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Screening of biogenic residues and setting up sustainable scenarios for commercial biorefineries around Europe

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Introduction

- The interest for biofuels has increased concerning the global needs for sustainable energy
- Gasification of biogenic residues becomes an attractive option for syngas production that can be utilized for subsequent biofuels production
- Biogenic residues, such as agricultural residues, may be lower quality carbon sources compared to the sugar-, starch- and oil plants used for conventional liquid biofuels, but they do not come in conflict with food production and tend to avoid land use restrictions
- Biogenic residues are aligned with the EU's biofuels policy documented in the RED II directive, mentioning the promotion of residue based biofuels, or so-called advanced biofuels

The current study presents a methodology for the development of commercial biorefinery case studies across Europe by implementing sustainable supply chains based exclusively on biogenic resdidues

Objectives

- An extended screening of biogenic residues capacities around Europe
- To select and analyze the type of biogenic residues as feedstock for biofuel production based on the available capacity in each case study
- Identification of suitable locations for the development of commercial scale biorefinery scenarios
- To ensure the financial sustainability of the assumed scenarios by setting a target of < 10 €/MWh concerning the average feedstock supply price

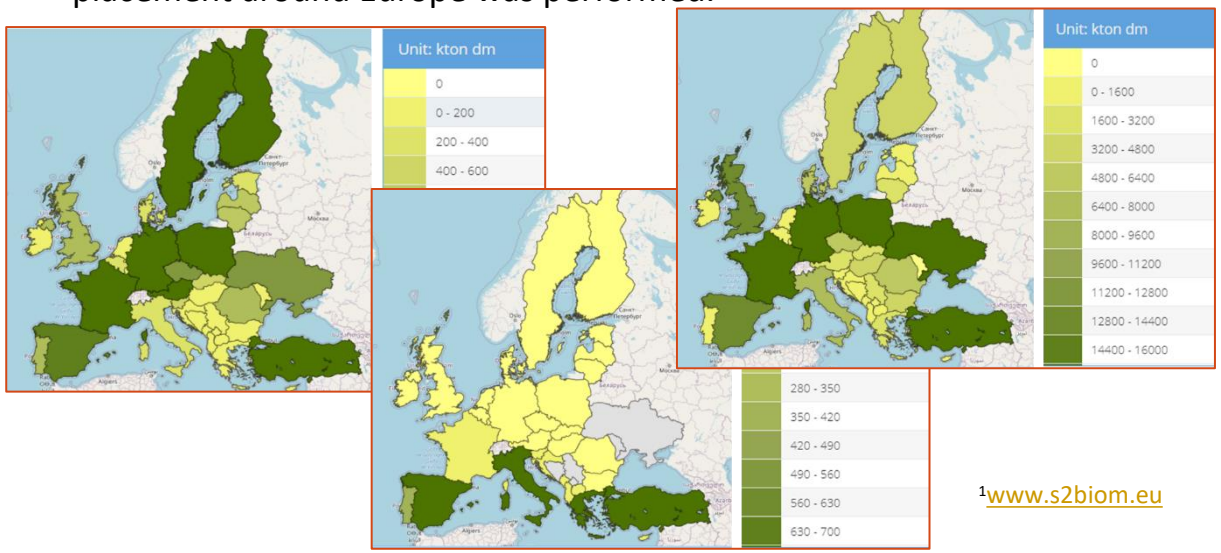
Feedstock screening and selection

The three (3) main axes on which the feedstock selection and characterization was largely based were:

- ✓ Availability (capacities)
- ✓ Technical requirements
- ✓ Market specifications

Availability

- An extended screening of biogenic residues capacities around Europe took place, utilizing the S2BIOM[1] database and a general feedstock placement around Europe was performed.



[1] www.s2biom.eu

Technical requirements

Technical criteria
Heating value
Moisture content
Elemental composition (gasification behavior)
Ash content & composition (e.g. alkali metals)
Sulfur, Chlorine, Nitrogen content
Bulk density & particle size distribution

- Utilizing literature data as well as taking advantage of the experience of the consortium in technical matters (e.g. gasification), the most important technical criteria have been identified.

Market specifications

Technical criteria
Availability & sustainable sourcing
Transport costs, storability and storage costs
Seasonality impact
Pre-treatment requirements
Compatibility with the Energy Policies (e.g. RED II)

- Utilizing literature data as well as taking advantage of the experience of the consortium in supply chains and logistic models for agro-biomass, the most important market criteria have been identified.

Feedstock screening and selection

- An attempt has been made to involve the most promising types of feedstock from each residual biomass category and from various European regions

- Aim of this strategy is on the one hand to involve the widest possible spectrum of biogenic residues, and on the other hand, to maximize the territorial impact of the study by handling different feedstock and supply chains all around Europe

CATEGORY	COUNTRIES		
Administrative level: NUTS 3, Scenario: 2030	Weight: Absolute (kton dm)		
Agricultural residues	GREECE		
Woody pruning & orchards residues	EL651	EL652	EL653
Residues from vineyards	9	3	9
Residues from olive tree plantations	**125**	**44**	**126**
Agricultural residues	SPAIN		
Woody pruning & orchards residues	Granada	Almeria	Murcia
Residues from vineyards	3	2	19
Residues from olive tree plantations	**288**	200	35
Residues from fruit tree plantations	26	18	88
Residues from citrus tree plantations	29	20	90
Agricultural residues	ITALY		
Straw/Stubbles	Venezia	Pordenone	Udine
Cereal straw	72	45	**96**
Maize stover	186	147	**312**
Sunflower straw	6	3	7
Primary residues from forests	FINLAND		
Logging residues from final fellings &thinnings	Helsinki	Varsinais	Satakunta
Logging residues from final fellings from conifer trees	**322**	265	251
Logging residues from thinnings from conifer trees	**132**	124	91

- ✓ **Olive and vineyard prunings** from Greece & Spain respectively
- ✓ **Cereal straw** from Italy
- ✓ **Logging residues `from final fellings & thinnings/wood residues** from Finland
- ✓ **Airports & ports biogenic wastes** all around Europe


Olive prunings (Greece)


Vineyard prunings (Spain)


Straw (Italy)


Bark (Finland)


Airports &ports residues

Feedstock characterization

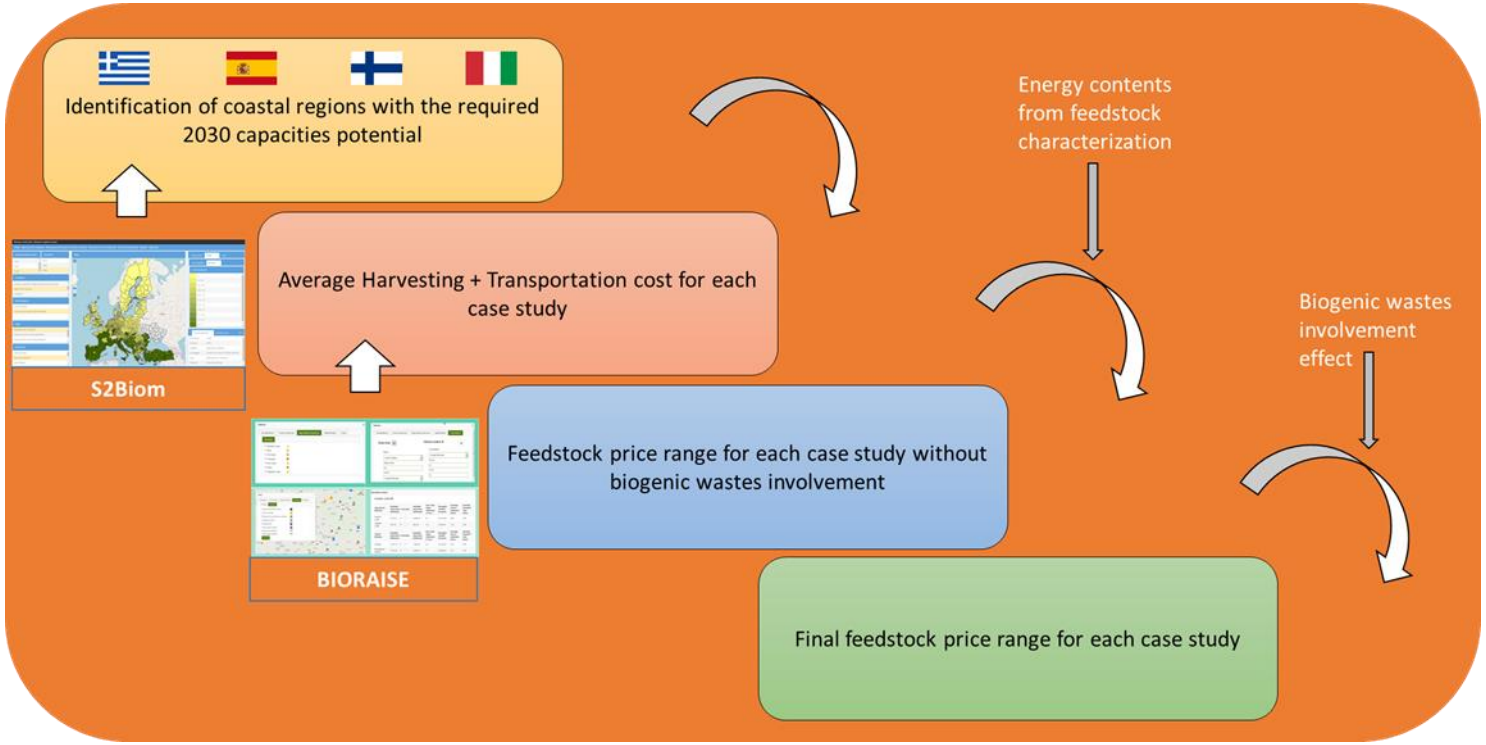
Sample		Olive prunings	Vineyard prunings	Cereal straw	Forest residue
Parameter	Units	Measured values		Given values from past measurements	
Ash	% (d.b)	4.20	3.70	4.50	2.60
C	% (d.b.)	49.05	48.47	47.51	52.20
H	% (d.b.)	7.78	5.99	7.39	5.70
N	% (d.b.)	0.36	0.84	0.10	0.50
O	% (d.b.)	38.55	40.92	40.44	38.96
S	% (d.b.)	0.06	0.08	0.06	0.04
CL	% (d.b.)	N.d	0.07	0.08	N.d
HHV	MJ/kg (d.b.)	19.42	18.99	18.08	20.80
LHV	MJ/kg (d.b.)	17.74	17.69	16.48	19.64

HHV: *High Heating Value*
LHV: *Low Heating Value*
N.d: *Not detected*

Case studies definition

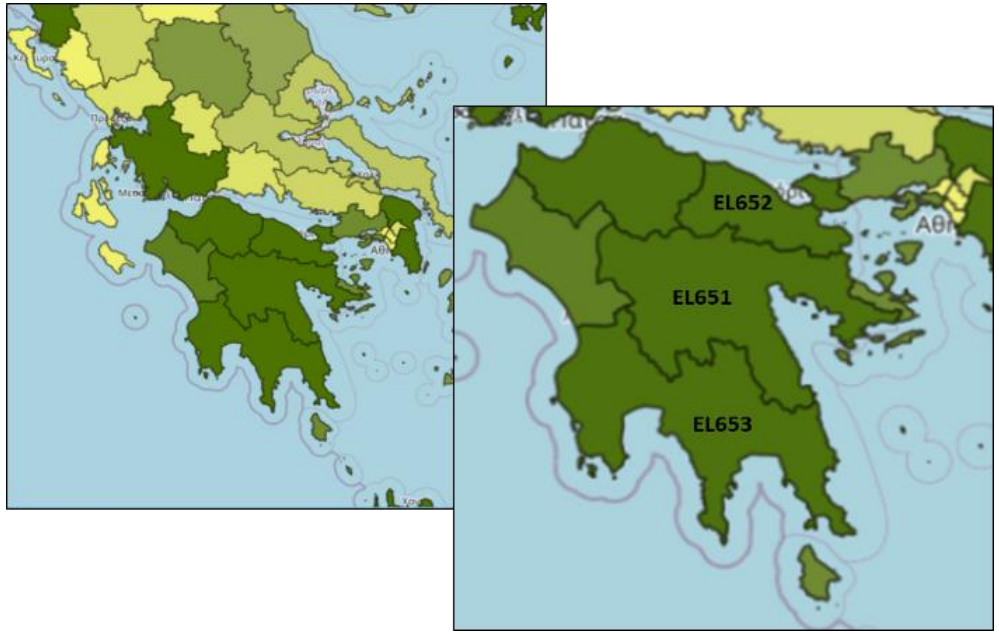
Methodology

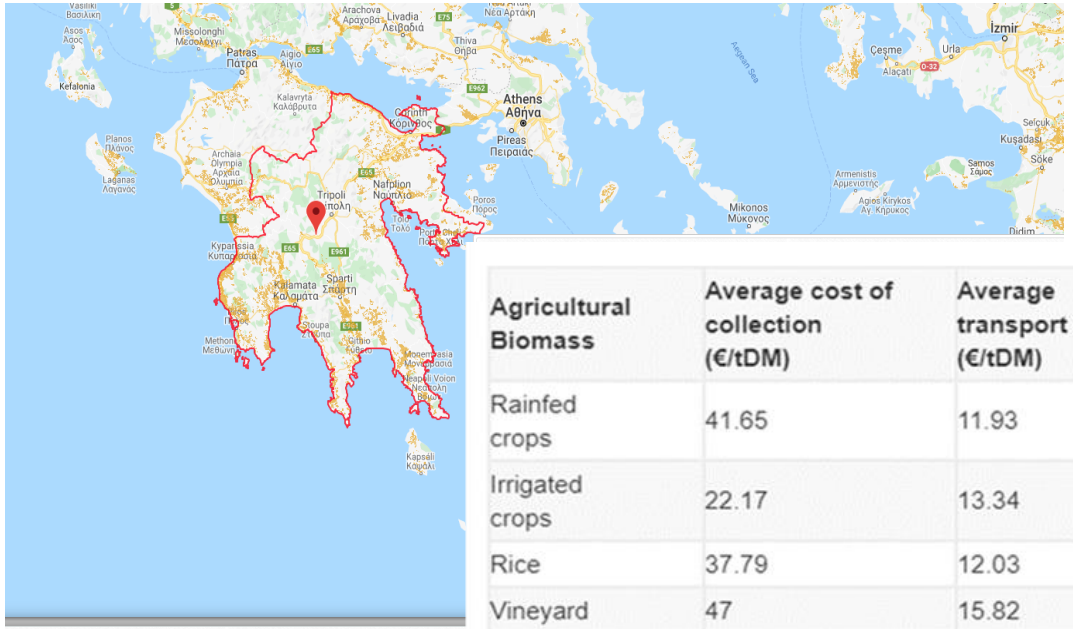
- Feedstock annual needs of around **250 kt/year** ~200 MWth plant
- The feedstock screening was performed with the use of **S2Biom platform** and taking into account the **2030 expectations**
- The **collecting/harvesting cost** as well as the **transportation cost** are the two costs that basically form the final average feedstock price and intended to be less than **10 €/MWh**
- The harvesting & transportation cost for each case study are obtained with the assistance of **BIORAISE GIS platform**
- It is investigated how the gradual involvement of **biogenic wastes** affects the developed scenarios and the average feedstock price



Scenarios development

Greece



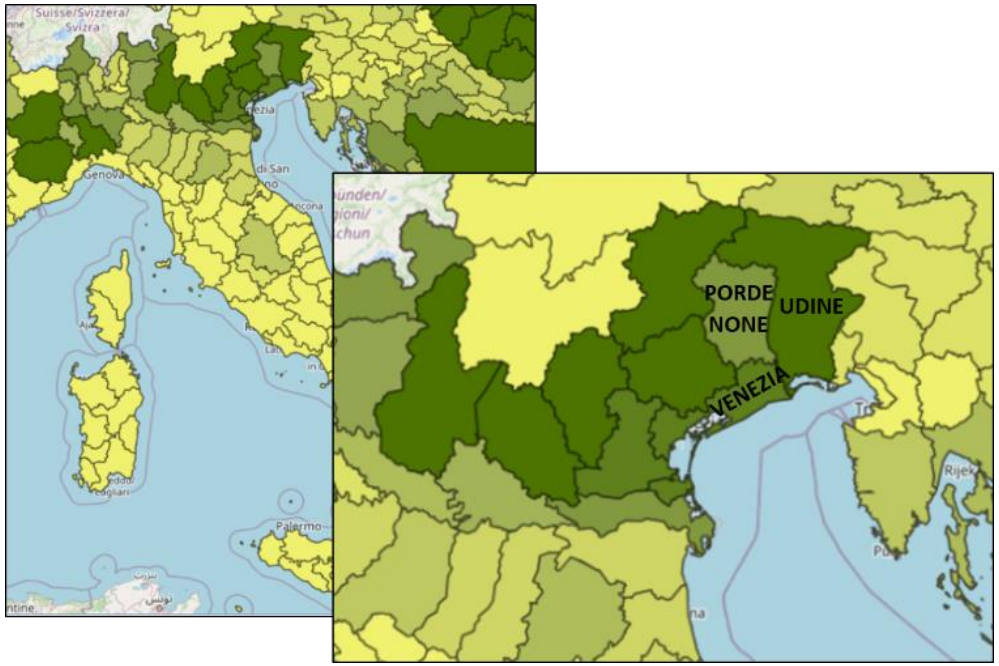


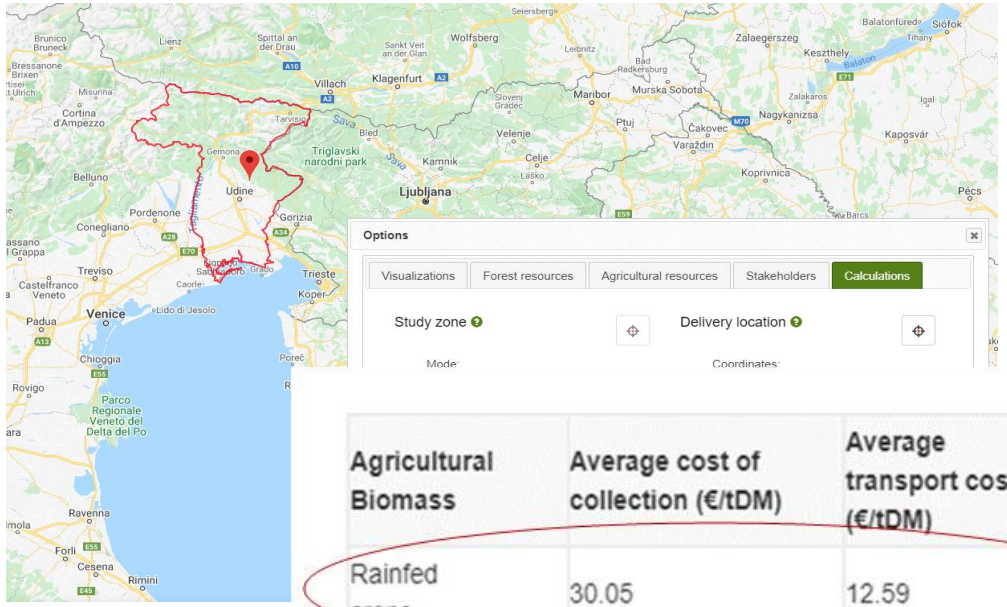
Agricultural Biomass	Average cost of collection (€/tDM)	Average transport cost (€/tDM)
Rainfed crops	41.65	11.93
Irrigated crops	22.17	13.34
Rice	37.79	12.03
Vineyard	47	15.82
Orchards	50	14.31
Olive	38	14.86

Case (Country)	Greece
Feedstock	Olive prunings
Region	Peloponnese
Average collection cost (€/t DM)	38
Average transport cost (€/t DM)	14.86
Feedstock LHV (MJ/kg) / (MWh/t)	17.74 – 18.95 / 4.928 – 5.264
Estimated average feedstock price (€/MWh)	10.04 – 10.73

Scenarios development

Italy



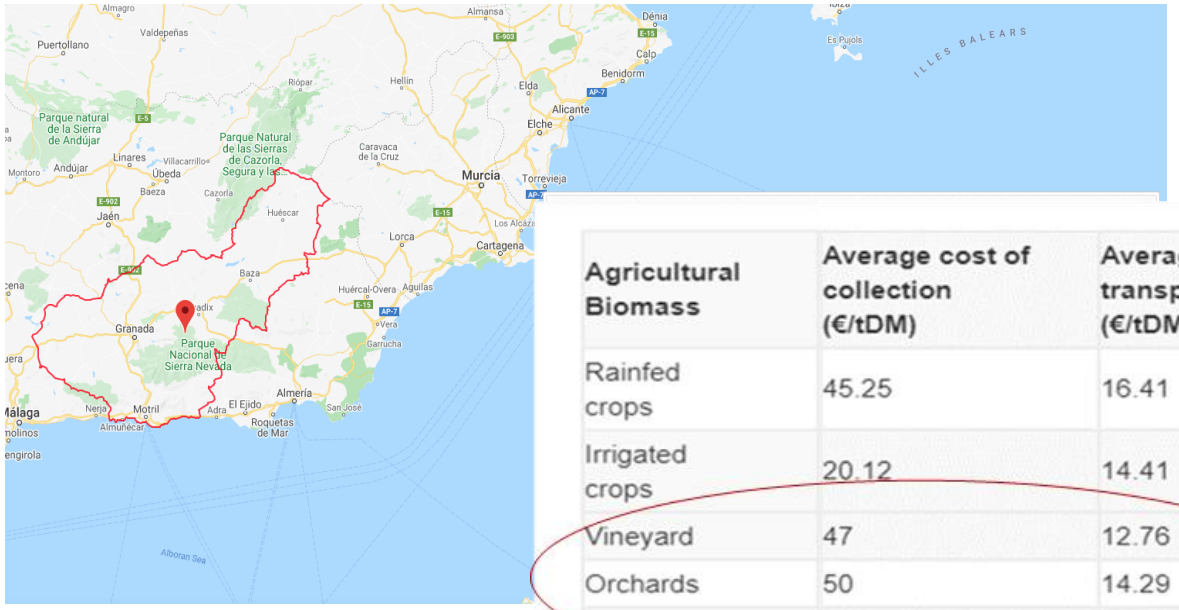


Agricultural Biomass	Average cost of collection (€/tDM)	Average transport cost (€/tDM)
Rainfed crops	30.05	12.59
Vineyard	47	8.84

Case (Country)	Italy
Feedstock	Straw
Region	Udine
Average collection cost (€/t DM)	30.05
Average transport cost (€/t DM)	12.59
Feedstock LHV (MJ/kg) / (MWh/t)	16.48 – 17.73 / 4.578 – 4.925
Estimated average feedstock price (€/MWh)	8.66 – 9.31

Scenarios development

Spain

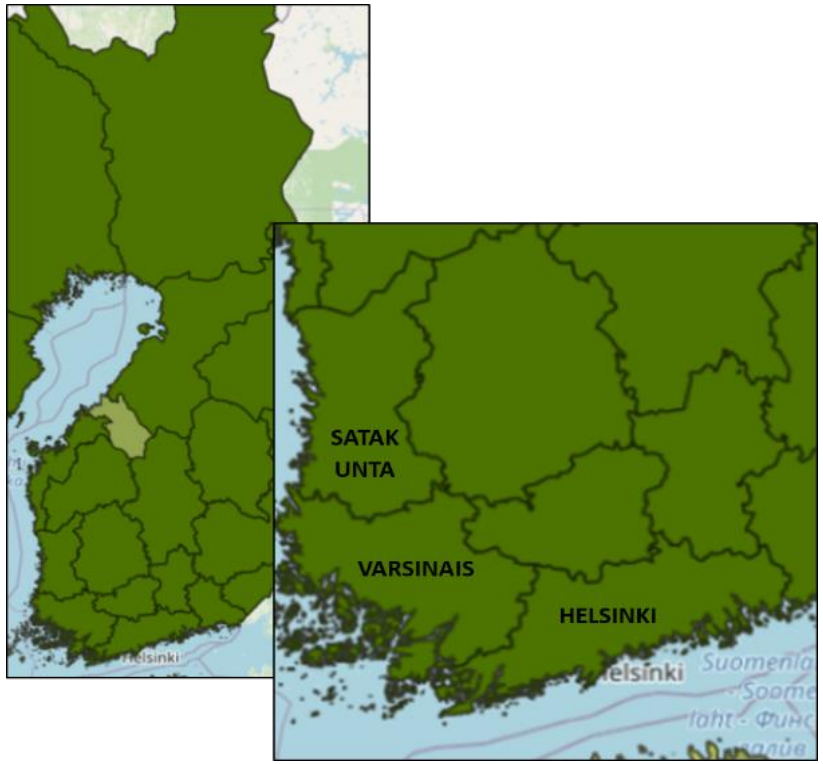


Agricultural Biomass	Average cost of collection (€/tDM)	Average transport cost (€/tDM)
Rainfed crops	45.25	16.41
Irrigated crops	20.12	14.41
Vineyard	47	12.76
Orchards	50	14.29
Olive	38	14.37

Case (Country)	Spain
Feedstock	Prunings (olive, vineyard, orchards)
Region	Granada
Average collection cost (€/t DM)	45
Average transport cost (€/t DM)	13.81
Feedstock LHV (MJ/kg) / (MWh/t)	17.8 – 19 / 4.944 – 5.278
Estimated average feedstock price (€/MWh)	11.14 – 11.90

Scenarios development

Finland



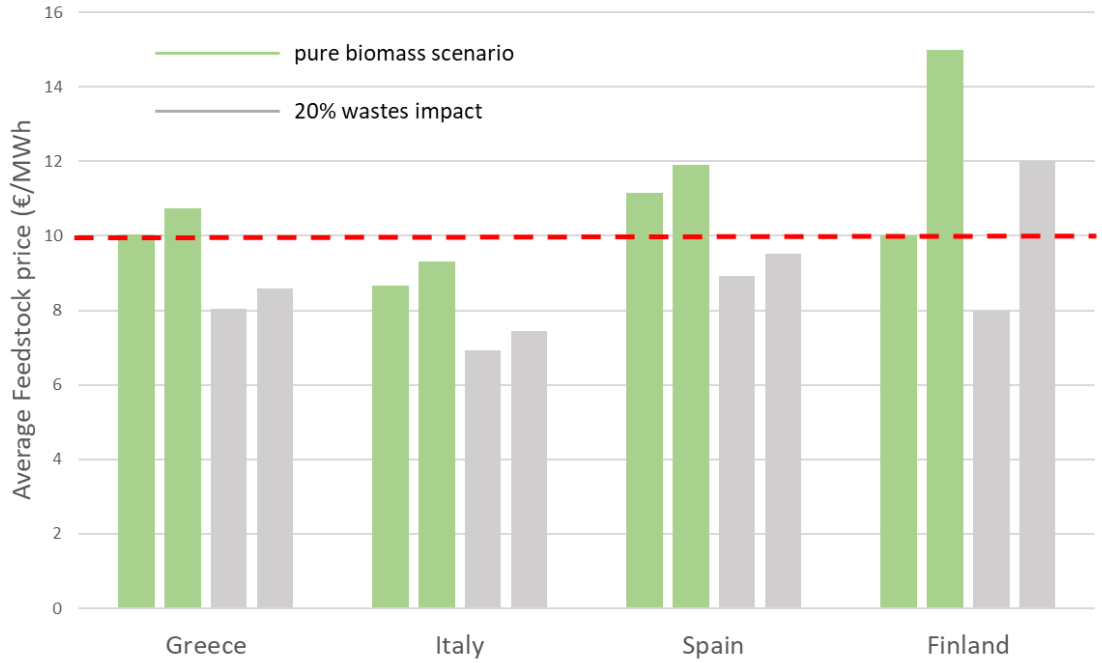
- Since the BIORAISE GIS platform is dedicated to Mediterranean countries, the feedstock cost calculation for the Finnish case study could not be performed with this way. However, Finland has an active bioenergy market which allows a reliable feedstock price assumption.
- After taking into account the capacities of the region, the competition of other biomass-based plants and the future expectations regarding the selected feedstock prices, an average feedstock price range is set for the case study of Finland at **10-15 €/MWh**

Case (Country)	Finland
Feedstock	Logging & wood residues
Region	Helsinki, Satakunta, Varsinais-Suomi
Estimated average feedstock price (€/MWh)	10 – 15

Results

Biogenic wastes involvement

- Wastes are considered as a very economical feedstock and this is mainly due to the so-called **gate-fees which are the fees charged by the operators of waste management facilities for disposal of received waste.**
- Pre-treatment costs covering collection, separation, shredding and baling as well as transportation costs **are at least recovered from the gate-fees**, since aim of the gate-fees is to generate profit that will encourage investors from the private sector to be involved. **The gate-fee is the driving force for waste management.**
- The airports and ports biogenic wastes will enter the developed scenarios with **a price of 0 €/t and with a limited involvement of 20% in each country's feedstock mixture.**



Country	Greece	Italy	Spain	Finland
Feedstock	Olive prunings	Straw (cereal, maize stover, sunflower)	Prunings (olive, vineyard, orchards)	Logging & wood residues
Region	Peloponnese	Udine	Granada	Helsinki, Satakunta, Varsinais-Suomi
Estimated average feedstock price (€/MWh)	10.04 – 10.73	8.66 – 9.31	11.14 – 11.90	10 - 15
Average feedstock price with 20% biogenic wastes involvement (€/MWh)	8.03 – 8.58	6.93 - 7.45	8.91 – 9.52	8 - 12

Conclusions

- Taking into account that the financial feasibility of a commercial biorefinery starts from at least 100 MWth, **the medium scale of 200 MWth was selected to navigate the developed scenarios**. Other similar projects, involving biomass gasification for liquid fuels production (BtL), assume a plant of 200 MWth to support their techno-economic analysis. This fact will also facilitate the benchmarking with other similar or competitive gasification based technologies.

- For every case study it has been assumed the establishment of a commercial plant which targets **both aviation and maritime biofuels**. However, the potential inclination of the process to only one type of fuel may be critical to ensure sustainability of the plant in a country where the production of both type of fuels is not favorable.

- **The calculated feedstock costs for each case study were all around 10 €/MWh, while even with the most conservative assumptions for biogenic wastes in terms of involvement and cost, the feedstock prices fall below 10 €/MWh**. Only the case of Finland can be characterized relatively unpredictable and this is due to the fact that Finland biomass market is more mature and active in comparison to the other selected countries involving more stakeholders and consequently presenting higher feedstock demand and price.

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Thank you for your attention!

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