Spain

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

Calliope Panoutsou, Asha Singh, Daniel Garcia Galindo; David Sanchez

c.panoutsou@imperial.ac.uk; daniel.garcia@fcirce.es; dsanchez@cener.com

This project is co-funded by the European Union within the 7th Frame Programme. Grant Agreement n°608622.
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.

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

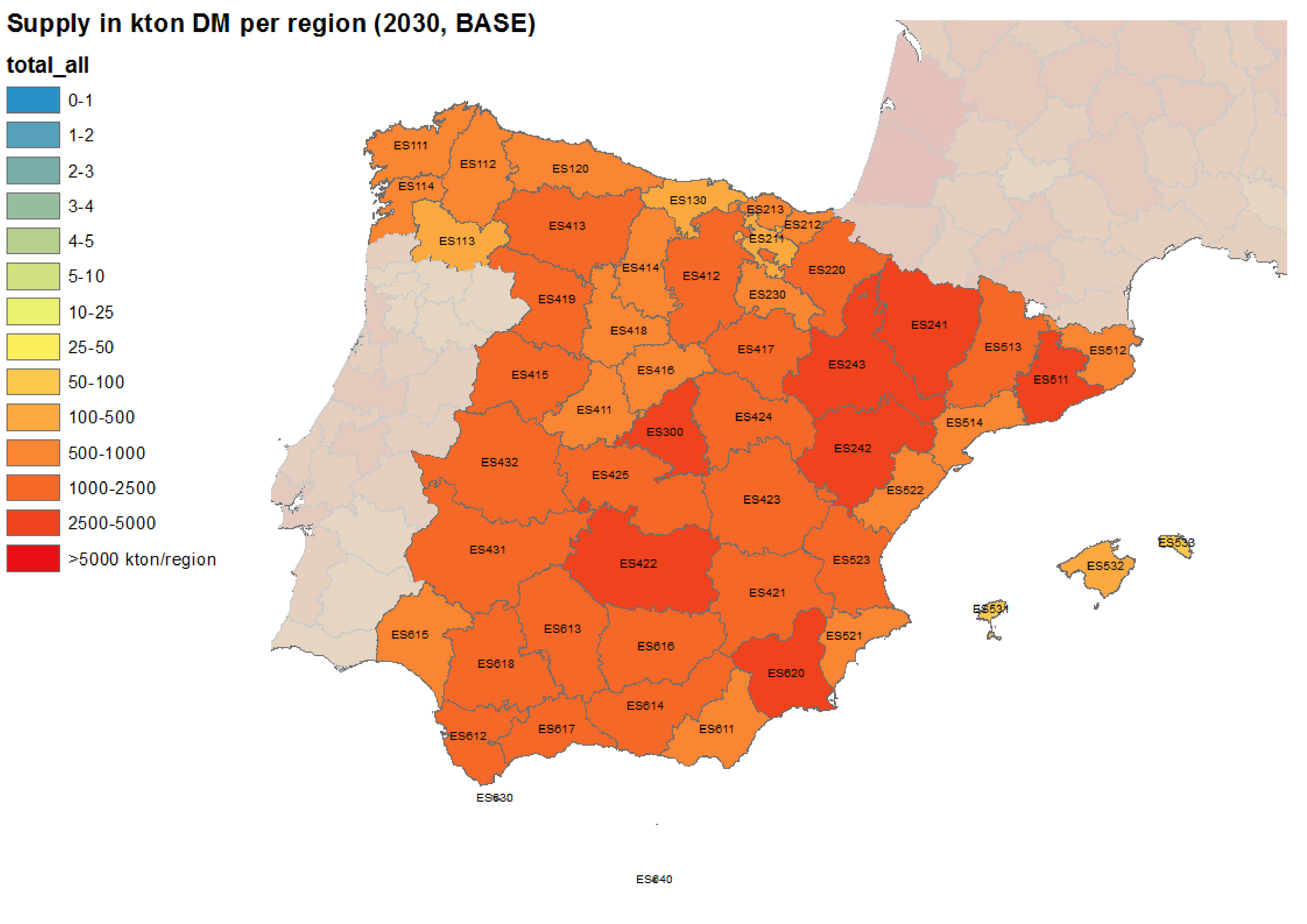
- Where is biomass found?
- What is estimated sustainable potential by 2030?
- What are the sustainable potentials by biomass type and where can they be found?
- How do feedstocks perform in terms of sustainability risks?
- Which value chains have high resource and energy efficiency?
- What is the national 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, measured in ‘000 dry tonnes per year

* The estimated potentials include sustainability criteria as required by the Renewable Energy Directive.

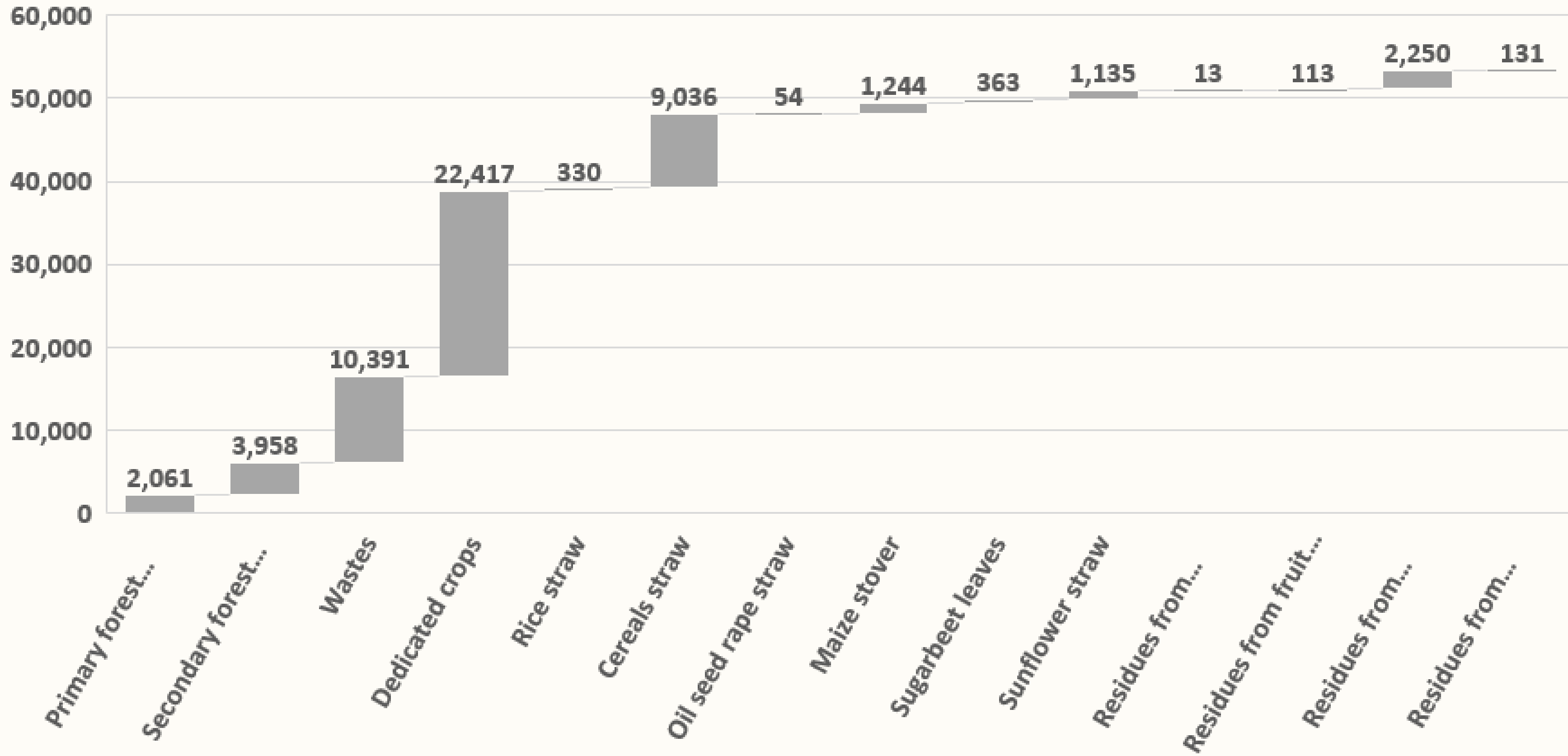
Total lignocellulosic biomass by region



What is the availability per biomass type?

- Sustainable potential from residues, dedicated crops, biowastes and post consumer wood totals 53.5 m dry tonnes / year.
- Primary forestry production accounts for an additional 9.93 m dry tonnes / year.
- The following slide presents a graph of potential available lignocellulosic biomass by source, excluding primary forestry production.

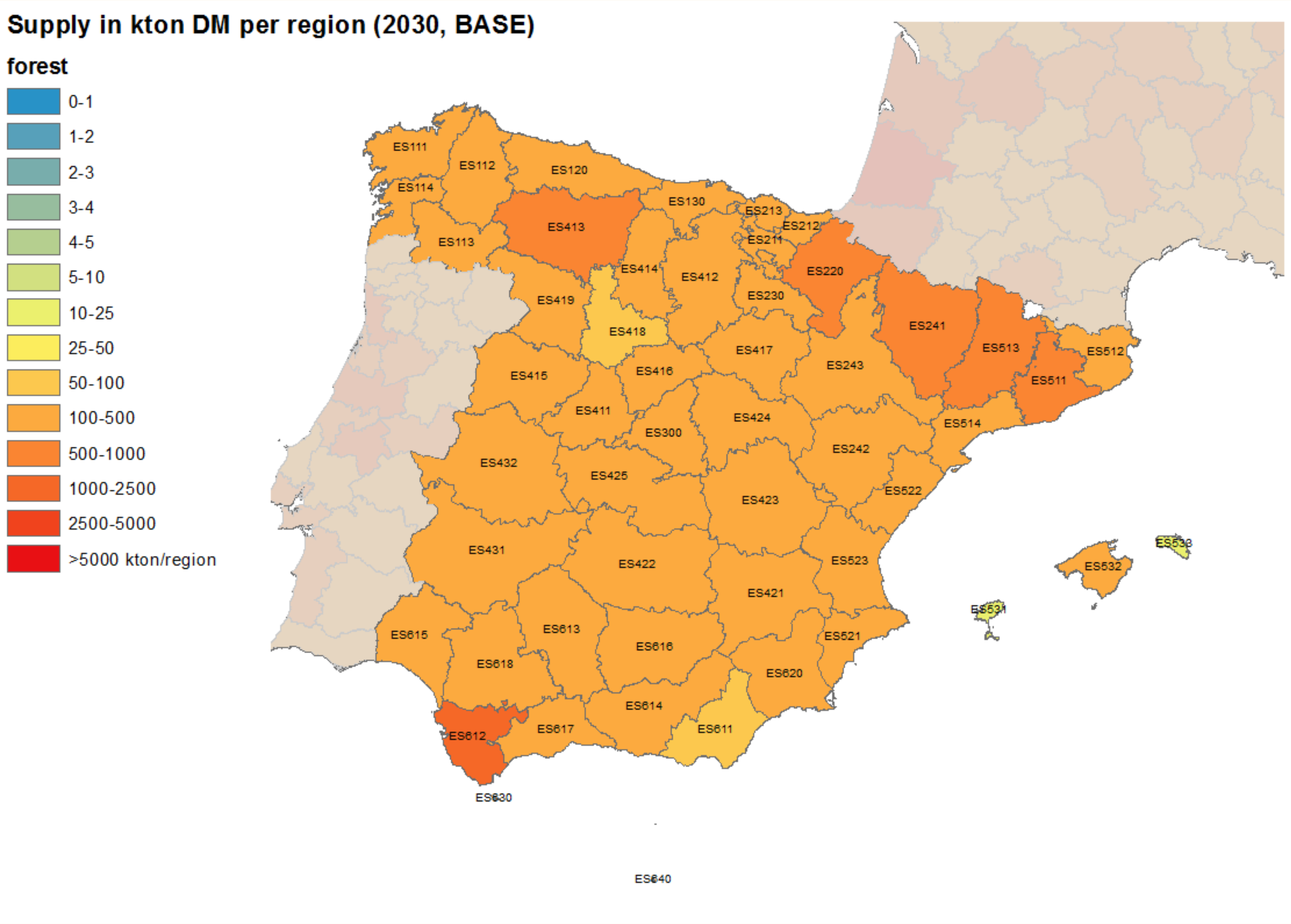
Lignocellulosic biomass availability by source by 2030 (‘000 dry tonnes)



What are the sustainable potentials by biomass type and where can they be found?

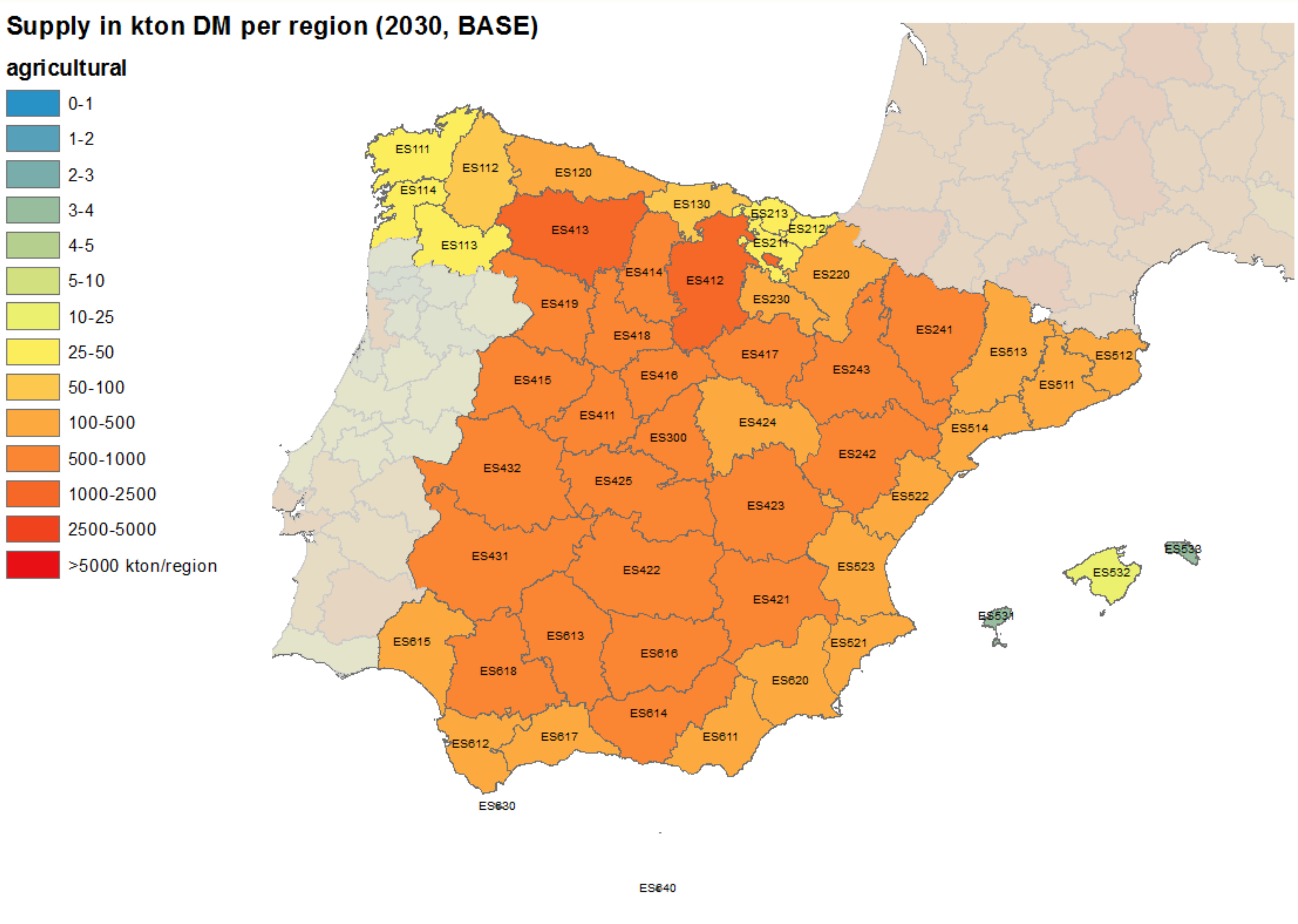
- The following slides present maps of estimated sustainable potential lignocellulosic biomass by region and by main source, namely:
  - Forest (primary forestry production, field residues and secondary forest residues)
  - Agriculture (primary field residues and tree prunings)
  - Biowastes and post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

Forest



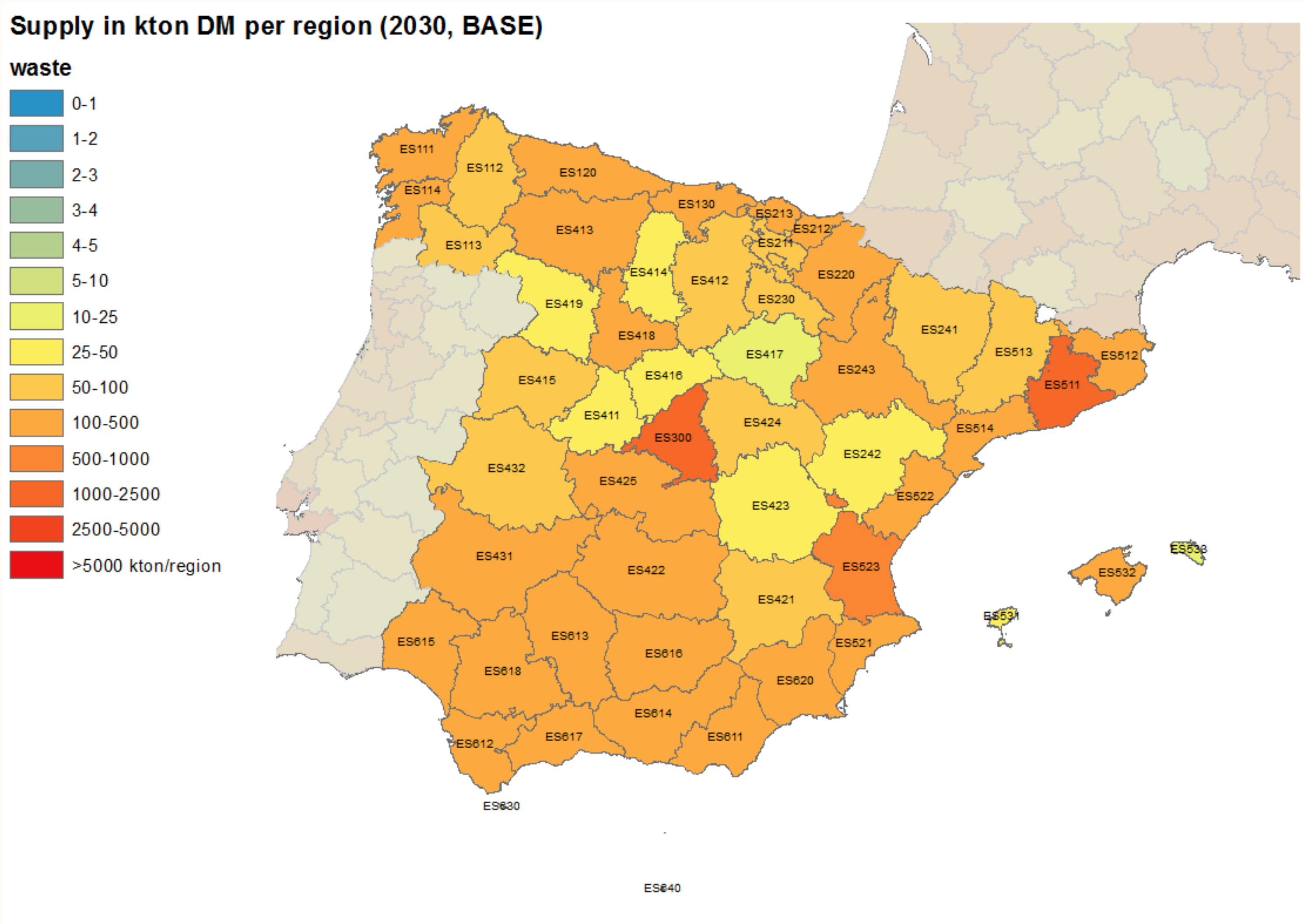
- Annual sustainable potential up to 15.95m dry tonnes

Agriculture



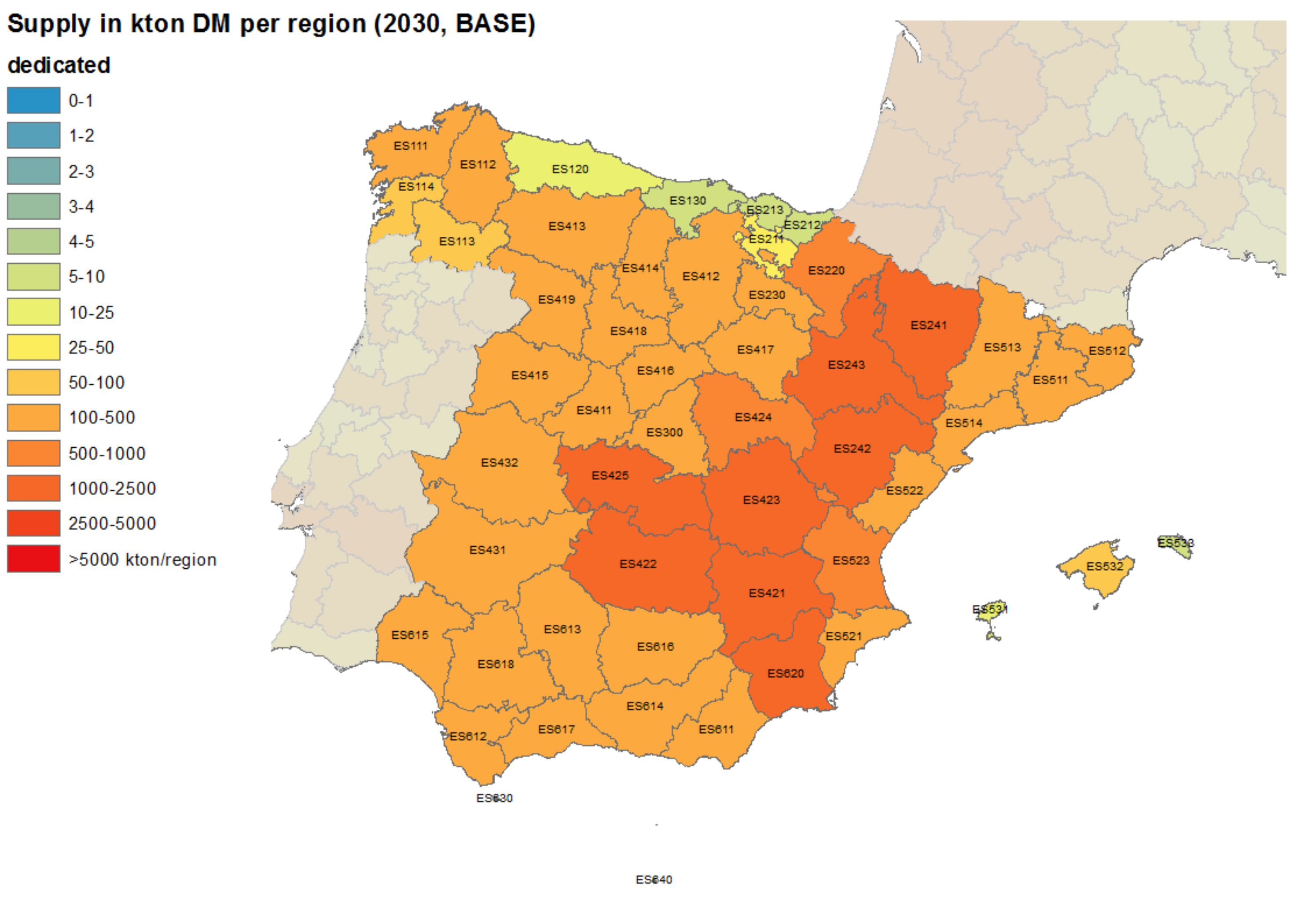
- Annual sustainable potential up to 14.67m tonnes

Biowastes and post consumer wood



- Annual sustainable potential up to 10.4 m tonnes

Dedicated perennial crops



- Annual sustainable potential up to 22.4m tonnes

How do feedstocks perform in terms of sustainability risks?

Feedstock		Sustainability risks (high- red; moderate- yellow; low- green)			
		Land use (iLUC risk)	Biodiversity	Soil & Carbon stock	Water
Primary forestry production	Stemwood from thinnings & final fellings	Positive in preventing forest fires, especially in dry arid climatic conditions	Loss of dead wood and stumps may negatively influence species diversity and soil fauna. Contrary to this, leaving them all on the ground may result in increased fertilisation (N and wood ash) and negative impacts on vegetation	Increased risk of soil erosion; risk to loose soil organic carbon; risk to loose nutrients and risk of reduced soil fertility and soil structure when overharvesting forest residues	No effect on the quantity; If no removal leads to increased fertilisation the leaching on N to water may increase.
Primary forestry production	Stem and crown biomass from early thinnings				
Primary forestry residues	Logging residues from final fellings				
Primary forestry residues	Stumps from final fellings				
Secondary residues from wood industries	Saw mill residues	None	None	There are debates that using the wood in panel boards, creates a carbon stock in comparison to combustion of the wood	None
Secondary residues from wood industries	Other wood processing industry residues				
Agricultural residues	Straw/stubbles	None	Biodiversity loss when harvesting too many crop residues. This may also have adverse effect on soil biodiversity	Moderate risk to loose soil organic carbon when overharvesting crop residues; risk to loose nutrients when overharvesting	None
Agricultural residues	Woody prunning & orchards residues				
Secondary residues of industry utilising agricultural products	By-products and residues from food and fruit processing industry	None	None	None	None
Biodegradable municipal waste	Biodegradable waste	None	Positive in regions where it avoids landfill	Positive in regions where it avoids landfill; Digested organic waste is a source of soil improving material.	Lower risk of water pollution in regions where it avoids landfill
Post consumer wood	Hazardous post consumer wood	None	Positive in regions where it avoids landfill	Positive in regions where it avoids landfill	Lower risk of water pollution in regions where it avoids landfill
Post consumer wood	Non hazardous post consumer wood				
Perennial lignocellulosic crops	Miscanthus, switchgrass, giant reed, willow, poplar	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?

Feedstock		Sustainability risks (high- red; moderate- yellow; low- green)			
		Land use (iLUC risk)	**Biodiversity**	**Soil & Carbon stock**	**Water**
Primary forestry production	Stemwood from thinnings & final fellings				
Primary forestry production	Stem and crown biomass from early thinnings				
Primary forestry residues	Logging residues from final fellings				
Primary forestry residues	Stumps from final fellings				
Secondary residues from wood industries	Saw mill residues				
Secondary residues from wood industries	Other wood processing industry residues				
Agricultural residues	Straw/stubbles				
Agricultural residues	Woody prunning & orchards residues				
Secondary residues of industry utilising agricultural products	By-products and residues from food and fruit processing industry				
Biodegradable municipal waste	Biodegradable waste				
Post consumer wood	Hazardous post consumer wood				
Post consumer wood	Non hazardous post consumer wood				
Perennial lignocellulosic crops	Miscanthus, switchgrass, giant reed, willow, poplar				

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

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

Value chains: wastes

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

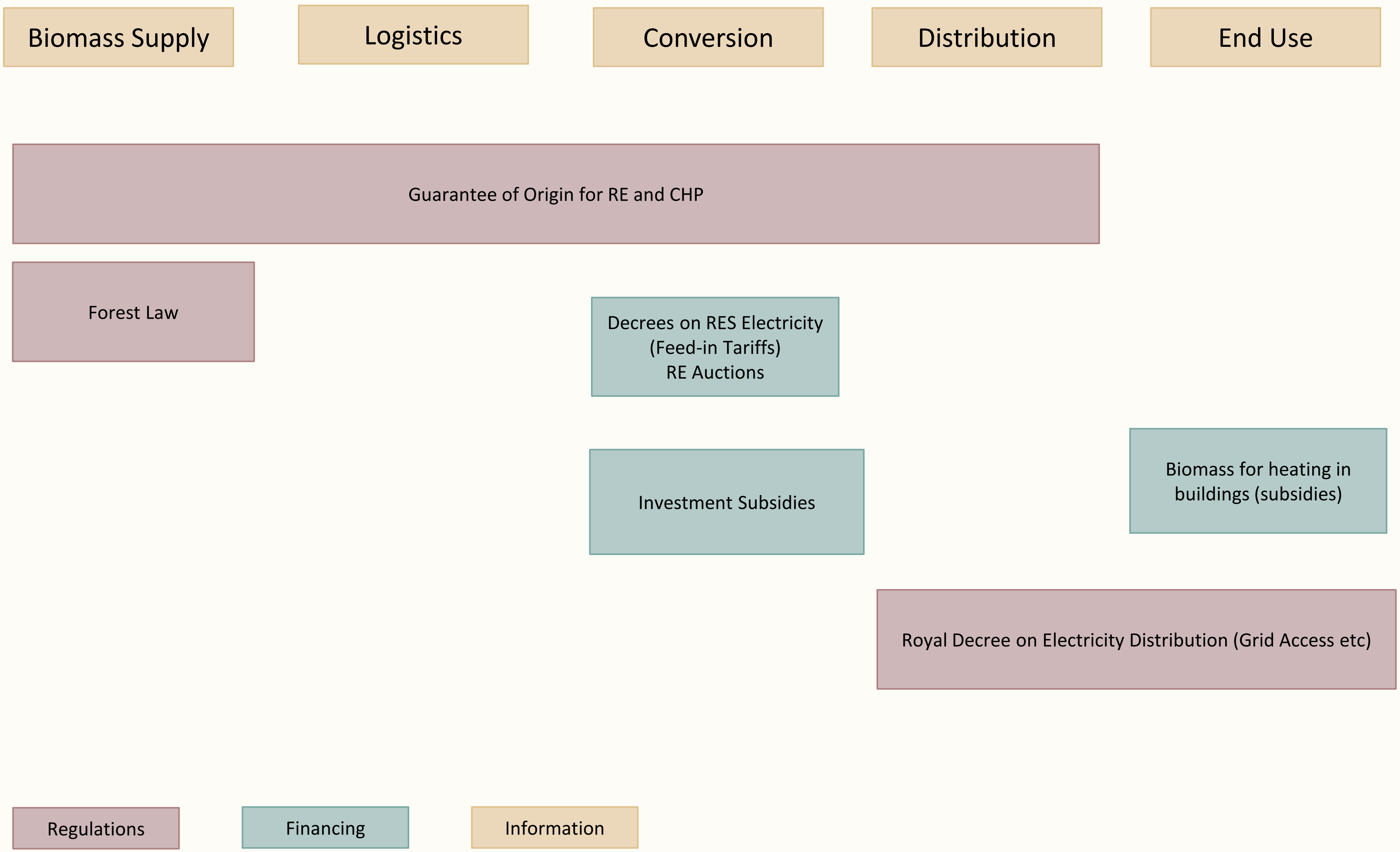
			Cumulative energy demand (GJ inputs/GJ outputs)	Non-renewable energy requirement (GJ non-renewable inputs/GJ outputs)	Output service quality (€ outputs- € inputs (excl.biomass), per dry tonne of biomass input at plant gate)	GHG reduction, compared to reference (%)	Levelised life cycle cost, based on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

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



Current policy: agriculture & dedicated crops

Biomass Supply

Logistics

Conversion

Distribution

End Use

Guarantee of Origin for RE and CHP

Decrees on RES Electricity
(Feed-in Tariffs)
RE Auctions

Common Agricultural Policy

Investment Subsidies

Biomass for heating in buildings (subsidies)

Royal Decree on Electricity Distribution (Grid Access etc)

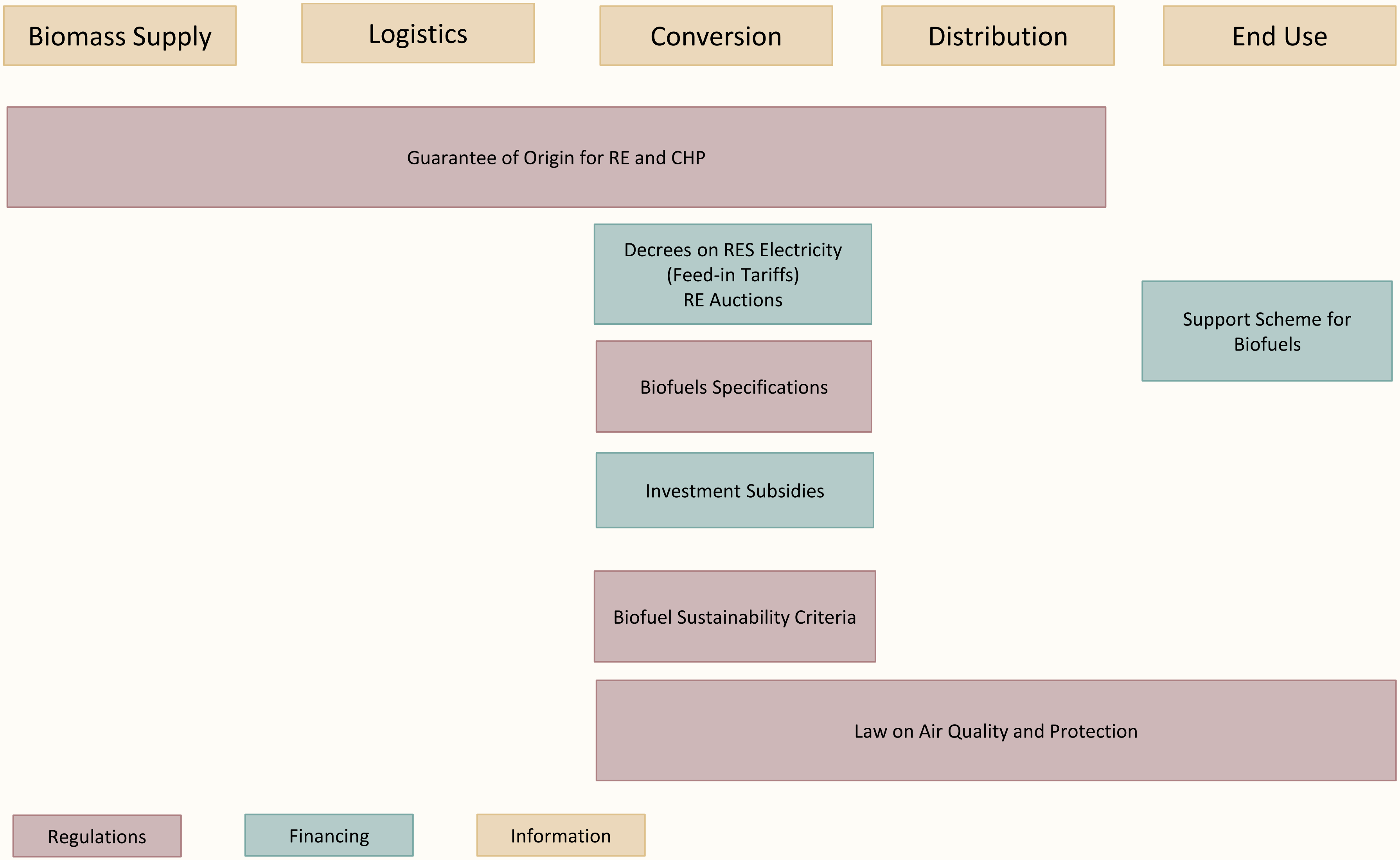
Animal By-Products

Regulations

Financing

Information

Current policy: wastes



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

High impact | Moderate impact

	Biomass sourcing	Logistics
Wastes	AT: Waste management & Regulation on recycling of waste wood (High impact)	BE: VLAREM- collecting & treatment (High impact)
	DE: Kreislaufwirtschaftsgesetz-KrWG- Waste disposal (High impact)	
	NL: strategic initiative for anaerobic digestion of MSW- organics (High impact)	
Forest biomass	FI: private forest owners (High impact)	
	FI: forest certification (Moderate impact)	
	BE: Subsidies for afforestation and forest management (High impact)	
Agricultural biomass	AT: ÖPUL – Austrian Agri-environmental Programme: Tailored investment support with market sector focus (High impact)	
	DE: EEG- Feedstock bonus for plants using straw (High impact)	
Dedicated crops	DE: ÖPUL – "Gemeinschaftsaufgabe Agrarstruktur und Küstenschutz" provides farmers with financial support for the cultivation of short rotation coppices. (High impact)	

Good Practice- End use sectors

High impact · Moderate impact

Conversion → Distribution → End Use

Heat

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

CHP

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

Transport biofuels

- DE: Federal Immission Control Act (BImSchG) (Moderate impact)
- UK: Renewable Transport Fuel Obligation (RTFO) and certification system (High impact)
- DE: Energy Tax Act (EnergieStG) : It accounts for transport biofuels (Moderate impact)
- 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 (High impact)

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 | Logistics | Conversion | Distribution | End Use

Guarantee of Origin for RE and CHP

Forest Law

Decrees on RES Electricity (Feed-in Tariffs)

Investment Subsidies

Maintain subsidies/ loans for biomass heating & 'band' payments for specific residual streams only

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

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

Biomass for heating in buildings (subsidies)

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

Royal Decree on Electricity Distribution (Grid Access etc)

Regulations | Financing | Information

*Shaded boxes show recommended new measures

Recommended new policy: agriculture & dedicated crops

Biomass Supply

Logistics

Conversion

Distribution

End Use

Guarantee of Origin for RE and CHP

Biomass for heating in buildings (subsidies)

Common Agricultural Policy

Decrees on RES Electricity (Feed-in Tariffs)

Animal By-Products

Green electricity feed-in tariff regulation: **introduce feedstock premium for agricultural residues**

Maintain subsidies/ loans for biomass heating & 'band' payments for specific residual streams only

Standards for agricultural biomass

Investment Subsidies

Royal Decree on Electricity Distribution (Grid Access etc)

Regulations

Financing

Information

Recommended new policy: wastes

Biomass Supply | Logistics | Conversion | Distribution | End Use

Guarantee of Origin for RE and CHP

Standards for biowastes

Decrees on RES Electricity (Feed-in Tariffs)

Support Scheme for Biofuels

Feed-in tariff regulation: **introduce feedstock premium for biowastes**

Biofuels Specifications

Climate & Energy Fund: Band payments for specific biowaste streams only

Investment Subsidies

Biofuel Sustainability Criteria

Law on Air Quality and Protection

Regulations | Financing | Information

Conclusions

- Spanish regions have relatively high biomass availability. The national lignocellulosic biomass potential is around 53.5m 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
- Deliverable 1.8: A spatial data base on sustainable biomass cost-supply of lignocellulosic biomass in Europe - methods & data sources. From: Dees, M., B. Elbersen, J. Fitzgerald,, M. Vis, P. Anttila, N. Forsell, J. Ramirez-Almeyda, D. García Galindo, B. Glavonjic, I. Staritsky, H. Verkerk, R. Prinz, A. Monti, S.Leduc, M. Höhl, P. Datta, R. Schrijver, M. Lindner, J. Lesschen, K. Diepen & J. Laitila (2016): http://www.s2biom.eu/en/publications-reports/s2biom.html
- 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’

Project coordinator

Scientific coordinator

Project partners

Maps: DLO Altera, 2016

This project is co-funded by the European Union within the 7th Frame Programme. Grant Agreement n°608622.
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.