Finland

Roadmap for lignocellulosic biomass and relevant policies for a biobased 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.
Context

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, presented in 1,000 dry tonnes per year

* The estimated potentials include sustainability criteria as required by the Renewable Energy Directive.
Total lignocellulosic biomass by region

Supply in kton DM per region (2030, BASE)

- **total_all**
  - 0-1
  - 1-2
  - 2-3
  - 3-4
  - 4-5
  - 5-10
  - 10-25
  - 25-50
  - 50-100
  - 100-500
  - 500-1000
  - 1000-2500
  - 2500-5000
  - >5000 kton/region
What is the availability per biomass type?

- Sustainable potential from residues, dedicated crops, biowastes and post consumer wood totals 21.2 million dry tonnes / year.

- Primary forestry production accounts for an additional 29.9 million 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 (1,000 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 agricultural residues)
- Agriculture (primary field residues and tree prunings)
- Biowastes and post consumer wood
- Dedicated perennial crops
• Annual sustainable potential up to 47.36 million dry tonnes
Agriculture

- Annual sustainable potential up to **1.72 million tonnes**
Biowastes and post-consumer wood

- Annual sustainable potential up to 1.45 million tonnes
Dedicated perennial crops

- Annual sustainable potential up to 0.62 million 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>Stemwood from thinnings &amp; final fellings</td>
</tr>
<tr>
<td>Primary forestry production</td>
<td>Stem and crown biomass from early thinnings</td>
</tr>
<tr>
<td>Primary forestry residues</td>
<td>Logging residues from final fellings</td>
</tr>
<tr>
<td>Secondary residues from wood industries</td>
<td>Stumps from final fellings</td>
</tr>
<tr>
<td>Secondary residues from wood industries</td>
<td>Saw mill residues</td>
</tr>
<tr>
<td>Secondary residues from wood industries</td>
<td>Other wood processing industry residues</td>
</tr>
<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</td>
<td>By-products and residues from food and fruit processing</td>
</tr>
<tr>
<td>agricultural products</td>
<td>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>
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<td><strong>Biodiversity</strong></td>
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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>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td><strong>Combustion at small-medium scale including buildings</strong></td>
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<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>-</td>
</tr>
<tr>
<td><strong>Combustion at medium scale, heat led</strong></td>
<td></td>
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<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>-</td>
</tr>
<tr>
<td><strong>Biochemical - lignocell. hydrolysis and fermentation</strong></td>
<td></td>
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<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>
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</tbody>
</table>
## Value chains: wastes

<table>
<thead>
<tr>
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<th>Energy efficiency</th>
<th>Greenhouse gases</th>
<th>Air quality</th>
<th>Technological maturity</th>
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<tbody>
<tr>
<td><strong>Waste incineration and energy recovery</strong></td>
<td></td>
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</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>
<td>Fully commercial</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>-</td>
<td>Issues in terms of emissions of waste incineration. Emission control is circa one third of project cost.</td>
<td>-</td>
</tr>
<tr>
<td><strong>Combustion at medium scale, heat driven</strong></td>
<td></td>
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</tr>
<tr>
<td><strong>Strength</strong></td>
<td>&gt;85% conversion efficiency in case of heat only; 65-85% efficiency for CHP installations.</td>
<td>Low input of fossil fuels; especially in case of CHP GHG savings can be high</td>
<td>Better control options for PM emissions compared to small scale installations.</td>
<td>Fully commercial</td>
</tr>
<tr>
<td><strong>Weakness</strong></td>
<td>-</td>
<td>-</td>
<td>Still higher PM emissions than natural gas combustion.</td>
<td>-</td>
</tr>
<tr>
<td><strong>Gasification &amp; CHP at medium scale - heat driven</strong></td>
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<td></td>
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</tr>
<tr>
<td><strong>Strength</strong></td>
<td>Up to 80% conversion efficiency, depending on heat only or CHP installations.</td>
<td>Low/no input of fossil fuels; especially in case of CHP GHG savings can be high</td>
<td>Low emissions of gas engine or turbine</td>
<td>(Early) commercial</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Key indicators per value chain</td>
<td>Cumulative energy demand (GJ inputs/GJ outputs)</td>
<td>Non-renewable energy requirement (GJ non-renewable inputs/GJ outputs)</td>
<td>Output service quality (€ outputs- € inputs excl. biomass), per dry tonne of biomass input at plant gate</td>
<td>GHG reduction, compared to reference (%)</td>
</tr>
<tr>
<td>------------------------------</td>
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<td>---------------------------------</td>
</tr>
<tr>
<td><strong>Forest biomass</strong></td>
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</tr>
<tr>
<td><strong>Households</strong></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>
</tr>
<tr>
<td><strong>Services</strong></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>
</tr>
<tr>
<td><strong>Industry</strong></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>
</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>
</tr>
<tr>
<td><strong>Agricultural biomass</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Households</strong></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>
</tr>
<tr>
<td><strong>Services</strong></td>
<td></td>
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</tr>
<tr>
<td><strong>Industry</strong></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>
</tr>
<tr>
<td><strong>Utility</strong></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>
</tr>
<tr>
<td><strong>Bioethanol 2nd</strong></td>
<td>Cellulose-EtOH</td>
<td>2.44 GJ/GJ</td>
<td>0.054 GJ/GJ</td>
<td>144 €/ton d.m.</td>
</tr>
<tr>
<td><strong>Biowastes</strong></td>
<td></td>
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</tr>
<tr>
<td><strong>Industry/ Utility</strong></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>
</tr>
<tr>
<td><strong>Transport</strong></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>
</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**
- Act on Financing of Sustainable Forestry
- Small diameter trees energy subsidy
- Sustainable forestry funding for fixed-period

**Logistics**
- Act on Forest Management Associations
- Act on Trade in Forest Reproductive Material
- Forest act
- Forest Damages Prevention Act
- Timber Measurement Act
- Nature Conservation Act
- Water Acts
- Wilderness Act
- Act on Jointly Owned Forests

**Conversion**
- Act on regional development
- Energy Aid
- Energy Taxes
- Fuel Tax
- Production subsidies for renewable electricity

**Distribution**
- Act on emission trading
- Act on Energy Certificates for Buildings
- Act on Environmental Impact Assessment Procedure
- Act on placing timber and wood products to market
- Act on the sustainability of biofuels and bioliquids
- Biofuels for transport obligation
- Decree on air quality
- Emission regulations for combustion plants
- Energy efficiency Act
- Energy efficiency agreements and audits
- Environmental Protection Act
- Guarantee of origin of electricity
- Public procurement rules

**End Use**
- Cleantech strategy
- Energy and Climate Roadmap 2050
- Finland’s regional development strategy 2020
- Finnish bioeconomy strategy
- Government Decision on Energy Efficiency Measures
- Innovation policy guidelines
- National Energy and Climate Strategy for 2030
- Transport 2030
# Current policy: agriculture & dedicated crops

## Biomass Supply
- CAP: Finnish Rural Development Programmes
- Fertiliser Product Act
- Fertiliser Products and their Control
- Fertiliser Products Decree
- Organic Products
- Nature Conservation Act
- Water Acts
- Wilderness Act

## Logistics

## Conversion
- Act on regional development
- Energy Aid
- Energy Taxes
- Fuel Tax
- Production subsidies for renewable electricity

## Distribution
- Act on emission trading
- Act on Energy Certificates for Buildings
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- Energy efficiency agreements and audits
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- Public procurement rules

## End Use
- Cleantech strategy
- Energy and Climate Roadmap 2050
- Finland’s regional development strategy 2020
- Finnish bioeconomy strategy
- Government Decision on Energy Efficiency Measures
- Innovation policy guidelines
- National Energy and Climate Strategy
- Transport 2030
<table>
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<th>Conversion</th>
<th>Distribution</th>
<th>End Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classification of wood waste</td>
<td>Waste act</td>
<td>Act on regional development</td>
<td>Act on Energy Certificates for Buildings</td>
<td>Biofuels for transport obligation</td>
</tr>
<tr>
<td>Wilderness Act</td>
<td></td>
<td>Energy Taxes</td>
<td>Act on placing timber and wood products to market</td>
<td>Emission regulations for combustion plants</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fuel Tax</td>
<td>Act on the sustainability of biofuels and bioliquids</td>
<td>Energy efficiency Act</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Biofuels for transport obligation</td>
<td>Energy efficiency agreements and audits</td>
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<td></td>
<td>Environmental Protection Act</td>
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<td></td>
<td>Guarantee of origin of electricity</td>
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<td>Public procurement rules</td>
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**Regulations**
- Act on emission trading
- Act on Energy Certificates for Buildings
- Act on Environmental Impact Assessment Procedure
- Act on placing timber and wood products to market
- Act on the sustainability of biofuels and bioliquids
- Biofuels for transport obligation
- Decree on air quality
- Emission regulations for combustion plants
- Energy efficiency Act
- Energy efficiency agreements and audits
- Environmental Protection Act
- Guarantee of origin of electricity
- Public procurement rules

**Financing**
- Cleantech strategy
- Energy and Climate Roadmap 2050
- Finland’s regional development strategy 2020
- Finnish bioeconomy strategy
- Government Decision on Energy Efficiency Measures
- Innovation policy guidelines
- National Energy and Climate Strategy
- Transport 2030
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
  - BE: VLAREM- collecting & treatment
  - 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

- AT: Waste management & Regulation on recycling of waste wood
- BE: VLAREM- collecting & treatment
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### Good Practice - End use sectors

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<tbody>
<tr>
<td><strong>Heat</strong></td>
<td><strong>CE</strong></td>
<td><strong>AT</strong></td>
</tr>
<tr>
<td>UK: Renewable Heat Initiatives (RHI)</td>
<td>AT: Climate and Energy Fund-Subsidy scheme wood heating.</td>
<td><strong>High impact</strong></td>
</tr>
<tr>
<td></td>
<td>NL: Energy Investment Allowance (EIA), tax reductions for boilers</td>
<td><strong>Moderate impact</strong></td>
</tr>
<tr>
<td></td>
<td>ES: BIOMCASA I &amp; II, funding for efficient use of biomass</td>
<td><strong>High impact</strong></td>
</tr>
<tr>
<td></td>
<td>DE: repayment bonus from market program (MAP) and soft loans with low interest rates public sector bank KfW</td>
<td><strong>Moderate impact</strong></td>
</tr>
<tr>
<td><strong>CHP</strong></td>
<td></td>
<td><strong>DE</strong></td>
</tr>
<tr>
<td>AT: Green Electricity Act &amp; CHP Act: refines scales of applications and target specific sectors and biomass resource types and end uses.</td>
<td>DE: Federal Immission Control Act (BImSchG)</td>
<td><strong>Moderate impact</strong></td>
</tr>
<tr>
<td>DE: Renewable Energy Sources Act 2014 - Act (EEG 2014); Market premium (in EEG § 35); Flexibility premium for existing installations (EEG, § 54)</td>
<td></td>
<td><strong>Moderate impact</strong></td>
</tr>
<tr>
<td>UK: Renewables Obligation (RO) scheme, based on green certificates favouring certain technologies</td>
<td></td>
<td><strong>High impact</strong></td>
</tr>
<tr>
<td><strong>Transport biofuels</strong></td>
<td></td>
<td><strong>DE</strong></td>
</tr>
<tr>
<td>UK: Renewable Transport Fuel Obligation (RTFO) and certification system</td>
<td>DE: Energy Tax Act (EnergieStG) : It accounts for transport biofuels</td>
<td><strong>Moderate impact</strong></td>
</tr>
<tr>
<td>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</td>
<td></td>
<td><strong>High impact</strong></td>
</tr>
<tr>
<td><strong>Biobased products</strong></td>
<td></td>
<td><strong>DE</strong></td>
</tr>
<tr>
<td></td>
<td>DE: National Bioeconomy Strategy</td>
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<tr>
<td></td>
<td>SE : Swedish Research and Innovation Strategy for a Bio-based Economy</td>
<td><strong>High impact</strong></td>
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**Recommended new policy**: forest

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- Public procurement rules

Support for wood from young stands. Support for forest residues should be continued in electricity generation (FiP). CO₂ tax for fossil fuels in heat production part

Sliding premiums (FiP) until 2020 in electricity production and tenders or auction in the future for 2030. Investment support for new technologies. Higher CO₂ tax > 100 €/CO₂ ton

### Regulations
- Nature Conservation Act
- Water Acts
- Wilderness Act
- Act on Jointly Owned Forests

### Financing

### Information

*Shaded boxes with bold letters show recommended new measures*
### Biomass Supply
- CAP: Finnish Rural Development Programmes
- Fertiliser Product Act
- Fertiliser Products and their Control
- Fertiliser Products Decree
- Organic Products
- Nature Conservation Act
- Water Acts
- Wilderness Act

### Logistics

### Conversion
- Act on regional development
- Energy Aid
- Energy Taxes
- Fuel Tax
- Production subsidies for renewable electricity
- Act on emission trading
- Act on Energy Certificates for Buildings
- Act on Environmental Impact Assessment Procedure
- Act on placing timber and wood products to market
- Act on the sustainability of biofuels and bioliquids
- Biofuels for transport obligation
- Decree on air quality
- Emission regulations for combustion plants
- Energy efficiency Act
- Energy efficiency agreements and audits
- Environmental Protection Act
- Guarantee of origin of electricity
- Public procurement rules

### Distribution
- Investment support for new technologies.
- Higher CO$_2$ tax > 100 €/CO$_2$ ton

### End Use

### Regulations

### Financing

### Information
- Cleantech strategy
- Energy and Climate Roadmap 2050
- Finland’s regional development strategy 2020
- Finnish bioeconomy strategy
- Government Decision on Energy Efficiency Measures
- Innovation policy guidelines
- National Energy and Climate Strategy
- Transport 2030

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**Recommended new policy: agriculture & dedicated crops**

- Investment support for new technologies.
- Higher CO$_2$ tax > 100 €/CO$_2$ ton
## Recommended new policy: wastes

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- Cleantech strategy
- Energy and Climate Roadmap 2050
- Finland’s regional development strategy 2020
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Conclusions

- Finnish regions have relatively high biomass availability. The national lignocellulosic biomass potential is around 21.2 million dry tonnes / year (excluding primary forest harvest), with forest, agriculture and waste sources all significant.

- The existing policy framework is generally strong, with several Finnish policies being considered European Good Practice.

- 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 biobased 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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The sole responsibility of this publication lies with the author. The European Union is not responsible for any use that may be made of the information contained therein.

Maps: DLO Altera, 2016