The Chain Design Tool LocaGIStics

Bert Annevelink

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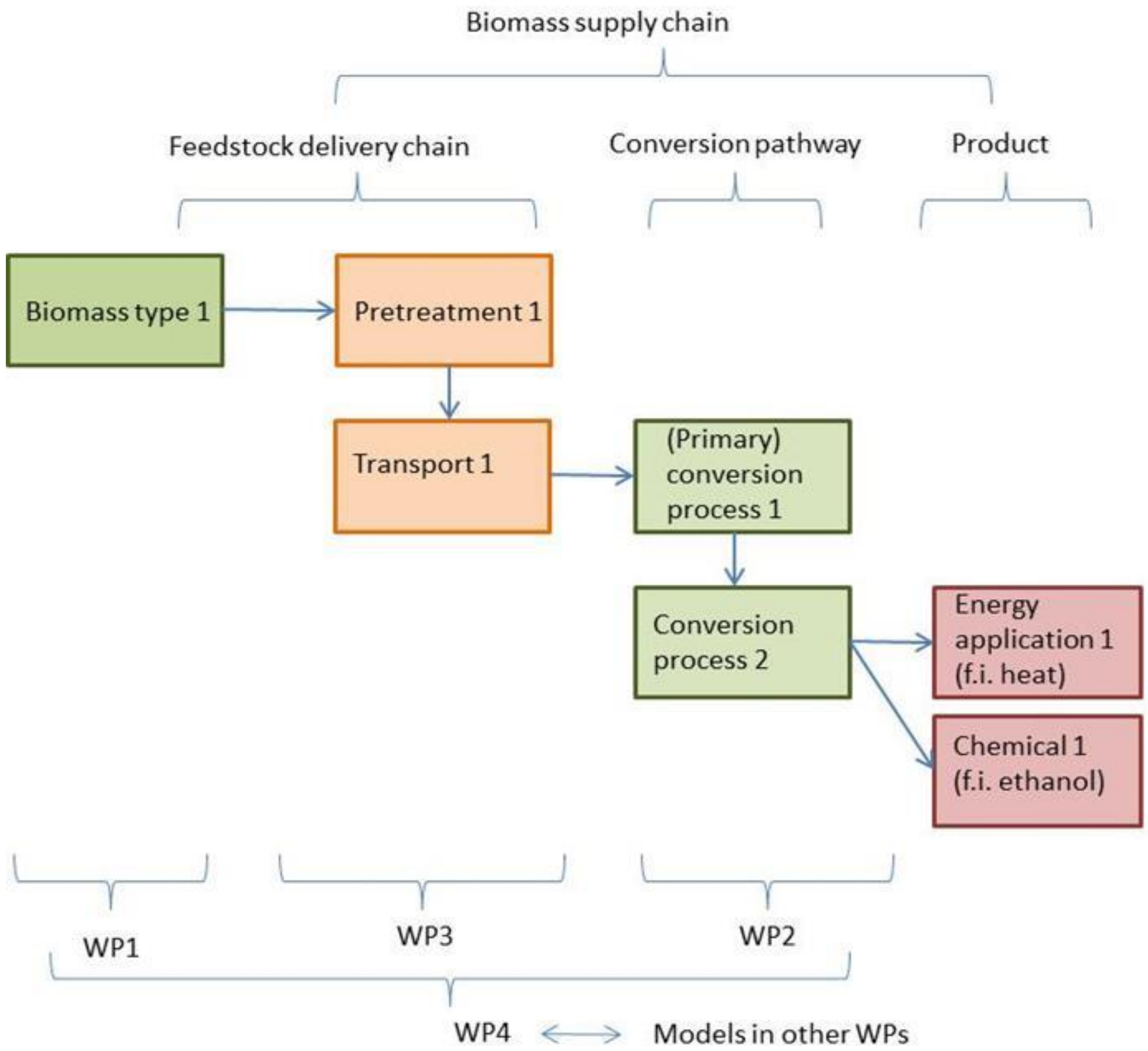
Outline

- logistics & chain design in S2Biom
- BeWhere versus LocaGIStics
- specifications LocaGIStics
- five examples
- testing

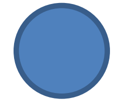
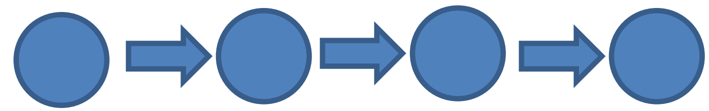
Biomass supply chain

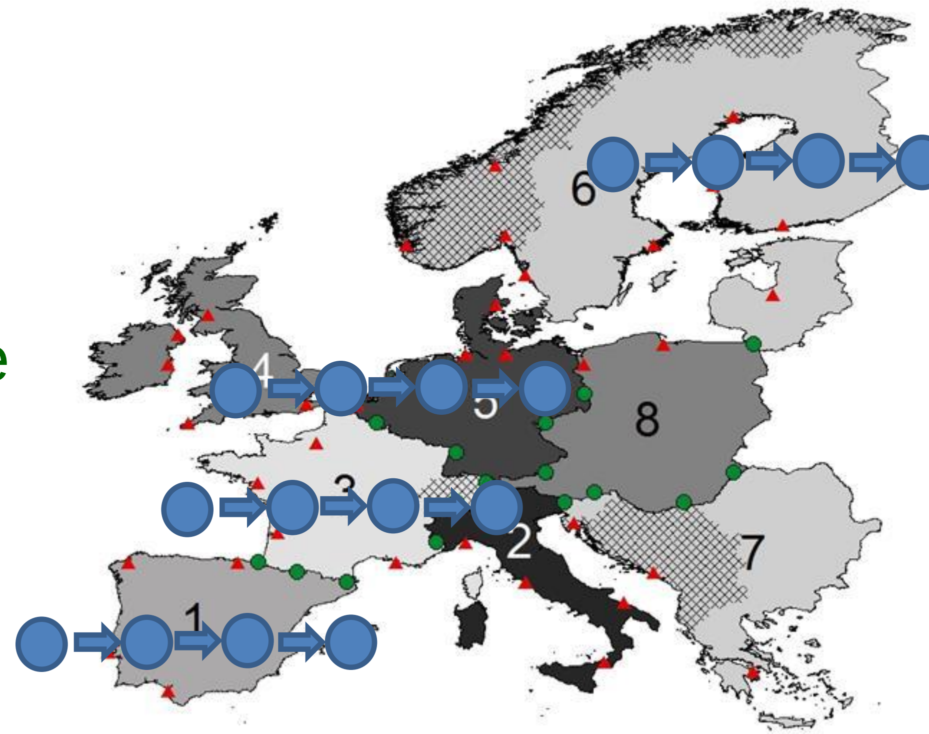


Objectives & tasks WP3

- 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

From component to case study

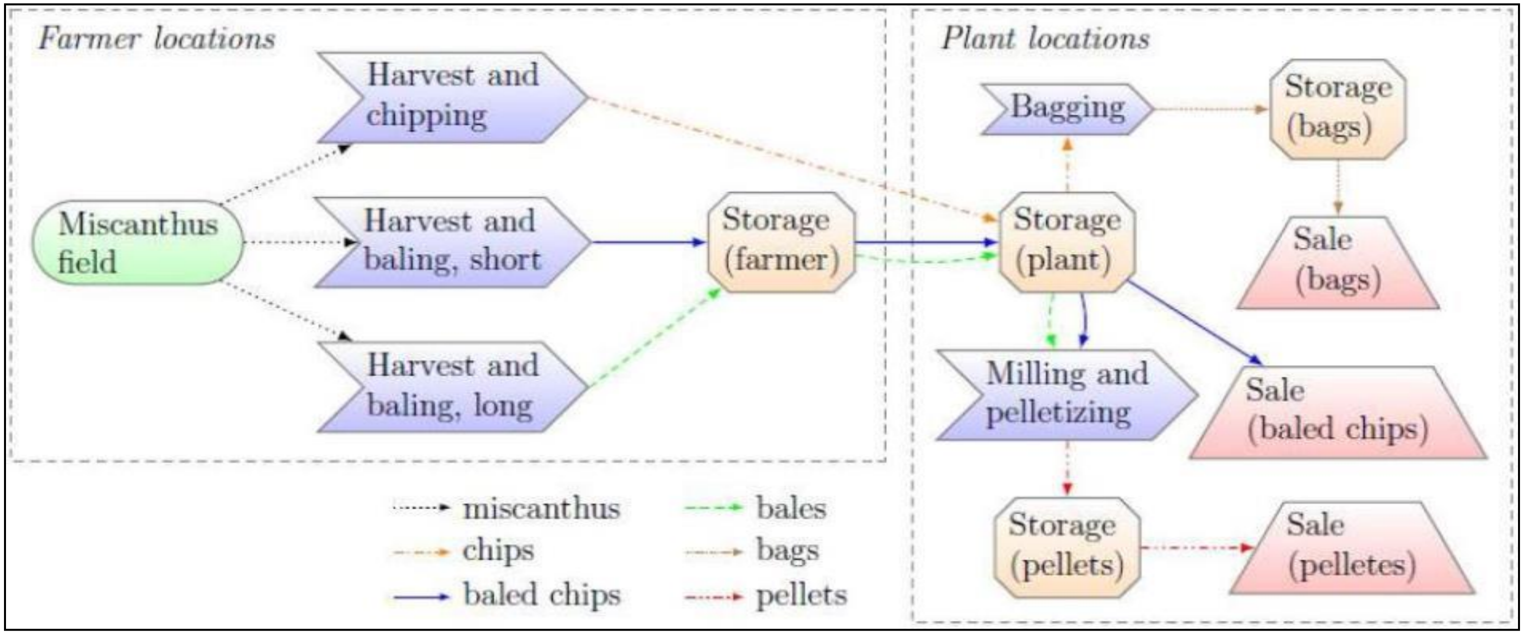
- **logistical component:** 
- **logistical concept/chain:** 
- **logistical concepts will be translated to**
  1. EU level (BeWhere)
  2. regional advanced case studies (LocaGIStics):
     - Finland (Infres)
     - France (LogistEC)
     - Spain (Europruning)



Case study LogistEC

Two options Burgundy:

1. Miscanthus bales through farm to pellet factory
2. Miscanthus chips straight to pellet factory



Chain LogistEC

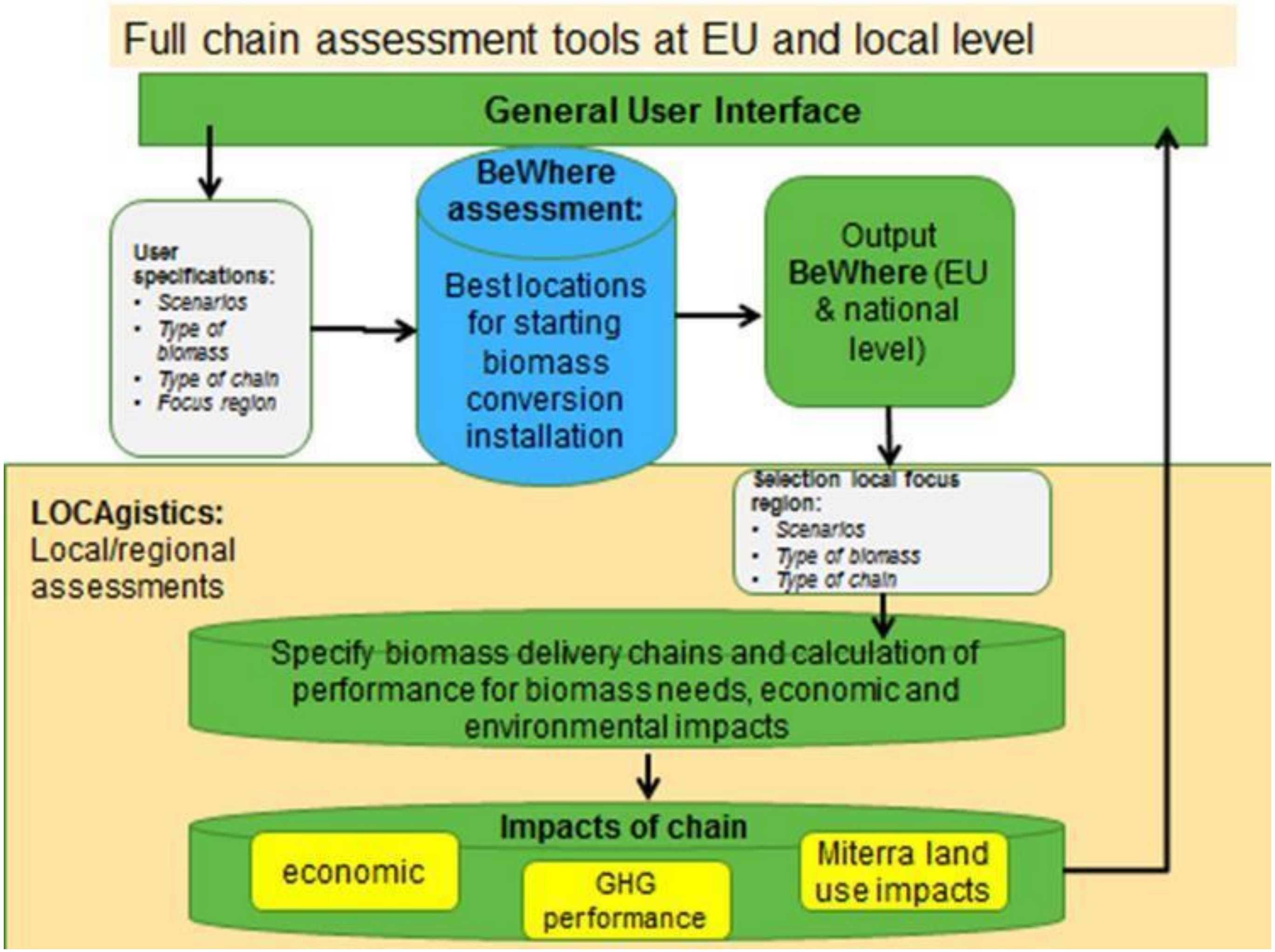
The biomass value chain ‘Option 2 - Miscanthus chips straight to pellet factory’ in Burgundy, France.

What?	How?	Where?
harvesting & chipping of Miscanthus	tractor 240 hp (Fendt vario 724) with mower & chipper blowing chips straight into trailer	on the field
transport chips	tractor 200 hp & trailer (capacity 50 m^3 or 6.1 t) Platform truck (capacity 65 m^3 or 8 t)	from roadside to pellet factory
unloading of chips	telehandler 75 hp (Manitou)	at pellet factory
storage of chips	in storage building	at pellet factory
on-site conveying of chips	conveyor belt	at pellet factory
pelletizing of chips	pelletization	at pellet factory
on-site conveying of pellets	conveyor belt	at pellet factory
storage of pellets	pellet silo	at pellet factory
on-site conveying of pellets	conveyor belt	at pellet factory
package pellets in bags	big bag filling system	at pellet factory
load bags with pellets	telehandler	at pellet factory
transport bags with pellets	truck	from pellet factor to conversion site
unload bags with pellets	telehandler	at conversion site
storage of bags with pellets	storage building	at conversion site
on-site conveying of pellets	conveyor belt	at conversion site
bioenergy production	combustion installation	at conversion site

General logistical concepts

Variant 1	Variant 2
pre-treatment integrated with harvesting/collecting	stand-alone pre-treatment later on in the biomass chain
indirect supply through biomass yards to the final conversion location	direct supply from the road-side to the final conversion location
multi-modal transportation (combination of different types)	only one transport modality (road, water or rail)
standardized biocommodities (e.g. wood pellets, ethanol, pyrolysis oil)	‘raw’ biomass (e.g. wood chips, bales)
‘light’ pre-treatments (e.g. comminution, densification, drying)	‘intensive’ pre-treatments (e.g. pyrolysis, torrefaction)
many small-scale conversion plants	one large-scale conversion plant

Two tools for assessments: BeWhere & Locagistics



BeWhere / LocaGIStics

BeWhere

- supply chain optimization
- national level
- policy maker
- rough grid
- determine the optimal geographic location of production plants

LocaGIStics

- supply chain simulation
- regional level
- project developer
- finer grid
- use one of the plant locations optimized from BeWhere & refine it

Regional level: LocaGIStics

- LocaGIStics is a visual, interactive tool for the specification and assessment of biomass value chains at regional level
- there is a link with BeWhere model on an EU-/country level (output transferred to LocaGIStics)
- graphical user interface combined with calculations in a dedicated excel-file (see annex)

User interface - total

S2Biom

Tools / LocaGIStics

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Countries
France
Spain

Areas of interest
Burgundy

Cases
Burgundy straw and miscanthus

Variants

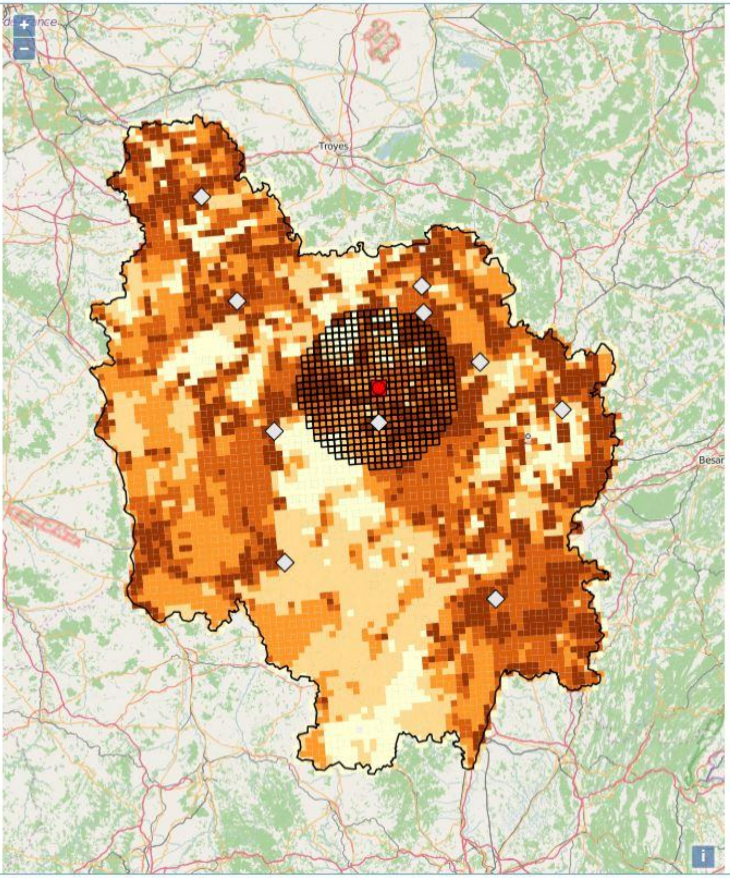
Name	Financial...	Energy pr...	Net GHG av...
Variant 1	2,233,855	414,416	39,540
Variant 2	3,504,588	432,465	41,392
Variant 3	3,599,277	437,612	41,898

Create | Summarize

Biomass types

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

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

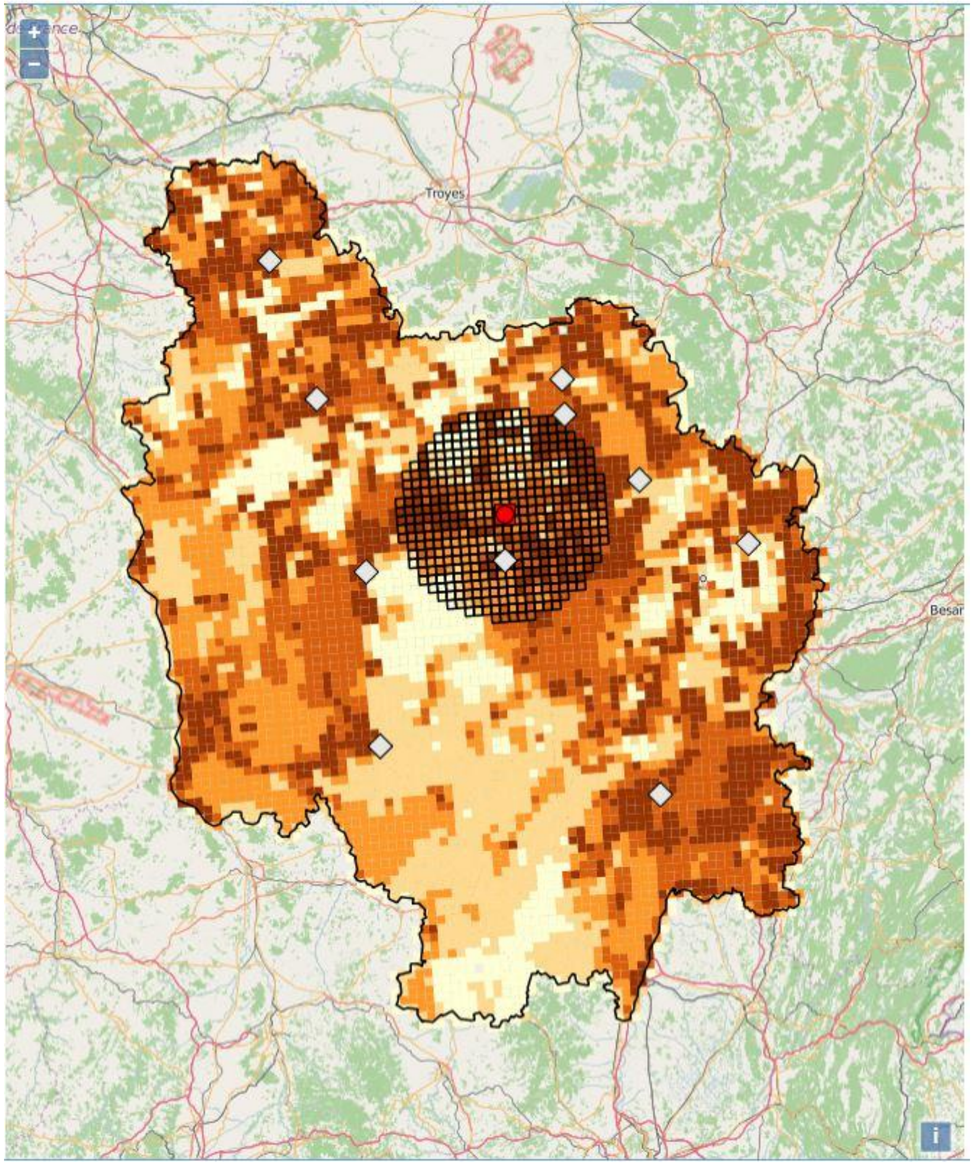
Name	Financial...	Energy pr...	Net GHG av...
Variant 1	2,233,855	414,416	39,540
Variant 2	3,504,588	432,465	41,392
Variant 3	3,599,277	437,612	41,898

Biomass types

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

User interface - middle

- regional biomass availability per grid cell
- powerplant locations suggested for the whole Burgundy region based on calculations of BeWhere (white points)
- LOCAgistics will further analyse chain towards one power plant in more detail (red square)



User interface - right hand side

- **power plant**

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 point**

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

Specify a case study (1)

- **make new variant of biomass value chain design**

Edit variant

Name:	Test 1
Financial profit:	0
Energy profit:	0
Net GHG avoided:	0
Change in organic matter content (kton CO2-eq):	0
Direct N2O emission (kton CO2-eq):	0
Indirect N2O emission (kton CO2-eq):	0

Reset Submit

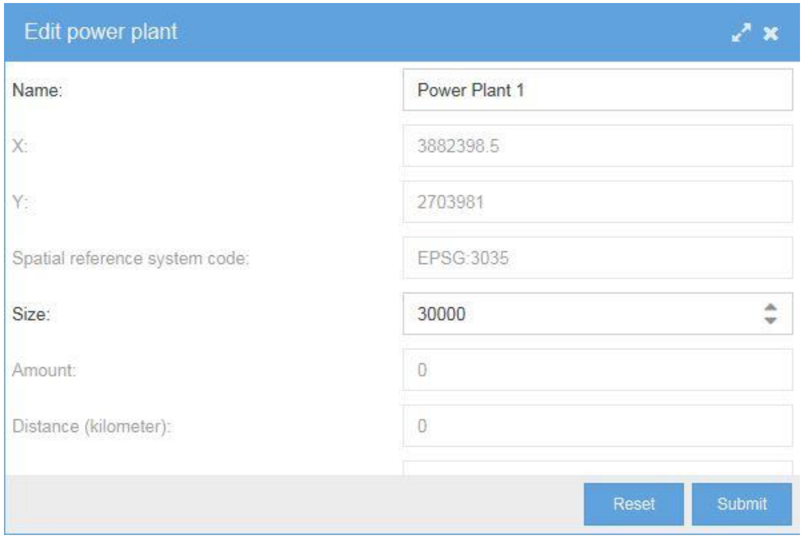
- **specify share of biomass types**

Biomass types

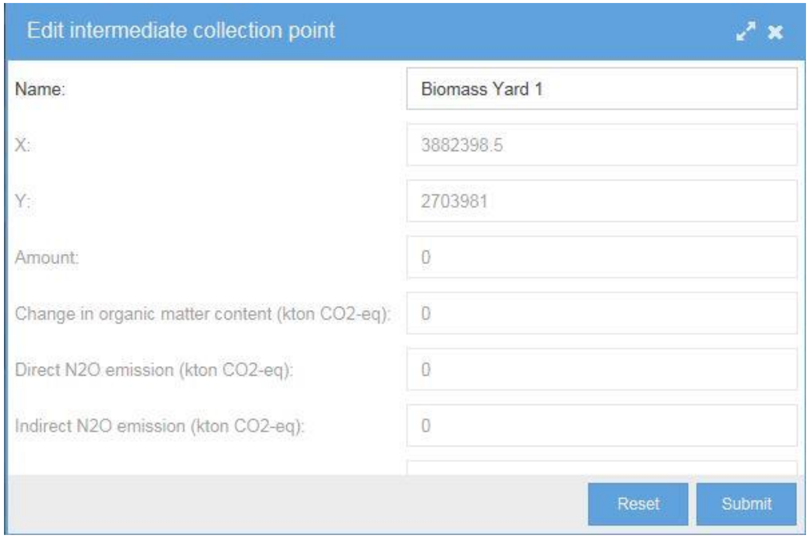
Name	Availa...	Field -...	ICP -...
Straw	33	14	9
Miscanthus	0	15	10

Specify a case study (2)

- **create biomass conversion plant**

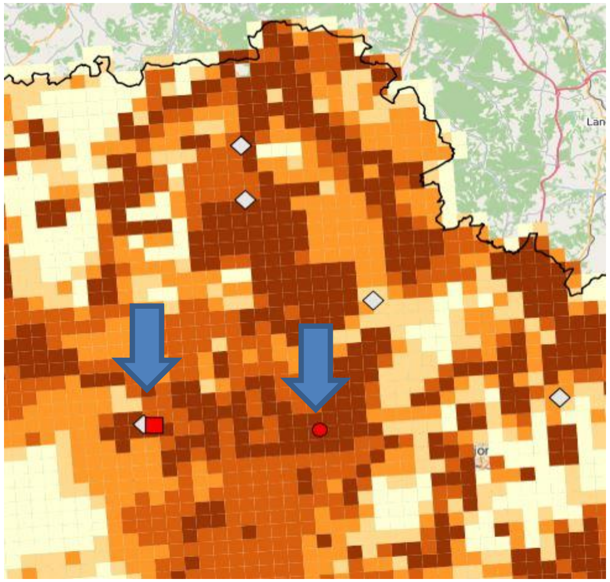


- **create intermediate collection point**

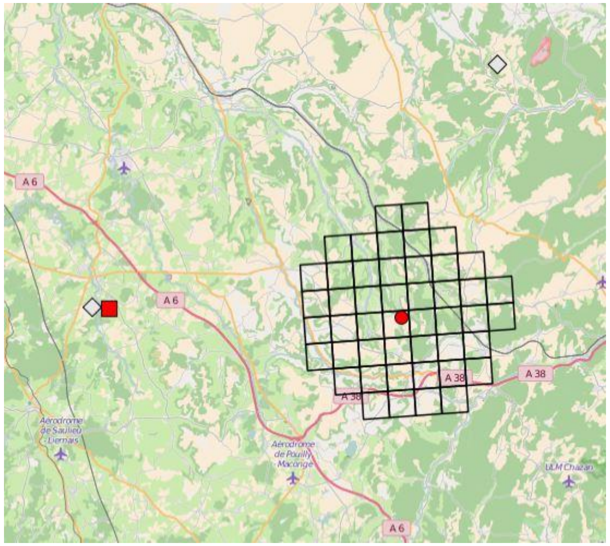


Specify a case study (3)

- **position biomass conversion plant (red square) and intermediate collection point (red circle) on the map**



- **hide biomass maps to see surface map of the area**



Specify a case study (4)

- **start calculation**

Variants

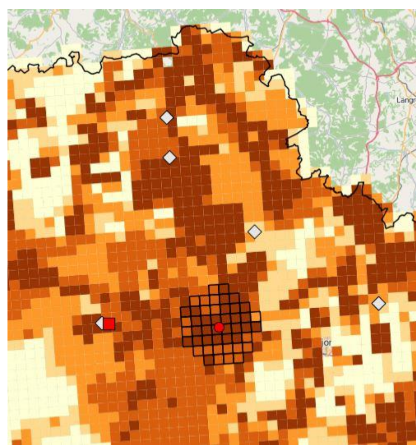
Name ↑	Financial profit	Energy profit	Net GHG avoided
Test 1	0	0	0

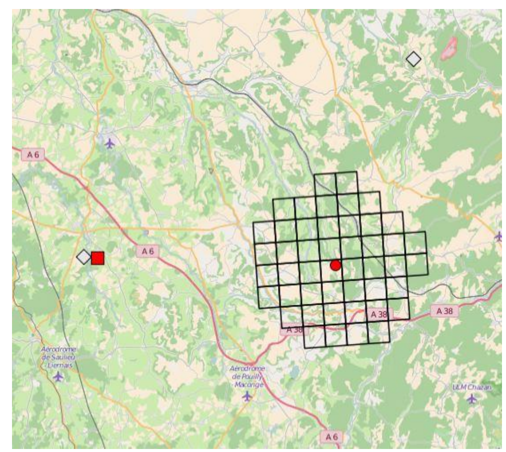
- **a GIS based 'peeling heuristic' determines biomass used (ton dm) and transport distances (ton.km) based on biomass availability maps**

- **analyse results**

Variants

Name ↑	Financial profit	Energy profit	Net GHG avoided
Test 1	3,598,124	436,487	41,790





Specify a case study (5)

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- **analyse results**

Variants

Task	Financial profit	Energy profit	Net GHG avoided	Ton fresh	Ton dry matter
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 3b	2,165,579	412,817	39,389	34,971	30,075

Variants

Task	F...	E...	N...	T...	T...	Change in organic matter content (kton CO2-eq)	Direct N2O emission (kton CO2-eq)	Indirect N2O emission (kton CO2-eq)
Variant 1	2...	4...	3...	3...	3...	0	0	0
Variant 2	3...	4...	4...	3...	3...	4,752,850	155,665	130,748
Variant 3	3...	4...	4...	3...	3...	3,949,717	105,818	126,148
Variant 3b	2...	4...	3...	3...	3...	0	0	0

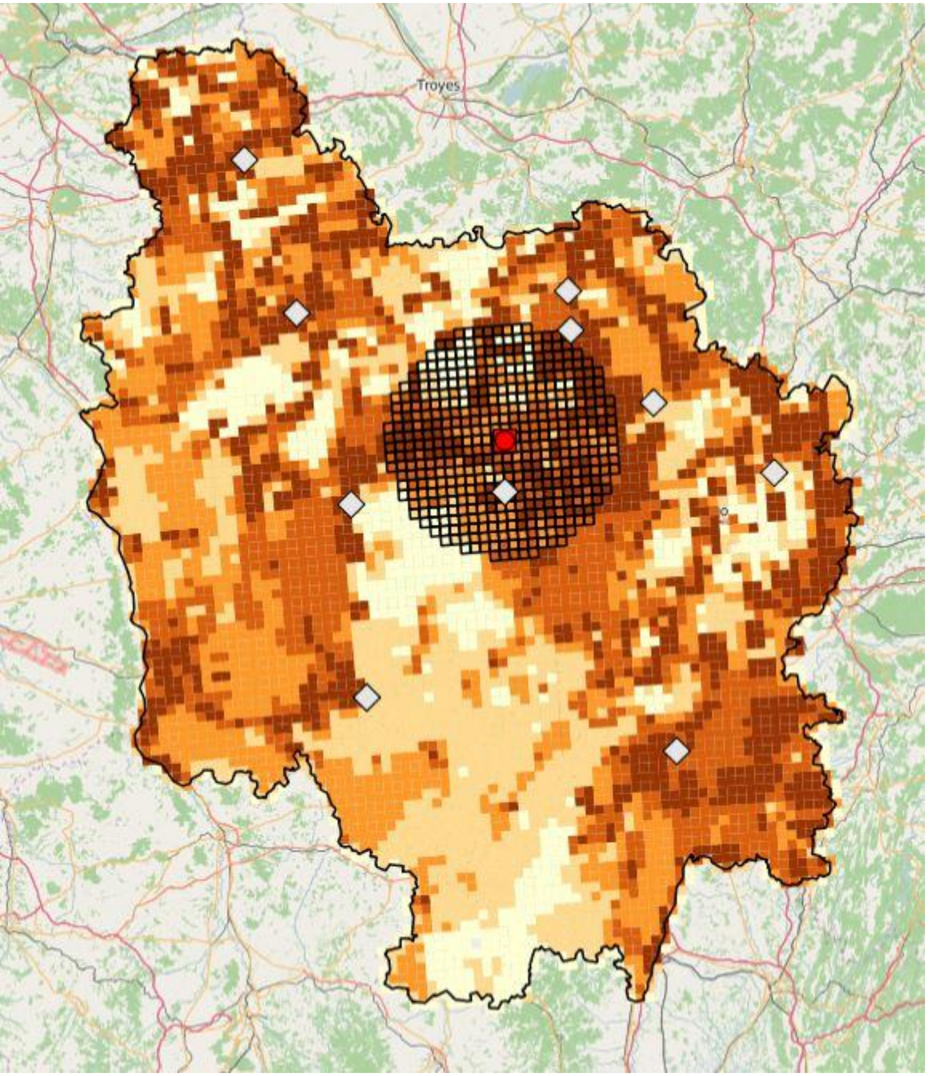
Variants

Task	F...	E...	N...	T...	T...	C...	D...	I...	Distance ICP -> BCP (km.)	Distance ICP -> BCP (ton km.)	Distance field -> ICP (km.)	Distance field -> ICP -> BCP (ton km.)
Variant 1	2...	4...	3...	3...	3...	0	0	0	3,833	148,159	18,192	733,725
Variant 2	3...	4...	4...	3...	3...	4...	1...	1...	1,124	151,265	2,820	415,223
Variant 3	3...	4...	4...	3...	3...	3...	1...	1...	3,973	1,643,259	530	207,798
Variant 3b	2...	4...	3...	3...	3...	0	0	0	31,321	1,615,525	11,739	554,167
Variant 4	3...	4...	4...	3...	3...	4...	9...	1...	2,459	1,673,339	178	116,308
Variant 5	2...	4...	3...	3...	3...	0	0	0	26,668	1,653,065	6,296	332,567

Five variants as an example

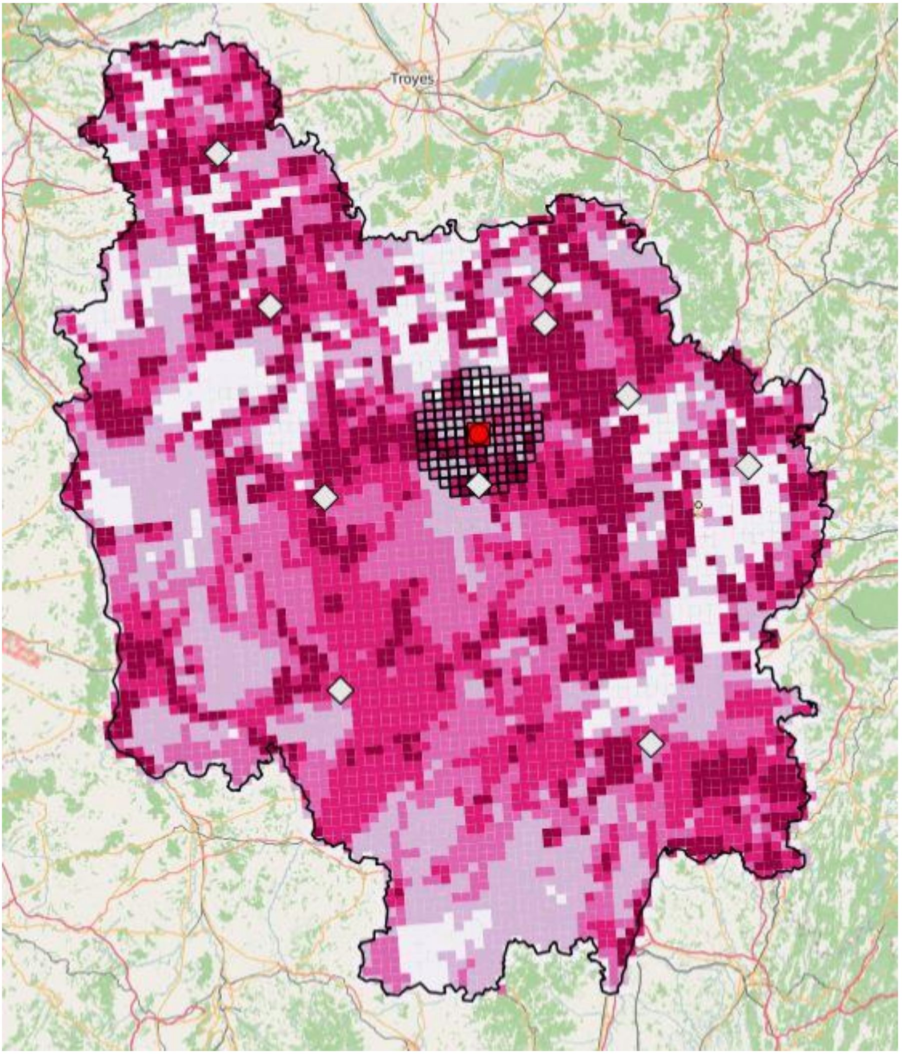
1. powerplant & no biomass yard; only straw
2. powerplant & no biomass yard; straw & Miscanthus
3. powerplant & one biomass yard; straw & Miscanthus
4. powerplant & two biomass yards; straw & Miscanthus
5. powerplant & two biomass yards; only straw

Variant 1 - powerplant & no biomass yard; only straw



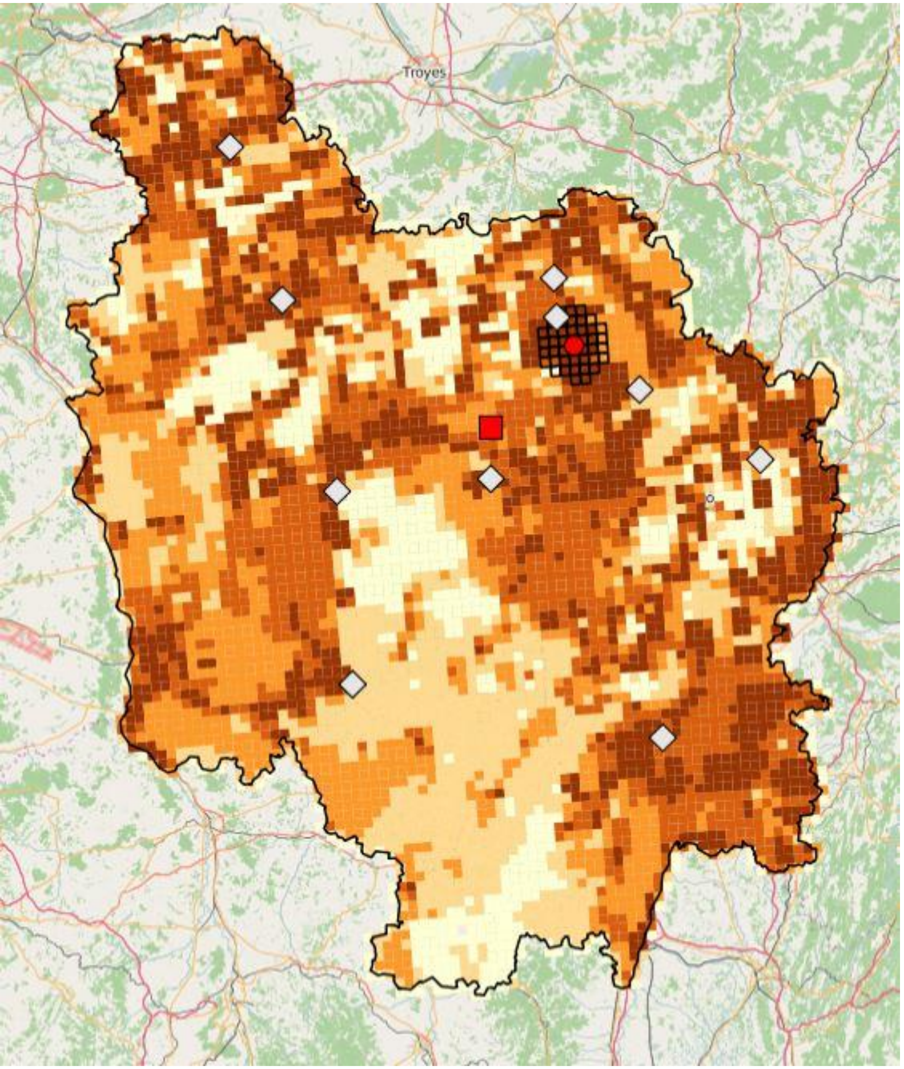
- **map is shown for available straw**
- **only 33% straw available, no Miscanthus (0%)**
- **the size of the collection circle can be influenced:**
  - by assuming a higher or lower biomass availability % for a certain biomass type
  - but also by adding more biomass types (e.g. also include Miscanthus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

Variant 2 - powerplant & no biomass yard; straw & Miscanthus



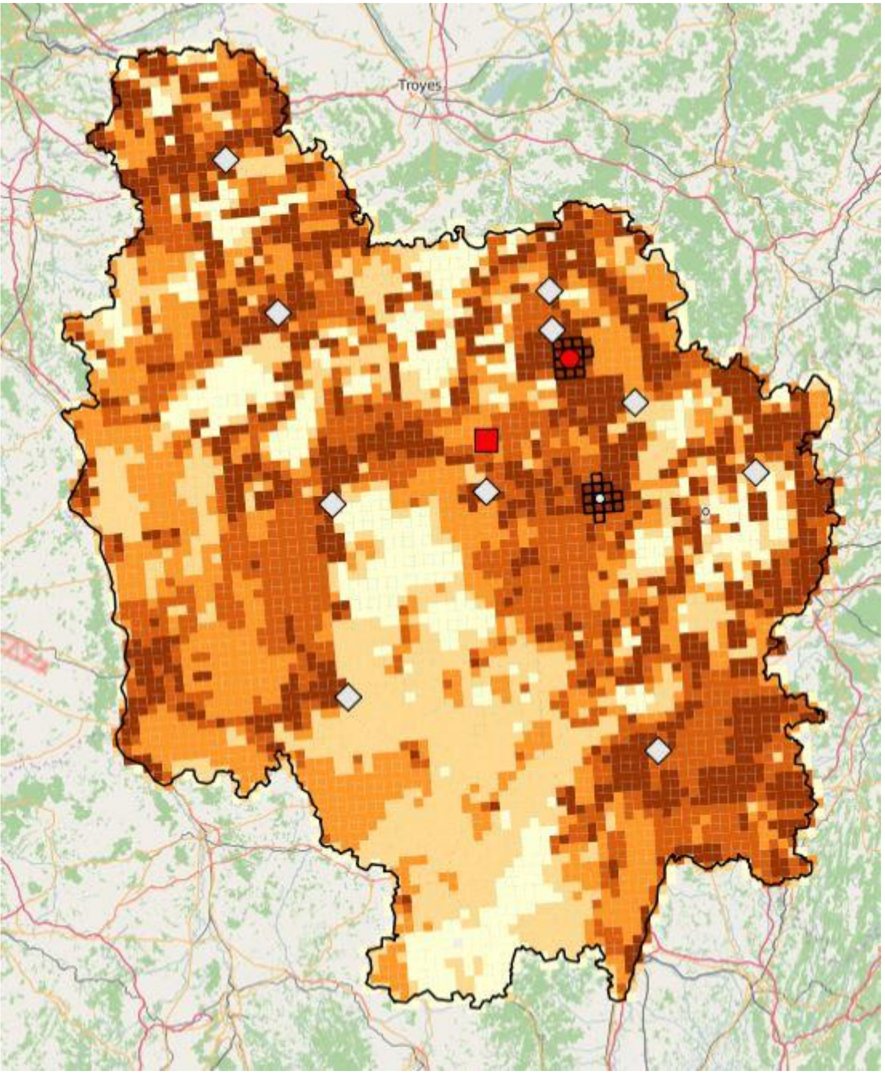
- different map is shown now: for Miscanthus (purple)
- smaller supply circle, because Miscanthus now is also available at closer distance
- notice that calculation results are different (e.g. profit)

Variant 3 - powerplant & one biomass yard; straw & Miscanthus



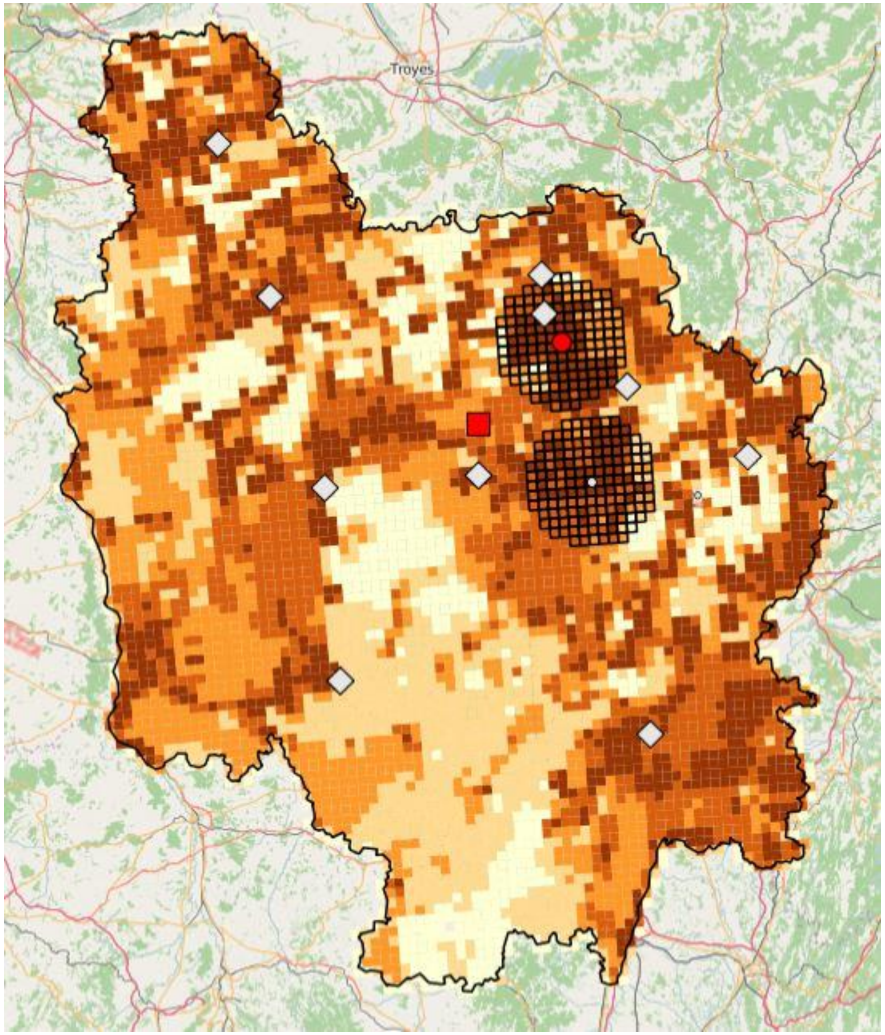
- separate location for power plant (red box) and intermediate collection point (red circle)
- intermediate collection point located near to area with a high biomass availability (e.g. rural area)
- power plant located near to area with a high energy demand (e.g. city)

Variant 4 - powerplant & two biomass yards; straw & Miscanthus



- 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



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

Testing

public site:

http://s2biom.alterra.wur.nl

user name: demo

password: helsinki

Thank you for your attention!

bert.annevelink@wur.nl

FOOD & BIOBASED RESEARCH
WAGENINGEN UR

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

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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

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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