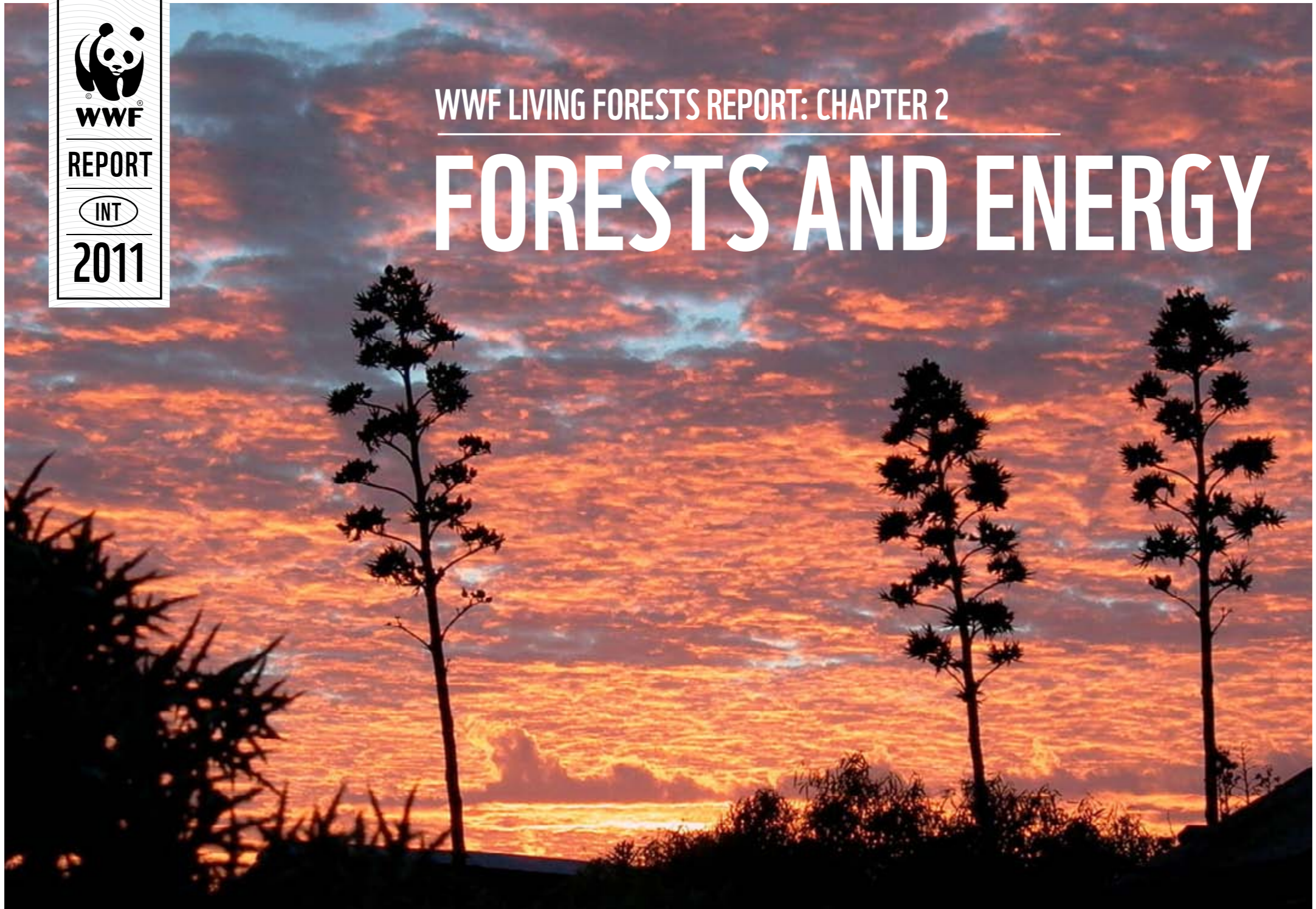




WWF LIVING FORESTS REPORT: CHAPTER 2

# FORESTS AND ENERGY



# SUSTAINABLE ENERGY FOR 10 BILLION PEOPLE<sup>1</sup>

For millennia we have managed forests and harvested wood for energy.

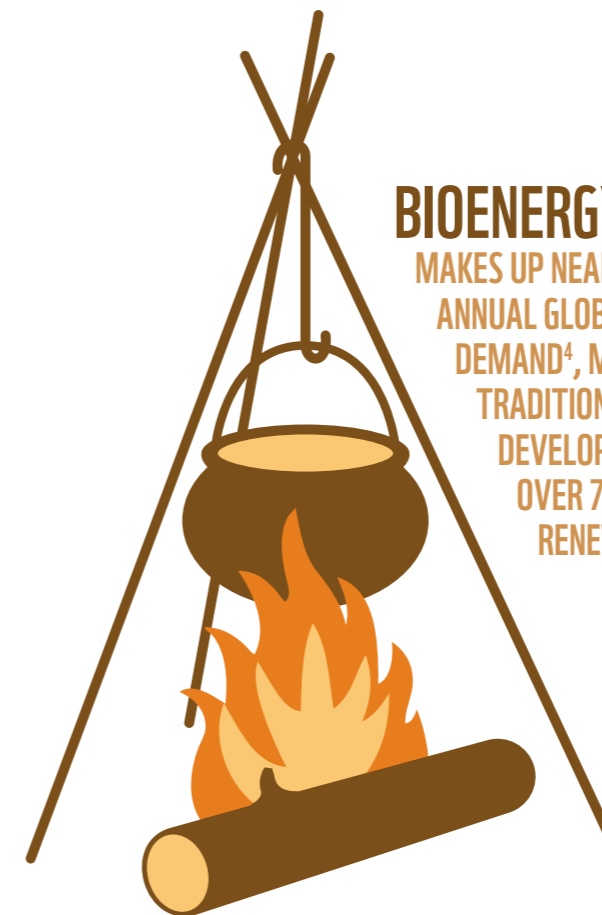
Although much of the world still relies on wood for cooking and heating, most of the energy we use comes from highly concentrated fuels formed from organisms that lived millions of years ago. This reliance on fossil fuels is unsustainable –

cheap, easily accessible oil, coal and gas are running out and their use also releases huge amounts of into the atmosphere, driving climate change and acidifying oceans. Nuclear power, often cited as a climate-friendly alternative, is expensive, relies on exhaustible uranium supplies and poses heavy environmental, health and security risks.

WWF envisions a world where energy consumption is reduced and supplied 100 per cent from renewable sources by 2050<sup>2</sup>. A scenario detailed for WWF's *Energy Report* suggests that, to achieve this vision, 40 per cent of energy demand will need to be met with

Bioenergy can provide diverse sustainable alternatives to fossil fuels, plus new incomes and increased energy security for rural communities. However, for these benefits to be realized, its use must be carefully planned, implemented and monitored for environmental and social sustainability. Expanding bioenergy production has the potential to compound food and water shortages and accelerate natural habitat loss. Managing these risks will require strong social and environmental safeguards. Future technologies may allow energy to be produced from feedstocks that use less of the world's finite land and water resources and are viable for a wide range of uses<sup>3</sup>.

This chapter of the *Living Forests Report* explores the land-use implications of a growing bioenergy sector, looking at the main trends projected over the next few decades.



## BIOENERGY

MAKES UP NEARLY 15 PER CENT OF ANNUAL GLOBAL PRIMARY ENERGY DEMAND<sup>4</sup>, MAINLY THROUGH TRADITIONAL FUELWOOD USE IN DEVELOPING COUNTRIES, AND OVER 75 PER CENT OF ALL RENEWABLE ENERGY<sup>5</sup>

WWF aspires to a future where humanity's global footprint stays within the Earth's ecological limits and the planet's natural resources are shared equitably. During the 2011 International Year of Forests, WWF's *Living Forests Report* is part of a year-long conversation with partners, policymakers and business about how forests can contribute to this vision. The report uses the Living Forests Model to explore pathways to achieve and maintain WWF's target of Zero Net Deforestation and Forest Degradation (ZNDD) by 2020. Our goal is to compare different future scenarios, look at the implications of policies and inform debate. Find out more about the *Living Forests Report*, ZNDD and the Living Forests Model [↔](#).



# BIOENERGY: TRADITIONAL AND FUTURE USES

WWF is committed to environmentally, socially and economically sustainable renewable energy.

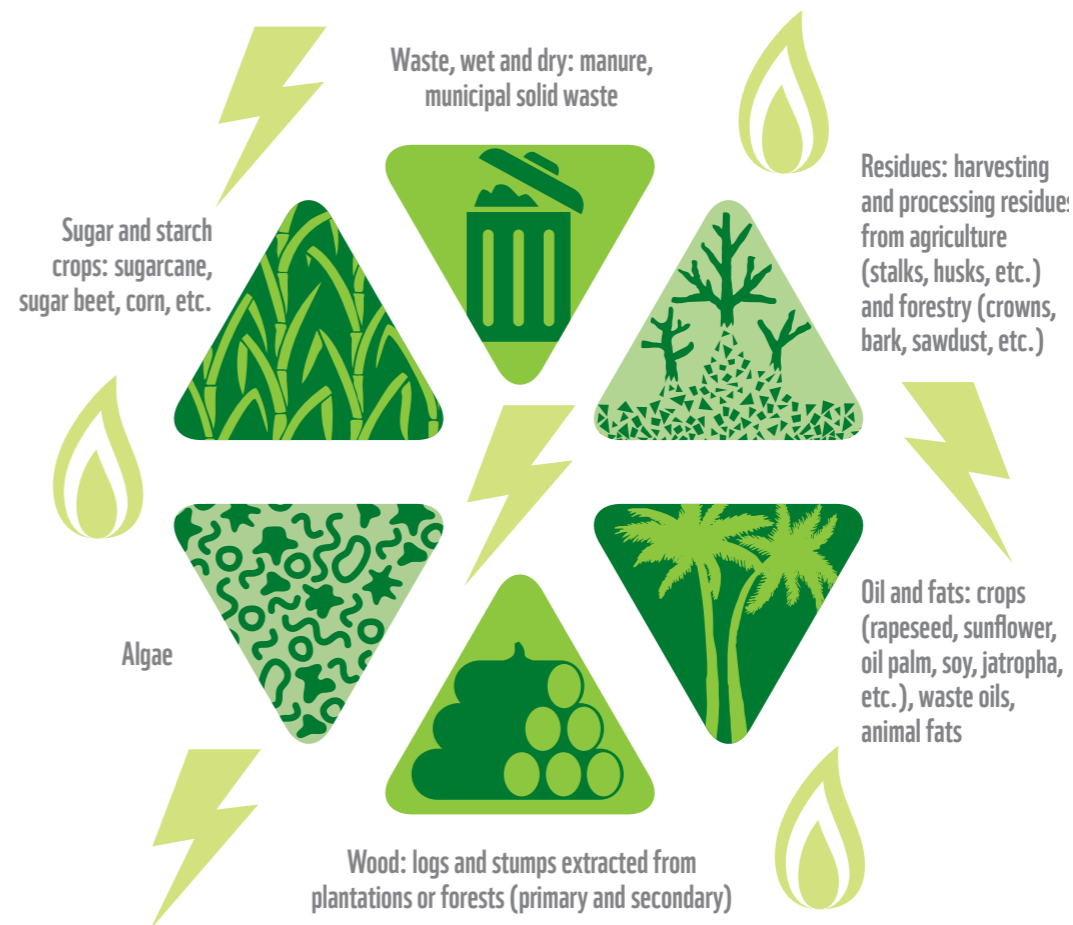
LEARN MORE ABOUT WWF'S VISION OF A WORLD POWERED 100% BY RENEWABLE ENERGY

Bioenergy is a term used to describe all energy derived from biological sources ( ) – from a simple wood fire to complex technologies that turn algae into fuel. The way biomass is used, i.e. <sup>1</sup>, differs significantly depending on where people live and their economic status:

**Traditional uses:** According to the Food and Agriculture Organization (FAO), wood is the main source of energy for well over 2 billion people living in developing countries<sup>6</sup>. More than 70 per cent of wood harvested in Asia and the Pacific, and 90 per cent in Africa, is used for fuel<sup>7</sup>, compared to about 20 per cent in Europe<sup>8</sup>.

**New technological uses:** In recent years, industrialized countries have turned back to using biomass, but with new and emerging technologies, to produce heat, electricity and liquid fuels ( ).

As technology evolves, an increasing variety of biomass feedstocks will become suitable for conversion to bioenergy; wood, however, is likely to remain one of the most important<sup>9</sup>. In the EU today over half of all biomass-based electricity production uses wood and wood waste<sup>10</sup>. Whether the net environmental, social and climate impacts of bioenergy are positive or negative will depend largely on what policy and market safeguards are put in place.



# THE LIQUID BIOFUEL CHALLENGE

Using more biofuels is a priority for many countries.

LAND ACQUISITION ASSOCIATED WITH FOOD PRODUCTION AND BIOFUELS IS ALREADY CREATING ENVIRONMENTAL AND SOCIAL PROBLEMS

WWF's vision of a world powered 100 per cent by renewable energy depends on a major expansion of bioenergy, including liquid biofuels in sectors without other renewable alternatives<sup>11</sup>.

Biofuel development has been characterized in terms of 'generations' to illustrate its technological sophistication. First generation biofuels convert sugar starches and oils into fuel – an already proven technology. Second generation biofuels convert plant and animal waste into fuels – either by using enzymes or through the gasification of biomass material followed by a gas-to-liquid process. Biomass that could be used in this process includes all types of trees, grasses and organic wastes. Second generation biofuels are not currently commercially viable at scale, but their development could significantly expand the volume and variety of bioenergy feedstocks in the future. Third<sup>12</sup> and fourth generation biofuels are being researched; the former are made from algae while the latter is a vaguer description of hypothetical production methods including genetic manipulation of organisms.

Large-scale commercial first generation biofuel production is growing rapidly – and encouraging a global 'land grab' as companies and governments acquire land for feedstock production. Rapid land acquisition associated with food production and biofuels is already creating environmental and social problems<sup>13</sup>. If biofuel is to be part of a sustainable and ethical renewable energy solution, enabling measures are needed. These should include careful land-use planning, good governance and industry standards to ensure production does not threaten food and water supplies or biodiversity, displace vulnerable people, or increase atmospheric carbon<sup>14</sup>.



# EFFICIENCY, EQUITY AND ENERGY DEMAND

Development of bioenergy must be viewed within social and political contexts. While the rich world squanders energy, many poor people do not have enough.

One-and-a-half billion people in developing countries lack access to electricity. Worldwide, 2.6 billion people use traditional biomass, mainly wood and charcoal, for cooking. Most, almost three-quarters, do not have access to efficient stoves; in sub-Saharan Africa, only 6 per cent of those using traditional biomass have stoves. The result is wasteful fuel use; significant time and effort spent collecting firewood; forest degradation; and serious health effects from wood smoke, which along with coal smoke kills almost 2 million people a year<sup>15</sup>.

Efficient, sustainable bioenergy could help address these disparities and be a major contributor to the global energy supply. Sustainable local bioenergy sources could provide energy and income to some of the world's poorest or most remote communities.

While higher oil prices make renewable energy a more attractive option to governments and investors, the recent shift to bioenergy has mostly been driven by subsidies and mandated government targets (see appendix)<sup>16</sup>. In both local and export markets, bioenergy can help to even out fluctuations in power generation due to variability in other renewable sources such as wind and solar.

But bioenergy poses serious social and environmental risks that need to be managed. Poorly planned and implemented bioenergy feedstock production could result in more inequity, such as further concentration of land ownership; displacement of small farmers and forest-dependent peoples; polluting cultivation methods; higher food prices, and additional pressure on the food supply in places that can least afford it<sup>17</sup>. The rich should not continue to expand and outsource their energy footprint at the expense of poor people and high biodiversity ecosystems.



## SUSTAINABLE LOCAL BIOENERGY SOURCES COULD PROVIDE ENERGY AND INCOME TO SOME OF THE WORLD'S POOREST OR MOST REMOTE COMMUNITIES

# EFFICIENT WOODSTOVES AND FUELWOOD PLANTATIONS IN THE CONGO

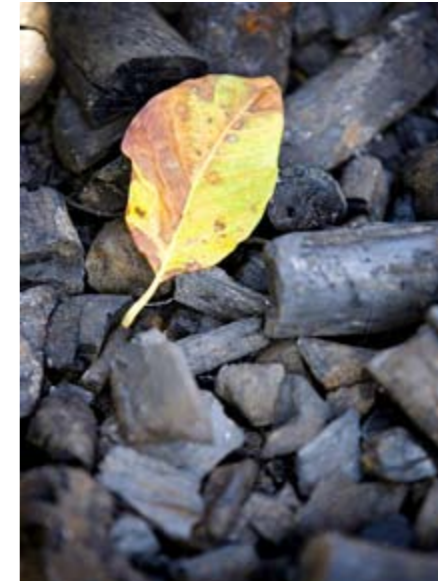
In many parts of the world, wood-fired cooking and heating technologies are inefficient and contribute to unsustainable fuelwood harvesting.

Inefficient fuelwood use damages forests and human health. Women are hardest hit as they often collect firewood and have to cover longer distances as nearby forests are depleted. They also usually do the cooking, so are most exposed to smoke.

To reduce the environmental and health impacts of traditional fuelwood use, people need access to alternatives, such as renewable energy sources, local fuelwood plantations, and efficient, affordable stoves and heating systems. Such efforts must be balanced by respect for cultural traditions. The challenges should not be underestimated – efficient woodstove projects have been attempted since the 1970s and many have failed.



The Eco-Makala project aims to supply sustainable wood energy to the population of Goma, a city near the southwest borders of Virunga National Park in the Democratic Republic of Congo, while also reducing rural poverty and protecting the national park. The biggest threats to Virunga are an influx of refugees and illegal logging in the southern part of the park. The project plans to replant 4,200ha of forest within five years. For the rural populations, investment in legal fuelwood plantations could reduce poverty and contribute to development.







Today, 2.6 billion people worldwide use traditional biomass, mainly wood and charcoal, for cooking. Access to efficient, sustainable bioenergy could reduce time spent collecting firewood, decrease forest degradation and reduce mortality caused by wood smoke. © Kate Holt / WWF-UK

# INCENTIVES AND CONTROLS

As of 2010, at least 119 countries had some type of national renewable energy target or support policy<sup>18</sup>.

Government support for bioenergy, which is mostly focused on biofuels, was around US\$20 billion worldwide in 2009. The International Energy Agency estimates that support to biofuels will rise to US\$45 billion (2009 dollar value) by 2020 and US\$65 billion by 2035<sup>19</sup>. The primary motives for support include climate change mitigation, energy security and protecting national industries.

WWF reviewed a selection of policy frameworks for bioenergy, primarily biofuel, development in producer and consumer countries (see page 27). Even in this limited sample, there is huge variation in required GHG savings and how compliance is assessed. Similarly, there is little consistency in the scope and strength of social and environmental safeguards on production of feedstocks.

Very few countries have introduced new forestry regulations to address issues specific to the harvesting and use of forest biomass for new energy generation technologies<sup>20</sup>.

A 2007 study of developing countries observed that many had ambitious bioenergy targets, but lacked supporting legislation. Where legislation existed, it was often confused, failed to address [land use](#) and created [policy uncertainty](#)<sup>21</sup>. Additional action is needed in consumer countries, including financial and technical support for developing countries.

Most current policy incentives focus on first generation biofuels. The prospect of greater climate benefits from second generation biofuels suggests a need to create new policy incentives to support their research and development<sup>22</sup>.

**VERY FEW COUNTRIES HAVE INTRODUCED NEW FORESTRY REGULATIONS TO ADDRESS ISSUES SPECIFIC TO THE HARVESTING AND USE OF FOREST BIOMASS**





# BALANCING BIOENERGY AND SUSTAINABILITY IN SWEDEN

Forest biomass is an important source of energy in Sweden – but can increasing demand be met sustainably?

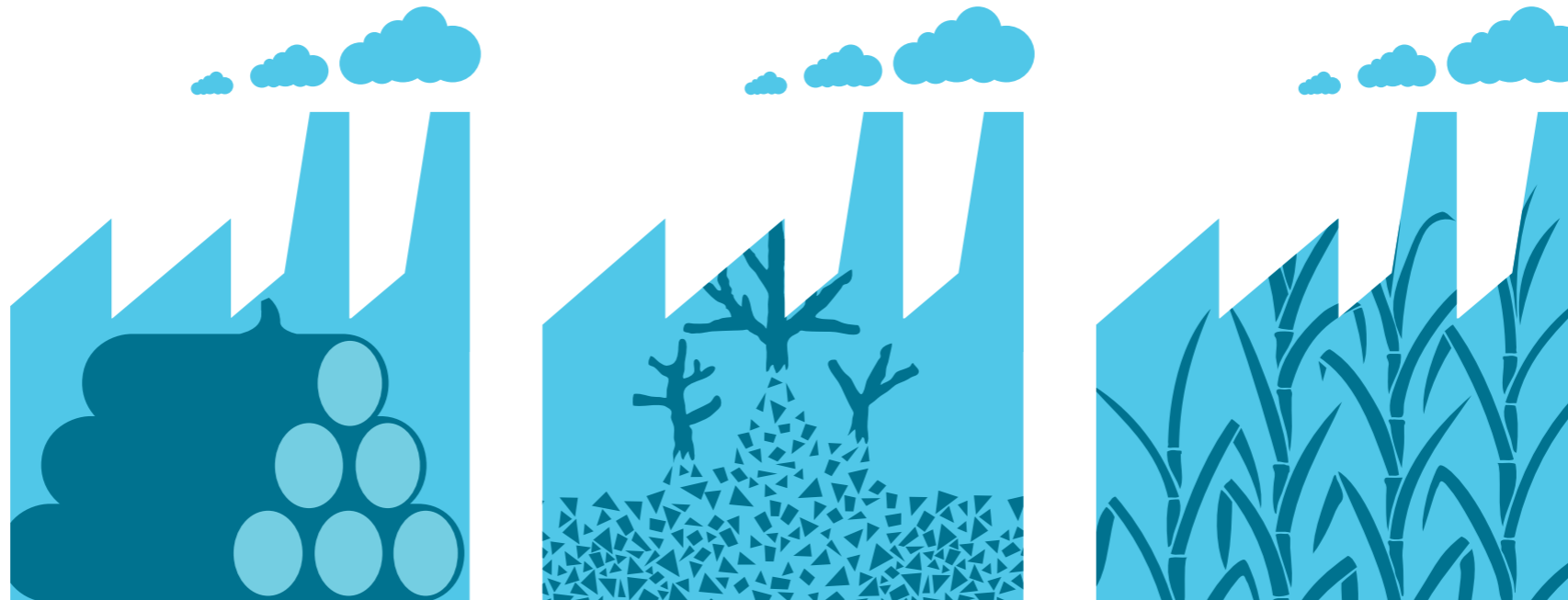
In 1970, Sweden produced about 43<sup>23</sup> of energy from biomass; by 2010 bioenergy production was up to 122 TWh<sup>24</sup>. More than 80 per cent of bioenergy feedstock is estimated to come directly or indirectly from forests, with 70 per cent from mill residues

(e.g. bark, sawdust and black liquor) and the remainder as fuelwood and residues directly from the forest.

Sweden's renewable energy action plan estimates an increase in gross energy consumption of 14 per cent by 2020 compared to 2005<sup>25</sup>, and it has an EU obligation to meet nearly half its energy needs through renewable sources by 2020. Part of the government strategy to meet these targets is to use more wood fuels and to introduce practices such

as stump removal to increase biomass harvest per hectare<sup>26</sup>. This presents a difficult trade-off between using all a tree's biomass (stumps, branches, etc.), which removes valuable nutrients and habitat such as deadwood, or leaving residues in the forest but harvesting a greater area.

The lack of ambitious energy-saving plans may further boost demand and thus undermine the long-term sustainability of forests. WWF-Sweden is promoting measures to reduce energy consumption, achieve sustainable forest management and make biomass part of the solution.



# HOW COULD BIOENERGY AFFECT ZNDD TARGETS?

Increasing use of bioenergy could cause additional forest degradation and loss.

Bioenergy feedstock production could hinder the achievement of ZNDD if natural forests are degraded by more intensive biomass harvesting. Forests could also be converted to make space for bioenergy crops and plantations, or for farming displaced by bioenergy production.

**Crop-based bioenergy** for biofuel production is well established. Some 90-100 billion litres of and at least 18-20 billion litres of are produced annually, primarily in the United States, Brazil and Germany and mainly for the transport sector<sup>27</sup>. More than one-third of US corn production was used for ethanol in 2008<sup>28</sup>. Yet liquid biofuels, bioethanol and biodiesel, accounted for less than 2 per cent of global transport fuels in 2007<sup>29</sup>. Projections suggest this share will rise fast; the International Energy Agency suggests that biofuels could provide 27 per cent of total transport fuels by 2050<sup>30</sup>. Finding land to grow feedstocks will increase pressure on forests and other natural ecosystems.

**Forests** are the main sources of firewood and charcoal wood. Projected population growth in regions reliant on traditional wood energy, as well as demand for wood for new bioenergy production technologies, could expand or intensify the harvesting of forest wood. Increased reliance on forest biomass could either motivate better forest stewardship or drive high-impact extraction practices that lead to degradation and eventually deforestation.

**Fast-growing tree plantations** are increasing in Europe and North America, often using poplar and willow. In the tropics and the southern hemisphere, eucalyptus, acacia and pine plantations produce raw materials, mainly for timber and fibre. Increasing bioenergy demand could expand these plantations. Planted forests in Southeast Asia increased from 10 million ha in 1990 to 14.5 million ha in 2010<sup>31</sup>. Much of this has been established through clearing natural forests<sup>32</sup>. In other parts of the world, recent expansion has mainly been on degraded grazing land or grassland and shrub habitats; these may also have high biodiversity and social values.

The scale of future deforestation and forest degradation associated with bioenergy will depend on policies governing production and use of bioenergy in agriculture and forestry. Preventing extra forest loss or degradation demands policies that require genuine GHG savings, protect biodiversity, prevent leakage and include strong social safeguards.



**BIOENERGY FEEDSTOCK PRODUCTION COULD HINDER THE ACHIEVEMENT OF ZNDD IF NATURAL FORESTS ARE DEGRADED BY MORE INTENSIVE BIOMASS HARVESTING**



**PREVENTING FOREST LOSS DEMANDS POLICIES THAT REQUIRE GENUINE GHG SAVINGS, PROTECT BIODIVERSITY, PREVENT LEAKAGE AND INCLUDE STRONG SOCIAL SAFEGUARDS**



Practices such as stump removal could increase biomass harvest per hectare, but would remove valuable nutrients and habitat such as deadwood. The alternative is leaving residues in the forest, but harvesting a greater area. © Wild Wonders of Europe /Pete Oxford / WWF



# PROJECTING BIOENERGY FUTURES

WWF has developed the Living Forests Model with the International Institute for Applied Systems Analysis (IIASA) to compare future scenarios and analyse policies related to reducing deforestation.

FOR MORE  
INFORMATION  
ON THE LIVING  
FORESTS MODEL  
AND SCENARIOS  
PLEASE SEE  
CHAPTER 1

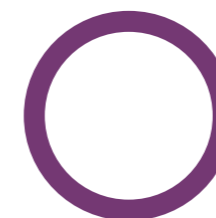


The Living Forests Model draws on IIASA's G4M and GLOBIOM models<sup>33</sup> to show geographically explicit land-use change under different scenarios, as described in chapter 1 of the *Living Forests Report*. The Model lets us explore the implications of projected changes in bioenergy use.

As discussed in the first chapter, the Living Forests Model shows that it is possible to achieve ZNDD by 2020 through better governance, a shift to sound forest stewardship and more productive use of arable non-forest land. If we fail to make that shift, we squander valuable forests. To prevent runaway climate change, we need to cut emissions from deforestation and forest degradation now; the longer we leave this, the harder it will become.

**MAINTAINING ZNDD AFTER 2030 WITHOUT SHORTFALLS IN FOOD, TIMBER, BIOMATERIALS OR BIOENERGY REQUIRES FORESTRY AND FARMING PRACTICES THAT PRODUCE MORE WITH LESS LAND AND WATER, AND NEW CONSUMPTION PATTERNS THAT MEET THE NEEDS OF THE POOR WHILE ELIMINATING WASTE AND OVER-CONSUMPTION**

The scenarios that provide the main analysis for this chapter are:



**Do Nothing:** assumes our behaviour continues along historical trends. Primary energy from   is projected to more than triple from 2010 to 2050 due to energy demand and competitiveness of bioenergy. Land is made available through productivity gains in agriculture, planting on degraded land<sup>34</sup> and conversion of natural habitats outside protected areas.



**Target:** ZNDD (with near zero gross rate of loss of natural and semi-natural forest) reached by 2020 and maintained at that level indefinitely.



**Bioenergy Plus:** described on the next page.



**Pro-Nature:** including two scenarios (Pro-Nature and Pro-Nature Plus) in which natural ecosystems identified as important for biodiversity in several conservation mapping processes are excluded from conversion.



**Diet Shift:** total global consumption of animal calories is maintained at 2010 global level, with convergence in per capita consumption across regions.

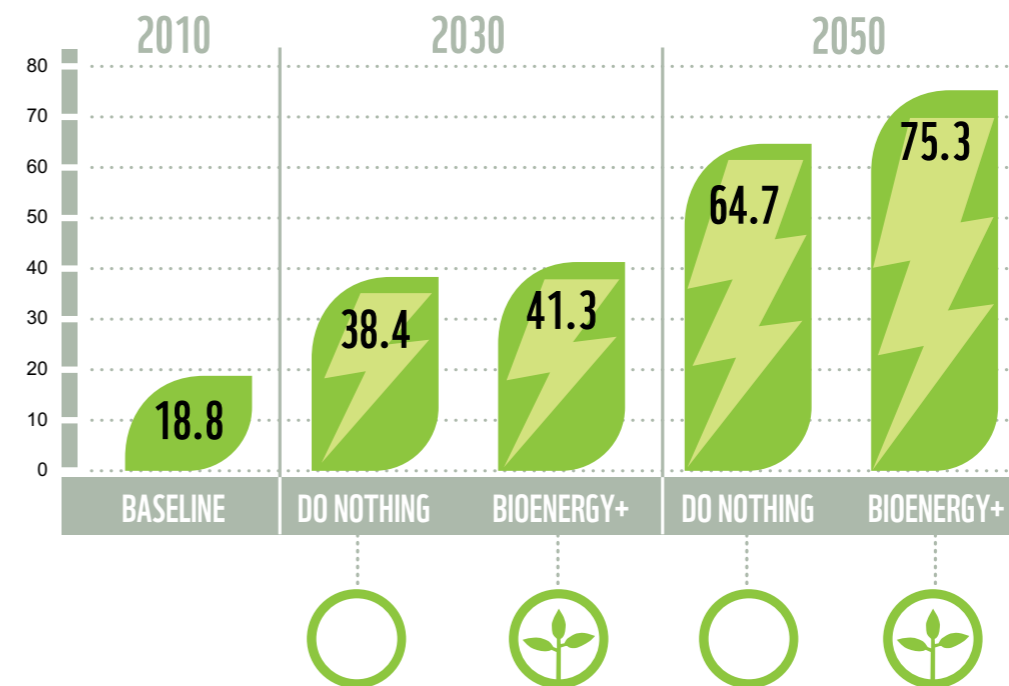
# THE BIOENERGY PLUS SCENARIO

The Bioenergy Plus Scenario builds a picture of the relationship between forests and bioenergy under more ambitious GHG emission mitigation and renewable energy policies.

The projected demand for bioenergy in Bioenergy Plus is based on the “global 2°C scenario” derived from the POLES (Prospective Outlook for the Long-term Energy System) model<sup>35</sup>. The scenario projects demand for bioenergy from land-based feedstocks (excluding those not competing for land, such as municipal solid waste, industrial waste and algae) of 75.3EJ final energy supply in 2050, of which 16.9EJ are liquid biofuels.

This approximates the projected bioenergy demand in the Ecofys scenario developed to assess the feasibility of WWF’s vision of 100 per cent renewable energy by 2050<sup>36</sup>.

**HIGHER CARBON PRICES, MORE AMBITIOUS GHG REDUCTION AND MORE EFFICIENT ENERGY CONVERSION DISTINGUISH BIOENERGY PLUS FROM THE DO NOTHING SCENARIO**



Final energy supply based on bioenergy from land-based feedstocks in 2010 and in 2030 and 2050 under the Do Nothing Scenario and the Bioenergy Plus Scenario, in EJ

# THE BIOENERGY PLUS SCENARIO

The Bioenergy Plus Scenario helps explore implications for global land availability and productivity of producing sufficient bioenergy feedstocks to meet future demand.

## Some important assumptions of the Bioenergy Plus Scenario include:

- A higher carbon price (i.e. above today's price of US\$40/tonne of CO<sub>2</sub>) and more ambitious GHG emission reduction targets than the Do Nothing scenario. This makes bioenergy more competitive relative to fossil fuels, provided it delivers genuine, full life-cycle carbon savings. This competitiveness is tempered, however, by higher bioenergy feedstock prices as more bioenergy is used.
- The land-based bioenergy feedstocks are produced in natural forests managed jointly for biomass and timber production, timber plantations and croplands. Harvesting in natural forests is modelled on a .
- Tree tops, branches and stumps (harvesting residues) are not removed from forests, to protect soils and long-term fertility.
- Traditional fuelwood is harvested on a sustained yield basis, phasing out current uses that cause forest loss or degradation. This shift is achieved, despite population growth, by increasing fuelwood sourced from dedicated plantations and reducing per capita fuelwood demand through more efficient stoves and heating systems that are less detrimental to human health.



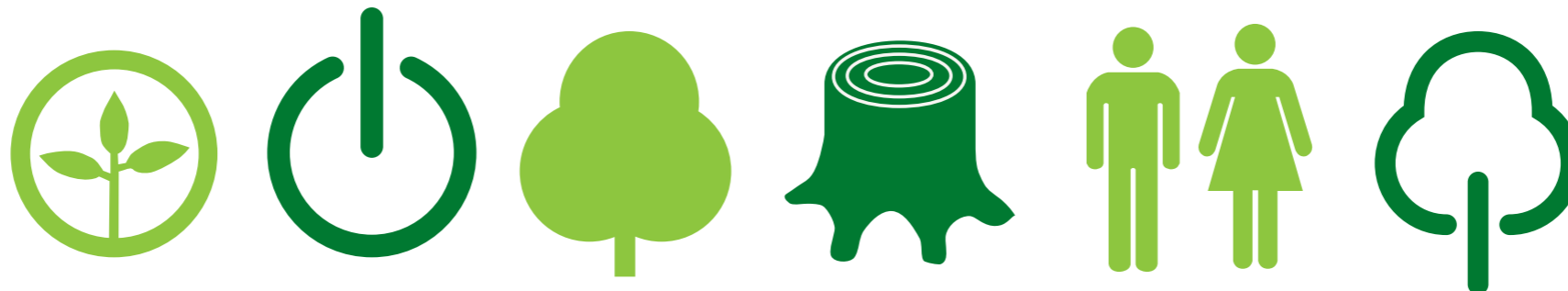
The Do Nothing and Bioenergy Plus Scenarios assume four main processes of bioenergy conversion

### Traditional uses

- **Wood heat:** primary energy from wood turned into heat for domestic cooking and heating.
- **Heat from other biomass:** primary energy from sources such as dung and crop residues turned into heat for domestic cooking and heating.

### New technological uses

- **First generation biofuels:** mainly bioethanol and (fatty acid methyl esters) produced from starchy and oily agricultural crops. The main crops are sugarcane, corn, rapeseed, soya and oil palm.
- **Polygeneration:** primary energy from mostly woody biomass turned into electricity and heat (i.e., combined heat and power) or second generation biofuels produced mainly from wood, turned into transport fuel, gas, electricity and heat.







Development of bioenergy in community-managed forests and grasslands could be an important source of income for rural families. The Roundtable on Sustainable Biofuels stresses that free, prior and informed consent should be the basis of all consultations with communities. © Simon de TREY-WHITE / WWF-UK

# WHAT THE MODEL SHOWS US

Bioenergy use will not be a major cause of forest loss, assuming more natural forests are managed sustainably for timber and biomass production. However, this could cause conversion of other natural ecosystems, unless appropriate safeguards are in place.

**SOME EXPANSION OF BIOENERGY WILL BE DRIVEN BY PUBLIC POLICY INCENTIVES NOT LINKED TO CLIMATE CHANGE - SUCH AS ENERGY SECURITY GOALS**

## Deforestation

Without additional policies in place to halt deforestation and forest degradation, both the Do Nothing and Bioenergy Plus Scenarios project bioenergy leading to some increased deforestation. Bioenergy is, however, not a major direct driver of forest loss<sup>37</sup>. (See graphic on following page.)

In theory, deforestation due to the expansion of bioenergy feedstock production should be limited in the Bioenergy Plus Scenario, as this assumes energy and climate policy frameworks will require reduced GHG emissions. This prompts a move from the production of first generation crop-based biofuels to second generation biofuels derived from wood harvested in managed natural forests or plantations established on non-forest land. However, the Model projects that these frameworks are not enough to stem deforestation completely, as some expansion of bioenergy will be driven by public policy incentives not linked to climate change – such as energy security goals – or markets that do not require compliance with environmental safeguards.



**DO NOTHING AND BIOENERGY PLUS SCENARIOS PROJECT BIOENERGY LEADING TO SOME INCREASED DEFORESTATION**



**2040-2050 LAND COMPETITION BECOMES MOST ACUTE.**

## Natural Ecosystems

We focus on 2040 to 2050, as this is the period within the Living Forests Vision when the food and energy demands of a rising global population make land competition most acute. Projected loss of non-forest ecosystems<sup>38</sup> such as shrublands is 8.5 million ha per year under Do Nothing, with 4.3 million ha attributed to bioenergy. Under Bioenergy Plus, projected loss is 10 million ha per year, with 5.8 million ha attributed to bioenergy. Impacts on other ecosystems are greater if forests are more strictly protected; so if the Target and Bioenergy Plus Scenarios are combined, projected loss of other natural habitats grows to 13.5 million ha per year, with 8 million ha (60 per cent) due to bioenergy.

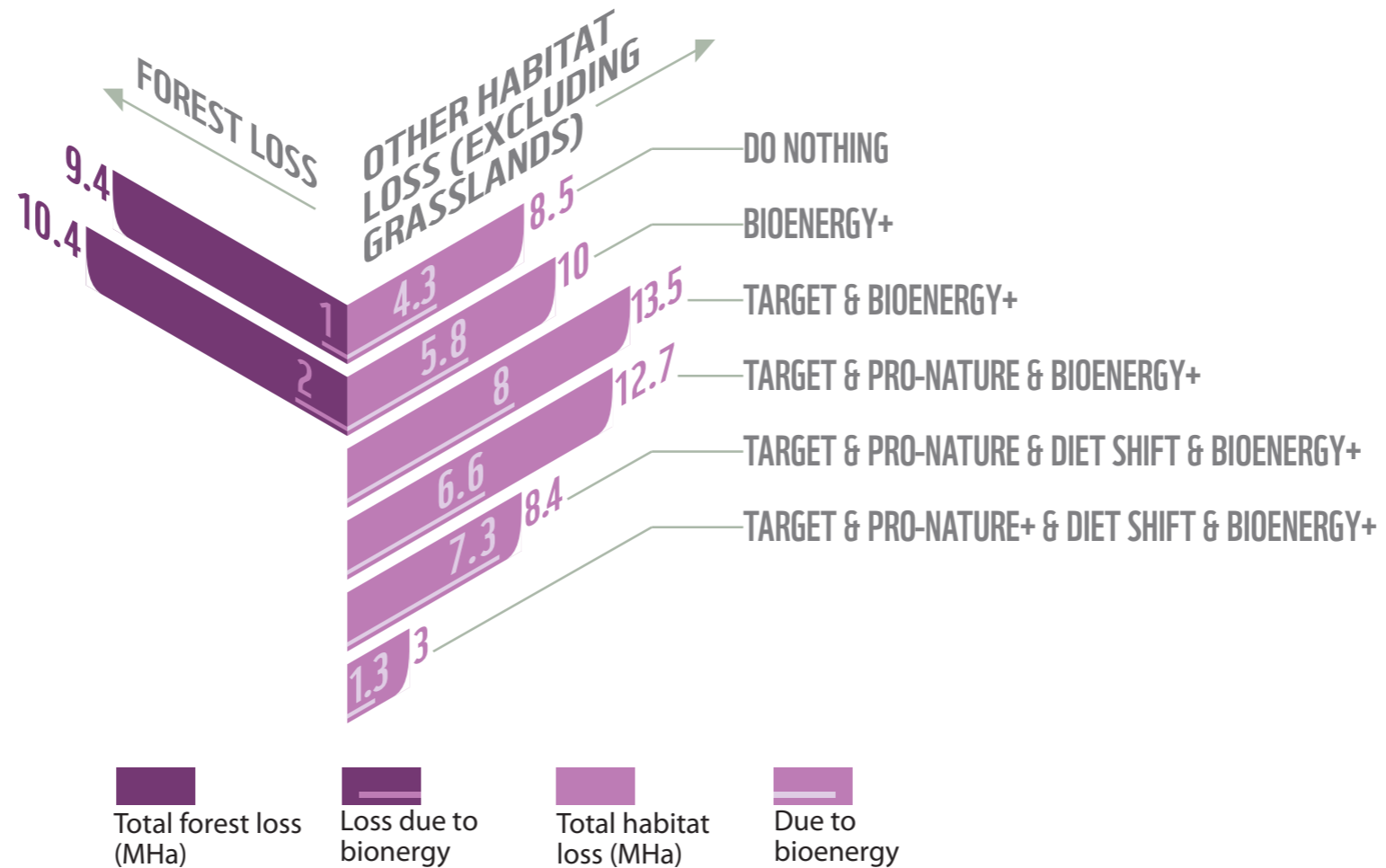
Such land-use changes could have major social, cultural and economic impacts, along with impacts on biodiversity and ecosystem services. Adding the Pro-Nature Scenario blocks the expansion of bioenergy production into non-forest ecosystems identified as important for biodiversity conservation. Yet this only has a marginal impact on the projected rate of loss of other natural ecosystems: 12.7 million ha per year, of which 6.6 million ha is due to bioenergy feedstock production. Pro-Nature Plus without any reduction in projected commodity consumption (not shown in the graphic) would further reduce loss of non-forest ecosystems; however, as the findings of chapter 1 of the *Living Forests Report* show, this would result in dramatically higher food prices. The addition of Diet Shift reduces the total loss of other ecosystems to 8.4 million ha per year under Pro-Nature and 3 million ha per year under Pro-Nature Plus without raising food prices significantly.



# WHAT THE MODEL SHOWS US

## Projected impacts of scenarios on natural forests and other habitats

The rate of change in the area of natural forest and other natural habitats under selected scenarios for the years 2040–2050 (averaged rate of change over this period in millions of hectares per year), including the portion that can be attributed to bioenergy.





# WHAT THE MODEL SHOWS US

The Living Forests Model projects that more natural forests will be managed to produce wood and other biomass, and that a significant increase in bioenergy use will require a parallel increase in fast-growing tree plantations.



**PROJECTIONS SUGGEST THAT RELATIVELY PRISTINE FORESTS WILL ALSO NEED TO BE MANAGED**

## The impact of bioenergy expansion on natural forests

Today 1.2 billion hectares of forests, or 30 per cent, have production designated as their primary function<sup>39</sup>. The projected expansion of forest management in the Living Forests Model (see graphic) is driven primarily by demand for bioenergy. Between 2040 and 2050, the area of managed forest will increase by a projected 14.5 million ha per year under Bioenergy Plus; the total area managed for production of timber and biomass will expand by 304 million hectares between 2010 and 2050<sup>40</sup>.

Adding the objective of maintaining near zero forest loss (as in the Target Scenario) has only a marginal impact, increasing the rate of expansion of forest management to 15.7 million ha per year. This is because the Bioenergy Plus Scenario assumes the expansion is via sustainable forest management that does not cause forest loss or degradation. Similarly, introducing a broader nature conservation element into the projections through adding the Pro-Nature Scenario has an incremental impact, with the Model projecting 17.1 million additional hectares of forests per year managed for production. A change in diets as assumed under the Diet Shift scenario reduces this rate to 14.2 million ha per year. However, adding the Pro-Nature Plus Scenario “pushes” bioenergy feedstock production into natural forests by excluding the conversion of large areas of other natural habitat and nearly doubles the size of the additional forest area that needs to be allocated to production each year to 27.9 million hectares.

The Model allows more forests to be managed for timber and biomass production in preference to outright loss of forests or other natural ecosystems with high conservation value through conversion to energy plantations. This is based on an assumption that such managed forests will still support much of the original biodiversity and ecosystem services. Some forests brought under management might already be

degraded or affected by illegal use; in these cases management can bring positive environmental and social benefits. However, projections suggest that relatively pristine forests will also need to be managed, and great care will be needed to maintain or enhance their social and environmental values.

The biodiversity and carbon implications of extracting more biomass from more forests will depend on factors such as the intensity of management, quality of environmental practices and connectivity with protected areas. From a social perspective, management not under the direct control of indigenous peoples or local communities needs to ensure forests remain accessible for traditional uses. Indeed, bioenergy could provide an additional revenue stream for forest communities that motivates them to manage rather than clear forests.

## The impact of bioenergy demand on tree plantations

Tree plantations already have the capacity to supply some two-thirds of industrial roundwood, even though they correspond to only 6.6 per cent of the global forest area<sup>41</sup>. The Bioenergy Plus Scenario in particular suggests that new fast-growing plantations could be an important source of bioenergy feedstocks and fibre. As the graphic on the following page shows, the projected rate of new plantation establishment between 2040 and 2050 ranges from 3.7 to 13 million hectares per year, depending on the scenario. The lowest figure is because Pro-Nature Plus projects much less land available for plantation expansion, pushing feedstock production into a larger area of natural forests.

Well-managed plantations in the right places can play a positive role in a future renewable energy strategy. Plantations that do not replace natural or valuable semi-natural habitats can have positive environmental and social impacts. They can help recover degraded or over-grazed land, or be part of a mosaic of monocultures, community-managed agro-forestry and natural ecosystem regeneration. However, in some regions, without significant changes in policies and practices, expansion of intensively managed plantations will continue to have negative impacts – for instance, threatening the rights or livelihoods of forest-dependent peoples or destroying valuable ecosystems and biodiversity.

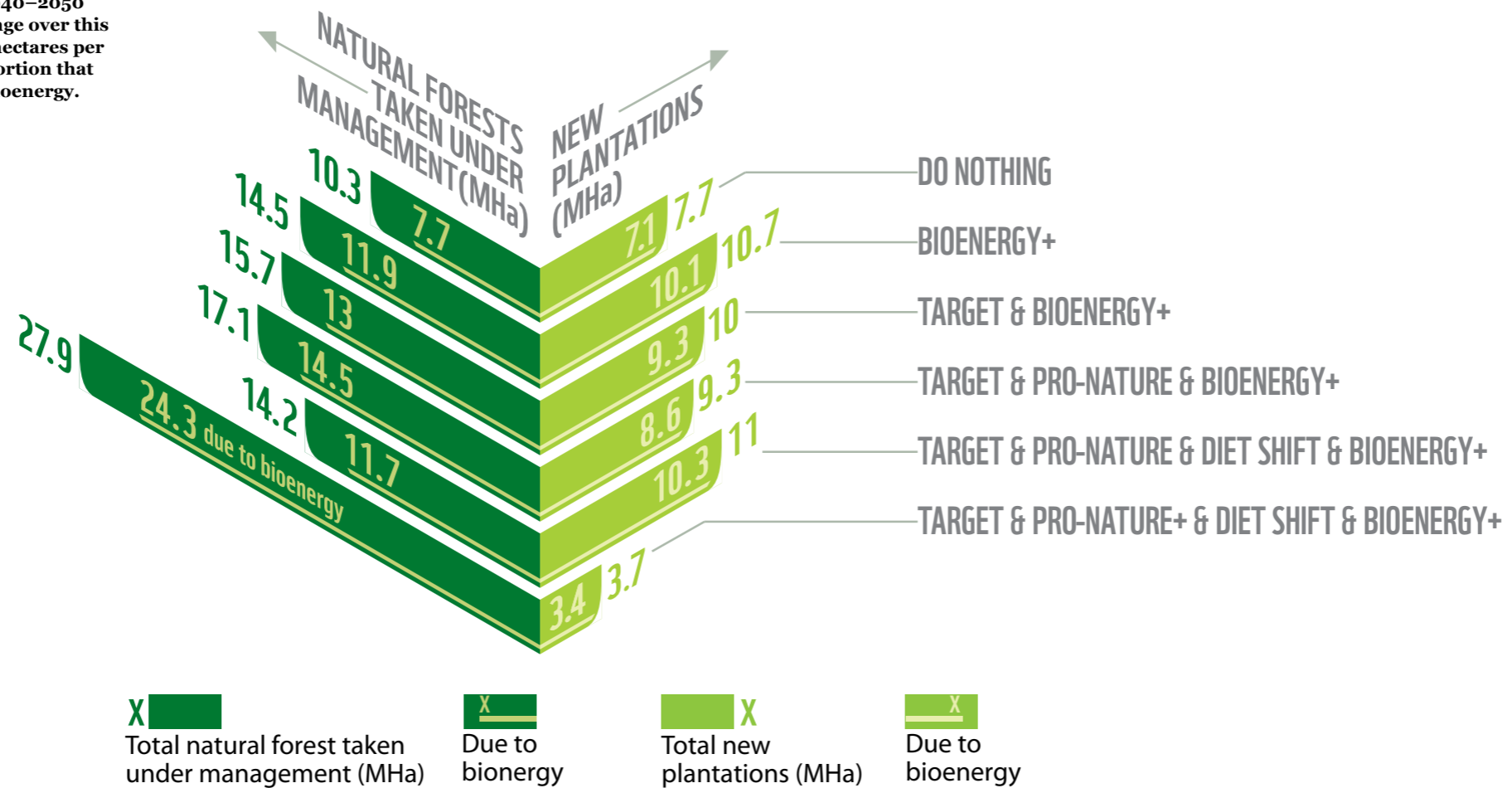


**WELL-MANAGED PLANTATIONS IN THE RIGHT PLACES CAN PLAY A POSITIVE ROLE IN A FUTURE RENEWABLE ENERGY STRATEGY**

# WHAT THE MODEL SHOWS US

## Projected impacts of scenarios on production forests and plantations

Growth in tree plantations and managed area of natural forest for the years 2040–2050 (averaged rate of change over this period in millions of hectares per year), including the portion that can be attributed to bioenergy.





Strict protection of forests could increase the impact of bioenergy expansion on grasslands and other ecosystems with high conservation values. Reducing overall energy consumption and improving agricultural efficiency are essential to conserving biodiversity. © Martin Harvey / WWF-Canon



# WHAT THE MODEL SHOWS US: FOOD CONSUMPTION AND SECURITY

Achieving ZNDD while increasing bioenergy use could affect food security and will require changes in both efficiency of agriculture and consumption patterns.



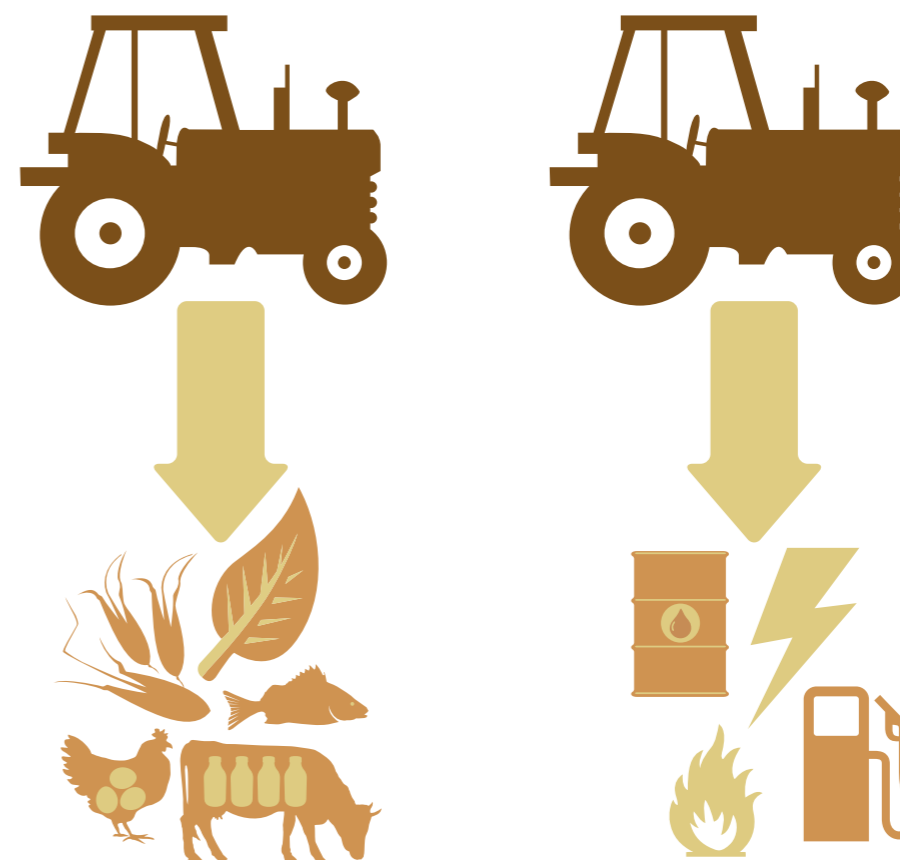
**RISING DEMAND FOR BIOENERGY IS ONE OF SEVERAL FACTORS CITED FOR DRIVING UP COMMODITY AND FOOD PRICES**

The Living Forests Model and WWF’s *Living Planet Report*<sup>42</sup> show pressures on natural forests and other ecosystems can be substantially reduced by changes in consumption patterns and increased agricultural efficiency. These changes are also needed to avoid negative effects of bioenergy production on food security<sup>43</sup>.

Rising demand for bioenergy, and in particular crop-based biofuel, is one of several factors cited for driving up commodity and food prices and taking land out of food production. The FAO warns that biofuel production represents a major risk for long-term food security<sup>44</sup>. There are, however, multiple factors behind commodity and food price increases, including poor harvests linked to extreme weather events; declining food stocks; high oil and energy prices raising the cost of inputs and transport; speculative transactions and export restrictions leading to hoarding and panic buying<sup>45</sup>. Isolating the exact influence of bioenergy on food price and security is difficult in these circumstances.

WWF’s Living Forests Vision includes a more equitable distribution of food across the globe; the equity question is addressed in the Diet Shift Scenario (see chapter 1 [↔](#)). The Living Forests Model projects that achieving and sustaining ZNDD while meeting global demand for food, fibre and energy is possible if we move toward a more equitable global diet sourced from more efficient agriculture.

[↔](#), for example, which aim to produce food and bioenergy feedstock simultaneously, offer potential for sustainable food and energy in small-scale production systems in some regions. This could dampen food price volatility by increasing flexibility to switch from energy to food production to mitigate food shortages.



# SUSTAINABILITY CRITERIA FOR CROP AND WOOD- BASED BIOENERGY

WWF urges governments and industry to link renewable bioenergy with sustainability safeguards.

The Roundtable on Sustainable Biofuels (RSB) is a WWF-supported multi-stakeholder initiative to develop standards for the sustainability of biofuels. The RSB Principles<sup>4</sup>, listed below, include the primary safeguards that should inform all bioenergy development. These operate as an overarching standard, incorporating standards for specific commodities as appropriate. Not all principles are applicable in every case, and not all commodity-specific schemes have incorporated the full range of principles yet; addressing obvious gaps is a priority.

**Principle 1: Legality.** Biofuel operations shall follow all applicable laws and regulations.

**Principle 2: Planning, Monitoring and Continuous Improvement.** Sustainable biofuel operations shall be planned, implemented and continuously improved through an open, transparent and consultative impact assessment and management process and an economic viability analysis.

**Principle 3: Greenhouse Gas Emissions.** Biofuels shall contribute to climate change mitigation by significantly reducing lifecycle GHG emissions as compared to fossil fuels.

**Principle 4: Human and Labour Rights.** Biofuel operations shall not violate human rights or labour rights, and shall promote decent work and the well-being of workers.



**Principle 5: Rural and Social Development.** In regions of poverty, biofuel operations shall contribute to the social and economic development of local, rural and indigenous people and communities.

**Principle 6: Local Food Security.** Biofuel operations shall ensure the human right to adequate food and improve food security in food insecure regions.

**Principle 7: Conservation.** Biofuel operations shall avoid negative impacts on biodiversity, ecosystems and conservation values.

**Principle 8: Soil.** Biofuel operations shall implement practices that seek to reverse soil degradation and/or maintain soil health.

**Principle 9: Water.** Biofuel operations shall maintain or enhance the quality and quantity of surface and ground water resources, and respect prior formal or customary water rights.

**Principle 10: Air.** Air pollution from biofuel operations shall be minimized along the supply chain.

**Principle 11: Use of Technology, Inputs and Management of Waste.** The use of technologies in biofuel operations shall seek to maximize production efficiency and social and environmental performance, and minimize the risk of damages to the environment and people.

# SUSTAINABLE CHARCOAL IN THE SPINY FORESTS OF MADAGASCAR

Using fuelwood  
more efficiently  
and sustainably

is vital to achieving WWF's vision of 100 per cent renewable energy and the Living Forests Vision.



**WWF**  
IS WORKING WITH  
LOCAL PEOPLE  
TO REDUCE  
PRESSURE ON  
THE FOREST AND  
IMPROVE ENERGY  
SUSTAINABILITY

The dry spiny forests of southwestern Madagascar are a unique ecosystem. They exist nowhere else on Earth and include biologically outstanding habitats. The forests have a high level of endemism (unique species), with succulent and spiny plants dominating in a semi-arid environment. They are home to many species, including lemur and tortoise [↔](#).

The production of fuelwood and charcoal using wood from the spiny forest is becoming increasingly unsustainable. WWF is working with local people to reduce this pressure on the forest and improve energy sustainability. This includes promoting forest plantations for charcoal production, and training communities in new techniques to produce the same amount of fuelwood and charcoal with much less wood. WWF also supports a regulatory system for a chain of custody process, which encourages sustainable management in dedicated areas, transparency in the market, professionalization among charcoal producers and penalties for illegal use. In parallel, a regional energy forest committee is promoting improved cooking stoves, more effective law enforcement in relation to resource use, and implementation of the fuelwood chain of custody.



The forests of Madagascar are home to many species found nowhere else on Earth, including ring-tailed lemurs. © Martin Harvey / WWF-Canon




# BIOENERGY AND GREENHOUSE GASES

The potential of forest-based bioenergy to reduce GHG emissions depends to a large extent on how and where the feedstock is produced.

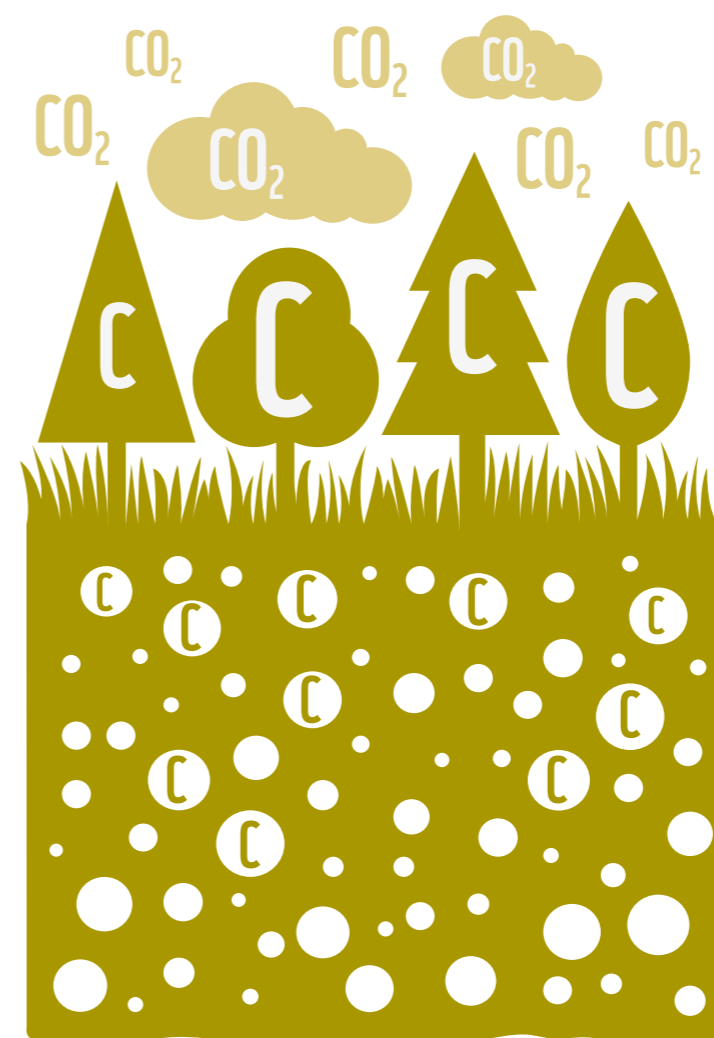
In theory, bioenergy can reduce GHG emissions because the carbon released can be recaptured during plant growth. However, the net balance depends on:

- the GHG emissions associated with bioenergy production (e.g., from direct or indirect land-use change required to cultivate or harvest the feedstock, production of fertilizers, and energy needed to convert feedstock to fuel)
- the accounting time frame (extracting biomass from an intact natural forest system is likely to cause a carbon debt, which will decrease slowly with time<sup>46</sup>; GHG emissions initially exceed those from fossil fuels)
- what fuel type is replaced<sup>47</sup>.

  
**17-420**  
YEARS OF BIOFUEL PRODUCTION TO REPLACE THE CARBON LOST IN CONVERSION OF FORESTS IN SOUTHEAST ASIA, BRAZIL AND THE UNITED STATES

The carbon cycles of forests are far more complex than those in agriculture, increasing the difficulty of understanding the potential carbon benefits from forest-based bioenergy. For example, research from Ontario, Canada, reports a substantial loss in forest carbon due to bioenergy production. Initially GHG emissions exceed fossil fuel-related emissions; the longer-term balance depends on the biomass source and what fuel is replaced. Emissions are larger when logs are used compared to residues. For example, ethanol from logs could increase emissions during a century of continuous production; while ethanol from residues achieves reductions after around a 70 year delay<sup>48</sup>.

Land-use change can have dramatic effects, especially if carbon-rich habitats are converted to agricultural production. Another study calculated that it would take 17 to 420 years of biofuel production to replace the carbon lost in conversion of forests in Southeast Asia, Brazil and the United States<sup>49</sup>. Conversely, a new timber plantation on previously degraded land could sequester carbon in the growing trees and stabilized soil, thus creating a positive average carbon balance over repeated biomass harvesting cycles<sup>50</sup>.



Based on the modelling and research data available to WWF, forests should and will play an increasing role in the global energy supply. However, more research and greater transparency is needed to work out potential climate benefits.

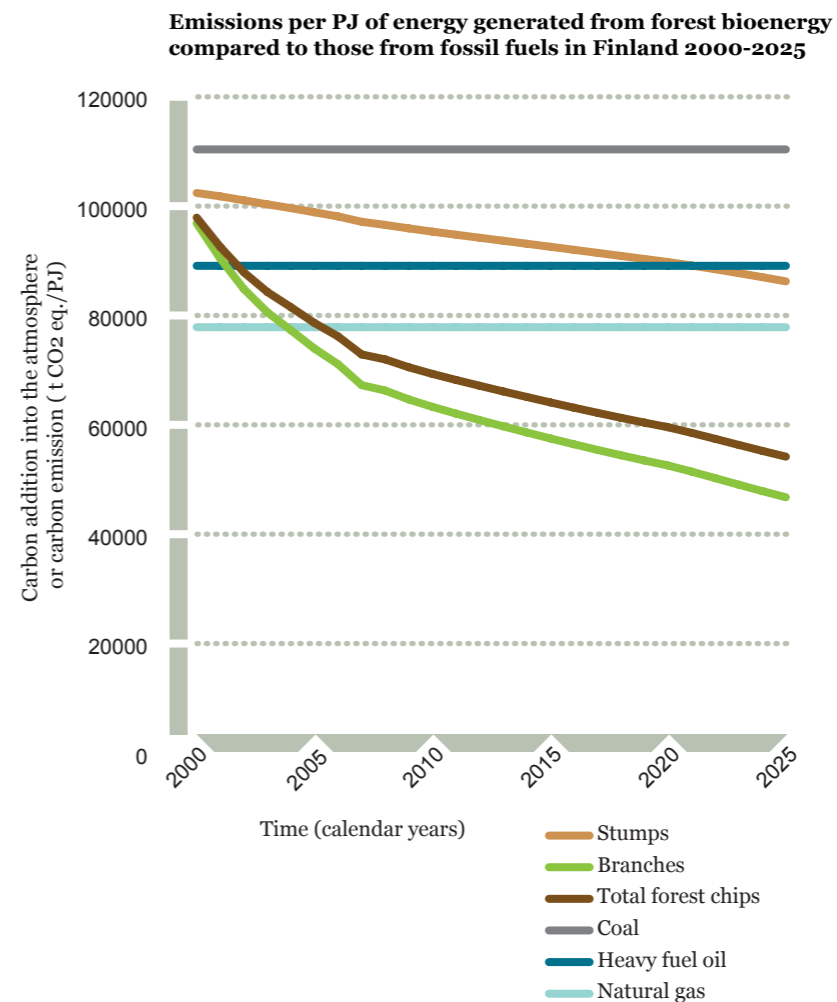
In addition, in most countries energy consumption is still growing; as a result, bioenergy will replace a relatively smaller proportion of fossil fuels, reducing the climate benefits. Simply adding bioenergy to a growing energy mix will not achieve necessary climate targets.

# FINNISH FORESTS AND CARBON

Research from Finland highlights the complexity of estimating climate impacts of bioenergy.

The Finnish Environmental Agency modelled the carbon impact of increased biomass use. They found that using more wood for bioenergy is leading to decreasing carbon stocks in the Finnish forests, because soil carbon levels are lower and burning wood releases more carbon than leaving dead wood to decay slowly. In addition, both transport and chipping of wood cause emissions. Research also showed that different parts of a tree have different GHG benefits<sup>51</sup>.

MORE WOOD FOR BIOENERGY IS LEADING TO DECREASING CARBON STOCKS IN THE FINNISH FORESTS



This compares emissions (in CO<sub>2</sub> equivalent) per PJ of energy generated from different forms of forest biomass and fossil fuel. Data for forest residue use was based on actual 2000–2008 figures and projections for 2009–2025, over which time biomass collection is expected to increase from 5 million m<sup>3</sup> in 2009 to 13.5 million m<sup>3</sup> in 2025. Because the decay process for unused residues left in the forest takes some time to start, net carbon impact of using forest residues for energy production decreases over time, and stumps decay more slowly than branches. Using branches thus delivers immediate savings, while other sources take longer to balance emissions. Total wood chips (stumps and branches) also produce lower emissions because more branches are used than stumps<sup>52</sup>.

# BIOENERGY IMPACTS ON WATER

Bioenergy expansion has significant implications for water resources and requires strong basin- and

catchment-level governance, particularly in water-scarce areas.



**2,500  
LITRES**  
OF WATER  
ARE REQUIRED  
TO PRODUCE  
ONE LITRE OF  
LIQUID BIOFUEL

Globally, irrigation water allocated to biofuel production is estimated at 44km<sup>3</sup>, or 2 per cent of all irrigation water. Some feedstocks – including sugar cane, oil palm and maize – are highly water intensive<sup>53</sup>. Under current production conditions it takes roughly 2,500 litres of water (about 820 litres of irrigation water) to produce one litre of liquid biofuel – the same amount needed on average to produce food for one person for one day<sup>54</sup>.

Current water footprint and techniques are insufficient to quantify impacts of all types of bioenergy production on water. Implications of water consumption vary greatly depending on what resource base is affected, its previous state, the location and timing of use, and the aggregated effects of all users within a catchment. Methods are being developed within the Water Footprint Network to account for localized water impacts based on consumptive water use (evaporation) and environmental flows needed to maintain a stable ecosystem<sup>55</sup>.

The water needs and impacts of bioenergy are often the same as for food production. The water constraints of river basins and the necessity of water for basic human needs and environmental functions make the context critical in any decisions about suitability and sustainability of water use in bioenergy. Water use needs to feature strongly in any guidelines on bioenergy, including the need for governance at basin and catchment scales.



**WATER USE NEEDS TO FEATURE  
STRONGLY IN ANY GUIDELINES ON  
BIOENERGY, INCLUDING THE NEED  
FOR GOVERNANCE AT BASIN AND  
CATCHMENT SCALES**





Some feedstocks – including sugar cane, oil palm and maize – are highly water intensive. It takes roughly the same amount of water to produce one litre of liquid biofuel as needed on average to produce food for one person for one day. © Adriano Gambarini / WWF-Brazil










# GUIDELINES FOR RESPONSIBLE CROP- AND PLANTATION-BASED BIOENERGY

## ACHIEVING THE LIVING FORESTS VISION REQUIRES GOOD GOVERNANCE AND THE INVOLVEMENT OF ALL RELEVANT STAKEHOLDERS

Existing standards and tools provide useful guidance on sustainability in bioenergy production.

Determining the optimal ratio of land and water to be used for food, bioenergy, biomaterials and fibre, carbon storage, biodiversity conservation, and cultural, spiritual and recreational purposes is one of society's greatest challenges. A range of standards and tools provide useful guidance to those wishing to navigate this challenge responsibly. However, comprehensive land-use decision-making needed to achieve the Living Forests Vision requires good governance and the involvement of all relevant stakeholders.

These sources of guidance include:

- the Responsible Cultivation Areas  methodology, which draws on a variety of existing approaches (EU Renewable Energy Sources Directive , Renewable Transport Fuel Obligation , Roundtable on Sustainable Biofuels  s (see page #), Bonsucro, Round Table on Responsible Soy , Roundtable on Sustainable Palm Oil )
- the Forest Stewardship Council  and related efforts to manage forests sustainably
- guidance being developed through the New Generation Plantations framework 
- responsible purchasing processes for forest products such as those developed by WWF's Global Forest & Trade Network 
- principles such as free prior informed consent.

One emerging conclusion from the *Living Forests Report* is the need to pull these and other complementary approaches together into a single coherent framework.



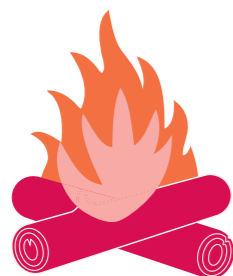
**Management:** practices should be based on the **Roundtable on Sustainable Biofuels principles** (see page #) or related standards. The **New Generation Plantations framework** was developed for the fibre and timber sectors but can also provide best practice for bioenergy tree plantations. It promotes plantations that maintain ecosystem integrity (i.e., cycles for water, carbon, nutrients and biodiversity); protect and enhance high conservation values; are developed through effective stakeholder processes; and contribute to economic growth and employment.

**Planning:** the **Responsible Cultivation Area (RCA)** methodology guides land selection for establishing energy crop plantations, which must:

- maintain or increase high conservation values
- not lead to significant reductions in carbon stocks
- respect formal and customary land rights
- not cause unwanted displacement effects (e.g., of food production)
- be in areas agriculturally suitable for the target crop.

This aims to optimize site selection but gives no guidance on management.

# CONCLUSIONS: IS BIOENERGY A THREAT OR A SOLUTION?



## INCREASED DEPENDENCE ON FUELWOOD FOR ENERGY PRODUCTION

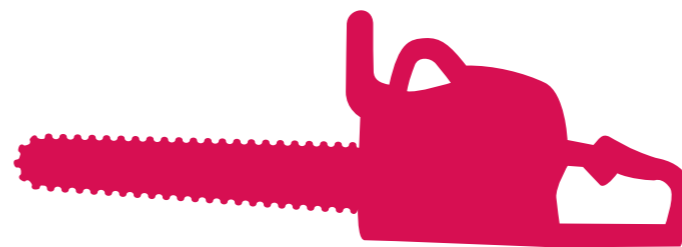
Badly managed bioenergy production can destroy valuable ecosystems, undermine food and water security, harm rural communities and prolong wasteful energy consumption.

Wood is the oldest form of fuel. New technologies are revitalizing this traditional energy source and making it, along with crop-based bioenergy, potentially a major contributor to equitable and renewable energy strategies. But there are important questions about how and where more bioenergy feedstock production can take place without negatively affecting biodiversity, food security, water resources or people's rights and livelihoods. Fuelwood collection is already a major cause of forest degradation in many low-income regions with poor governance and rising populations. Additionally, some liquid biofuel feedstocks are driving conversion of valuable habitats and causing concerns about food security.

In this chapter we have used WWF's Living Forests Model to project the implications of an increased dependence on fuelwood for energy production, particularly in relation to WWF's target of 100 per cent renewable energy by 2050.



## THE PROJECTED EXPANSION IN BIOENERGY CONSUMPTION WILL CREATE MAJOR ADDITIONAL STRESSES ON THE PLANET'S LAND AND WATER RESOURCES



From this exploration we can conclude:

**Without appropriate actions, policies and targets, increased reliance on bioenergy could have many negative impacts:**

- The projected expansion in bioenergy consumption will create major additional stresses on the planet's land and water resources.
- Most bioenergy comes from forest biomass and plantation-grown timber. Second-generation technologies could increase reliance on these sources, driving unsustainable expansion of fast-growing tree and crop plantations and extractive forestry in natural forests.
- Crop-based bioenergy competes for increasingly scarce productive land and could drive the conversion of forests and other natural ecosystems into cropland (for bioenergy, or food production displaced by bioenergy elsewhere).
- Bioenergy is not necessarily GHG neutral. The energy needed for cultivation, refining and transport, plus emissions from direct and indirect land-use change caused by increasing feedstock cultivation and biomass harvesting, may result in a negative carbon balance, particularly when intact natural forests are affected.



## CONCLUSIONS: IS BIOENERGY A THREAT OR A SOLUTION?

Well-managed bioenergy production can provide energy security, rural development, GHG emission savings and incentives for good forest stewardship.

The Living Forests Model presents a range of land-use and consumption options that influence the prospects for bioenergy to deliver social and environmental benefits. From this we can begin to build a picture of the actions, policies and targets we need to develop

efficient, equitable and sustainable bioenergy. These include:

- more equitably distributed and more efficiently produced energy
- a reduction in overall energy demand
- changes in consumption patterns, in particular less over-consumption and waste of food, to reduce the footprint of agriculture worldwide
- the further development and promotion of voluntary and regulatory frameworks to ensure bioenergy makes a positive contribution to GHG emission reduction and does not negatively affect biodiversity, food security, water resources or people's rights and livelihoods
- factoring bioenergy development into strategies to achieve ZNDD and conserve biodiversity

Allowing more of the world's forests to be managed to meet the demand for wood for bioenergy can reduce pressure to convert forests and other natural ecosystems to farms and plantations. However, this management must be subject to sustainability standards.

With rising populations and projected consumption levels, our planet does not have enough land to simultaneously conserve nature completely, feed the world and switch to 100 per cent renewable energy. However, we *can* achieve this if those of us with the highest resource use make some reductions in our overall consumption – for example by reducing the animal-based calories in our diets, as outlined in the Diet Shift Scenario in chapter 1<sup>56</sup>.

The Living Forests Model projections are based on technologies that we know today. Another potential pathway to alleviating the pressures on the Earth's ecosystems is accelerated research on prospective renewable



**WITH RISING POPULATIONS AND PROJECTED CONSUMPTION LEVELS, OUR PLANET DOES NOT HAVE ENOUGH LAND TO SIMULTANEOUSLY CONSERVE NATURE COMPLETELY, FEED THE WORLD AND SWITCH TO 100 PER CENT RENEWABLE ENERGY**

energy solutions that require less land and water. But we must not rely on technology alone – in the next chapter of the *Living Forests Report* we will consider further the role and management of forests in the timber and paper industries, and in future chapters we will look in more depth at issues relating to climate change and biodiversity conservation. All will raise vitally important issues in this continuing conversation on the future of our forests in the 21<sup>st</sup> century.

# GLOSSARY AND ACRONYMS



## FEEDSTOCK

**Biodiesel:** fuel produced by combining alcohol with vegetable (e.g., plant extracts such as palm oil, corn, soybean, canola/rapeseed, and sunflower) or animal oil/fats, or recycled cooking grease. The fuel can be used in pure form or added to conventional diesel<sup>57</sup>.

**Bioenergy:** Energy derived from biomass. This energy can be used to generate electricity, supply heat and produce liquid biofuels<sup>58</sup>.

**Bioethanol:** the most widespread biofuel, produced by fermentation, in a method similar to beer brewing, of biomass containing carbohydrates (e.g., starches and sugars) such as sugarcane, wheat and corn<sup>59</sup>.

**Biofuels:** fuels (e.g., fuelwood, charcoal, bioethanol, biodiesel, biogas/methane or biohydrogen) extracted through conversion technologies from wood, crops and waste material. There are many kinds of biofuels and their usage and performance in economic, environmental and social terms varies significantly depending upon technology, location and farming practices<sup>60</sup>.

**Biomass:** biological material derived from living or recently living organisms, such as wood and other crops. Biomass may also include biodegradable wastes that can be burnt as fuel. It excludes organic material such as fossil fuel which has been transformed by geological processes into substances such as coal or petroleum.

**Cellulose:** the basic structural component of plant cell walls, cellulose comprises about 33 per cent of all vegetable matter and is the most abundant of all naturally occurring organic compounds. Not digestible by humans, cellulose is a food for herbivorous animals (e.g., cows, horses), is processed to produce papers and fibres, and is chemically modified to yield substances used in the manufacture of such items as plastics, photographic films, etc<sup>61</sup>.

**Conversion methods:** technologies for converting biomass to energy. These differ depending on the feedstock, which can vary greatly in mass, energy density, size, moisture content and reliability of supply.

**Ecoregion:** a large area of land or water that contains a geographically distinct assemblage of natural communities that (a) share a large majority of their species and ecological dynamics; (b) share similar environmental conditions; and (c) interact ecologically in ways that are critical for their long-term persistence<sup>62</sup>.

**EJ:** exajoule (EJ) =  $10^{18}$  joules.

**FAME (Fatty Acid Methyl Esters):** the second most common biofuel, often made from rapeseed, oil palm or soya bean. The oils from these plants are converted into a diesel type fuel via a basic process called transesterification<sup>63</sup>.

**Feedstock:** wood, crops or waste products that can be used or converted into biofuels and bioenergy.

**First generation biofuels:** fuels produced from sugar, starches and oils<sup>64</sup>.

**Greenhouse gases (GHG):** those gaseous constituents of the atmosphere, both natural and artificial, that absorb and re-emit infrared radiation and that are responsible for global warming<sup>65</sup>.

**GWh:** gigawatt hour, unit of electrical energy equivalent to 1000 megawatt hours.

**Integrated Food Energy System (IFES):** a farming system designed to increase simultaneous production of food and energy through the sustainable use of biomass. They either combine production of food and feedstock on the same land (Type 1 IFES: intercropping, agroforestry or agropastoral systems) or use the by-products/residues of one production system as a base for the other (Type 2 IFES: 'closed loop' or 'zero waste' systems).

**Land-based feedstocks:** bioenergy feedstocks grown in croplands, plantations or natural forests (i.e., excluding bioenergy feedstocks that are not competing for land, such as municipal solid waste, industrial waste and algae).

**Leakage to other ecosystems:** in this context, impacts on other ecosystems from activities displaced from forests because of forest protection.

**Lignin:** the organic substance binding the cells, fibres and vessels that constitute wood and the lignified elements of plants, as in straw. After cellulose, it is the most abundant renewable carbon source on Earth<sup>66</sup>.



## FIRST GENERATION BIOFUELS:



**Living Forests Model:** developed for WWF by the International Institute for Applied Systems Analysis (IIASA), the Model draws on G4M and GLOBIOM models<sup>67</sup> to show geographically explicit land-use change under different scenarios. The G4M model projects future deforestation and land-use change by extrapolating from historical trends and taking into account future projections for population, GDP and infrastructure. GLOBIOM is an economic model that allocates land and resources optimally based on projected commodity and ecosystem-service demands under future GDP, population and policy scenarios.

**Lifecycle assessment:** a technique to assess the environmental aspects and potential impacts associated with a product, process or service by: 1) compiling an inventory of relevant energy and material inputs and environmental releases; 2) evaluating the potential environmental impacts associated with identified inputs and releases; and 3) interpreting the results to help make more informed decisions<sup>68</sup>.

**Natural forest:** forest composed of native species (a species that naturally exists at a given location or in a particular ecosystem, i.e. it has not been moved there by humans<sup>69</sup>) with natural ecosystem functions.

**PJ:** petajoule; PJ =  $10^{15}$  joules.

**Perverse incentives:** incentives (usually financial incentives such as grants, tax breaks, etc.) that inadvertently cause an unwanted result, such as support for biofuel production to combat climate change that actually results in net carbon emissions.

**Renewable energy:** energy generated from natural sources: water, wind, solar, biomass or geothermal<sup>70</sup>.

**Second generation biofuels:** liquid biofuels produced from lignocellulosic biomass<sup>71</sup>, such as agricultural residues, dedicated energy crops and wood residues.

**Sustained yield basis:** harvest at a rate of up to 100 per cent mean annual increment of stems, leaving stumps, branches and other organic debris behind to maintain healthy soil structure and to assist soil nutrient levels.

**TWh:** terawatt hour, unit of electrical energy equivalent to 1000 gigawatt hours.

**Zero Net Deforestation and Forest Degradation (ZND):** no net forest loss through deforestation and no net decline in forest quality through degradation. Zero net deforestation and degradation acknowledges that some forest loss could be offset by forest restoration. Zero net deforestation is thus not synonymous with a total prohibition on forest clearing. Rather, it leaves room for change in the configuration of the land-use mosaic, provided the net quantity, quality and carbon density of forests is maintained. It recognizes that, in some circumstances, conversion of forests in one site may contribute to the sustainable development and conservation of the wider landscape (e.g. reducing livestock grazing in a protected area may require conversion of forest areas in the buffer zone to provide farmland to communities). Managing forests to avoid degradation is often a key strategy to prevent deforestation<sup>72</sup>.



# APPENDIX: CHANGING STRATEGIES, DRIVING GROWTH

Bioenergy policies are supporting rapid development in many regions of the world. A few examples are given here.

POLICY FRAMEWORK	MAIN OBJECTIVES	BIOENERGY TARGET	BIOENERGY INCENTIVES	SAFEGUARDS
<b>EU</b> Renewable Energy Directive 2009/28/EC <sup>73</sup>	Climate; energy security; rural income	20% renewable energy by 2020, bioenergy expected to provide around 50% of all renewable energy produced in the EU; binding 10% renewable energy target (more than 90% is likely to be biofuels) in the transport sector.	Tariffs on biofuel imports to protect European production of biofuel. Tax incentives for member states. Feed-in tariff schemes for wood use in electricity and combined heat and power (CHP) production in place in some member states.	<b>Safeguards relate to biofuels only:</b> GHG savings: Minimum lifecycle GHG saving thresholds (relative to replaced fossil fuel) for biofuels: 35% by 2013, 50% by 2017; 60% after 2017 for new installations. <b>Feedstock safeguards:</b> Incentives only available if feedstocks do not originate from carbon-rich and biodiverse areas <sup>74</sup> .
<b>India</b> National Biofuels Policy 2009 <sup>75</sup>	Climate; energy security; rural development	10% biofuels in the transport sector by 2012, 20% by 2017.	Minimum price for oilseed crops. Bank loans to farmers for plantations. Biofuels exempt from excise duty. Tax concessions for bio-refinery machinery.	<b>GHG savings:</b> None <b>Feedstock safeguards:</b> None
<b>USA</b> Energy Independence and Security Act of 2007 <sup>76</sup>	Energy security; rural income	30 billion gallons by 2020 (50:50 conventional renewable fuels and advanced biofuels); 36 billion gallons by 2022.	Excise tax exemptions for bioethanol blended gasoline and biodiesel. Subsidies for bioethanol, blending, plant construction, new feedstocks, research and development. 24 states have renewable portfolio standards <sup>77</sup> .	<b>GHG savings:</b> Minimum lifecycle GHG saving thresholds (relative to replaced fossil fuel) for renewable fuel (20%); advanced biofuel (50%); biomass-based diesel (50%) and cellulosic biofuel (60%). <b>Feedstock safeguards:</b> Production must occur on land already cleared for agriculture. No specific legislation for forest biomass.
<b>California, USA</b> Bioenergy Action Plan 2006 (Executive order S-06-06) updated 2011 <sup>78</sup>	Climate; energy security; rural income	Biopower (biomass to electricity) produces 17,000–20,000 GWh by 2020. Minimum 40% of biofuels produced in state within California by 2020 and 50% by 2050.	Incentives for bioenergy production and use <sup>79</sup> ; e.g. US\$20 million for the production of biofuels plus US\$13.5 million for infrastructure to support production.	<b>GHG savings:</b> Same minimum reduction in GHG as USA at national level. <b>Feedstock safeguards:</b> Interagency Forestry Working Group to assess and define sustainability standards for biomass feedstock sourcing.

...continues

# APPENDIX: CHANGING STRATEGIES, DRIVING GROWTH

POLICY FRAMEWORK	MAIN OBJECTIVES	BIOENERGY TARGET	BIOENERGY INCENTIVES	SAFEGUARDS
<p><b>China</b> Medium and Long-Term Development Plan for Renewable Energy and The Renewable Energy Law (2006)<sup>80</sup>.</p>	<p>Climate; energy security; rural development</p>	<p>30 million MW per year of total installed capacity of biomass power generation by 2020, plus 50 million tonnes per year of biomass solid fuels, 440 billion m<sup>3</sup> per year of biogas, 10 million tonnes per year of bioethanol, 2 million tonnes per year of biodiesel.</p>	<p>Tax incentives and subsidies for bioenergy producing companies, including funds for research, setting standards and establishing demonstration projects. Technology support to encourage rural people to use more bioenergy.</p>	<p><b>GHG savings:</b> Reduce economy’s CO<sub>2</sub> emission intensity by 17% by 2015, relative to 2010 levels. <b>Feedstock safeguards:</b> Use saline and alkaline, sandy and barren land and barren mountains for bioenergy plantations. Choose suitable species as energy plants and cultivate using scientific methods. Develop new plant species as feedstocks. Limit grain production for biofuel use (quotas not yet set) and develop non-grain crops as biofuels.</p>
<p><b>Brazil</b> National Climate Change Plan 2008<sup>81</sup> and Plan for Energy Expansion (2010-2019)<sup>82</sup></p>	<p>Climate; energy security; rural development</p>	<p>Increase annual consumption of bioethanol by 11% by 2018 (from 2008 baseline). Cogeneration of electricity supply to reach 11.4% of total supply by 2030. Increase biomass electricity production to 8.5 GWh by 2019.</p>	<p>Tax incentives for biodiesel producers to purchase feedstocks from small family farms in poorer regions of the country. Reduction of deforestation. Biodiesel blending target 18% in 2011.</p>	<p><b>GHG savings:</b> Brazilian sugarcane bioethanol designated as advanced biofuel due to 61% reductions relative to fossil fuels on 2005 baseline. Minimum lifecycle GHG saving thresholds. <b>Feedstock safeguards:</b> Burning is prohibited in areas suitable for mechanical harvesting. Target of 20% of harvested area to eliminate burning by 2012, 100% by 2017. <b>Land-use zoning for sugarcane crops:</b> Sugarcane agro-ecological zoning by federal government provides guidelines on expansion of sugarcane production. <b>Labour safeguards:</b> Legislation requires that 1% of net sugar cane price and 2% of net ethanol price must be devoted to medical, dental, pharmaceutical, sanitary and educational services for workers.</p>

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