions

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Time horizon 30 years

Parameter

Biomass	Environment/Climate	Economy	Nature Protection
Use for	greenhouse-gases	employment	conditions and restrictions for use
electricity	acidification	invest and operating costs	protected areas
heat	particulates	technology development	landscape elements
transport	solid wastes		

The scenarios are based on many assumptions that change over time and correspond with one another.

Potential Means Opportunity

Burning grain while others suffer from hunger? This is not an easy question to answer, as hunger is often the result of crises and poverty; rarely is hunger a problem resulting from the lack of fertile land. A serious discussion must, in the same way, scrutinize the cultivation of industrial and fiber crops – first and foremost, cotton – as well as our land-use intensive meat consumption, and whether or not Germany's engagement in aid to developing countries must increase. In addition, failure to protect the environment can, in the long-run, have a negative effect on agriculture in various regions of the world.

- There are synergies between nature conservation and biomass: perennial energy crops offer protection against erosion and enrich the landscape. Cutting by-products from landscape management can be used for energy: what is missing are logistics concepts and evidence of its profitability.
- The unbridled consumption of land for building and transport is coming to an end. This is because, with a decreasing population, land consumption also decreases, and more land can be recycled.
- Agricultural foreign trade is, more or less, the import or export of arable land for agricultural use. Current trends are extrapolated here: subsidized exports become fewer, imports stagnate. This is how land becomes "free."
- Many future technologies for biomass are still in their infancies. They develop along so-called learning curves. In the beginning, big advances take place within a short time, causing technologies to become more efficient in less and less time, sinking costs. Biomass use profits from this mechanism.

Technology Assessment

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Pre-Selection

Which technology chains are considered?

Material-Flow Analysis

Tool: GEMIS

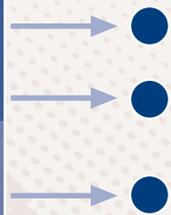
All Technologies

- land use
- emissions
- solid wastes
- costs
- nature protection
- etc.

GEMIS

assessment

Best Technologies



Data collection/ compilation

Which technology chains exist?
(biomass >> technologies >> fuels)

Criteria

Which parameters are considered?

Result

Which technology is most promising?

There is a multitude of biomass technologies. This assessment of technologies has identified the best from a cost and from an environmental point of view.

"Who's Who" of Technology

The software GEMIS, determines, for each scenario, which environmental pollutants are released by the demand for energy, heat, and transport in Germany, and what kind of costs arise.*

The "scenario generator," another program, helps with the modeling of demand. These can vary by size and by the mix of energies.

What's important: this tool can be used for further discussion.

Biomass can be used to produce energy in many different ways – for example, wood can either be burned directly in an oven for heat production, or a gasifier can produce wood gas that subsequently drives an engine, which produces electricity and heat. An engine can run on biogas obtained from manure just as easily.

To figure out which technology makes most sense for which biomass, we must determine which one costs the least and creates the least environmental impacts for each unit of energy. A comparison of technologies by the computer model GEMIS provides clarity here. The emission of greenhouse gases and air pollutants, solid wastes, cumulative energy and land-use, as well as costs and effects on employment serve as criteria for this assessment.

Comparing technologies has shown one thing very clearly: the environmental problems of biomass use are fewest when it is transformed into gaseous fuels like biogas or wood gas. That's why many small, efficient power plants are using gaseous fuels – decentralized energy supplies and climate protection go hand in hand here.

* Global Emission Model for Integrated Systems

Heating With and Without a Grid

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■ | 2010
■ | 2030



■ | 2010



scenario sustainability

Above:
Cost impact of heating and local heating systems in comparison with conventional heating

Below:
and the accompanying emissions.

Heating Without Oil and Gas

Biomass through water pipes: investment in local and district heating is worthwhile, if enough heat customers join in. However, to finance a new network, initial support is often necessary.

On account of easy handling, wood pellets are especially suitable in smaller applications.

Instead of running one's own central heating system, it is more environmentally friendly and economical to burn wood in thermal power stations, and to bring their waste heat to customers by way of local heating grids. By doing so, the logistics are also simpler and the heat customers need no stores of fuel.

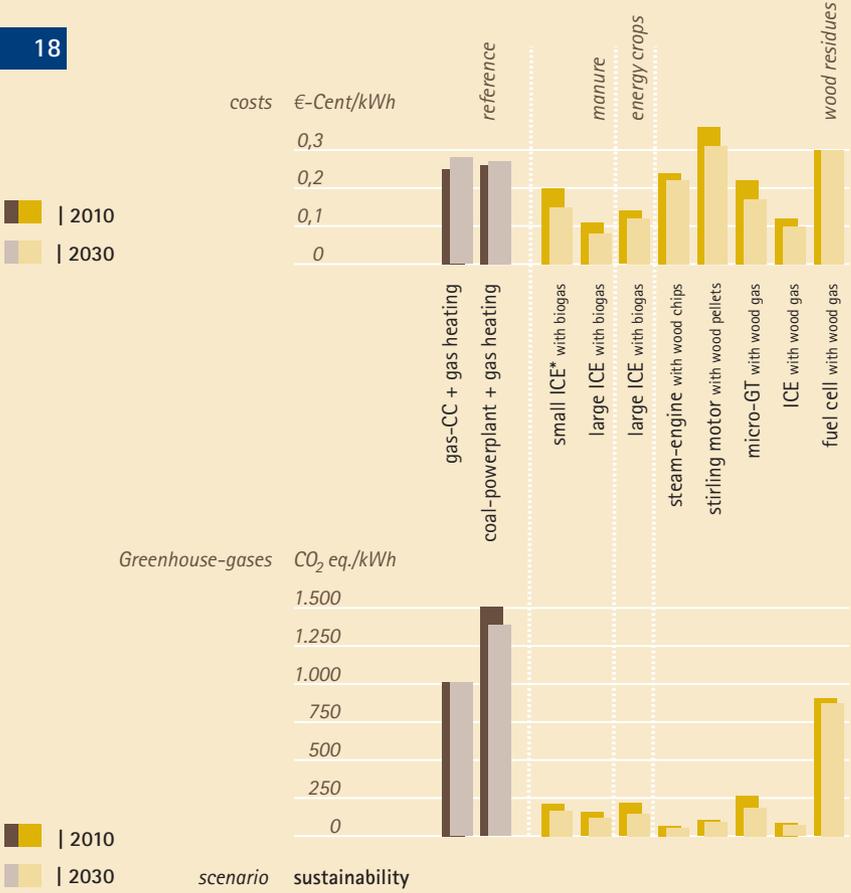
Today, wood and wood chips already deliver a considerable amount of energy, at 220 PJ per year.

Wood chips and, above all, wood pellets supply clean heat for domestic use, but are still somewhat more expensive for the consumer than heating with oil or natural gas. With foreseeable increases in fossil energy costs, most biomass options will become competitive by 2020.

Straw is attractive for heat plants that initially convert entire bales of straw into gas (gasification), and then burn it with low emissions. For buildings the size of hotels or schools, this is already economical today. On the other hand, it remains very expensive to burn entire grain-type plants in boilers – and, moreover, brings about higher emissions of air pollutants.

All in all, biomass heating systems perform very well. What works even better: use of biomass in facilities that produce electricity and heat together (combined heat and power generation = CHP). Their success depends on the development of heat distribution networks. This is necessary from an ecological point of view, and requires corresponding economic incentives.

Electricity and Cogeneration



Above:
 Cost impact of electricity and heat from biomass CHP in comparison with conventional electricity and gas heating

Below:
 and the accompanying emissions.

CHP – A Strong Team

Wet biomass cultivations are planted twice per season. Neither cultivation becomes fully ripe, but both supply markedly high yields of biomass when extensively planted.

There is a wide range of technologies for combined heat and power generation.

They vary, for example, from small steam engines and ORC processes, to gas-driven engines and combined-cycle (CC) power plants with gas and steam turbines. All of these technologies feed electricity into the power grid, and need a local or district heating grid to make use of their waste heat.

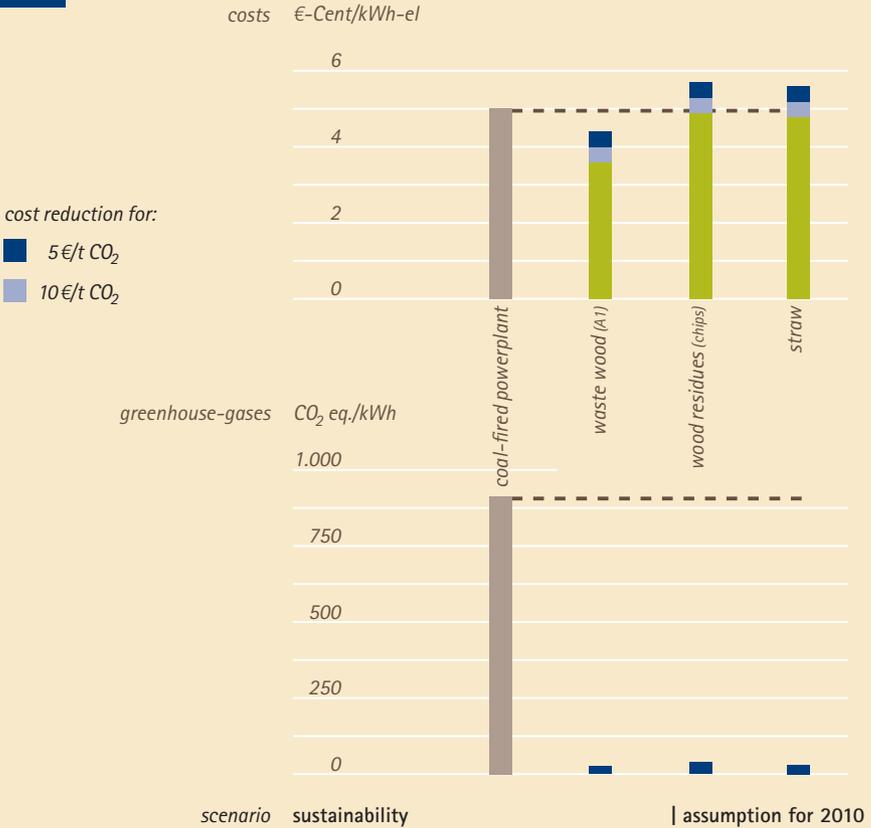
Energy demand will also be high in the future, which is why combined heat and power generation (CHP) plays a key role in the development of bioenergy. Anaerobic fermentation with subsequent use of biogas is a process that is already available on the market for use in packaged heat and power plants. The impacts on emissions, costs, and employment are especially positive if the biogas is produced from a type of renewable raw material called "wet biomass," or if the biomass derives from organic wastes that have been separately collected.

The gasification of solid biomass promises to be a true technology of the future – assuming an active introduction to the market.

Apart from that, solid biomasses can be used directly in furnaces coupled with steam engines and ORC processes. ORC, which stands for "organic Rankine cycle," uses an organic working-medium instead of water. However, both of these technologies have a relatively limited electric efficiency. The assessment of technologies makes it clear that the smallest CHP systems like micro-gas turbines and Stirling engines, due to higher costs, need more initial support to become marketable.

There are great hopes for fuel cells. It seems, however, that these hopes are still far beyond of the actual use. From today's point of view, biomass fuel cells will not be available for mass production until 2020.

10% Biomass in Coal Powerplants



Above:
Emissions trading creates incentive for combined combustion of biomass.

Below:
Greenhouse gases are also reduced by the direct replacement of coal.

Co-firing a Transitional Option

Co-firing can give a quick shove to the production of electricity and heat from biomass: already existing coal-fired power plants and boilers can be equipped with added stores and conveyors so that biomass can provide up to 10% of their output. Coal is replaced by wood chips and straw, which reduces emissions of carbon dioxide and other emissions.

Above all, logistics and the market for biofuels can be developed in this way. From this point of view and from a cost and an environmental perspective, co-firing is an economical "first-step" technology, though little impulse for employment would be triggered.

About the sample calculation
below:

If a coal-fired power station co-fires biomass, it's initially somewhat more expensive than using only coal. The additional costs could, however, be covered by emissions trading: For CO₂ produced by burning biomass, no emissions certificate is necessary, so the operator needs to buy fewer certificates (or can sell his own), thus saving money that the biofuel can be financed with.

However, coal-fired power stations are so large that supplying adequate amounts of biomass for co-firing might be a limiting factor. Less problematic and thus more environmentally friendly is co-firing in medium-sized coal-fired co-generation plants, which feed their waste heat into existing district heating grids.

Because a sustainable climate protection policy leads, in the long term, to a drastic reduction of coal use, cofiring is only an interim solution. In the meantime decentralizing energy supplies has priority when using biomass.

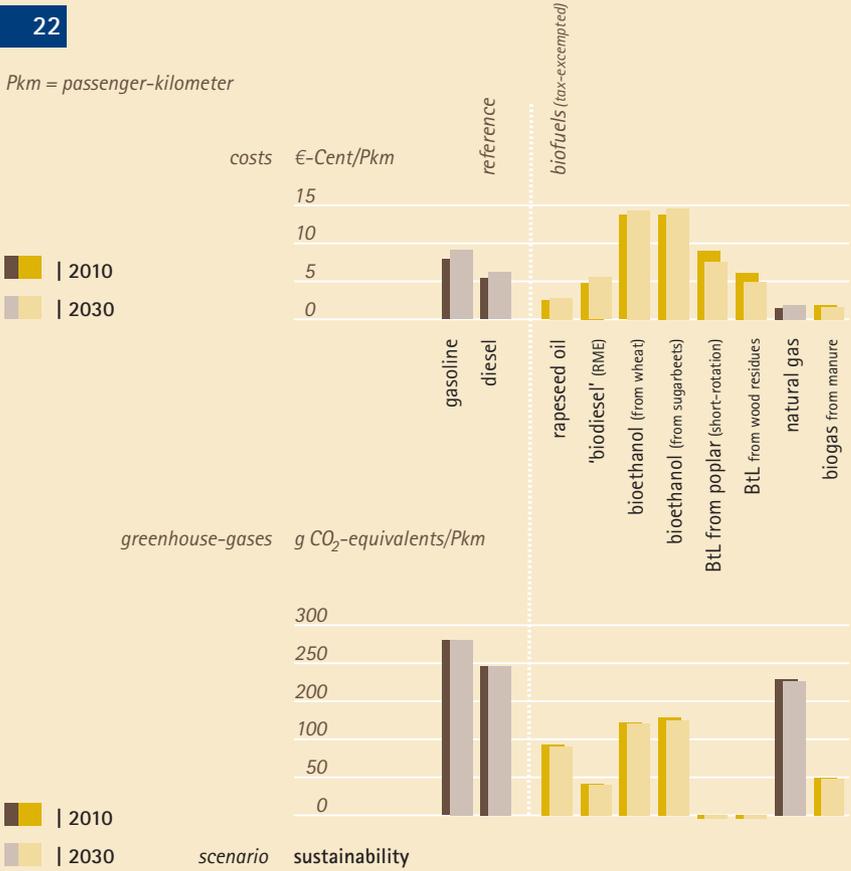
<i>Sample calculation</i>	Co-firing of waste wood
<i>Reduction of greenhouse gases</i>	888 g/kWh
<i>Cost per kWh</i>	4.4 €-cent/kWh-el
<i>Estimated CO₂ price</i>	5 €/t => 0.0005 €-cent/g CO ₂
<i>Cost reduction per kWh</i>	-888 g/kWh * 0.0005 €-cent/g CO ₂ = -0.4 €-cent/kWh

Due to emissions trade at this price, production costs would be lowered by €-cent 0.4/kWh-el to €-cent 4.0/kWh-el.

Biofuels for Cars

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Pkm = passenger-kilometer



Above:
 Many biofuels are comparable to normal gasoline and diesel.

Below:
 For climate protection, all biofuels are worth it.

Mobile With Biofuels

Whoever sees and smells rape fields thinks of biodiesel. In Germany, biodiesel is primarily produced from rapeseed oil. Bioethanol is produced from sugar beets and wheat.

The production of vegetable oils, biodiesel, and bioethanol will remain comparatively costly in the long-run as well. Extensive cultivation, especially of sugar beets, can also be disadvantageous from the point of view of nature (and soil) conservation.

Biomass-to-Liquids (BtL) are extremely clean "designer fuels" which replace diesel and gasoline. Through gasification and then synthesis, BtL can be produced from a wide range of solid biomasses, like wood or straw.

Besides the biofuels already in use today, biogas, like natural gas, is available for use in cars and busses. As normal pumps cannot be used for natural gas or biogas, infrastructure needs to be adjusted. Biomass-to-Liquids (BtL) manage without a change of infrastructure, as they can be used in conventional motors, and require no infrastructure of their own. These fuels are still in the beginning stages of development, but have considerably greater potential in the long-run. This is why BtL ought to merit greater attention.

As is already the case with heat and electricity, fuel cells are often seen as the ideal solution for transport. A comparison with biofuels in conventional motors shows that fuel cells for transport will hardly be competitive until 2030.

Employment Impulse



Biomass creates employment nationwide, especially if it's used for energy production in CHP power plants.

Which Use Brings the Best Results?

To summarize at the half-way mark, the most important technologies will, once again, be briefly mentioned – technologies which are already in use today as well as those with a promising future.

Besides efficiency and costs, it is especially important to consider how great the biomass potential for each technology is, and to what extent it affects employment.

Biomasses are best used in combined heat and power generation (CHP). Here, they can be used in smaller plants as well as in larger thermal power stations. In the long run, solid-oxide fuel cells will be available as well.

There are many practical uses of biogas. Because it can be used just like natural gas, the technological developments for biogas-powered electricity, heat and transport have already made significant progress.

Processes that convert biomass to a gaseous fuel are therefore becoming key technologies for future use of bioenergy. Among these are anaerobic fermentation, which is already widely used today, and gasifying solid fuels which is still in great need of development. These are certainly the processes with the greatest need for development.

Equally important is the establishment of decentralized CHP technologies for solid fuels. Their potential for development, in terms of reducing costs and increasing efficiency, is as high as that of gasification.

Among biofuels for transport, Biomass-to-Liquids have the greatest potential along with the least emissions and costs in the long run. Biogas is an option for fleets of vehicles with their own filling stations like, for example, municipal busses.

There are a great many technologies – as varied themselves as the biomasses they utilize. In this regard, there is no lack of opportunities to utilize the potentials which already exist.

An Active Biomass Policy

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The figures and recommendations presented in this brochure are valid only on the assumption that energy will be strictly conserved.

This is why a reduction in energy use is the foundation for renewable energies and modern power plants with higher efficiency.

Erneuerbare-Energien-Gesetz (EEG) = Renewable Energy Sources Act

Biomasse-Verordnung = Biomass Ordinance

Biomass can, at over 14%, cover a considerable share of Germany's energy supply in the future. Already considered in this figure are restrictions which arise from limited land-use and meet strict environmental criteria.

Biomass use will not, at current levels, be enough to meet goals of climate protection, despite their potential. Both proven and new methods are needed to provide the necessary push:

The Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz = EEG) guarantees fixed feed-in tariffs for green electricity that has been innovatively generated. The 2004 EEG revision increases support for small-scale power plants. It also makes special effort to support decentralized plants which use biogas and those which integrate themselves into the natural material circulation of agriculture without accumulating hazardous substances. The bonus provision for both fermentation of agricultural substrates and forest products fills a gap in the EEG.

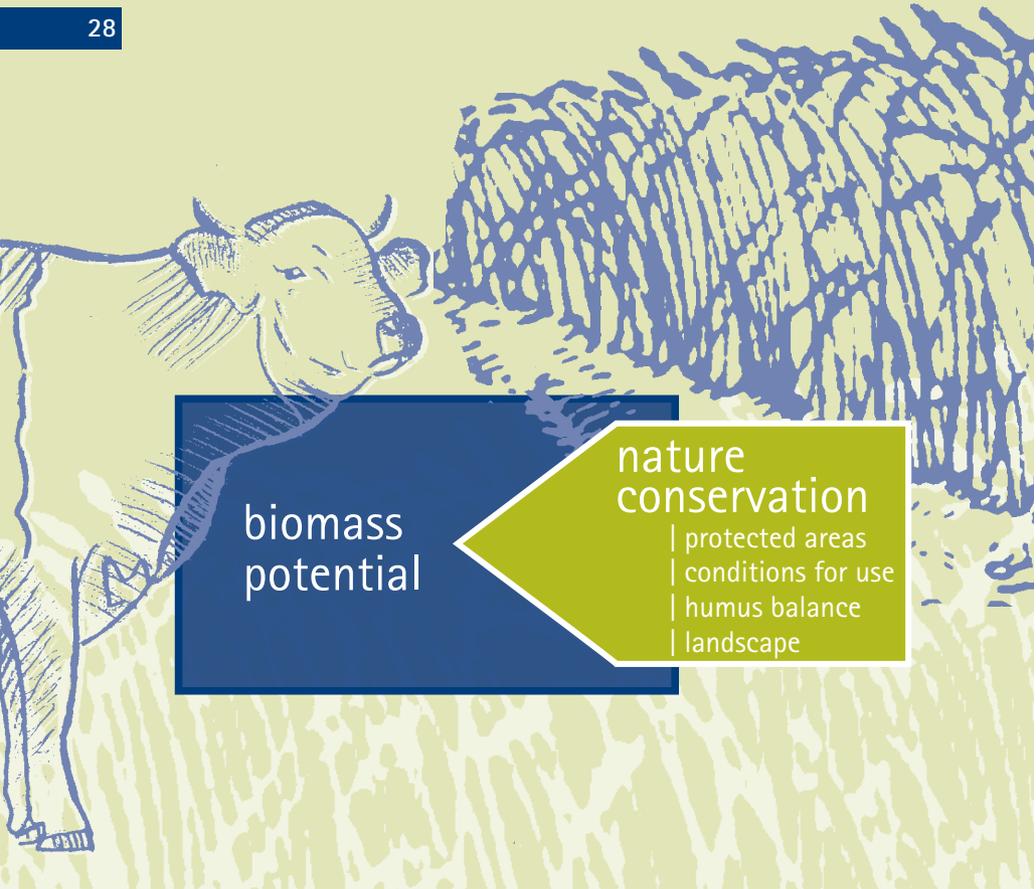
The incentives for the cultivation of energy crops are, as a whole, still too few – for short-rotation forestry as well as annual energy crops. Further incentives are necessary here – also outside of the EEG: e.g., in the process of implementing EU agricultural policy in Germany.

An Active Biomass Policy

- trade in emissions rights helps* Co-firing biomass in coal-fired boilers and power plants is an option, though not within EEG, for the immediate and relatively inexpensive production of electricity and heat from biomass. The small additional costs of co-firing could be covered by incentives from the CO₂ emission trading scheme. After 2020, co-firing will lose its importance, as coal will likely be increasingly replaced by decentralized and renewable energies.
- an instrument for the heat market* For decentralized CHP systems, local heating grids are the key to success: here, an effective instrument to support their implementation is urgently needed. This would be of benefit not only to biomass, but to solar and geothermal as well as decentralized fossil-fuel-based CHP systems at the same time. This is why the CHP bonus in the new EEG is an important step towards an efficient biomass use.
- Combined Heat and Power Generation Act* The upcoming revision of the German CHP law could also take biomass into account. For example, local heating could, through the combined support of CHP law, emissions trading, and the new EEG, become much more attractive.
- Show how it can go: demonstration programs* The new EEG supports electricity from renewable energies and is an effective instrument for the establishment of developed technologies, but it cannot help a pilot plant make the jump to readiness for mass production: in particular, smaller steam engines

Nature Conservation and Bioenergy

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biomass
potential

nature
conservation

- | protected areas
- | conditions for use
- | humus balance
- | landscape

Protected areas and conditions for use reduce biomass potential, as nature conservation has priority in the places where species retreat.

An Active Biomass Policy

and ORC processes can, similar to smaller and mid-sized gasifiers with packaged co-generation, supply green electricity and heat until 2020. However, gasification is not yet economically viable. A demonstration program should provide the necessary impulses for quicker development within the market.

tax-free in the driver's seat

If biofuels' share of the market increases, its exemption from the mineral oil tax would eventually be put to the test. But, because biofuel is environmentally neutral, it should at least remain exempt from the eco-tax.

In the meantime, BtL can also help the huge potential of solid biomasses find their way into the tank. Here, however, the technological data is uncertain, and there is an urgent need for research.

new alliance

It is often implied that the development of bioenergy is at conflict with the goals of nature conservation. However, the results of this project have shown that the nature conservation goals and the use of biomass for energy can be compatible. In fact, the cultivation of productive perennial crops contributes valuably to erosion protection. On the other hand, the cultivation of energy crops on ecologically valuable wet grasslands should be avoided – the potentials are great enough without the use of these areas. A synergy could even be achieved between nature conservation and biomass cultivation through the use of energies from agricultural and landscape

Information On The Internet

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Biomass is a diverse, renewable source of energy with great potential in Germany. Included are by-products like manure and organic wastes as well as crops grown specifically for energy production and forest products. They can be used directly or be transformed into standardized fuels.

This brochure is about determining which position biomass could take in the future – if we take the right steps today.

Further information can be found at:

www.oeko.de/service/bio/de/index.htm

www.erneuerbare-energien.de/1024/

and for more about GEMIS:

www.gemis.de

An Active Biomass Policy

management by-products. Questions of the economic feasibility of such concepts call for further research. Here, Federal and State Governments must cooperate and should, above all, come to realistic agreements about the implementation of legislative goals.

*fair trade – not just for
coffee and cocoa*

If the demand for biomass increases, the German market would also become attractive for imports. So far, the criteria which guarantee a sustainable supply of biomass are still lacking. However, the same void exists for food imports. A new position on foreign trade must be found.

The scenarios show that the chosen basic conditions decisively influence the level of potential for the use of biomass. This is why future policy must link together waste management, nature conservation, and agriculture and include questions of what is acceptable.

Thereby, various (thoroughly welcome) accompanying effects and a corresponding distribution of burdens will be initiated. Particularly important are the roles of employment, the development of rural areas, landscape preservation, and the supply of clean energy.

Bioenergy offers, all in all, great opportunities for a sustainable development – not only on a national level, but also for states and local communities.

Research Partners

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Project management

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Project partners

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<http://www.umsicht.fhg.de>

Institut für Energetik und Umwelt gGmbH, Leipzig – IE
<http://www.ie-leipzig.de>

Institut für Energie- und Umweltforschung gGmbH
 Heidelberg – IFEU
<http://www.ifeu.de>

Institut für Zukunfts-Energie-Systeme,
 Saarbrücken – IZES
<http://www.izes.de>

TU Braunschweig, Institut für Geoökologie,
 Abt. Umweltsystemanalyse
<http://www.tu-braunschweig.de/geooekologie/abteilungen/usa>

TU München, Lehrstuhl f. Wirtschaftslehre d. Landbaues
<http://www.wzw.tum.de/wdl/>

Assisted by

TU Berlin, Inst. f. Landschaftsarchitektur u. Umweltplanung
http://www.tu-berlin.de/fb7/ile/fg_lb/index.htm

FICHTNER Ingenieurdienstleistungen und Consulting
<http://www.fichtner.de/>

Administrative assistance

PTJ – Projektträger Jülich
<http://www.fz-juelich.de/ptj/>

Scientific consulting

Umweltbundesamt Berlin
<http://www.umweltbundesamt.de>

Support and scientific consulting

Bundesministerium für Umwelt, Naturschutz und
 Reaktorsicherheit
<http://www.bmu.bund.de>
<http://www.erneuerbare-energien.de>

Project management  **Öko-Institut e.V.**

Project partners  **Fraunhofer**
Institut
Umwelt-, Sicherheits-,
Energietechnik UMSICHT



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Administrative assistance



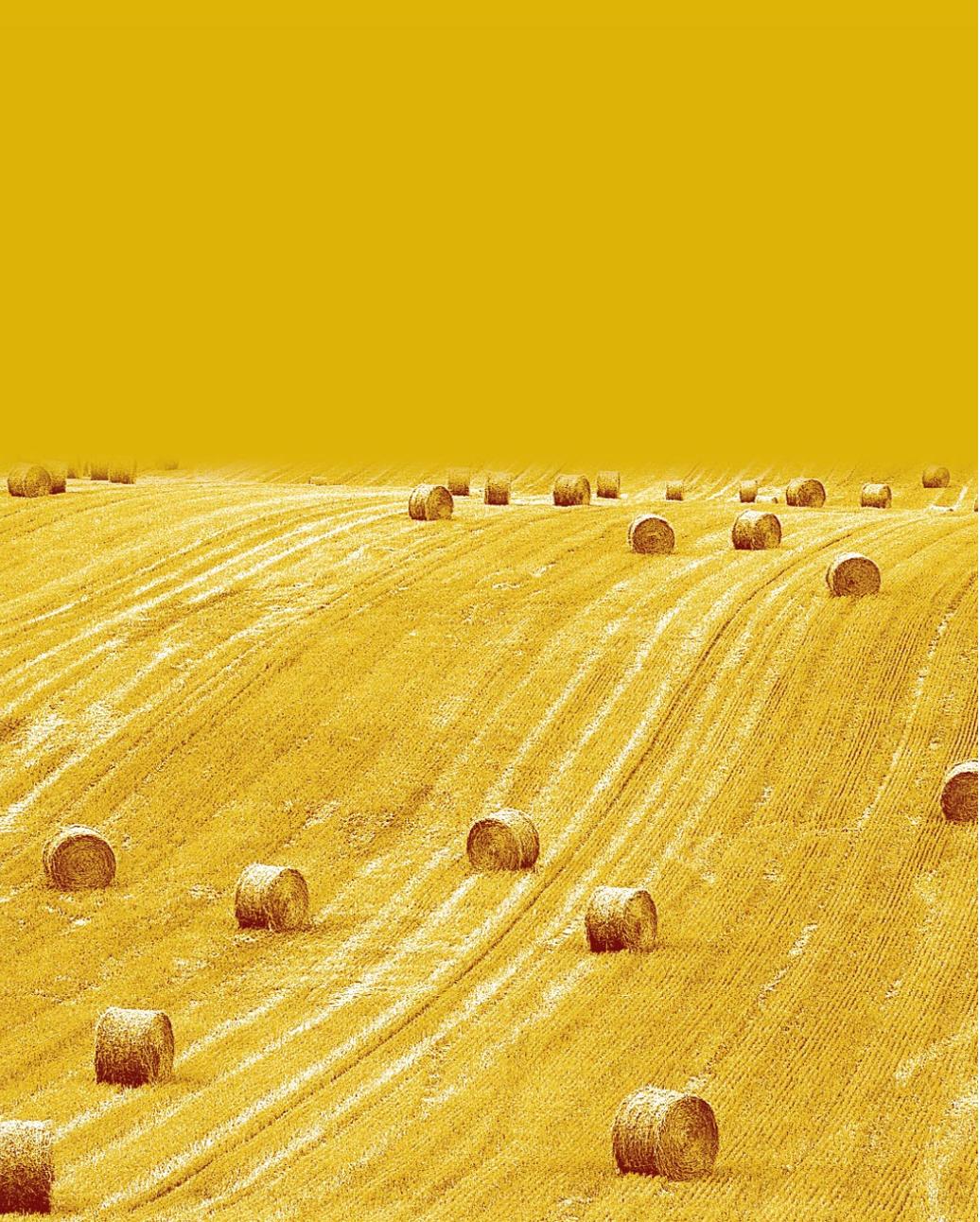
Scientific consulting



*Support and
scientific consulting*



Federal Ministry for the
Environment, Nature Conservation
and Nuclear Safety



Research Partners of the Öko-Instituts e.V.:



You can find the full report on: <http://www.oeko.de/service/bio/de/index.htm>