MUSIC
Market Uptake Support for Intermediate Bioenergy Carriers

«Residual biomass mobilization strategies for intermediate bioenergy carriers

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ΚΑΠΕ CRES CERTH

CONTENTS

- MUSIC project
- Intermediate bioenergy carriers
- Torrefaction technology
- The Greek Case-study
- Biomass supply strategies
- Conclusions

RATIONALE & OVERALL OBJECTIVE

Why Intermediate Bioenergy Carriers – IBCs ?

- Biomass is bulky and difficult to handle.
- Converting it into intermediary products like **Pyrolysis Oil**, **Torrefied Biomass** & **Microbial Oil** increases the energy density and makes it easier to transport, store and use.

General objective

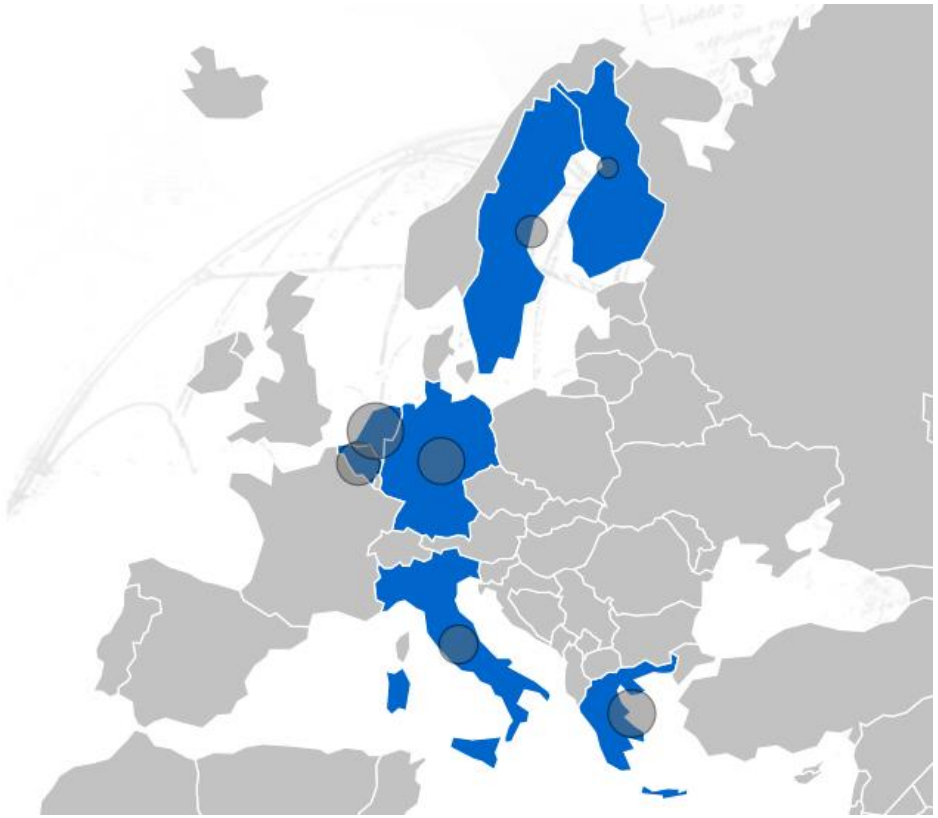
- To facilitate the further introduction of intermediate bioenergy carriers by developing feedstock mobilisation strategies, improved logistics and IBC trade centres.

THE MUSIC TEAM

www.music-h2020.eu

Renewable energy advisory SME's

(Bio)energy RTD institutes



Member organisations

Case study partners (economic actors)

3 year project (Sep 2019 – Aug 2022) , ca. 3M Euro budget, 16 partners from 7 countries

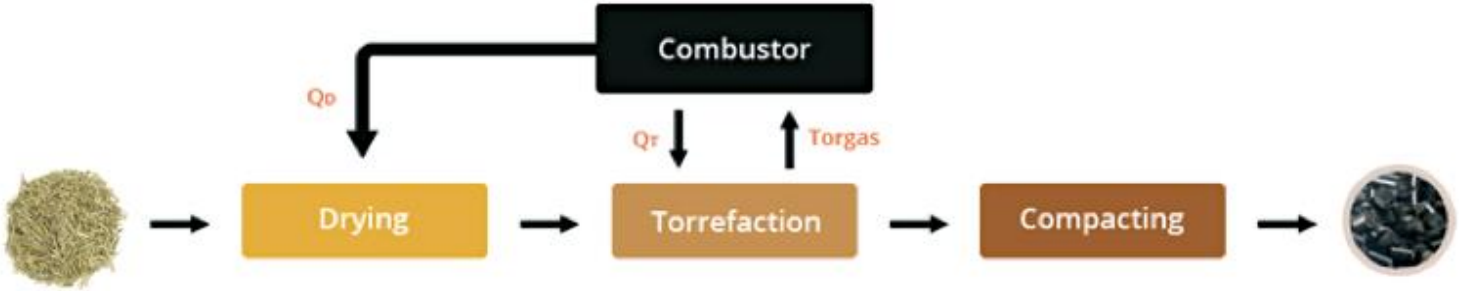
INTERMEDIATE BIOENERGY CARRIERS

Pyrolysis oil	Torrefied biomass	Microbial oil
		
Obtained by fast heating of biomass in the absence of oxygen, resulting in a liquid IBC.	Obtained by slow heating of biomass in the absence of oxygen, resulting in a solid IBC.	Obtained by fermentation of lignocellulosic-derived sugars from biomass, resulting in a liquid IBC.

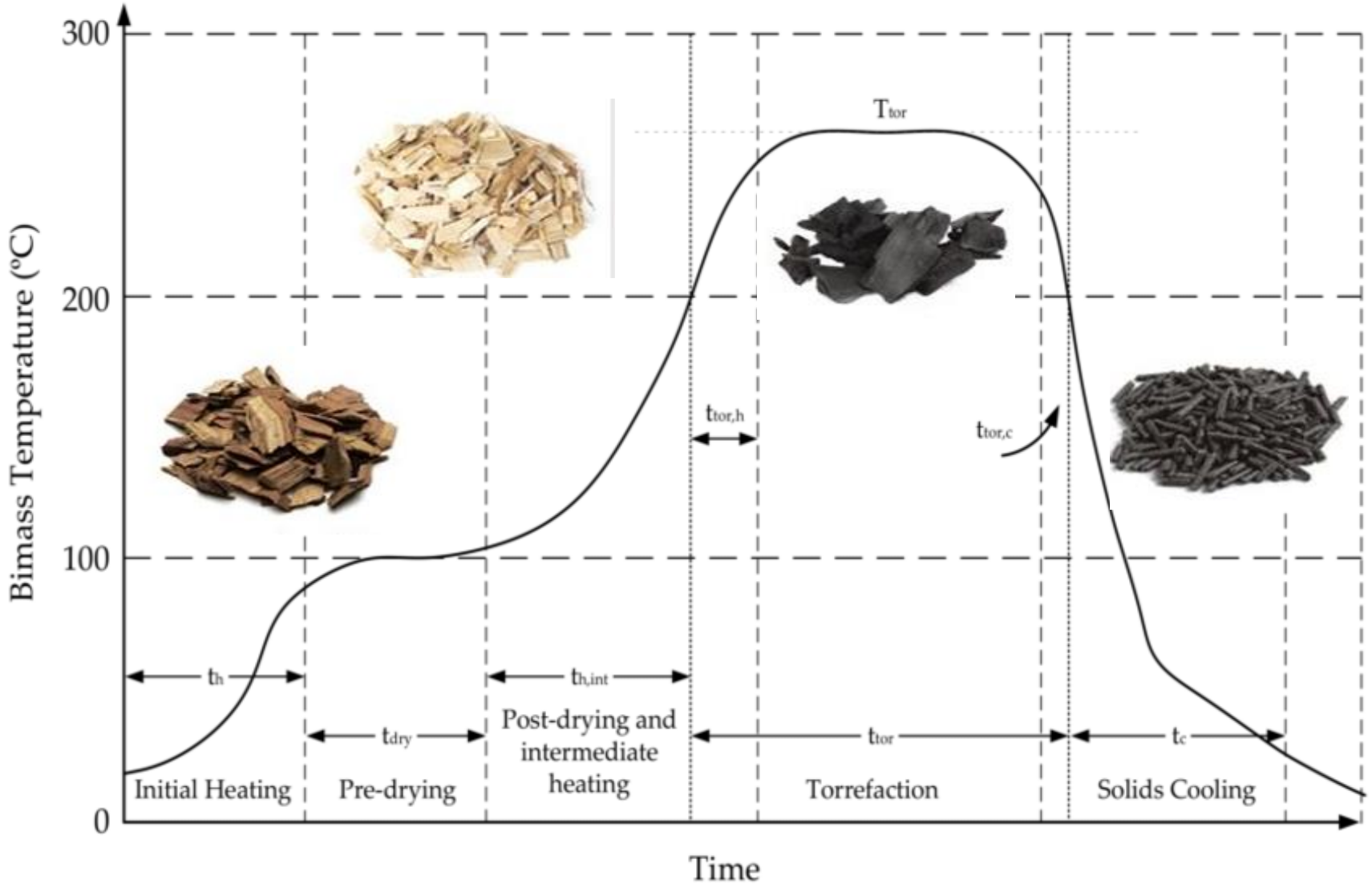
TORREFACTION

A thermal process at 200-300 °C in absence of oxygen to convert biomass into a coal-like material, which has better fuel characteristics than the original biomass.

During torrefaction, three different products are produced:
(1) brown to black uniform solid biomass, which is used for bioenergy applications,
(2) condensable volatile organic compounds comprising water, acetic acid, aldehydes, alcohols, and ketones,
(3) non-condensable gases like CO2, CO, and small amounts of methane.



Stages of torrefaction



Advantages of torrefaction

- Higher moisture (14-60 wt)%
- Lower heating value (6-13 MJ/kg)
- Lower energy density (0,7-1 MWh/m3)
- Higher O/C (0,5-0,8) and H/C ratios (1,2-2)
- Hygroscopic
- Poorer grindability
- Non-uniform properties

Solid raw biomass
- Wood (branches; bark)
- Agricultural residues
- Grass (various types)
- Demolition wood
- Solid Recovered Fuel
-

Torrefaction

- 200-300 °
- Absence of oxygen

- Lower moisture (3-8 wt%)
- Higher heating value (19-24 MJ/kg)
- Higher energy density (1,3-2 MWh/m3)
- Lower O/C (0,2-0,4) and H/C ratios (0,8-1,2)
- Hydrophobic
- Better grindability
- More uniform properties

Torrefied biomass

Status of torrefaction initiatives as of early 2015

Developer	Technology	Location(s)	Production capacity (ton/a)	Scale and status Pilot scale: 0.05- 0.55 tph Demo scale: 0.5- 2 tph Commercial scale: > 2tph	Full integration (pre-treatment, torrefaction, combustion, heat cycle, densification)	Status
Clean Electricity Generation (UK)	Oscillating bed	Derby (UK)	30,000	Commercial scale	Yes	Available/operational
Horizon Bioenergy (NL)	Oscillating belt conveyor	Steenwijk (NL)	45,000	Commercial scale	Yes	Dismantled
Solvay (FR) / New Biomass Energy (USA)	Screw reactor	Quitman (USA/MS)	80,000	Commercial scale	Yes	Available/operational
Topell Energy (NL)	Fluidised bed	Duiven (NL)	60,000	Commercial scale	Yes	Mothballed
Torr-Coal B.V. (NL)	Rotary drum	Dilsen-Stokkem (BE)	30,000	Commercial scale	Yes	Available/operational
Airex (CAN/QC)	Cyclonic bed	Bécancour (CAN/QC)	16,000	Demonstration scale		Available/operational
Agri-Tech Producers LLC (USA/SC)	Screw reactor	Allendale (USA/SC)	13,000	Demonstration scale	Yes	Scheduled to be built
Andritz (AT)	Rotary drum	Frohnleiten (AT)	10,000	Demonstration scale	Yes	Out-of-service
Andritz (DK) / ECN (NL)	Moving bed	Stenderup (DK)	10,000	Demonstration scale		Unknown
BioEndev (SWE)	Dedicated screw reactor	Holmsund, Umea (SWE)	16,000	Demonstration scale	Yes	Available (2015)
CMI NESA (BE)	Multiple hearth	Seraing (BE)	Undefined	Demonstration scale		Unknown
Earth Care Products (USA)	Rotary drum	Independence (USA/KS)	20,000	Demonstration scale		Available/operational
Grupo Lantec (SP)	Moving bed	Urnieta (SP)	20,000	Demonstration scale		Unknown
Integro Earth Fuels, LLC (USA)	Multiple hearth	Greenville (USA/SC)	11,000	Demonstration scale		Unknown
LMK Energy (FR)	Moving bed	Mazingarbe (FR)	20,000	Demonstration scale		Unknown
River Basin Energy (USA)	Undefined	Laramie (USA/WY)	Undefined	Demonstration scale		Available/operational
Teal Sales Inc (USA)	Rotary drum	White Castle (USA/LA)	15,000	Demonstration scale		Available/operational
Torrec (FI)	Moving bed	Mikkeli (FI)	10,000	Demonstration scale		Available/operational
Agri-Tech Producers LLC (US/SC)	Screw reactor	Raleigh (USA/NC)	Undefined	Pilot stage		Available/operational
Airex (CAN/QC)	Cyclonic bed	Rouyn-Noranda (CAN/QC)	Undefined	Pilot stage		Available/operational
Airex (CAN/QC)	Cyclonic bed	Trois-Rivières (CAN/QC)	Undefined	Pilot stage		Available/operational
Arigna Fuels (IR)	Screw reactor	County Roscommon (IR)	Undefined	Pilot stage		Available/operational
CENER (SP)	Rotary drum	Aoiz (SP)	Undefined	Pilot scale		Available/operational
Terra Green Energy (USA)	Multiple hearth	McKean County (USA/PA)	Undefined	Pilot scale		Available/operational
Wyssmont (USA)	Multiple hearth	Fort Lee (USA/NJ)	Undefined	Pilot scale		Unknown
CEA (FR)	Multiple hearth	Paris (FR)	Undefined	Laboratory scale		Available/operational
Rotawave, Ltd. (UK)	Microwave	Chester (UK)	Undefined	Laboratory scale		Unknown
Bio Energy Development & Production (CAN)	Fluidised bed	Nova Scotia (CAN/NS)	Undefined	Unknown		Unknown

GREEK CASE STUDY: USE OF TORREFIED BIOMASS IN DISTRICT HEATING PLANT

- Operates an extensive district heating network – **2,000** public and residential buildings – **3,000** to **5,000** consumers.
- From **2005** until **2020** – heat capacity from Amyntaio CHP plant at **7€/MWh.**
- Implemented a **30 MW_{th}** biomass/lignite co-firing district heating plant.
- Current fuel-mix (**50%-50%** energy ratio).
  - Wood-chips **(20 €/MWh)**
  - Lignite **(13€/MWh)**
- Produced **heat selling price** rose from **41,3 €/MWh** (2019) to **56,8 €/MWh** (2021).

Biomass feedstocks with diverse characteristics + Lack of cooperation with local producers + Difficulties in biomass contractualization + Seasonal variability = Inability to utilize the full potential of local biomass capacities

Difficulties in handling/firing

Unexploited quantities

Unstable prices

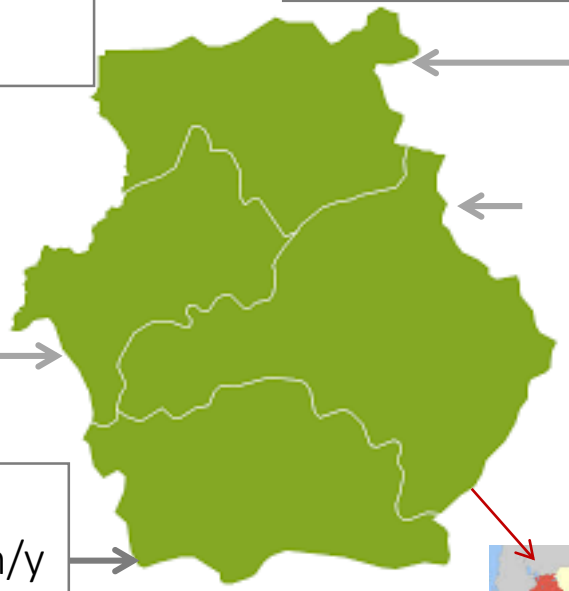
Quantities/Properties → Insecurity of supply

Need for organizing biomass mobilization by involving local stakeholders

Theoretic biomass potential in West Macedonia

Kastoria region:
Total biomass:~ 47,000 t dm/y
- 41,000 t dm/y mainly straw
- 4,000 t dm/y pruning
- 1,800 t dm/y firewood

Florina region:
Total biomass:~ 120,000 t dm/y
- 104,000 t dm/y cereals (of which 55,600 t dm/y is corn residues)
- 11,000 t dm/y pruning (vineyards, fruit trees)



Kozani region:
Total biomass:~ 225,000 t dm/y
- 203,000 t dm/y cereals (of which 50,000 t dm/y is corn residues)
- 8,000 t dm/y pruning (vineyards, fruit trees)

Grevena region:
Total biomass:~ 91,000 t dm/y mainly straw

Biomass availability

- Availability of biomass near the district heating plant is significant, including mainly corn stalks and cobs and tree pruning, still not exploited due to challenging logistics.

Biomass availability year around												
Months	1	2	3	4	5	6	7	8	9	10	11	12
Straw						■	■	■				
Corn and sunflower residues									■	■	■	
Pruning	■	■	■									■
Forest residues						■	■	■	■			
Residues from forest industries	■	■	■	■	■	■	■	■	■	■	■	■

BIOMASS MOBILIZATION

Straw/ corn residues/pruning

Truck

10-50 km

Residues transferred directly to the district heating plant

or

Truck

10-50 km

Residues transferred in the torrefaction unit

Torrefaction unit

Truck

~10 km

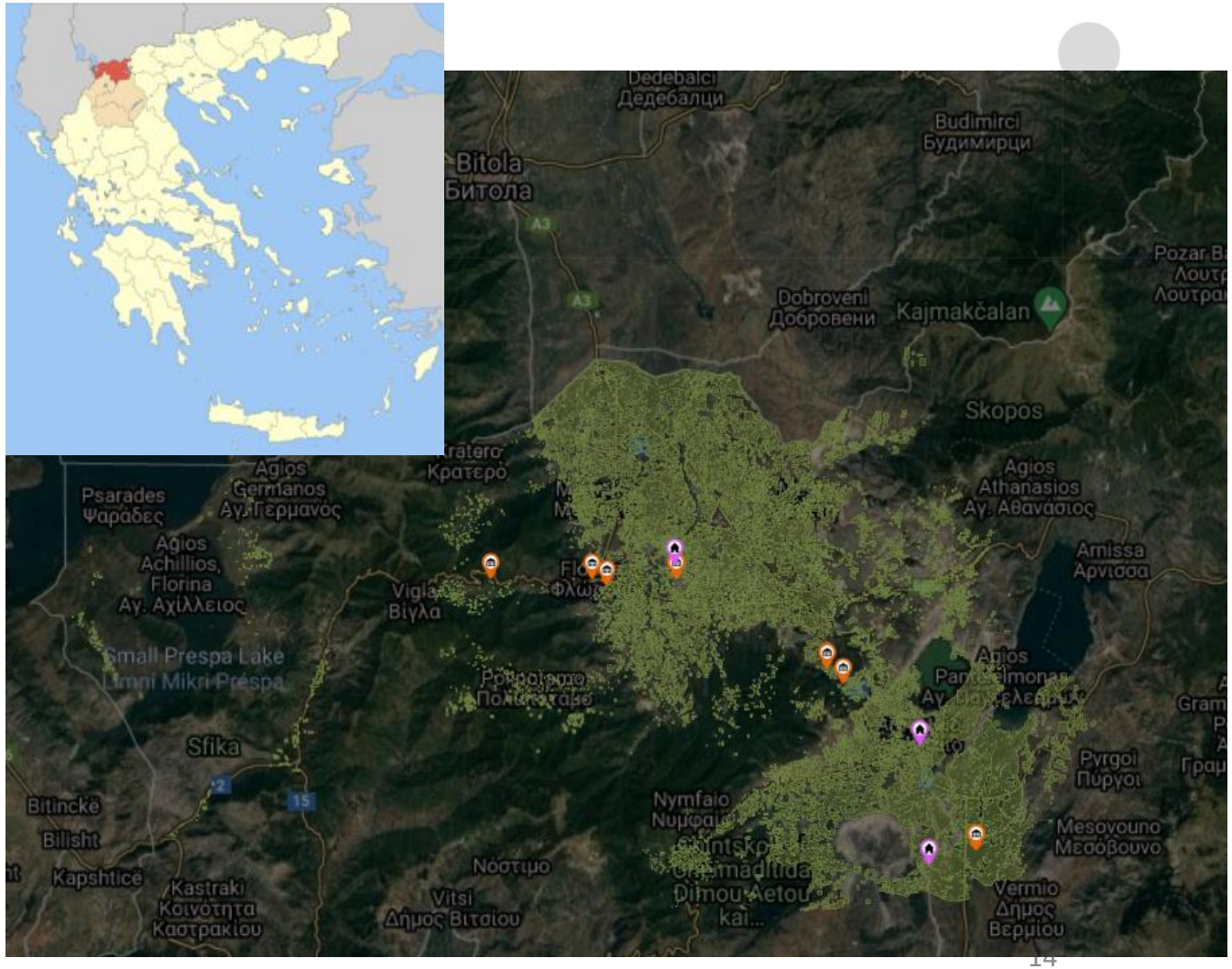
DETEPA 30 MWth Amyntaion DH plant

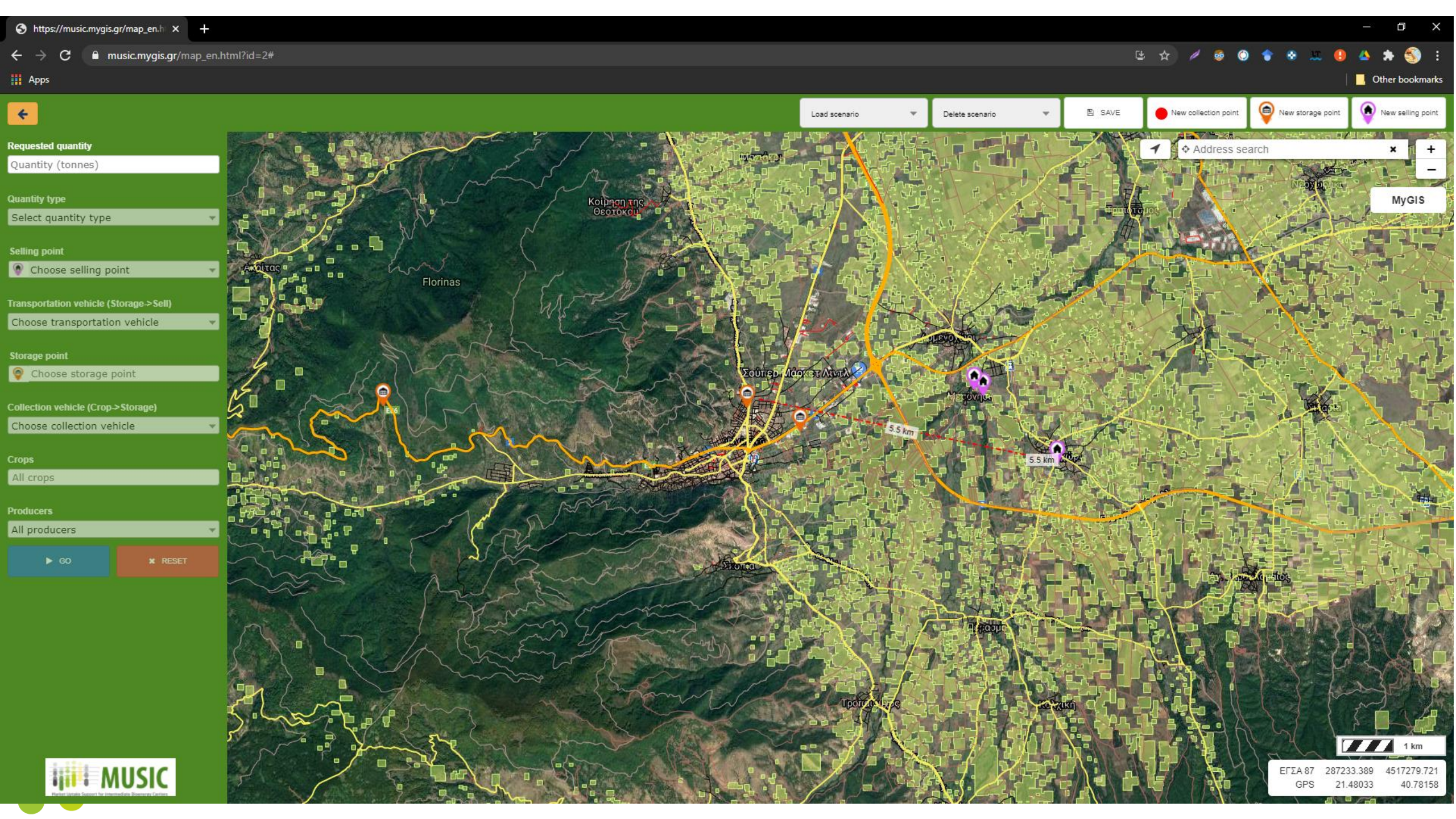
Music-mygis model

Objective: A GIS application to help the user select the fields where the biomass will be collected, places to be stored/torrefied and sold and calculate the related logistics costs.

MODEL PARAMETERS

- **Selling point**: the final destination of the biomass (client).
- **Transportation vehicle**, which will transport the biomass from the storage point to the selling point. Each vehicle type takes into consideration:
  - Capacity (volume)
  - Maximum payload (weight)
  - Biomass packaging type (e.g.. Big bags, rectangular bales, etc.)
  - Transportation cost (Fuel/oil consumption and costs, service costs etc.)
  - Time and cost to load/unload
- **Storage point**: is the collection point of all biomass before it is transported to the client.
- **Collection vehicle**, which will transport the biomass from the collection points to the storage point. It has similar functionality to the transportation vehicle.
- **Crops**: Crop residues (maize, vineyards, pome fruits, stone fruits and other tree species).




https://music.mygis.gr/map_en.h
music.mygis.gr/map_en.html?id=2#
Apps
Other bookmarks
Load scenario
Delete scenario
SAVE
New collection point
New storage point
New selling point
Requested quantity
Quantity (tonnes)
Quantity type
Select quantity type
Selling point
Choose selling point
Transportation vehicle (Storage->Sell)
Choose transportation vehicle
Storage point
Choose storage point
Collection vehicle (Crop->Storage)
Choose collection vehicle
Crops
All crops
Producers
All producers
GO
RESET
Address search
MyGIS
Florinas
5.5 km
5.5 km
1 km
ΕΓΣΑ 87 287233.389 4517279.721
GPS 21.48033 40.78158
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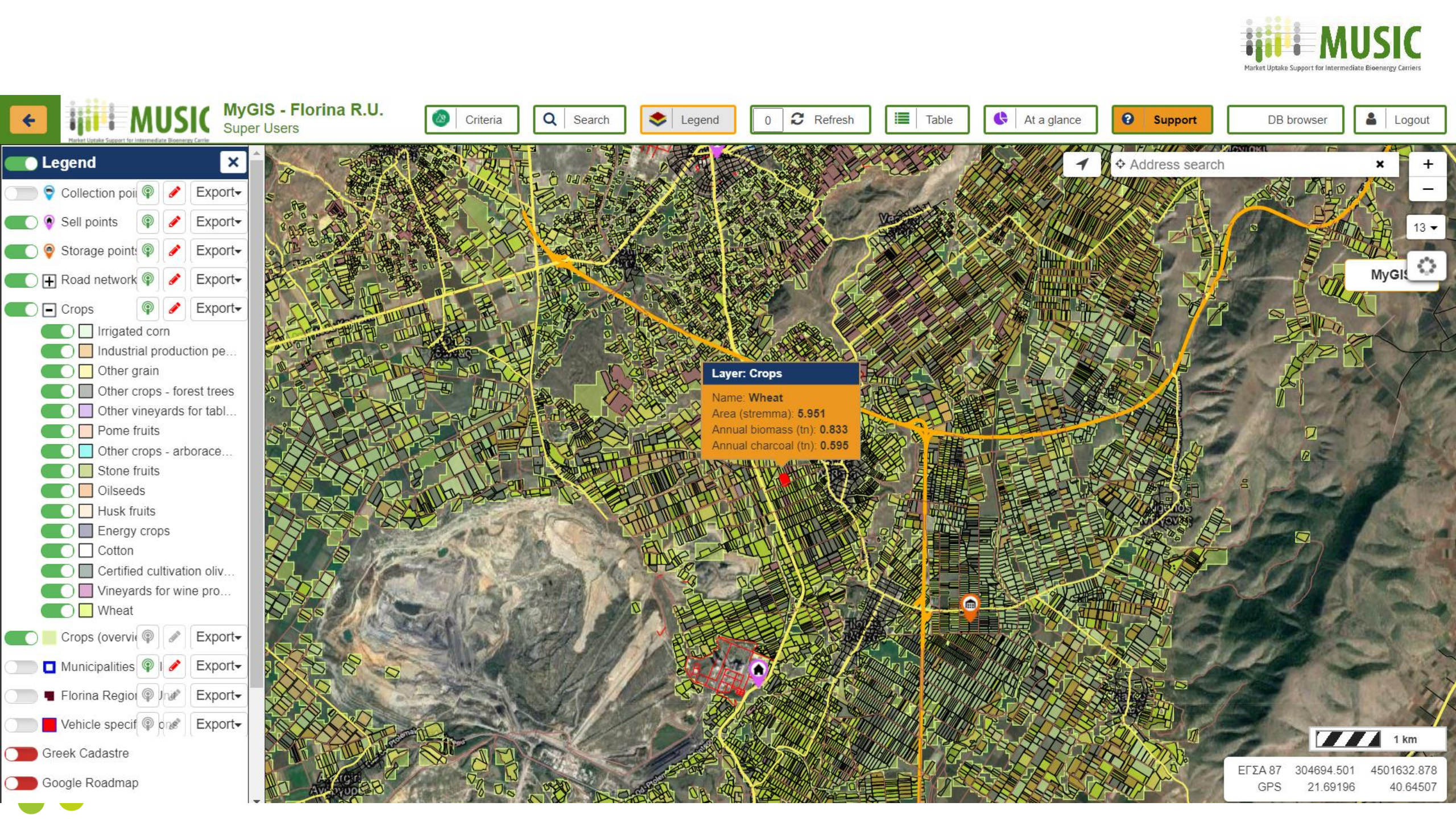
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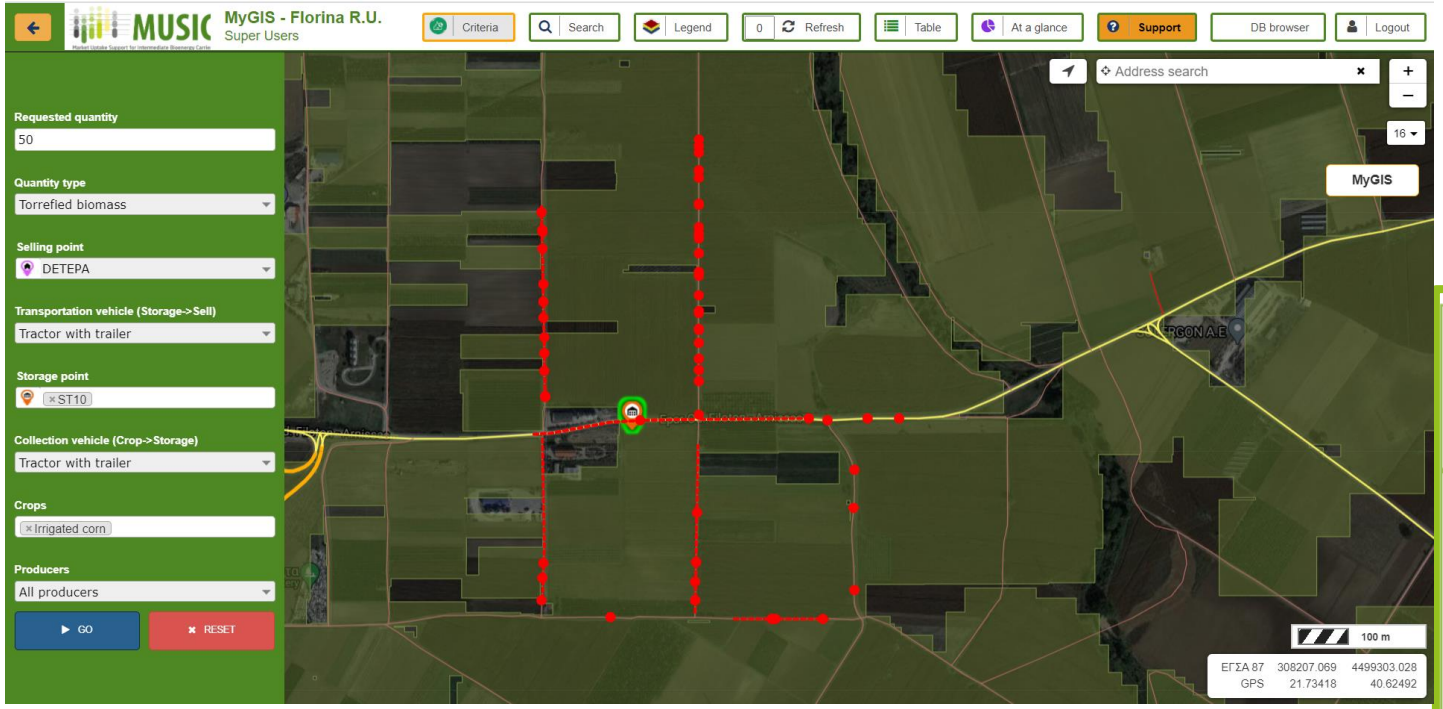
MyGIS - Florina R.U.
Super Users
Criteria
Search
Legend
0
Refresh
Table
At a glance
Support
DB browser
Logout
Legend
Collection poi
Export
Sell points
Storage point
Road network
Crops
Irrigated corn
Industrial production pe...
Other grain
Other crops - forest trees
Other vineyards for tabl...
Pome fruits
Other crops - arborace...
Stone fruits
Oilseeds
Husk fruits
Energy crops
Cotton
Certified cultivation oliv...
Vineyards for wine pro...
Wheat
Crops (overvi
Municipalities
Florina Regio
Vehicle specif
Greek Cadastre
Google Roadmap
Address search
13
MyGIS
Layer: Crops
Name: Wheat
Area (stremma): 5.951
Annual biomass (tn): 0.833
Annual charcoal (tn): 0.595
1 km
ΕΓΣΑ 87 304694.501 4501632.878
GPS 21.69196 40.64507

Selection of crops and vehicles

cropcode	biomass_cal_value	biomass_annual_ef	crop_gr	crop_en	id	char_cal_value	char_annual_ef
45.2	18330	0.21	Λοιπές καλλιέργειες - δενδρώδεις	Other crops - arboraceous	4	20070	0.17
36.3	19130	0.42	Λοιποί αμπελώνες για επιτραπέζια χρήση	Other vineyards for table use	8	20950	0.24
36.2	19130	0.42	Λοιποί αμπελώνες για παραγωγή οίνου	Vineyards for wine production	9	20950	0.24
1	17570	0.12	Σιτάρι	Wheat	11	20910	0.09
12	17770	0.31	Βαμβάκι	Cotton	15	21150	0.26
15	20080	0.13	Ελαιώνες πιστοποιημένης ελαιοκαλλιέργειας	Certified cultivation olive grove	16	21990	0.11
16	16090	0.14	Ενεργειακές καλλιέργειες	Energy crops	17	19140	0.12
2	16900	0.12	Λοιπά σιτηρά	Other grain	12	20110	0.09
4	16090	0.14	Ελαιούχοι σπόροι	Oilseeds	13	17700	0.12
21	19460	0.5	Καρποί με κέλυφος	Husk fruits	19	21410	0.43
49	20250	0.21	Λοιπές καλλιέργειες - δασικά δέντρα	Other crops - forest trees	5	22170	0.17
66	19650	0.53	Πυρηνόκαρπα	Stone fruits	6	21610	0.27
67	19220	0.41	Μηλοειδή	Pome fruits	7	21040	0.7
20.2	19960	0.53	Ροδακινιές μεταποίησης	Industrial production peaches	1	21860	0.42
3.1	20080	0.4	Αραβόσιτος ποτιστικός	Irrigation corn	2	23890	0.14

Vehicle specifications is not a geographic layer

Can carry Charcoal - Powder: YES	Service cost (€/km): 0.09
Maximum payload (tn) Charcoal - Pellets: 13.00	Can carry Biomass - Rectangular bale: YES
Vehicle name: Scania R164L480	Can carry Biomass - Bulk: YES
Capacity (m3): 20	Can carry Biomass - Round bale: YES
Average speed (km/hr): 65	Can carry Biomass - Big bags: YES
Work cost (€/hr): 15.00	Vehicle type: Truck
Load/unload time (hrs): 2.00	userID: 0
Fuel cost (€/l): 1.20	Maximum payload (tn): 20.00
Fuel consumption (l/km): 0.15	Maximum payload (tn) Biomass - Rectangular bales: 5.54
Payback €/year (vehicle): 0	Maximum payload (tn) Biomass - Round bales: 7.99
Payback €/year (trailer): 5500	Maximum payload (tn) Biomass - Bulk: 7.00
Year expenses (€): 1000	Maximum payload (tn) Biomass - Big bags: 6.89
	Maximum payload (tn) Charcoal - Powder: 5.40

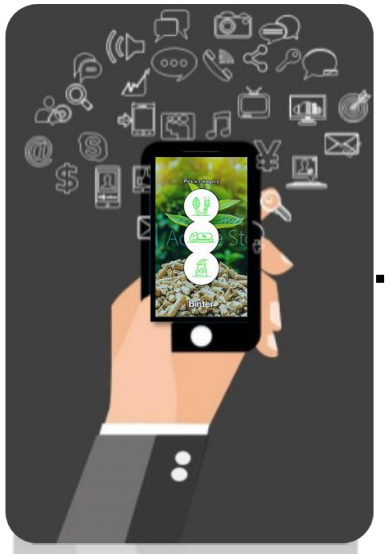


The model output consists of the **total biomass transportation cost** (as a sum of fixed, working, fuel and service cost), and the total **distance, routes and time for the specific collection-storage-sale supply chain**.

Individual costs for the two stages: (Field->Storage Point Storage Point ->Selling Point)	Total Cost
Type of the vehicle selected	Collection-storage trips
Transport method	Collection-Storage total (km)
Total quantity (t)	Storage - Sell trips (km)
Routes	Storage Sell total (km)
Total distance (km)	Total routes
Distance based-time (hours)	Total distance (km)
Transport time (hours)	Total time (hours)
Fixed cost (€/h)	Total cost (€)
Work cost (€/h and €/t)	Grand total per ton (€)
Fuel cost (€/h and €/t)	Grand total per MJ (€)
Service cost (€/h and €/t)	
Energy content (MJ)	
Cost (€)	
Cost per ton (€/t)	
Cost per MJ (€/MJ)	

A smart phone app tool

Platform for mobilising biomass resources



Develop and/or expand trade Centre's for intermediate bioenergy carriers

A virtual trade Centre is developed via an on-line app

binter

Torrefaction facility

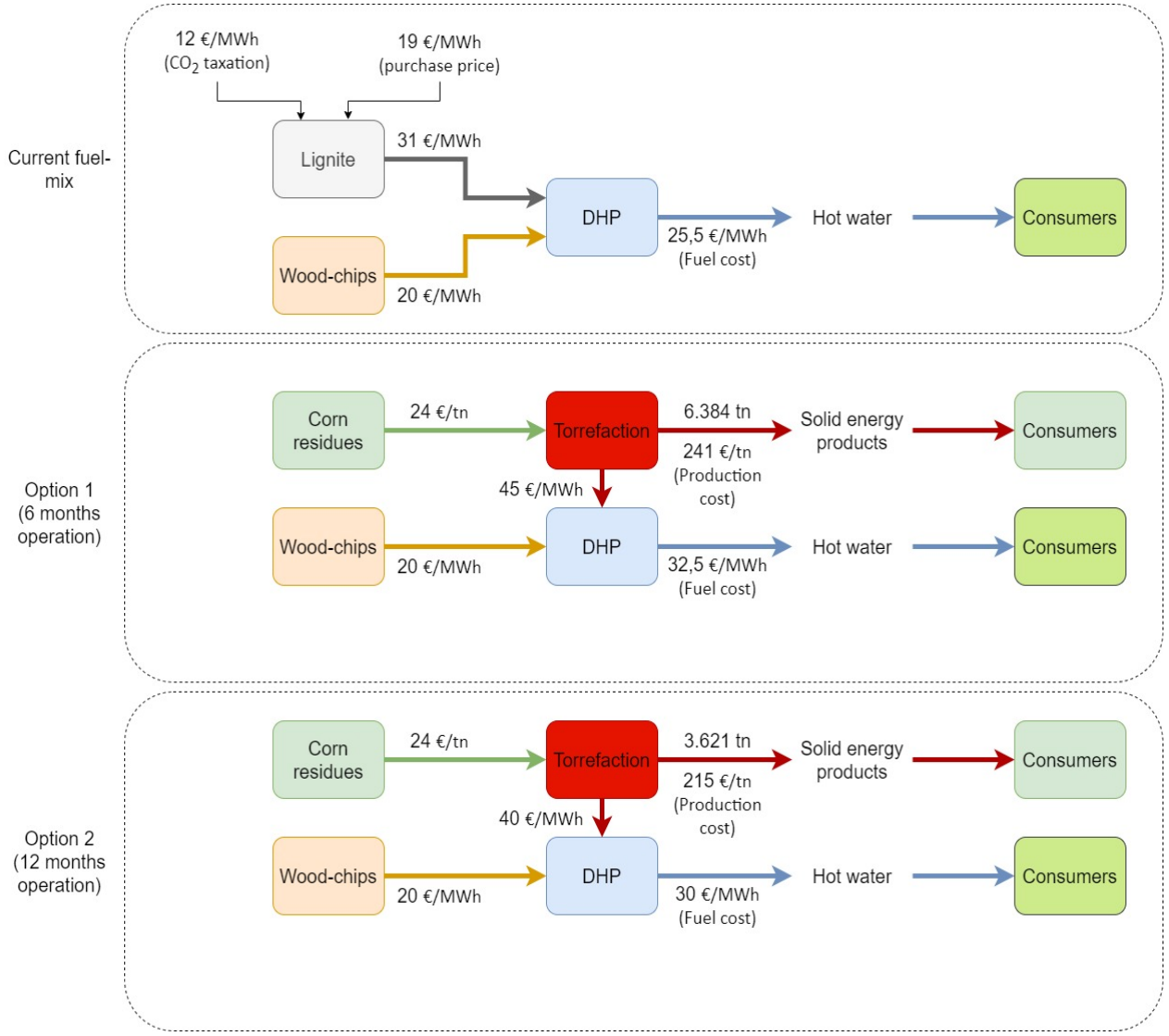
1. 1. Support the market development from mobilisation of feedstock towards IBC production and use

2. Farmers will advertise their available biomass by automatically uploading it in a database

3. IBC plants can then organize the feedstock logistics towards collection of the desired types of biomass

4. Photographs, geographic and quantity of the available biomass and other relevant data are upload on the platform, so that IBC producers can organize efficient collection

Scenarios for use of torrefied biomass in district heating plants



- Biomass procurement is a significant cost item
- Current fuel-mix (50%-50% energy ratio).
  - Wood-chips: 89 €/t (20 €/MWh)
  - Lignite: 35 €/τόνο (13€/MWh)
- Procurement costs for corn residues: 24 €/t and transport costs : 0,05 €/ tkm.
- The torrefaction investment cost is mainly related to the torrefaction reactor size and can even double the total cost, depending on the application
- Trade of excess torrefied biomass could mitigate investment costs.

CONCLUSIONS

- This **ongoing work** is the **stepping stone** and constitutes the road map for **large-scale implementation** at multiple **regional** (district heating & power) **plants** and relevant (**cement, quick lime or magnesite**) **industries** in the region.
- **Synergies** – farmers, transporters, end-users → **Mobilization** of **unexploited** quantities → **Security** of supply.
- The investigation of the **local agricultural practices** can lead to a better understanding of the **biomass supply chain** and the associated **costs**.
- **Torrefaction** can **homogenize** biomass feedstocks with **diverse characteristics → standardization → contractualization.**
- The **applicability** of torrefaction in a **regional level** is highly dependent on the **cost minimization** of the overall **torrefied biomass value chain**.
- The torrefaction **investment cost** is mainly related to the **torrefaction reactor size** and can even **double** the total cost, depending on the application.
- **Lignite** (even with the carbon tax) and **wood-chips** fuel mix is the most **attractive option** from an economic point of view. However, it is only **feasible** as long as lignite is available (until 2025).
- Although torrefaction does not seem to be financially advantageous for DETEPA, it could solve the handling issues of non-woody biomass and create **a secondary market of standardized solid biomass fuels**, that will generate enough revenue for DETEPA to offset investment costs.
- Finally, **lignite phase-out** is a huge **challenge** for Western Macedonia:
  - The energy sector will suffer from significant increases in production costs.
  - Region's **GDP** is deeply intertwined with **PPCs activities**.

Thank you for your attention!

For more info:

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