Testing LocaGIStics tool for biomass chain design and evaluation

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FOOD & BIOBASED RESEARCH
WAGENINGEN UR




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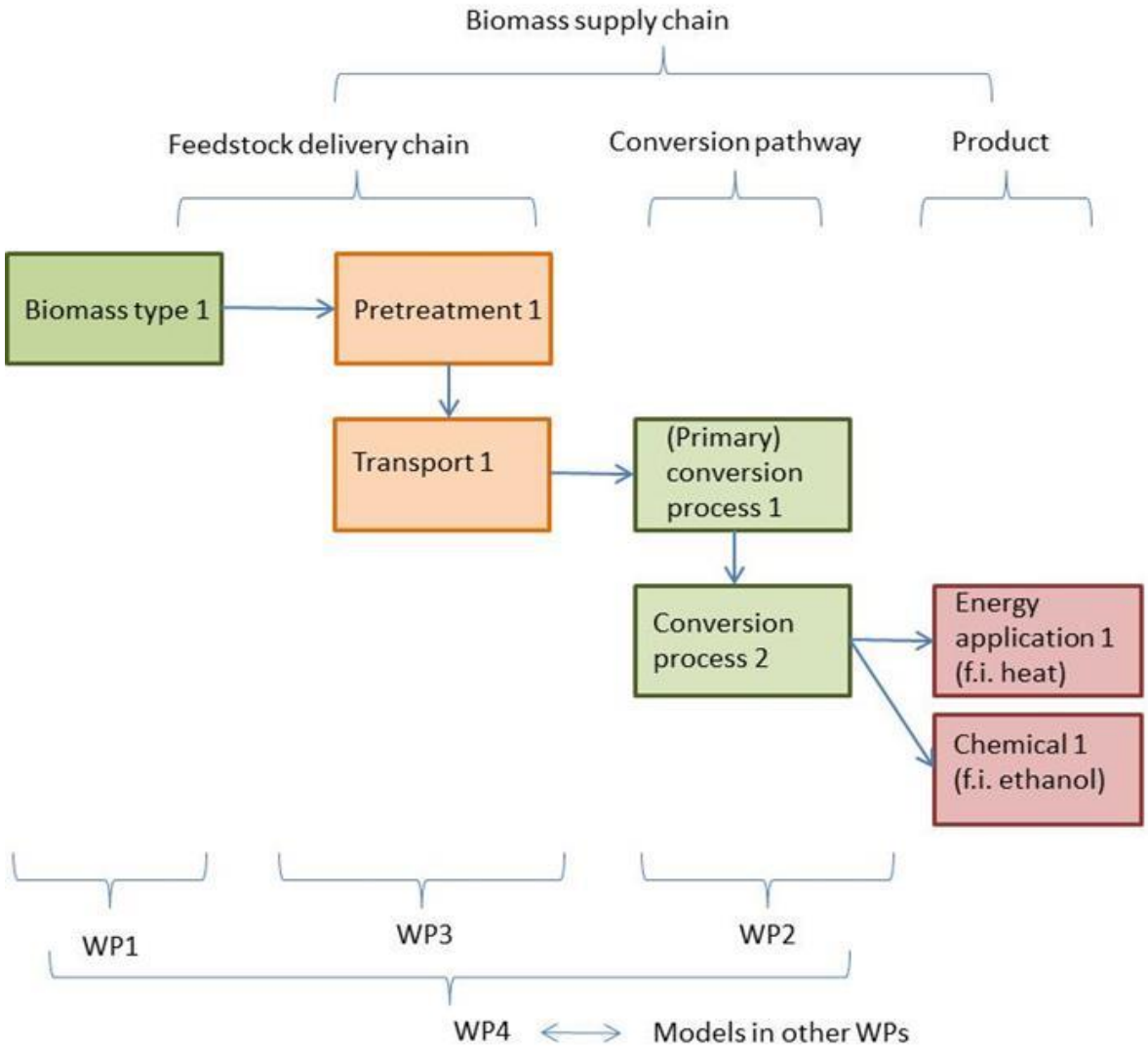
Outline

- Biomass supply chains
- BeWhere versus LocaGIStics
- Specifications LocaGIStics
- Testing the tool

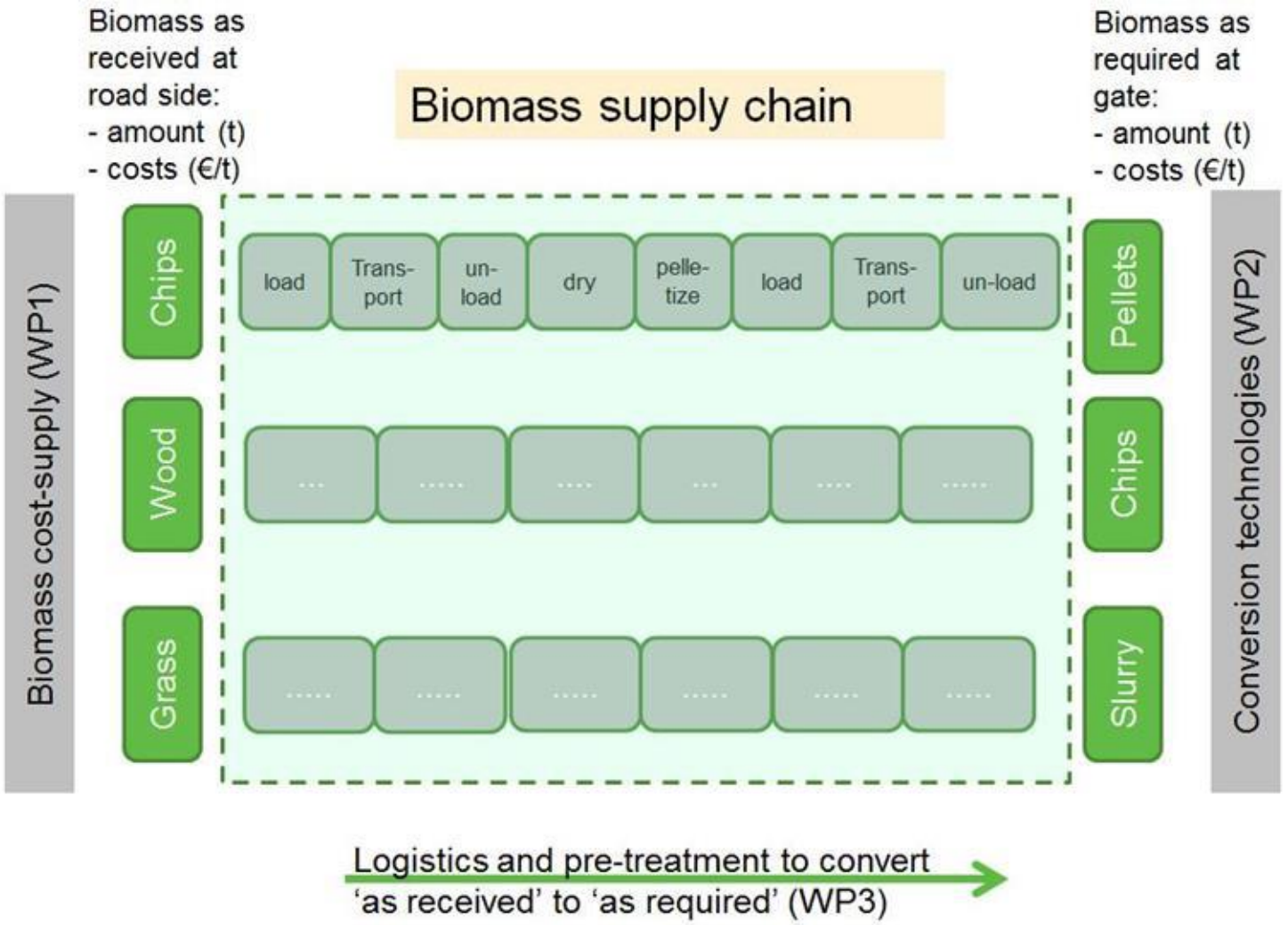
Biomass supply chain



Objectives & tasks WP3

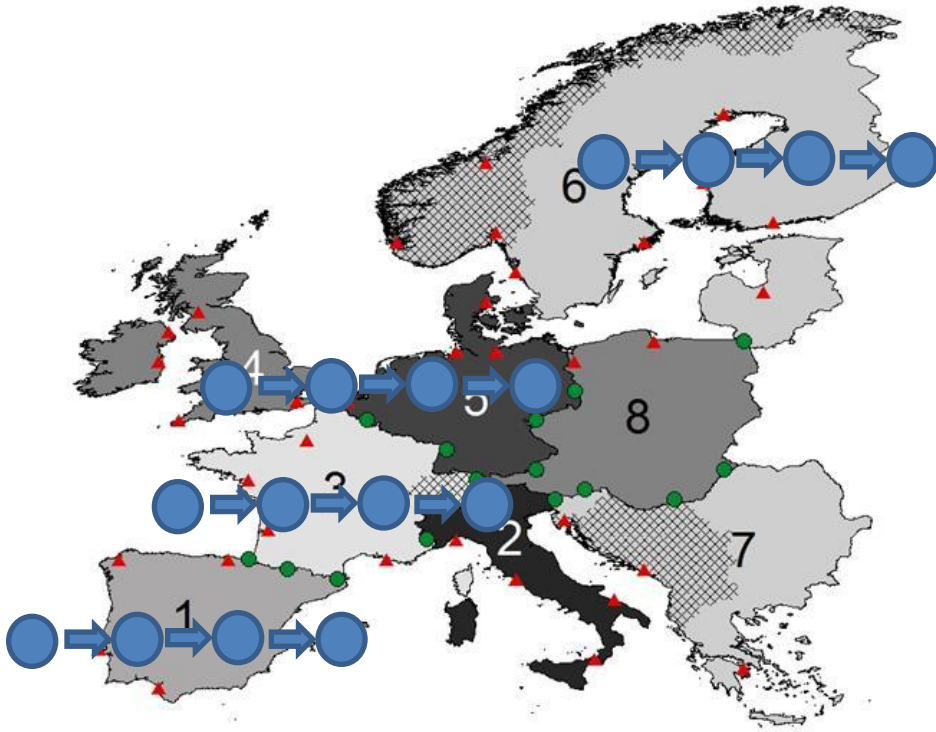
- to identify and characterise the main logistical components (such as storage, pre-treatment and transportation technologies)
- to identify and assess existing and develop new logistical concepts (e.g. biomass yards) to optimize sustainable non-food ligno-cellulosic biomass feedstock delivery chains
- to translate theoretical logistical concepts to specific cases, and design the most promising logistic supply-chains for cases at regional and European level

Biomass supply chains

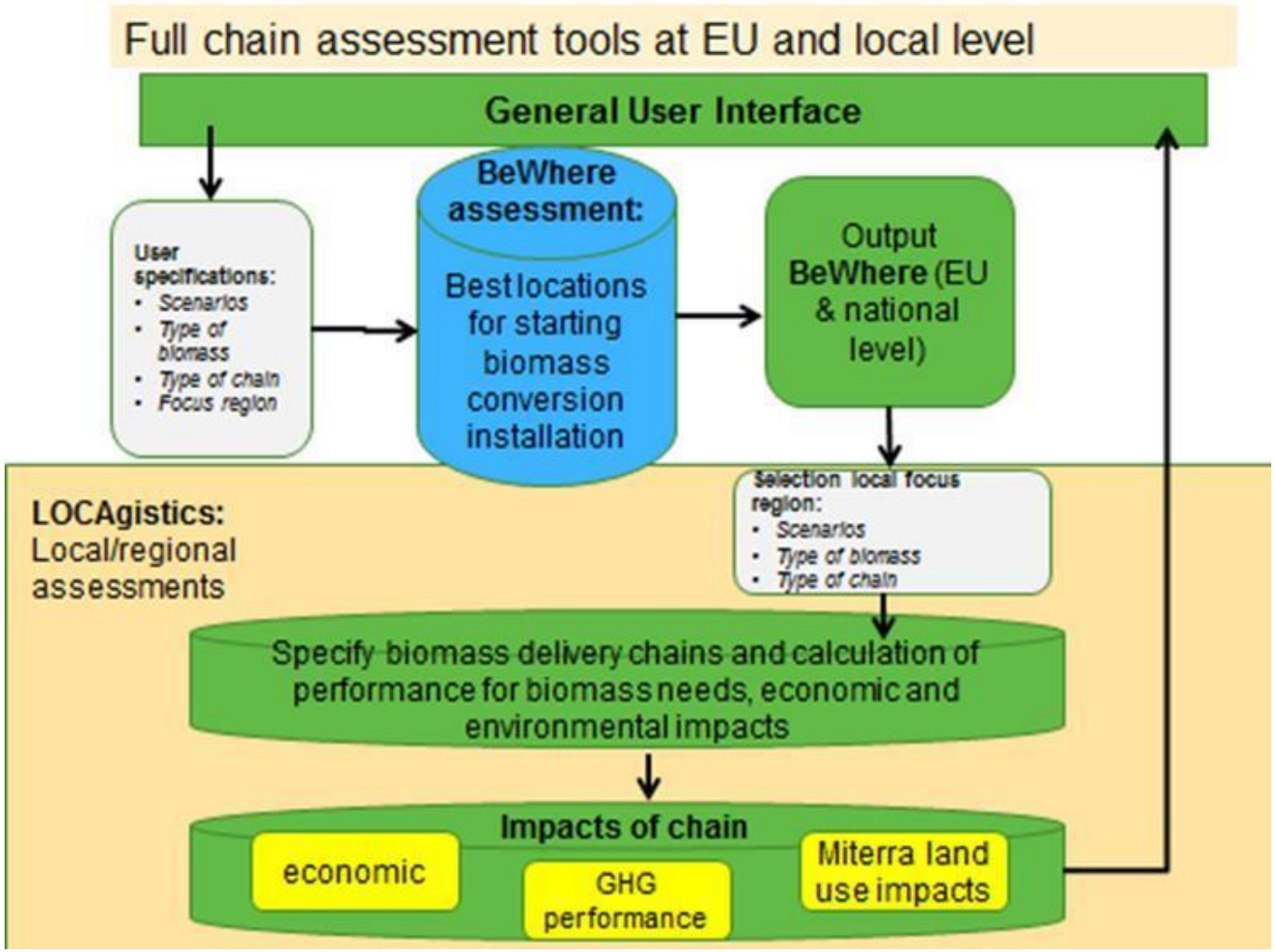


From component to case study

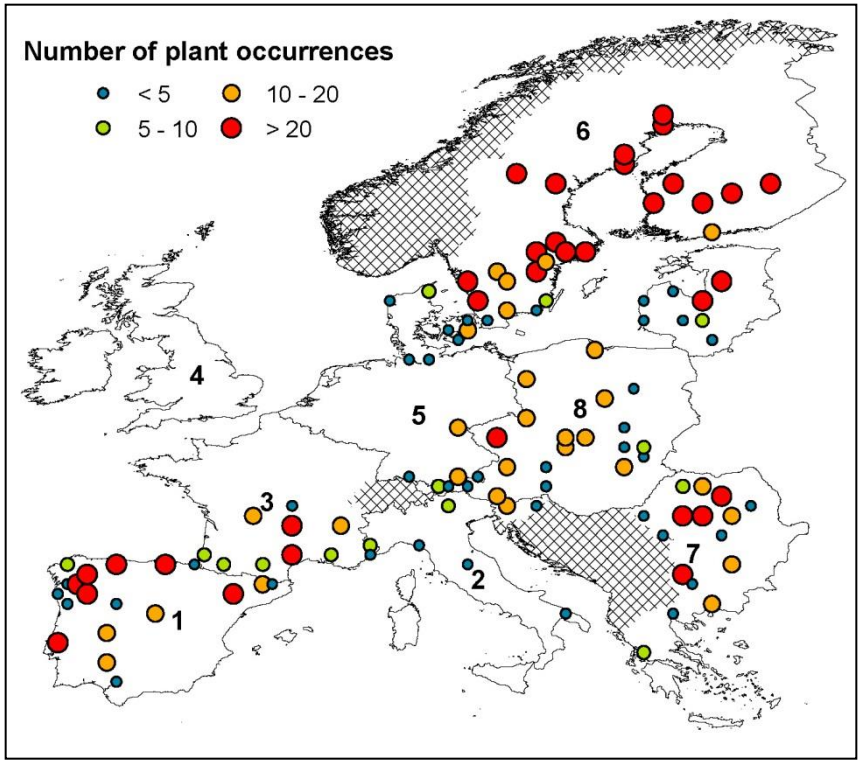
- **logistical component:**
- **logistical concept/chain:**
- **logistical concepts will be translated to**
  1. EU level (BeWhere)
  2. regional advanced case studies (LocaGIStics):
     - Finland (Infres)
     - France (LogistEC)
     - Spain (Europruning)

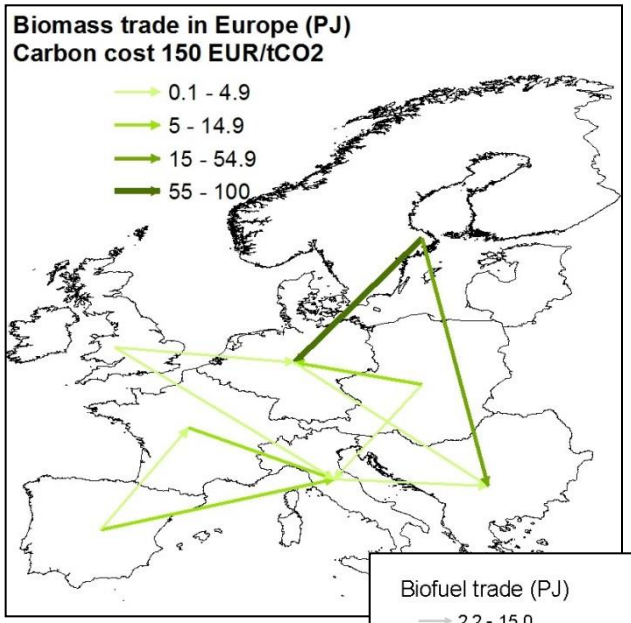


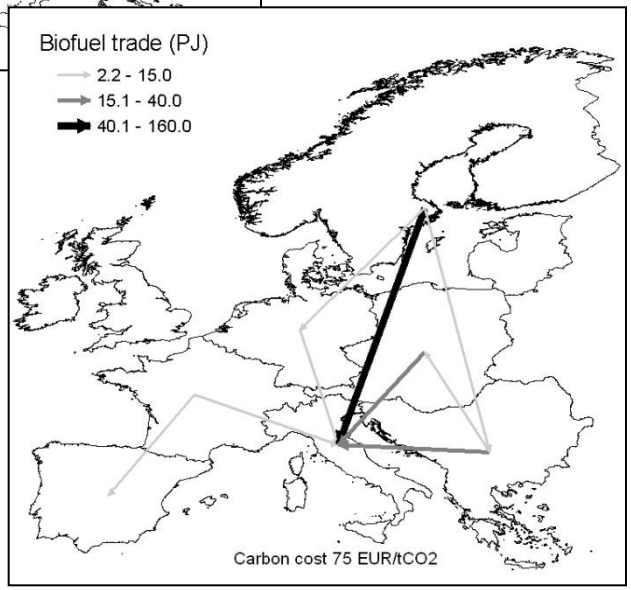
Two tools for assessments: BeWhere & Locagistics



Output BeWhere





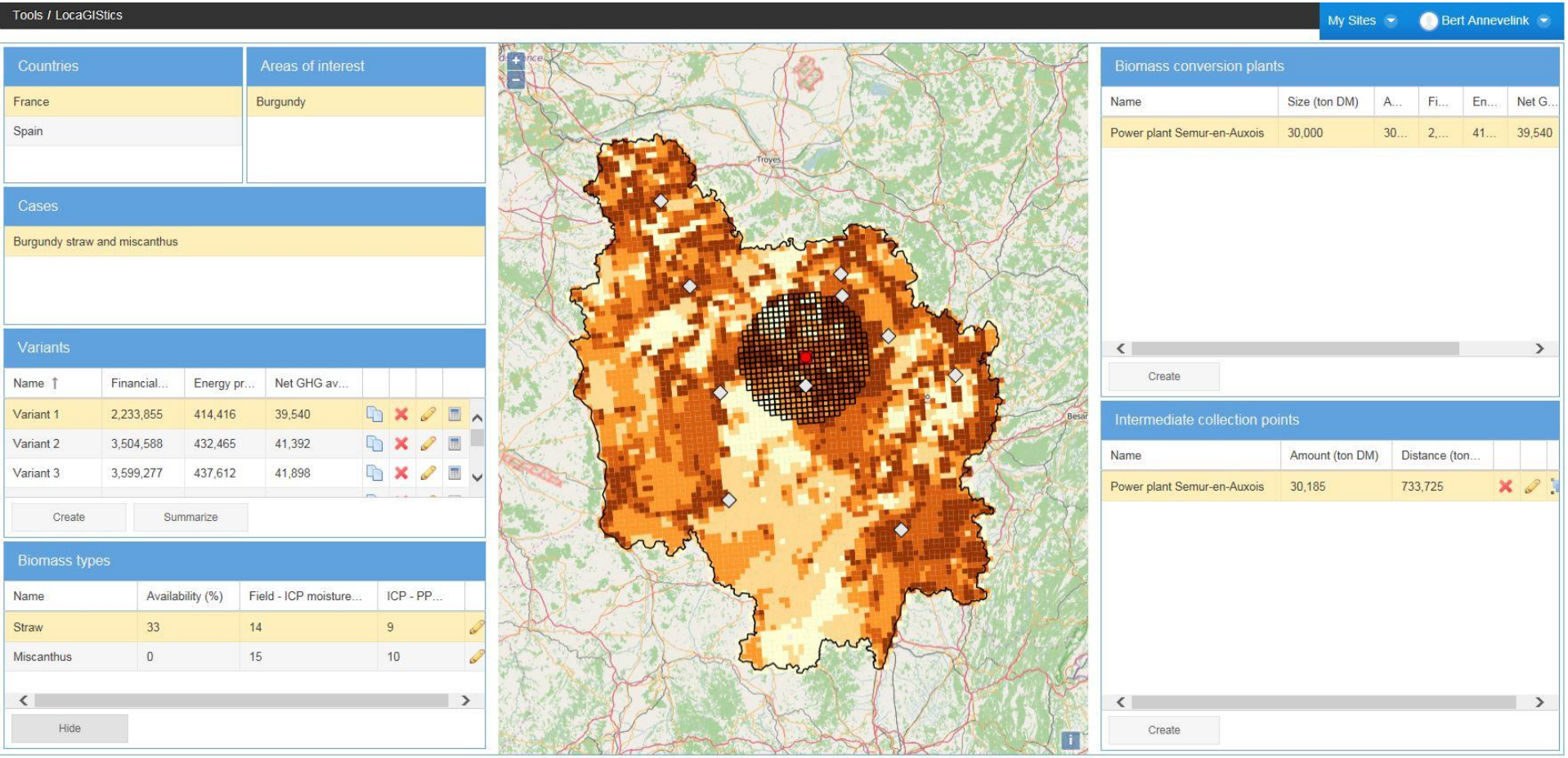


Source: Leduc et al., 2013
International Institute for Applied Systems Analysis (IIASA)

Regional level: LocaGIStics

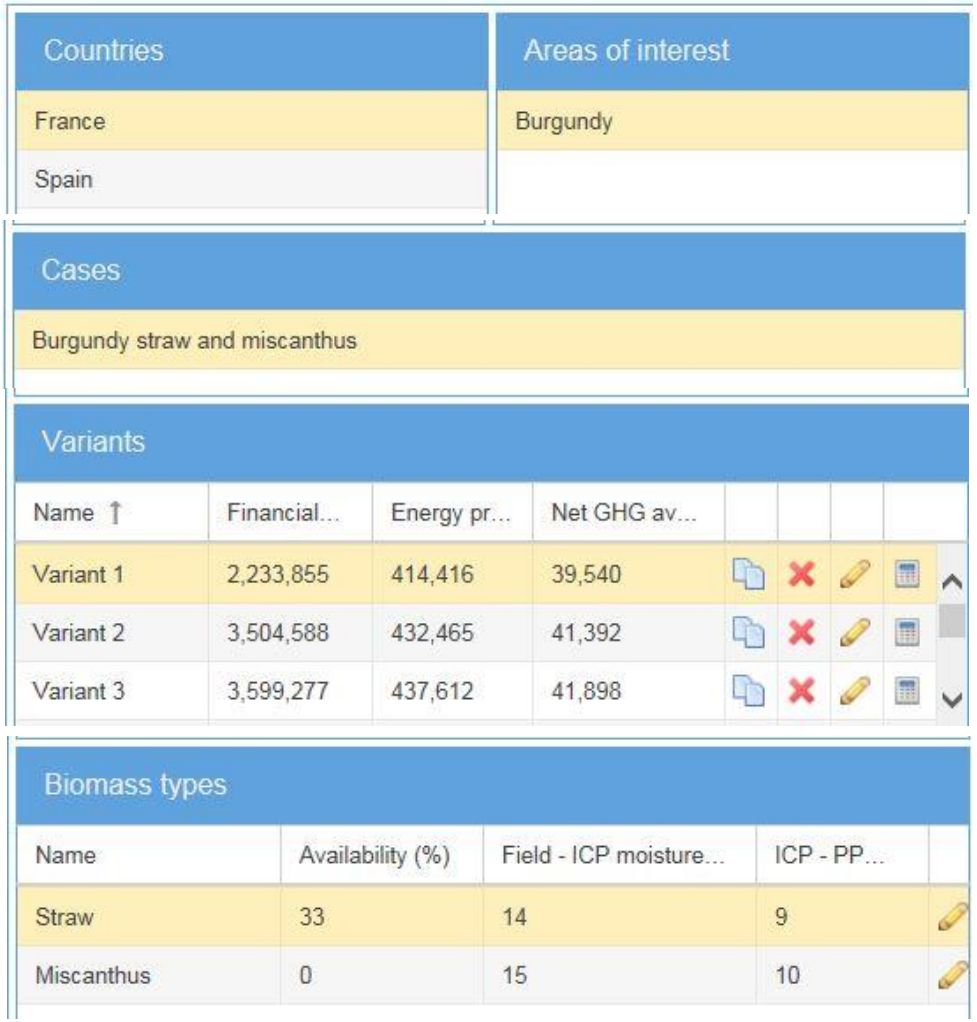
- LocaGIStics is a visual, interactive tool for the specification and assessment of biomass value chains
- it aims at regional level
- link with BeWhere model on an EU-/country level (output transferred to LocaGIStics)
- first developed in Dutch national ‘ME4’ project and now further developed for S2Biom

User interface - total



User interface - left hand side

- **country, area of interest, cases, variants, biomass types**



Countries	Areas of interest
France	Burgundy
Spain	

Cases
Burgundy straw and miscanthus

Variants

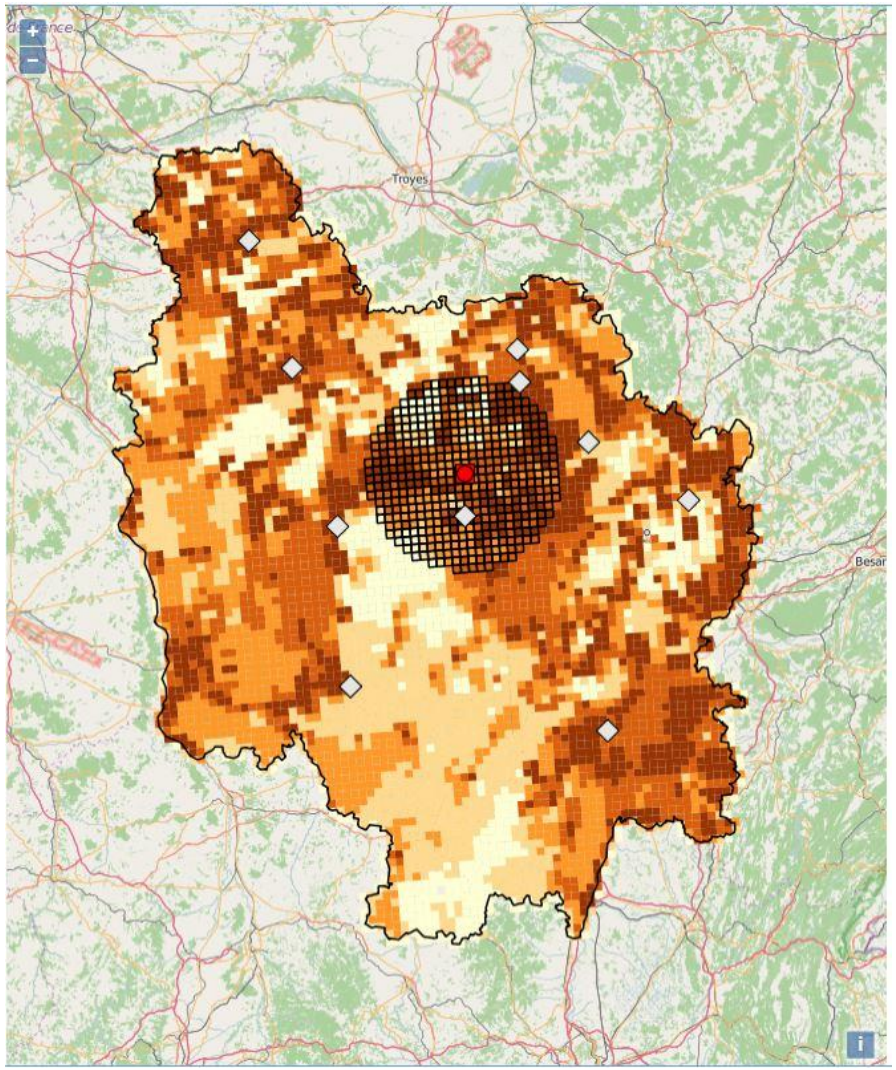
Name	Financial...	Energy pr...	Net GHG av...
Variant 1	2,233,855	414,416	39,540
Variant 2	3,504,588	432,465	41,392
Variant 3	3,599,277	437,612	41,898

Biomass types

Name	Availability (%)	Field - ICP moisture...	ICP - PP...
Straw	33	14	9
Miscanthus	0	15	10

User interface - middle

- regional biomass availability
- 10 powerplant locations suggested for the whole Burgundy region based on calculations BeWhere (white points)
- LOCAgistics will further analyse one of them in more detail



User interface - right hand side

- **power plant**
- **intermediate collection point**

Biomass conversion plants

Name	Size (ton DM)	A...	Fi...	En...	Net G...
Power plant Semur-en-Auxois	30,000	30...	2,...	41...	39,540

Intermediate collection points

Name	Amount (ton DM)	Distance (ton...			
Power plant Semur-en-Auxois	30,185	733,725			

Specify a case study

- position the power plant on the map
- position one or two intermediate collection points on the map
- start calculation: a GIS based ‘peeling heuristic’ determines biomass used (ton dm) and transport distances (ton.km) based on biomass availability maps

Four variants as an example

1. powerplant & no biomass yard; only straw
2. powerplant & no biomass yard; straw & Miscanthus
3. powerplant & one biomass yard; straw & Miscanthus
4. powerplant & two biomass yards; straw & Miscanthus

Variant 1

powerplant & no biomass yard; only straw

Tools / LocaGIStics

My Sites | Bert Annevelink

Countries

France
Spain

Areas of interest

Burgundy

Cases

Burgundy straw and miscanthus

Variants

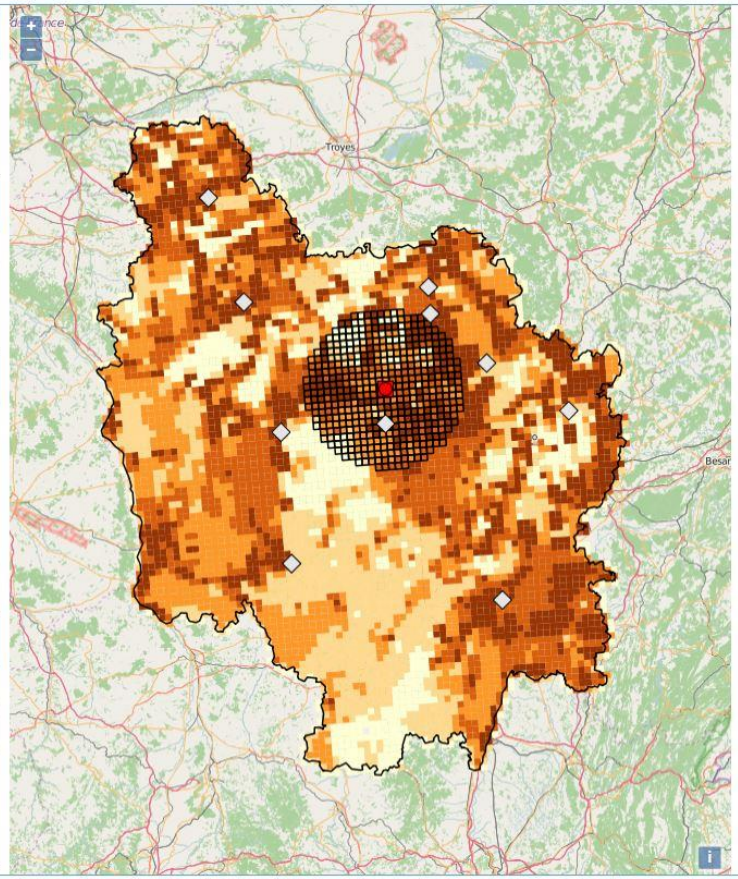
Name	Financial...	Energy pr...	Net GHG av...
Variant 1	2,233,855	414,416	39,540
Variant 2	3,504,588	432,465	41,392
Variant 3	3,599,277	437,612	41,898

Create | Summarize

Biomass types

Name	Availability (%)	Field - ICP moisture...	ICP - PP...
Straw	33	14	9
Miscanthus	0	15	10

Hide



Biomass conversion plants

Name	Size (ton DM)	A...	Fi...	En...	Net G...
Power plant Semur-en-Auxois	30,000	30...	2,...	41...	39,540

Create

Intermediate collection points

Name	Amount (ton DM)	Distance (ton...
Power plant Semur-en-Auxois	30,185	733,725

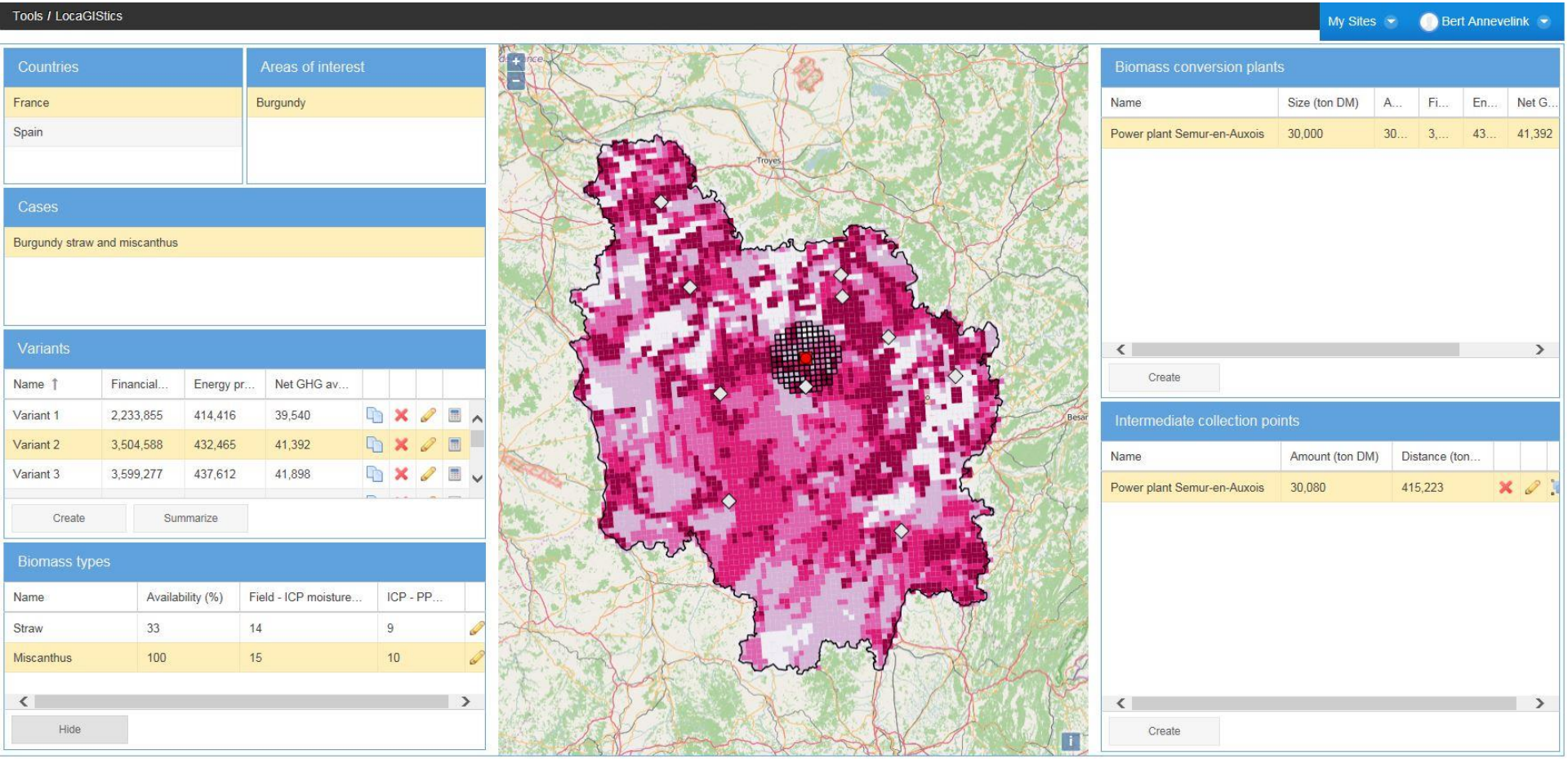
Create

Discussion Variant 1

- **map is shown for available straw (yellow)**
- **only 33% straw available, no Miscanthus (0%)**
- **the size of the collection circle can be influenced:**
  - by assuming a higher or lower biomass availability % for a certain biomass type
  - but also by adding more biomass types (e.g. also include Miscanthus in variant 2)

Variant 2

powerplant & no biomass yard; straw & Miscanthus



Discussion Variant 2

- different map is shown now: for Miscanthus (purple)
- smaller supply circle, because Miscanthus now is also available at closer distance
- notice that calculation results are different (e.g. profit)

Variant 3

powerplant & one biomass yard; straw & Miscanthus

Tools / LocaGIStics

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Countries

France
Spain

Areas of interest

Burgundy

Cases

Burgundy straw and miscanthus

Variants

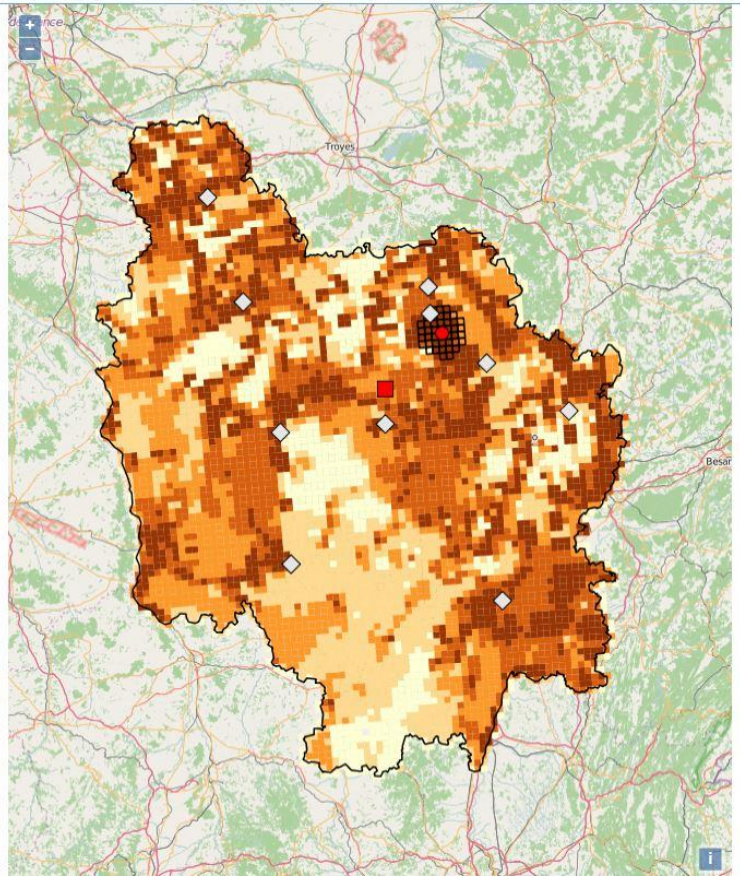
Name	Financial...	Energy pr...	Net GHG av...
Variant 1	2,233,855	414,416	39,540
Variant 2	3,504,588	432,465	41,392
Variant 3	3,599,277	437,612	41,898

Create | Summarize

Biomass types

Name	Availability (%)	Field - ICP moisture...	ICP - PP...
Straw	33	14	9
Miscanthus	100	15	10

Hide



Biomass conversion plants

Name	Size (ton DM)	A...	Fi...	En...	Net G...
Power plant Semur-en-Auxois	30,000	30...	3,...	43...	41,898

Create

Intermediate collection points

Name	Amount (ton DM)	Distance (ton...
ICP Magny-Lambert	30,316	207,798

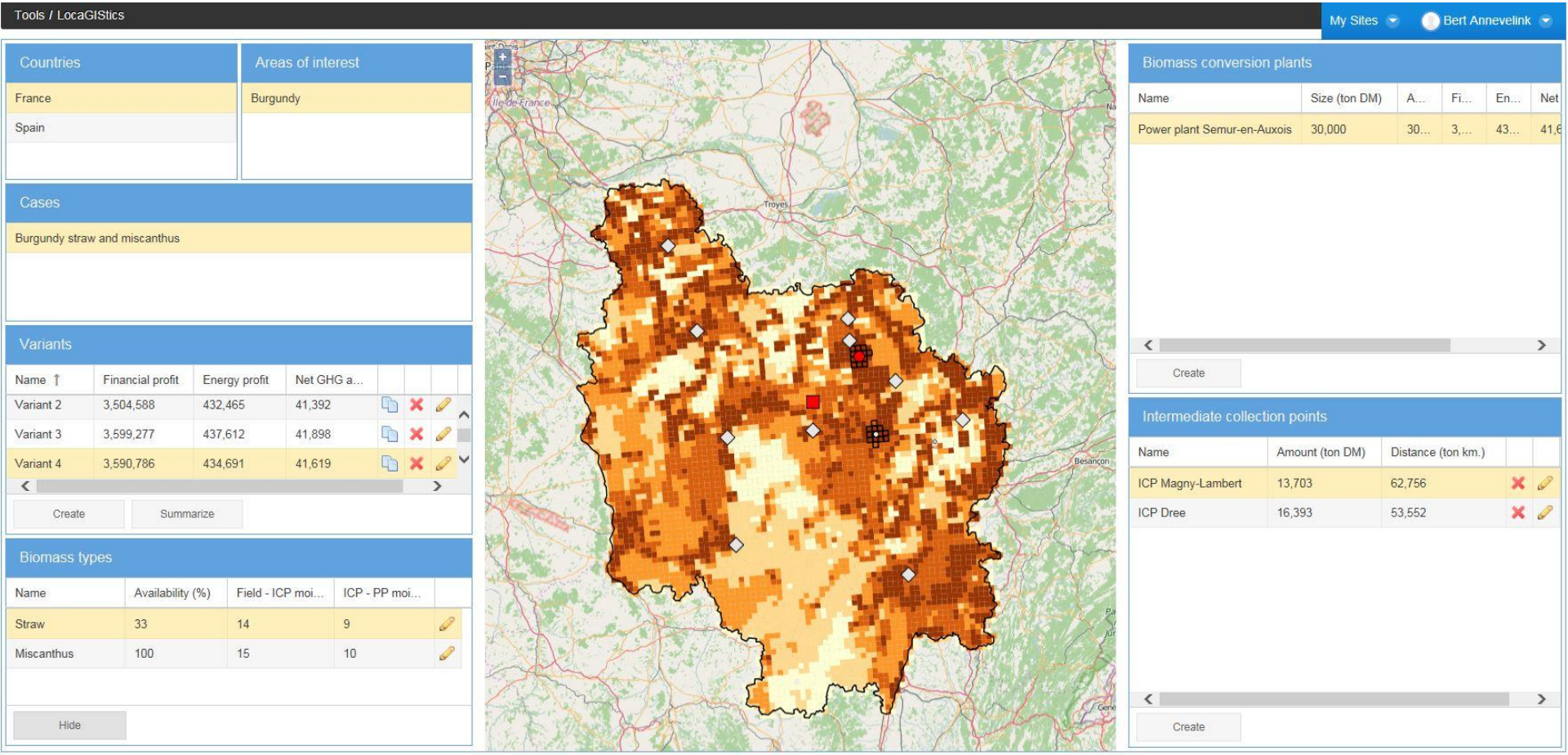
Create

Discussion variant 3

- separate location for power plant (red box) and intermediate collection point (red circle)
- intermediate collection point located near to area with a high biomass availability (e.g. rural area)
- power plant located near to area with a high energy demand (e.g. city)

Variant 4

powerplant & two biomass yards; straw & Miscanthus



Discussion Variant 4

- two intermediate collection points with a much smaller biomass collection circle
- for this size of the power plant two intermediate collection points is probably too much (very small circle)
- however, this can now be compared on costs, energy production and avoided GHG emissions with the tool

Variant 5

powerplant & two biomass yards; only straw

Tools / LocaGIStics

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Countries

France
Spain

Areas of interest

Burgundy

Cases

Burgundy straw and miscanthus

Variants

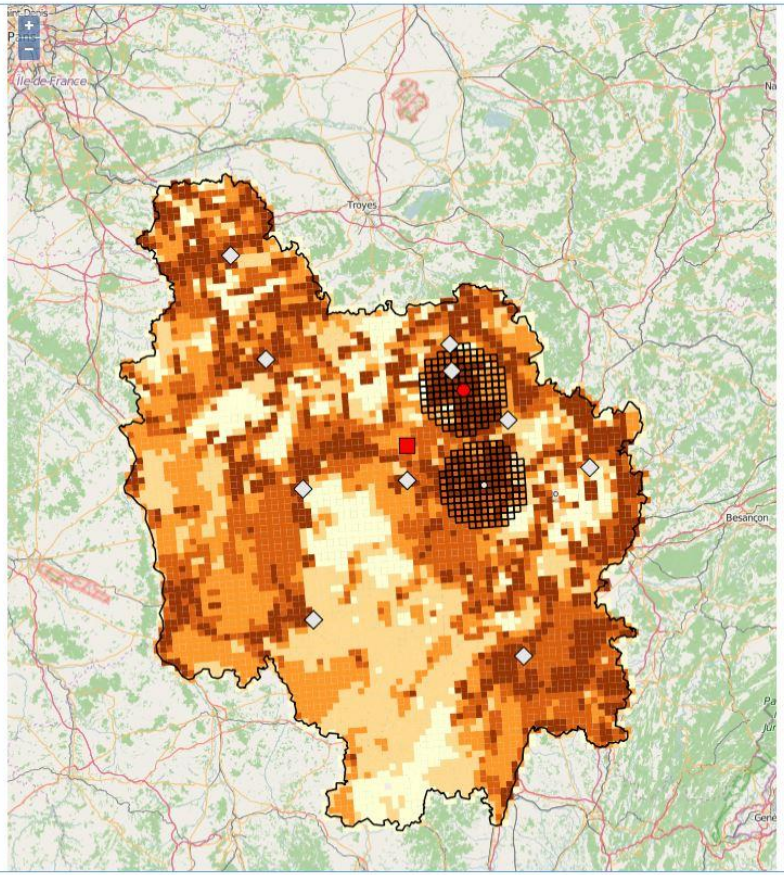
Name	Financial profit	Energy profit	Net GHG a…
Variant 3	3,599,277	437,612	41,898
Variant 4	3,590,786	434,691	41,619
Variant 5	2,185,450	412,737	39,381

Create | Summarize

Biomass types

Name	Availability (%)	Field - ICP moi…	ICP - PP moi…
Straw	33	14	9
Miscanthus	0	15	10

Hide



Biomass conversion plants

Name	Size (ton DM)	A…	Fi…	En…	Net
Power plant Semur-en-Auxois	30,000	30…	2,…	41…	39,3

Create

Intermediate collection points

Name	Amount (ton DM)	Distance (ton km.)
ICP Magny-Lambert	15,044	166,346
ICP Dree	15,023	166,220

Create

Discussion Variant 5

- two intermediate collection points with a larger biomass collection circle
- only straw might indeed require two points

Regional level: LocaGIStics

- **excel sheet calculates economics, energy production and avoided GHG emissions**

Variants

Task	Financial profit	Energy profit	Net GHG...	Ton fresh	Ton dry matter
Variant 5	2,185,450	412,737	39,381	34,961	30,067
Variant 1	2,233,855	414,416	39,540	35,099	30,185
Variant 2	3,504,588	432,465	41,392	35,267	30,080
Variant 3	3,599,277	437,612	41,898	35,571	30,316
Variant 4	3,590,786	434,691	41,619	35,317	30,096
Variant 6	3,640,437	435,355	41,698	35,243	30,007
Variant 7	3,530,676	434,886	41,641	35,335	30,111

Cost calculation method

- **LOCAgistics current cost calculation method based on Bioloco (logistical optimization model): 'simple chain calculation' in excel:**
  - specify basic chain data (biomass, storage, transport, loading/unloading, pre-treatment and conversion)
  - weight/volume restrictions of transport means
  - total transport distance calculated by 'biomass search procedure'
  - then overall revenues and costs are calculated

LocaGIStics basic chain data

Input basic	yellow = calculated	
Biomass basic	**B1**	**B2**
name	Straw	Miscanthus
Higher Heating value [GJ/ton dm]	17.00	18.50
initial moisture content [kg moisture/kg total]	16%	15%
biomass costs at roadside [euro/ton dm]	45.00	8.82
energy use biomass at roadside [GJ/ton dm]	0.50	0.84
Form basic	**F1**	**F2**
description form	bales	pellets
bulk density [kg dm/m3]	400	650
specific volume [m3/ton dm]	2.50	1.54
Storage basic	**S1**	**S2**
name	open air storage	covered storage
costs [euro/m3.month]	0.23	0.92
energy use [MJ/m3.month]	0.00	0.00
Transport basic	**FI to IC**	**IC to PP**
name	truck	walking floor
maximum volume [m3]	80	92.3
maximum weight [ton]	26.6	28
variable vehicle costs per driven km [euro/km]	3.26	3.10
fixed vehicle costs per load [euro]	0.00	0.00
transport energy [MJ/km]	4.48	4.48

LocaGIStics basic chain data

Transport basic	FI to IC	IC to PP
name	truck	walking floor
maximum volume [m3]	80	92.3
maximum weight [ton]	26.6	28
variable vehicle costs per driven km [euro/km]	3.26	3.10
fixed vehicle costs per load [euro]	0.00	0.00
transport energy [MJ/km]	4.48	4.48
Loading/unloading basic	**L1**	**L2**
transport type being (un)loaded	truck	walking floor
loading costs [euro/m3]	0.63	0.31
unloading costs [euro/m3]	0.50	0.25
loading energy [MJ/m3]	3.13	3.00
unloading energy [MJ/m3]	3.13	3.00
Pretreatment	**P1**	**P2**
name	pelletising	grinding
output form	pellets	powder
pretreatment costs [euro/m3]	22.80	9.74
pretreatment energy [MJ/m3]	4.00	6.00
drying costs [euro/ton moisture]	0.00	0.00
drying energy [MJ/ton moisture]	0.00	0.00

LocaGIStics basic chain data

Conversion	C1
name	combustion, grate boiler 5MWe, 10 MWth
net energy returns electricity [usable GJ/GJ input]	25.00%
net energy returns heat [usable GJ/GJ input]	60.00%
evaporation energy moisture [GJ/ton moisture]	2.256
capacity input [ton dm/month]	2,500
working hours [per month]	583
fixed costs plant + conversion [euro /year]	625,000.00
variable costs conversion [euro/ton dm input]	30.00
energy use [GJ/m3]	0.0002
emission CO2 [mg/Nm3]	0
emission NOx [mg/Nm3]	475
emission SO2 [mg/Nm3]	0
emission dust [mg/Nm3]	3,000
Revenues	**PP**
price electricity [euro/GJ]	53.61
price heat [euro/GJ]	3.17
Legenda	
B1 = biomass type 1; B2 = biomass type 2	
IC= intermediate collection point; PP = power plant	
FI=Field	

LocaGIStics chain design

Input chain	yellow = calculated organge = fixed				
Chain					**Formula**
case description	Burgundy				
calculation number	1				
biomass chain name	bioenergy				
Chain design	**B1 to IC1**	**B1(IC1) to PP**	**B2 to IC1**	**B2(IC1) to PP**	
	Straw to [default nan	Straw ([default name	Miscanthus to [defau	Miscanthus ([default	name]) to [default name]
Biomass					
biomass type	Straw	Straw	Miscanthus	Miscanthus	taken from Input basic
origin location	Field	IC1	Field	IC1	fixed
destination location	IC1	PP	IC1	PP	fixed
description form	bales	pellets	bales	pellets	taken from Input basic
bulk density [kg dm/m3]	400	650	400	650	taken from Input basic
specific volume [m3/ton dm]	2.50	1.54	2.50	1.54	1000/bulk density
biomass shipped fresh [ton fresh]	4,285	4,049	31,054	29,329	biomass dry matter / (100 - initial moisture content) * 100
moisture content [kg moisture/kg total]	14%	9%	15%	10%	only original biomass moisture content inserted, other manual
biomass shipped dry [ton dm]	3,685	3,685	26,396	26,396	transfer from LOCAgistics
Storage					
name	open air storage	covered storage	open air storage	covered storage	taken from Input basic
costs [euro/m3.month]	0.23	0.92	0.23	0.92	taken from Input basic
energy use [MJ/m3.month]	0.00	0.00	0.00	0.00	taken from Input basic
average storage time [month]	4.5	4.5	4.5	4.5	default that can be changed
Transport basic					
name	truck	walking floor	truck	walking floor	taken from Input basic
maximum volume [m3]	80	92	80	92	taken from Input basic
maximum weight [ton]	27	28	27	28	taken from Input basic
variable vehicle costs per driven km [euro/km]	3.26	3.10	3.26	3.10	taken from Input basic
fixed vehicle costs per load [euro]	0.00	0.00	0.00	0.00	taken from Input basic
transport energy [MJ/ton.km]	4.48	4.48	4.48	4.48	taken from Input basic
total transport [ton.km]	54,403	211,847	392,036	1,535,414	transfer from LOCAgistics
transported weigt per trip (if volume limited) [ton]	32.0	60.0	32.0	60.0	max volume/specific volume

LocaGIStics chain design

Loading/unloading basic					
transport type being (un)loaded	truck	walking floor	truck	walking floor	taken from Input basic
loading costs [euro/m3]	0.63	0.31	0.63	0.31	taken from Input basic
unloading costs [euro/m3]	0.5	0.25	0.5	0.25	taken from Input basic
loading energy [MJ/m3]	3.13	3.00	3.13	3.00	taken from Input basic
unloading energy [MJ/m3]	3.13	3.00	3.13	3.00	taken from Input basic
Pretreatment					
name	pelletising	grinding	pelletising	grinding	
biomass output	pellets	powder	pellets	powder	
pretreatment costs [euro/m3]	22.80	9.74	22.80	9.74	
pretreatment energy [MJ/m3]	4.00	6.00	4.00	6.00	
drying costs [euro/ton moisture]	0.00	0.00	0.00	0.00	
drying energy [MJ/ton moisture]	0.00	0.00	0.00	0.00	
Percentage moisture content	14	9	15	10	

LocaGIStics calculation

Costs and revenues value chain					
	organge = fixed				
Costs	**B1 to IC1**	**B1(IC1) to PP**	**B2 to IC1**	**B2(IC1) to PP**	**Sum**
purchase costs [euro]	165,818	0	232,815	0	398,632
storage costs [euro]	9,535	23,470	68,300	168,124	269,428
transport costs [euro]	5,542	10,946	39,939	79,336	135,764
number of transports	115	61	825	440	1,441
loading/ unloading costs [euro]	10,410	3,175	74,569	22,741	110,895
pretreatment costs [euro]	210,036	55,216	1,504,584	395,537	2,165,373
drying costs [euro]	0	0	0	0	0
variable conversion costs [euro]	0	110,545	0	791,886	902,432
fixed conversion costs [euro]	0	0	0	625,000	625,000
total conversion costs [euro]					1,527,432
Revenues					
electricity [euro]	7,294,567	electricity * payment electricity			
heat [euro]	1,035,200	heat * payment heat			

Costs and revenues value chain	
Costs	
purchase costs [euro]	biomass shipped dry [ton dm] * biomass costs at roadside [euro/ton dm]
storage costs [euro]	biomass shipped dry [ton dm] * specific volume [m3/ton dm] * storage costs [euro/m3.month] * average storage time [month]
transport costs [euro]	(total transport [ton.km] * variable vehicle costs per driven km [euro/km])/ transported weigt per trip (if volume limited) [ton]
number of transports	biomass shipped dry [ton dm] / max volume or year consumed biomass / transported weight (in case of volume limited)
loading/ unloading costs [euro]	biomass shipped dry [ton dm] * specific volume [m3/ton dm] * (loading costs [euro/m3] + unloading costs [euro/m3])
pretreatment costs [euro]	biomass shipped dry [ton dm] * specific volume [m3/ton dm] * pretreatment costs [euro/m3]
drying costs [euro]	biomass shipped dry [ton dm] * specific volume [m3/ton dm] * drying costs [euro/ton moisture]
variable conversion costs [euro]	biomass shipped dry [ton dm] * variable costs conversion [euro/ton dm input]
fixed conversion costs [euro]	fixed costs plant + conversion [euro /year] ONLY ONCE!
total conversion costs [euro]	variable conversion costs + fixed conversion costs [euro]

LocaGIStics output

Output simple chain calculation

Case description	Burgundy		
Calculation number	1		
Biomass chain name	bioenergy		
Total throughput:			
[ton dm]:			
from sources	30,081		
Revenues and costs:			
[euro]			
electricity revenues	7,294,567		
heat revenues	1,035,200	total revenues	8,329,766
purchase costs	398,632		
storage costs	269,428		
transport costs	135,764		
loading/unloading costs	110,895		
pretreatment costs	2,165,373		
drying costs	0		
conversion costs	1,527,432	total costs	4,607,524
		profit	3,722,243

Demonstration

public site:

http://s2biom.alterra.wur.nl/web/guest/home

test site:

http://s2biom-test.alterra.wur.nl/web/guest/home

Thank you for your attention!

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WAGENINGEN UR

**Bert Annevelink, Bas Vanmeulebrouk,
Igor Staritsky & Berien Elbersen**




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