Greece

Roadmap for lignocellulosic biomass and relevant policies for a bio-based economy in 2030

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What types of lignocellulosic biomass are included in the analysis?

Lignocellulosic biomass in this analysis includes:

- Forest biomass from primary forestry productions (fellings), primary field residues and secondary forest industry residues;
- Agricultural biomass from primary field activities;
- Biowastes and post consumer wood;
- Dedicated perennial crops.
The roadmap provides scientific evidence for policy, industry and regional stakeholders for the following issues:

- domestic, sustainable lignocellulosic biomass feedstock potentials at national/regional/local levels;
- resource and energy efficient value chains which are expected to be implemented at scale by 2030;
- Sustainability Risks;
- Key indicators per value chain;
- Policies that can facilitate uptake of indigenous lignocellulosic biomass;
- Recommended roadmap actions based on current good practices.
Key questions, addressed by S2Biom

- Where is biomass found?
- What is estimated sustainable potential by 2030?
- What are the sustainable potentials by biomass type and where can they be found?
- How do feedstocks perform in terms of sustainability risks?
- Which value chains have high resource and energy efficiency?
- What is the national policy landscape?
- What future policy interventions can be considered based on good practice?
Where is biomass found?

- The following slide presents a map with total sustainable* occurrence of lignocellulosic biomass by region, measured in ‘000 dry tonnes per year.

* The estimated potentials include sustainability criteria as required by the Renewable Energy Directive.
What is the availability per biomass type?

- Sustainable potential from residues, dedicated crops, biowastes and post consumer wood totals 6.24 m dry tonnes/year.
- Primary forestry production accounts for an additional 1.93 m dry tonnes/year.
- The following slide presents a graph of potential available lignocellulosic biomass by source, excluding primary forestry production.
Lignocellulosic biomass availability by source by 2030 (‘000 dry tonnes)
What are the sustainable potentials by biomass type and where can they be found?

- The following slides present maps of estimated sustainable potential lignocellulosic biomass by region and by main source, namely:
  - Forest (primary forestry production, field residues and secondary forest residues)
  - Agriculture (primary field residues and tree prunings)
  - Biowastes and post consumer wood
  - Dedicated perennial crops
Forest

- Annual sustainable potential up to 2.45m dry tonnes
Agriculture

- Annual sustainable potential up to 2.4m tonnes
Biowastes and post consumer wood

- Annual sustainable potential up to 2.26 m tonnes
Dedicated perennial crops

- Annual sustainable potential up to 1.17m tonnes
How do feedstocks perform in terms of sustainability risks?

<table>
<thead>
<tr>
<th>Feedstock</th>
<th>Sustainability risks (high- red; moderate- yellow; low- green)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Land use (iLUC risk)</td>
</tr>
<tr>
<td>Primary forestry production</td>
<td></td>
</tr>
<tr>
<td>Stemwood from thinnings &amp; final fellings</td>
<td></td>
</tr>
<tr>
<td>Primary forestry residues</td>
<td></td>
</tr>
<tr>
<td>Stem and crown biomass from early thinnings</td>
<td></td>
</tr>
<tr>
<td>Primary forestry residues</td>
<td></td>
</tr>
<tr>
<td>Logging residues from final fellings</td>
<td></td>
</tr>
<tr>
<td>Primary forestry residues</td>
<td></td>
</tr>
<tr>
<td>Stumps from final fellings</td>
<td>None</td>
</tr>
<tr>
<td>Secondary residues from wood industries</td>
<td></td>
</tr>
<tr>
<td>Saw mill residues</td>
<td></td>
</tr>
<tr>
<td>Secondary residues from wood industries</td>
<td></td>
</tr>
<tr>
<td>Other wood processing industry residues</td>
<td>None</td>
</tr>
<tr>
<td>Secondary residues from wood industries</td>
<td></td>
</tr>
<tr>
<td>Woody pruning &amp; orchards residues</td>
<td>None</td>
</tr>
<tr>
<td>Agricultural residues</td>
<td></td>
</tr>
<tr>
<td>Straw/stubbles</td>
<td></td>
</tr>
<tr>
<td>Agricultural residues</td>
<td></td>
</tr>
<tr>
<td>Woody pruning &amp; orchards residues</td>
<td>None</td>
</tr>
<tr>
<td>Secondary residues of industry utilising</td>
<td></td>
</tr>
<tr>
<td>industry residues from food and fruit processing</td>
<td>Positive in regions where it avoids landfill</td>
</tr>
<tr>
<td>industry</td>
<td></td>
</tr>
<tr>
<td>Biodegradable municipal waste</td>
<td></td>
</tr>
<tr>
<td>Biodegradable waste</td>
<td>Positive in regions where it avoids landfill</td>
</tr>
<tr>
<td>Post consumer wood</td>
<td>Positive in regions where it avoids landfill</td>
</tr>
<tr>
<td>Hazardous post consumer wood</td>
<td>Positive in regions where it avoids landfill</td>
</tr>
<tr>
<td>Post consumer wood</td>
<td></td>
</tr>
<tr>
<td>Non hazardous post consumer wood</td>
<td></td>
</tr>
<tr>
<td>Perennial lignocellulosic crops</td>
<td></td>
</tr>
</tbody>
</table>

- **Higher land productivity when marginal lands used; in case of agricultural lands potential (indirect) land use change;** Can provide winter shelter; birds nesting inside plants; may, however, destroy sensitive habitats (e.g. Steppic habitats, High Nature Value farmland, biodiversity rich grasslands) when introduced.
- **Potential use of marginal lands, which can increase soil quality and soil carbon stock;** Can damage soil structure (e.g. Harvesting, root removal after 20 years),
- **In arid circumstances ground water abstraction and depletion possible because of deep roots; Some use of fertilisers / pesticides which can be leached to ground water and pollute habitats, but effect is very limited.**
How do feedstocks perform in terms of sustainability risks?

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<td>Secondary residues from wood industries</td>
<td>Other wood processing industry residues</td>
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<tr>
<td>Agricultural residues</td>
<td>Straw/stubbles</td>
</tr>
<tr>
<td>Agricultural residues</td>
<td>Woody pruning &amp; orchards residues</td>
</tr>
<tr>
<td>Secondary residues of industry utilising agricultural products</td>
<td>By-products and residues from food and fruit processing industry</td>
</tr>
<tr>
<td>Biodegradable municipal waste</td>
<td>Biodegradable waste</td>
</tr>
<tr>
<td>Post consumer wood</td>
<td>Hazardous post consumer wood</td>
</tr>
<tr>
<td>Post consumer wood</td>
<td>Non hazardous post consumer wood</td>
</tr>
<tr>
<td>Perennial lignocellulosic crops</td>
<td>Miscanthus, switchgrass, giant reed, willow, poplar</td>
</tr>
</tbody>
</table>
Which value chains have high resource and energy efficiency?

- The following show value chains with relatively high efficiency in the following aspects:
  - Energy efficiency
  - Greenhouse gas emissions
  - Air quality
  - Technological maturity
## Value chains: forest and agriculture

<table>
<thead>
<tr>
<th>Energy efficiency</th>
<th>Greenhouse gases</th>
<th>Air quality</th>
<th>Technological maturity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Combustion at small scale including households</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Strength</strong></td>
<td>High conversion efficiency with modern technology</td>
<td>Low fossil input in the value chain</td>
<td>-</td>
</tr>
<tr>
<td><strong>Weakness</strong></td>
<td>Older stoves have low conversion efficiency. Heat not always efficiently used.</td>
<td>-</td>
<td>High emissions from older wood stoves.</td>
</tr>
<tr>
<td><strong>Combustion at small-medium scale including buildings</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Strength</strong></td>
<td>High conversion efficiency</td>
<td>Low fossil input in the chain</td>
<td>-</td>
</tr>
<tr>
<td><strong>Weakness</strong></td>
<td>-</td>
<td>-</td>
<td>Emissions better than smaller scale but higher than natural gas.</td>
</tr>
<tr>
<td><strong>Combustion at medium scale, heat led</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Strength</strong></td>
<td>High conversion efficiency</td>
<td>Low input of fossil fuels; high GHG savings especially for Combined Heat and Power</td>
<td>Better control options for emissions</td>
</tr>
<tr>
<td><strong>Weakness</strong></td>
<td>-</td>
<td>-</td>
<td>Higher emissions than natural gas combustion.</td>
</tr>
<tr>
<td><strong>Biochemical - lignocell. hydrolysis and fermentation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Strength</strong></td>
<td>-</td>
<td>High GHG savings in case of process integration and limited fossil input.</td>
<td>Ethanol has low emissions as transport fuel.</td>
</tr>
<tr>
<td><strong>Weakness</strong></td>
<td>Around 50% conversion efficiency</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
## Value chains: wastes

<table>
<thead>
<tr>
<th>Energy efficiency</th>
<th>Greenhouse gases</th>
<th>Air quality</th>
<th>Technological maturity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Waste incineration and energy recovery</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Strength</strong></td>
<td>Adding energy recovery to waste management improves its pathway; high efficiency if CHP</td>
<td>High GHG benefit, particularly compared to landfill (avoided methane emissions); energy recovery substitutes fossil fuels</td>
<td>If landfill is avoided, lower air emissions.</td>
</tr>
<tr>
<td><strong>Weakness</strong></td>
<td>Relatively low net energy output; auxiliary fuel may be required due to low calorific value of fuel</td>
<td>Issues in terms of emissions of waste incineration. Emission control is circa one third of project cost.</td>
<td>-</td>
</tr>
</tbody>
</table>

| **Combustion at medium scale, heat driven** | | | |
| **Strength** | >85% conversion efficiency in case of heat only; 65-85% efficiency for CHP installations. | Low input of fossil fuels; especially in case of CHP GHG savings can be high | Better control options for PM emissions compared to small scale installations. | Fully commercial |
| **Weakness** | - | - | Still higher PM emissions than natural gas combustion. | - |

| **Gasification & CHP at medium scale - heat driven** | | | |
| **Strength** | Up to 80% conversion efficiency, depending on heat only or CHP installations. | Low/no input of fossil fuels; especially in case of CHP GHG savings can be high | Low emissions of gas engine or turbine | (Early) commercial |
### Key indicators per value chain

<table>
<thead>
<tr>
<th>Value Chain</th>
<th>Application</th>
<th>Forest biomass</th>
<th>Cumulative energy demand (GJ inputs/GJ outputs)</th>
<th>Non-renewable energy requirement (GJ non-renewable inputs/GJ outputs)</th>
<th>Output service quality (€ outputs - € inputs (excl. biomass), per dry tonne of biomass input at plant gate)</th>
<th>GHG reduction, compared to reference (%)</th>
<th>Levelised life cycle cost, based on CAPEX and OPEX (incl. feedstock cost), expressed in relation to the output of energy carriers (€/GJ energy carriers)</th>
<th>Jobs in FTE along the full value chain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Household</td>
<td>Residential wood chips boilers - small scale (10-25 kW)</td>
<td>1.39 GJ/GJ</td>
<td>0.044 GJ/GJ</td>
<td>188 €/ton d.m.</td>
<td>92%</td>
<td>17 €/GJ</td>
<td>3 FTE/ MWth</td>
<td></td>
</tr>
<tr>
<td>Services</td>
<td>Wood chip boilers-large size (50 kW)</td>
<td>1.24 GJ/GJ</td>
<td>0.039 GJ/GJ</td>
<td>211 €/ton d.m.</td>
<td>93%</td>
<td>13 €/GJ</td>
<td>3.5 FTE/ MWth</td>
<td></td>
</tr>
<tr>
<td>Industry</td>
<td>CHP using solid biomass &gt; 15 MW</td>
<td>2.79 GJ/GJ</td>
<td>0.088 GJ/GJ</td>
<td>198 €/ton d.m.</td>
<td>93%</td>
<td>30 €/GJ</td>
<td>3.8 FTE/ MWth</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CHP using solid biomass 0.5 - 15 MW</td>
<td>1.31 GJ/GJ</td>
<td>0.042 GJ/GJ</td>
<td>280 €/ton d.m.</td>
<td>95%</td>
<td>19 €/GJ</td>
<td>3.5 FTE/ MWth</td>
<td></td>
</tr>
<tr>
<td>Household</td>
<td>Straw and agricultural residues for small scale local heating plants</td>
<td>1.39 GJ/GJ</td>
<td>0.089 GJ/GJ</td>
<td>170 €/ton d.m.</td>
<td>88%</td>
<td>18 €/MJ</td>
<td>3 FTE/ MWth</td>
<td></td>
</tr>
<tr>
<td>Services</td>
<td>Straw and agricultural residues for CHP &gt; 10 MW</td>
<td>1.31 GJ/GJ</td>
<td>0.084 GJ/GJ</td>
<td>253 €/ton d.m.</td>
<td>92%</td>
<td>20 €/GJ</td>
<td>3.8 FTE/ MWth</td>
<td></td>
</tr>
<tr>
<td>Utility</td>
<td>Direct co-firing coal process</td>
<td>1.21 GJ/GJ</td>
<td>0.030 GJ/GJ</td>
<td>253 €/ton d.m.</td>
<td>96%</td>
<td>20 €/GJ</td>
<td>3.5 FTE/ MWth</td>
<td></td>
</tr>
<tr>
<td>Bioethanol 2nd</td>
<td>Cellulose-EtOH</td>
<td>2.44 GJ/GJ</td>
<td>0.054 GJ/GJ</td>
<td>144 €/ton d.m.</td>
<td>85%</td>
<td>24 €/GJ</td>
<td>3.5 FTE/ MWth</td>
<td></td>
</tr>
<tr>
<td>Industry/ Utility</td>
<td>anaerobic digestion &amp; medium scale CHP</td>
<td>2.00 GJ/GJ</td>
<td>0.007 GJ/GJ</td>
<td>197 €/ton d.m.</td>
<td>88%</td>
<td>28 €/GJ</td>
<td>2 FTE/ MWth</td>
<td></td>
</tr>
<tr>
<td>Transport</td>
<td>anaerobic digestion + upgrading to methane</td>
<td>1.56 GJ/GJ</td>
<td>0.071 GJ/GJ</td>
<td>122 €/ton d.m.</td>
<td>81%</td>
<td>14 €/GJ</td>
<td>2.5 FTE/ MWth</td>
<td></td>
</tr>
</tbody>
</table>
What is the national policy landscape*?

- The following slides provide diagrams to illustrate how existing policies / measures support one or more of the following:
  - Biomass supply
  - Logistics
  - Conversion
  - Distribution
  - End use
- Policies / measures are categorised as: 1) Regulation, 2) Financing and 3) Information

* Policy mapping and respective recommendations are the result of intensive review but as the field is dynamic the authors appreciate there may be missing elements.
Current policy: forest

Biomass Supply
- Forest Law
- Good Agricultural Practices for prevention of nitrate pollution from agricultural activities
- Increasing of the value of forest products

Logistics

Conversion
- Biomass Heating Regulation
- Feed-in tariff scheme for RES-electricity
- Investment incentives law

Distribution
- Energy performance residential buildings
- Law on income tax
- Solid biofuels quality standards for heating applications

End Use
- Green Fund

Regulations

Financing

Information
Current policy: agriculture & dedicated crops

Biomass Supply
- CAP: Greek Rural Development Programmes
- Good Agricultural Practices for prevention of nitrate pollution from agricultural activities
- Increasing of the value of forest products

Logistics

Conversion
- Biomass Heating Regulation
- Feed-in tariff scheme for RES-electricity
- Investment incentives law

Distribution
- Green Fund
- Biofuels quota
- HELIOS: RES promotion and biofuels sustainability criteria
- Energy performance residential buildings

End Use
- Law on income tax
- Solid biofuels quality standards for heating applications

Regulations

Financing

Information
Current policy: wastes

Biomass Supply

Logistics

Conversion

Distribution

End Use

- Green Fund
- Biofuels quota
- HELIOS: RES promotion and biofuels sustainability criteria
- Energy performance residential buildings
- Law on income tax

Regulations

Financing

Information
What improvements can be made based on good practice*?

- The following slides illustrate selected policies from Member States that have had significant positive impact in promoting the use of lignocellulosic biomass.
- Based on this Good Practice, recommended new policies are shown (shaded boxes) to complement existing policies.

* Policy mapping and respective recommendations are the result of intensive review but as the field is dynamic the authors appreciate there may be missing elements.
**Good Practice - Feedstocks**

**Biomass sourcing**

- **Wastes**
  - AT: Waste management & Regulation on recycling of waste wood
  - DE: Kreislaufwirtschaftsgesetz-KrWG- Waste disposal
  - NL: strategic initiative for anaerobic digestion of MSW- organics

- **Forest biomass**
  - FI: private forest owners
  - FI: forest certification
  - BE: Subsidies for afforestation and forest management

- **Agricultural biomass**
  - AT: ÖPUL – Austrian Agri-environmental Programme: Tailored investment support with market sector focus
  - DE: EEG- Feedstock bonus for plants using straw

- **Dedicated crops**
  - DE: ÖPUL – “Gemeinschaftsaufgabe Agrarstruktur und Küstenschutz” provides farmers with financial support for the cultivation of short rotation coppices.

**Logistics**

- BE: VLAREM- collecting & treatment

**Impact Levels**

- High impact
- Moderate impact
Good Practice - End use sectors

### Heat
- **UK:** Renewable Heat Initiatives (RHI)
- **AT:** Climate and Energy Fund-Subsidy scheme wood heating.
- **NL:** Energy Investment Allowance (EIA), tax reductions for boilers.
- **ES:** BIOMCASAI & II, funding for efficient use of biomass.
- **DE:** Repayment bonus from market program (MAP) and soft loans with low interest rates public sector bank KfW.

### CHP
- **AT:** Green Electricity Act & CHP Act: refines scales of applications and target specific sectors and biomass resource types and end uses.
- **DE:** Renewable Energy Sources Act 2014 - Act (EEG 2014); Market premium (in EEG § 35); Flexibility premium for existing installations (EEG, § 54).
- **UK:** Renewables Obligation (RO) scheme, based on green certificates favouring certain technologies.

### Transport biofuels
- **FI:** Act of Excise Duty on Liquid Fuels, a taxation system, in which each component of a liquid fuel is taxed separately, based on its energy content and carbon dioxide emission, meaning reduced taxation for biofuels.
- **DE:** Federal Immission Control Act (BImSchG).
- **UK:** Renewable Transport Fuel Obligation (RTFO) and certification system.
- **DE:** Energy Tax Act (EnergieStG): It accounts for transport biofuels.

### Biobased products
- **DE:** National Bioeconomy Strategy.
- **DE:** National Bioeconomy Strategy.
- **SE:** Swedish Research and Innovation Strategy for a Bio-based Economy.
Recommended new policy*: forest

**Biomass Supply**
- Forest Law
  - Good Agricultural Practices for prevention of nitrate pollution from agricultural activities
- Increasing of the value of forest products
- Regulation on recycling of waste wood

**Logistics**

**Conversion**
- Biomass Heating Regulation
- Feed-in tariff scheme for RES-electricity
- Investment incentives law

**Distribution**
- Energy performance residential buildings
- Law on income tax
- Solid biofuels quality standards for heating applications

**End Use**
- Green Fund
  - Maintain subsidies/loans for biomass heating & ‘band’ payments for specific residual streams only

**Regulations**
- Forest Law: Elaborate on restrictions related to sustainability (e.g. concerning de-/ re-/afforestation).

**Financing**
- Fixed premiums
  - Follow-up tariffs for existing RES-E plants

**Information**
- Green electricity feed-in tariff regulation: *introduce premiums for specific diameters cuttings; thinnings, etc.*

*Shaded boxes show recommended new measures*
Recommended new policy: agriculture & dedicated crops

Biomass Supply
- CAP: Greek Rural Development Programmes
- Good Agricultural Practices for prevention of nitrate pollution from agricultural activities
- Standards for agricultural biomass
- Increasing the value of forest products

Logistics

Conversion
- Biomass Heating Regulation
- Feed-in tariff scheme for RES-electricity
- Investment incentives law

Distribution
- Green Fund
- Biofuels quota
- HELIOS: RES promotion and biofuels sustainability criteria

End Use
- Energy performance residential buildings
- Law on income tax
- Solid biofuels quality standards for heating applications

Regulations
- Regulation on agricultural raw materials for biofuels and bioliquids

Financing
- Maintain subsidies/loans for biomass heating & ‘band’ payments for specific residual streams only

Information
- Green electricity feed-in tariff regulation: introduce feedstock premium for agricultural residues
Recommended new policy: wastes

Biomass Supply

Logistics

Conversion

Distribution

End Use

Standards for biowastes

Feed-in tariff scheme for RES-electricity

Investment incentives law

Energy performance residential buildings

Law on income tax

Biomethane injection

Green electricity feed-in tariff regulation: introduce feedstock premium for biowastes

Green Fund

Biofuels quota

HELIOS: RES promotion and biofuels sustainability criteria

Energy performance residential buildings

Maintain subsidies/loans for biomass heating & ‘band’ payments for specific biowaste streams only

Regulations

Financing

Information
Conclusions

- Greek regions have relatively high biomass availability. The national lignocellulosic biomass potential is around 6.24 million dry tonnes/year (excluding primary forest harvest), with forest, agriculture, and waste sources all significant.

- The existing policy framework forms a foundation for future support measures to be introduced.

- The study has recommended a number of new policies (and refinements to existing policies) that are based on Good Practice and can further facilitate mobilisation of lignocellulosic biomass for a bio-based economy by 2030.
Further reading

- www.s2biom.eu

- www.biomass-tools.eu  *click* in main menu on ‘Biomass chain data’ ---> ‘Biomass characteristics’

- www.biomass-tools.eu  *click* in main menu on ‘Data downloads’
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