

Delivery of sustainable supply of non-food biomass to support a resource-efficient Bioeconomy in Europe

S2Biom summer school, Athens, Greece, 17-20 May, 2016

Session 2: Estimation of biomass availability for lignocellulosic biomass

Calculating the cost of lignocellulosic non-food biomass sources
(WP1)

Presenter: Raymond Schrijver, DLO - Alterra



- **For many dedicated crops markets are still underdeveloped and therefore no reliable market prices are available**
- **Reflect a situation close to market equilibrium**
- **Can be used for the construction of cost-supply curves**
- **Reflects minimum primary producer costs**

- **Method used: Activity Based Costing**
 - Identifying activities
 - Identifying factors influencing input, process and output of activities
 - Analyse associated costs and cost structure
 - Categorize costs (decomposition)

- **Applied to a range of different crops / feedstock with a unified quality (energy content / ton dm)**
- **For the EU at nuts 3 level, plus Ukraine etc.**
- **At three levels of input / output**
- **Independent from farm structure or – size**

- **Only those that specifically target a new bio economy route (→ sunken costs)**
- **Up to the farm gate (road side)**
- **Based on existing technologies and pathways**

Distinguished activities per crop

Crop	removal of roots and shrubs)	planting	rotating	disking/harrowing	cultivation	pressing/rolling	power harrowing	planting	sowing	plant material	transport	application	fertilizer application	spraying	weed control	irrigation	thinning	combining	cutting/tuberosus	harvesting/mowing	mulching	turning/fraking	balg	loading/transport	pruning	storage
Biomass crops																										
Biomass sorghum	0	1	1	1	0	0	0	1	1	0	1	1	0	0	0	1	0	0	1	0	0	1	1	1	0	0
Miscanthus	8	8	8	0	0	0	8	0	8	0	8	0	3	8	0	0	0	0	10	0	0	10	10	0	0	
Switchgrass	7	7	7	0	7	0	0	7	7	0	1	7	0	0	0	0	1	0	0	0	0	1	1	1	0	0
Giant reed	7	7	7	0	0	0	7	0	7	0	1	7	0	0	0	1	0	0	0	1	0	0	1	1	0	0
Cardoon	7	7	7	0	0	0	0	7	0	0	1	7	0	0	0	1	0	0	1	0	0	1	1	1	0	0
Reed Canary Grass	7	7	7	0	7	0	0	7	0	0	1	7	0	0	1	0	0	1	0	0	0	0	0	1	0	0
SRC Willow	8	8	8	8	8	0	8	0	8	8	2	3	0	0	0	2	0	0	0	0	0	0	0	2	0	0
SRC Poplar	8	8	8	8	0	0	8	0	8	8	2	3	2	0	0	2	0	0	0	0	0	0	0	2	0	0
Other SRC	8	8	8	8	0	0	8	0	8	8	2	3	8	0	0	2	0	0	0	0	0	0	0	2	0	0
Rice straw	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0
Cereals straw	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
Oil seed rape straw	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
Maize stover	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
Sugarbeet leaves	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Sunflower straw	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
Residues from vineyards	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0
Residues from fruit tree plantations	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0
Residues from olives tree plantations	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0
Residues from citrus tree plantations	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0
Residues from nuts plantations	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0
Unused grassland cuttings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0
Landscape care (grassy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0
Landscape care (woody)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0
Road side verges (grassy)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0
Road side verges (woody)	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0

- **Applied technology (mechanisation level)**
- **Soil fertility (yields)**
- **Water availability (yields)**
- **Parcel size and plot distance**
- **Natural handicaps**

General input

General input in three adjustable levels
(High, Medium, Low)

Case general info:		
country	UK	
grid id (MARS)	2466224	
NUTS region	NUTS2_input	
Interest rate	4%	
Yield level (Water limited yield)	m	unit
water input level	L	unit
method (mechanisation level)	Profile of farm labour	
soil preparation	M	S
soil preparation + sowing combi	M	S
planting / sowing	H	S
fertilizing	H	S
Pest / weed control / nursing	L	S
Irrigation	L	S
harvesting post harvesting	H	S
conditions (handicaps)	L	
Parcel width (100m)		2
Parcel length (100m)		3
distance parcel / home (km)		1

Crop input

Crop input covers:

- Yield
- Corresponding fertilizer use
- Corresponding water use

Also in three adjustable levels
(High, Medium, Low)

Crop	Crop yield (mt /ha, dm)		
	L	M	H
sugarbeet	10	15	20
wheat	3	6	9
wheat straw	4	5	6
maize			
miscanthus	8	10	12
switchgrass			
RCG			
Willow (SRC)			
Poplar (SRC)			
Giant Reed (arundo donax)			
prunings vineyard			
prunings other			

	price level germany (€/kg)	Price level country specific	
fertilizer			
N (Nitrogen)	1	1.07538018 / kg N	
P (Phosphate)	0.8	0.860304144 / kg P205	
K(Potassium)	0.5	0.53769009 / kg K20	
Mg (Magnesium)	1		
S (sulfur)	1		
Ca Chalk	1		
	price level germany (€/m3)		
Manure	1	1.07538018	
	price level germany (€/m3)		
Water	0.01	0.010753802 €/ m3	

- **Capital costs**

- Interest on average book value of used equipment (country specific)
- Depreciation on replacement value (country specific)
- Maintenance and storage of equipment
- Calculated charge per hour based on average seasonal deployment rate (contractor based)

Machinery input

Per field activity there is an option to choose equipment for one of three levels with respect to the capacity (High, Medium, Low)

Activity / treat	Type equipment	Capacity (low, medium, high)
disking /harrowing/ rotavating	nine furrow reversible	H
	disk harrow 3m	L
	disk harrow 4m	M
cultivating / hacking	rotavator 5m	H
	row crop cultivator 6m	L
	row hoe (rotary) 12m	M
pressing / rolling	tined weeder 24 m	H
	Cambridge- / crosskill roller /cultipacker 3m	L
	Cambridge- / crosskill roller /cultipacker 6m	M
	Cambridge- / crosskill roller /cultipacker 10m	H
One pass tillage train		L

- **Labour costs**

- Time consumption per activity

- Based on operational working width and – speed of equipment as well as on the capacity to handle biomass (3 mechanisation levels in the model)
- Parcel size and field / plot distance to farm
- Country specific price of (un)skilled labour taken from Eurostat
- Surcharge for overhead activities (post calculation)

Task Times for field operations

Task times are calculated for each field operation depending on:

- The machinery used
- Field characteristics
- Yield level

Formula for calculation of task times (per activity)

Background

The formulas can be applied to various working routes (see image)

Calculation of the (pure) task time per parcel:

fieldwork at constant speed

loading / onloading activities

transportation activities

$$PLFp = a \cdot Wp \cdot Lp + b \cdot (Wrp \cdot fa) + c \cdot Lp + d \quad (1)$$

$$a = a1 + a2 + a3 \quad (2)$$

$$a1 = (100 + RT) / (10 \cdot We \cdot V) \quad (2a)$$

$$a2 = APha / APc \cdot (TL / 60) \cdot (100 + RT) / 100 \quad (2b)$$

$$a3 = NTha \cdot (ETt / 60) \cdot (100 + RT) / 100 \quad (2c)$$

$$b = (wc + (Wpp / 10 \cdot wv)) \quad (3)$$

$$wc = (100 / We) \cdot (Etr / 60) \quad (4)$$

$$Wrp = (Wp - 2 \cdot Hw) \quad (5)$$

$$c = b \quad (6)$$

$$d = 2 \cdot Hw / We \cdot (Etr / 60) \cdot Fh \quad (7)$$

$$TTha = ((PLFp \cdot (100 + MT) / 100 + RRp + NHD \cdot (RRhdc + e \cdot Wp + f \cdot Pla)) / Pha) \cdot NP \quad (8)$$

$$NHD = (PLFp \cdot (100 + MT) / 100 + RRp) / (4 - NHD \cdot (RRhdc + e \cdot Wp + f \cdot Pla)) \quad (9)$$

$$e = 1 / (5 \cdot V) \quad (10)$$

$$f = 2 / Vt \quad (11)$$

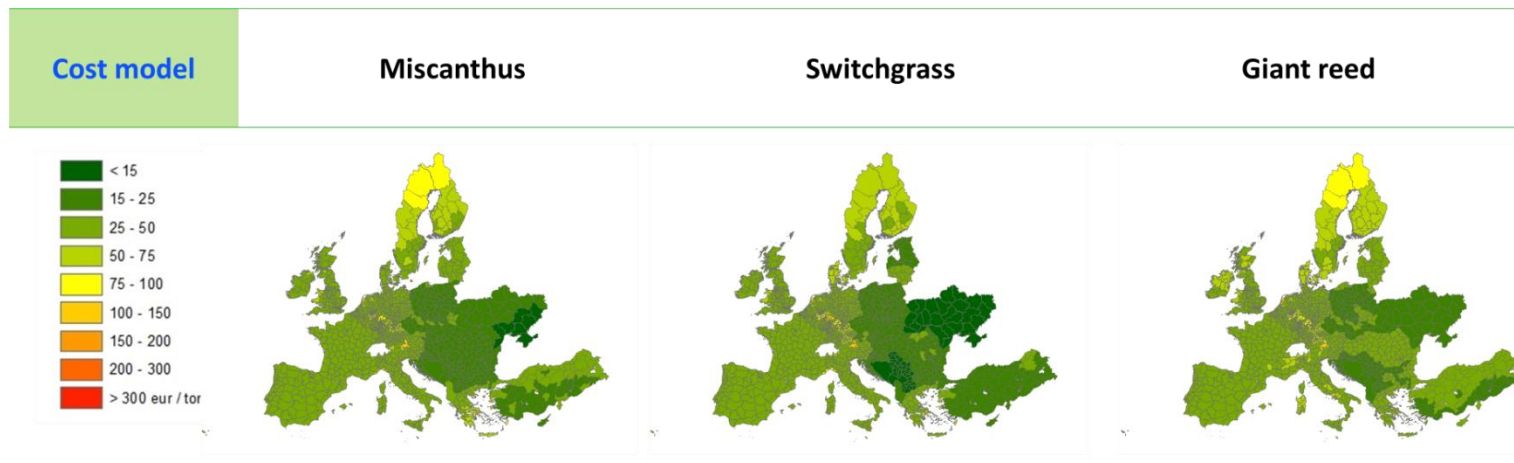
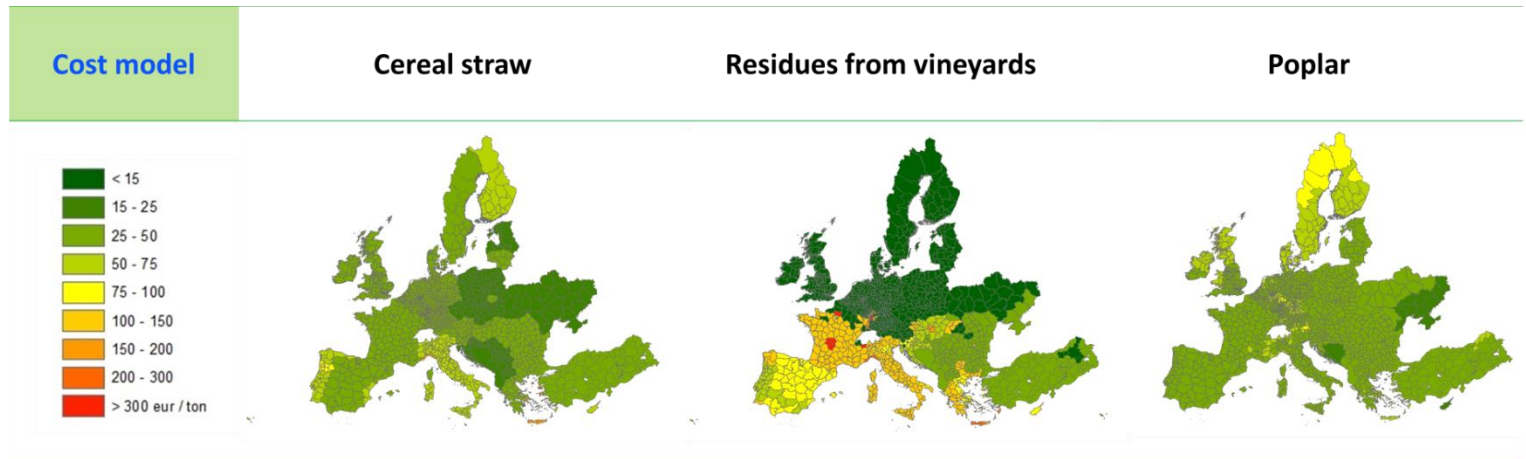
- **Land costs**
 - Post calculation of land rent (country specific)
- **Other variable / auxiliary costs**
 - Fuel, lubricant consumption
 - Replacement of withdrawn nutrients
 - Plant material, seed
 - Crop protection means
 - Water consumption

- **Choice of equipment**
 - Three levels, high, medium, low
 - Taken arbitrarily from a wide range of working methods, capacities, fuel consumptions, etc. from a list / database of German (KTBL) and Dutch (KWIN) sources.
 - Country specific correction factors for replacement values, fuel prices taken from Eurostat / FAO

- **Attribution of handicaps**
 - In the form of a surcharge on the time consumed by an activity (three levels)
 - Discrimination between water fed and irrigated yield levels (irrigation is a separate activity)

- All costs expressed in NPVa (Net Present Value annuity) in order to make annual and perennial crops comparable (=all expressed in present Euros).
- A 60 year coverage period is adapted to fully synchronize 1,3,5,10,15,20,30 and 60 year cycles. Cost differences after that period are negligible
- Formula: $p_v = f_v / (1+i)^n$; $p_{va} = [1 - 1(1+i)^n / i]$

- **Lowest applicable cost price for a given crop on a given location depends on:**
 - Regional yield level (water limited or irrigated)
 - Regional handicap level (three levels expressing a broad range of handicaps such as slope, soil conditions, e.g. bogginess, presence of stones)
 - Parcel size and distance to the field plot
 - Choice of equipment (mechanisation level)



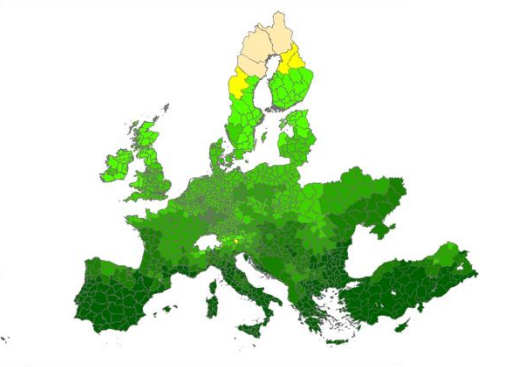
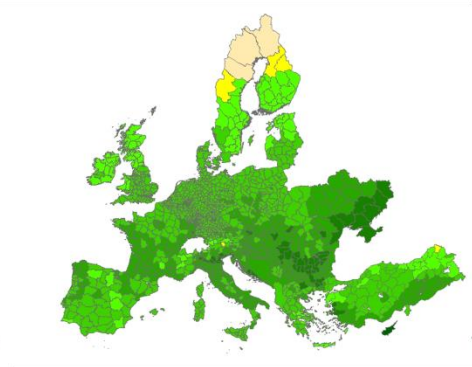
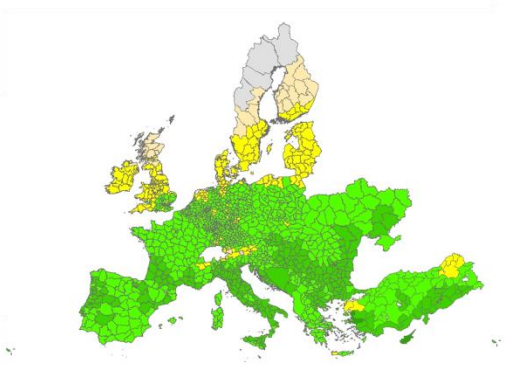
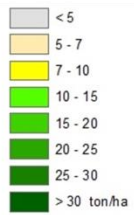
GIANT REED

L1
(low input/no irrigation)

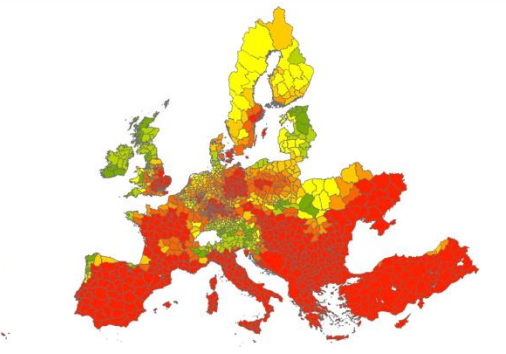
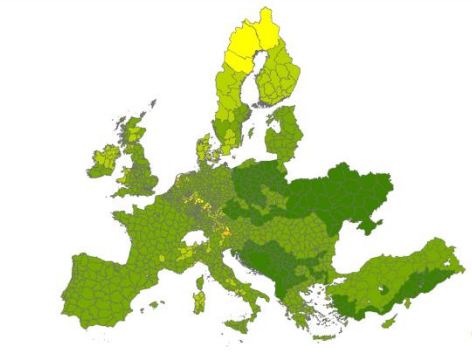
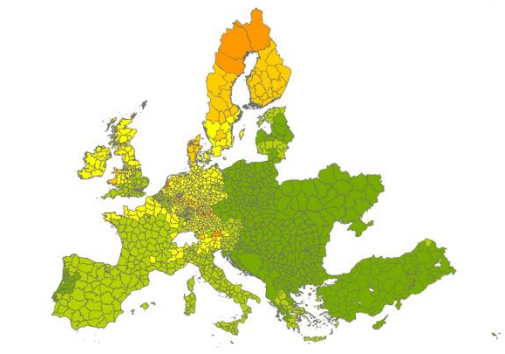
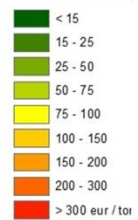
L2
(medium input/no irrigation)

L3
(high input/ irrigation)

Yield (ton/ha)



Cost (eur/ton)



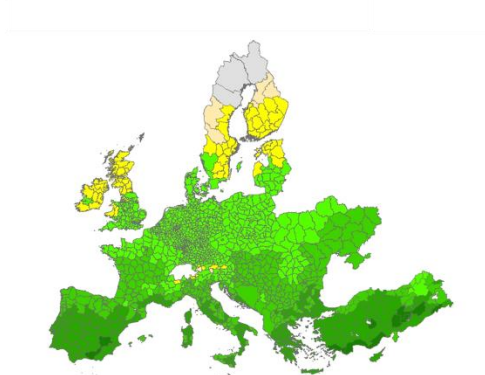
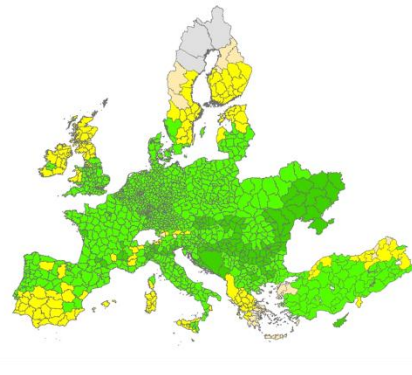
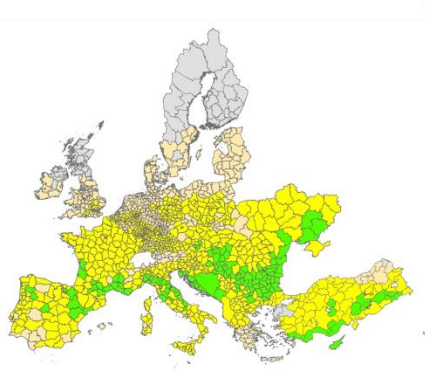
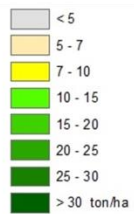
MISCANTHUS

L1
(low input/no irrigation)

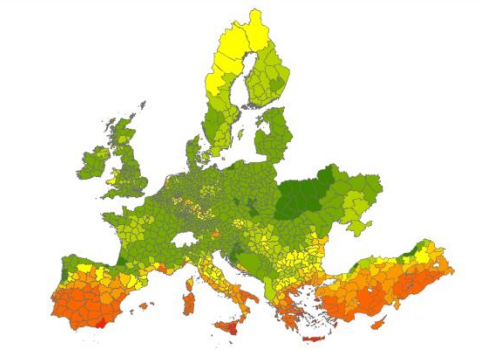
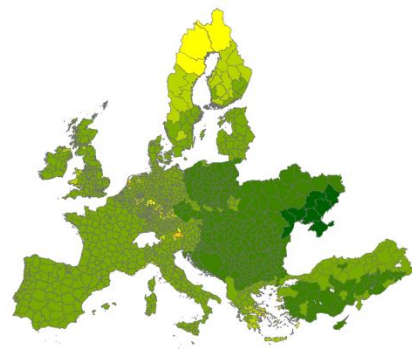
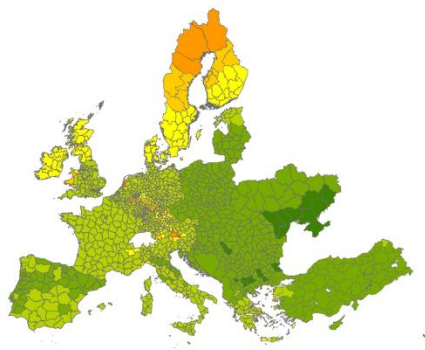
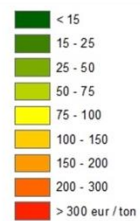
L2
(medium input/no irrigation)

L3
(high input/ irrigation)

Yield (ton/ha)



Cost (eur/ton)



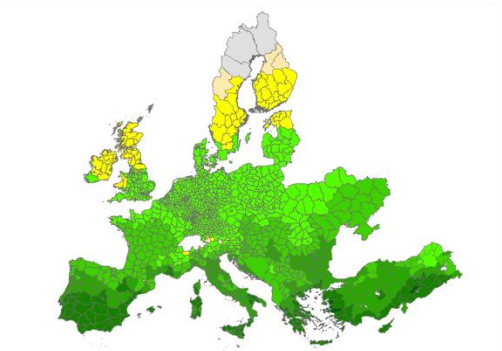
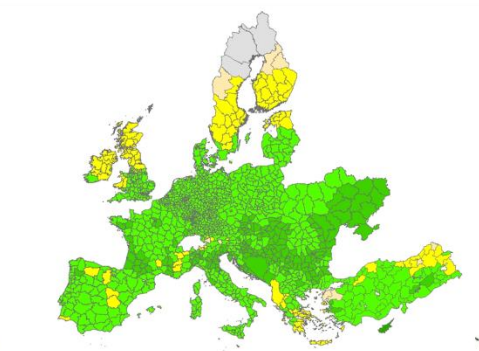
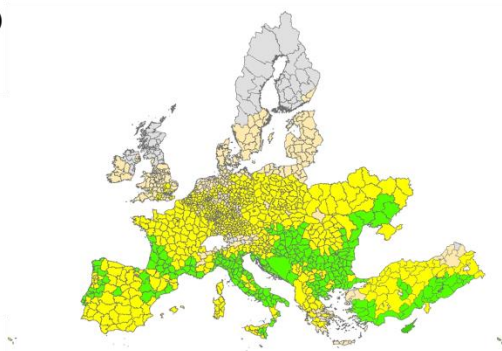
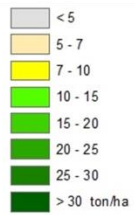
SWITCHGRASS

L1
(low input/no irrigation)

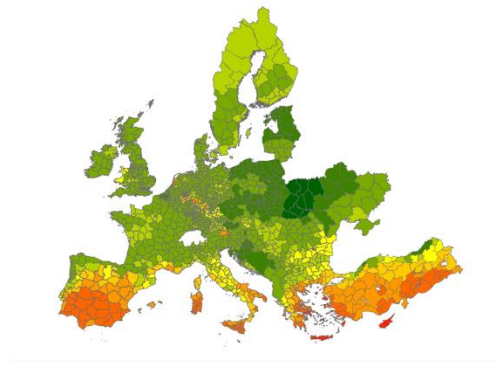
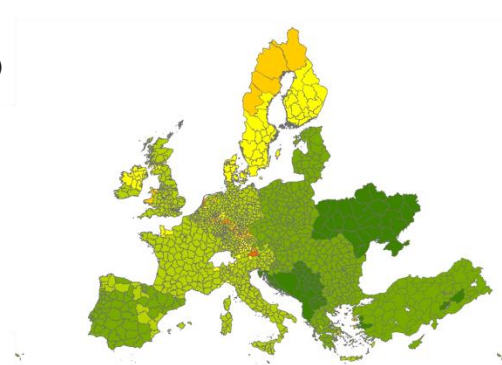
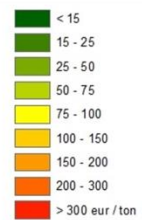
L2
(medium input/no irrigation)

L3
(high input/ irrigation)

Yield (ton/ha)



Cost (eur/ton)



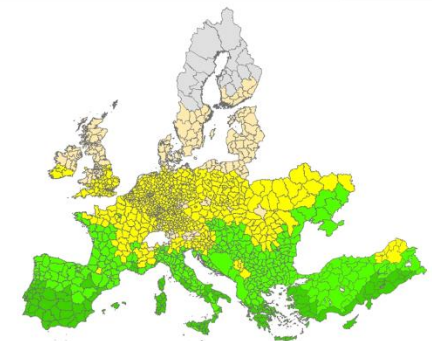
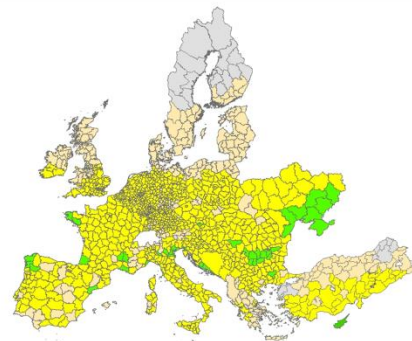
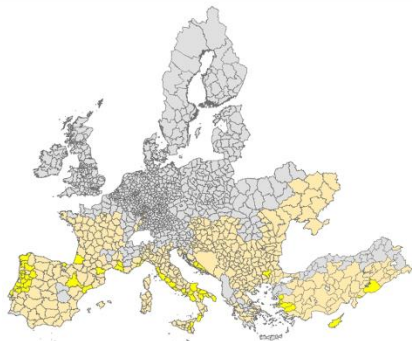
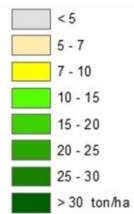
POPLAR

L1
(low input/no irrigation)

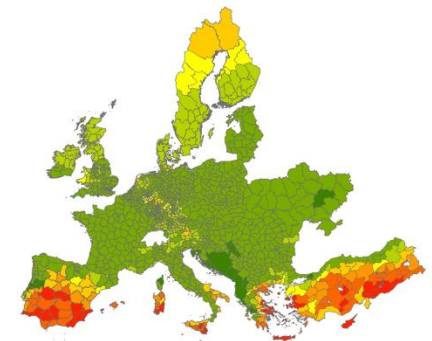
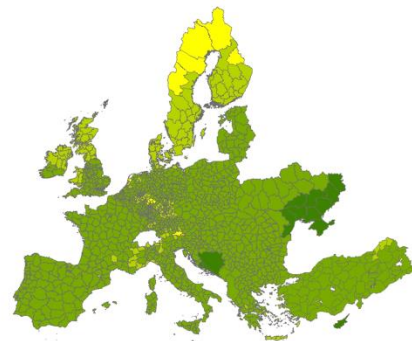
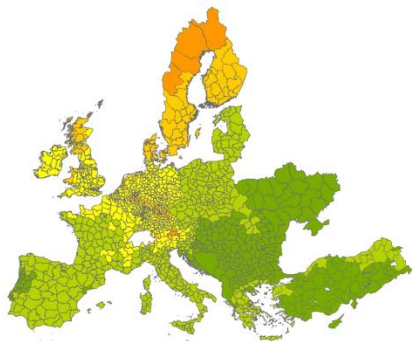
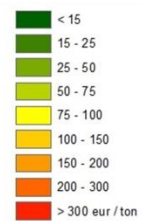
L2
(medium input/no irrigation)

L3
(high input/ irrigation)

Yield (ton/ha)



Cost (eur/ton)



Evaluation

- **No overhead cost included yet, while these can make up a considerable share of the cost**
- **Now need input data from cases on crop inputs and harvest operations**
- **Variation needs to concentrate on most influential cost factors. These need to be identified per type of biomass.**
- **Model needs to be made user friendly with a standard input and standard output**
- **Model used in 2 ways:**
 - To calculate cost levels for all regions
 - To be delivered as a model in the tool box to be used by independent users with own input and default input

- **For ABC e.g.:** <http://www.economist.com/node/13933812>
- **For explanation on how to calculate NPV and NPVa e.g.:**
 - <https://www.youtube.com/watch?v=8AmeJ4CS20E> AND
 - <https://www.youtube.com/watch?v=9L6eQUM23Ng>
- **On the topic of costs of machinery:**
 - <https://www.ktbl.de/online-anwendungen0/> (in German language)