

Biomass use for energy production and European experience in bioenergy resource mapping



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RES policy framework in the EU

RES White Paper (1997)

➤ **To double** the share of renewable energy from **6% to 12%** of gross energy consumption in Europe (EU-15) **by 2010**

RES Electricity Directive (2001)

➤ **To establish** a framework to **increase the share of renewables electricity from 14% to 22%** of gross electricity consumption **by 2010**

Directive on liquid biofuels (2003)

➤ **To achieve** a share of **5.75 % of biofuels** for transport in the total amount of fuels in Europe **by 2010**

Biomass Action Plan (2005)

EU Strategy for Biofuels (2006)

Green Paper “A European Strategy for Sustainable, Competitive and Secure Energy” (2006)

The EU Energy & Climate Change package (2008)

Energy & Climate Change

The 20-20-20 Energy and Climate package requires the EU, by 2020

- reduce the GHG emissions by 20%

- 20%



- increase the share of renewable energy to 20%
 - 10% RES in transport

+20%



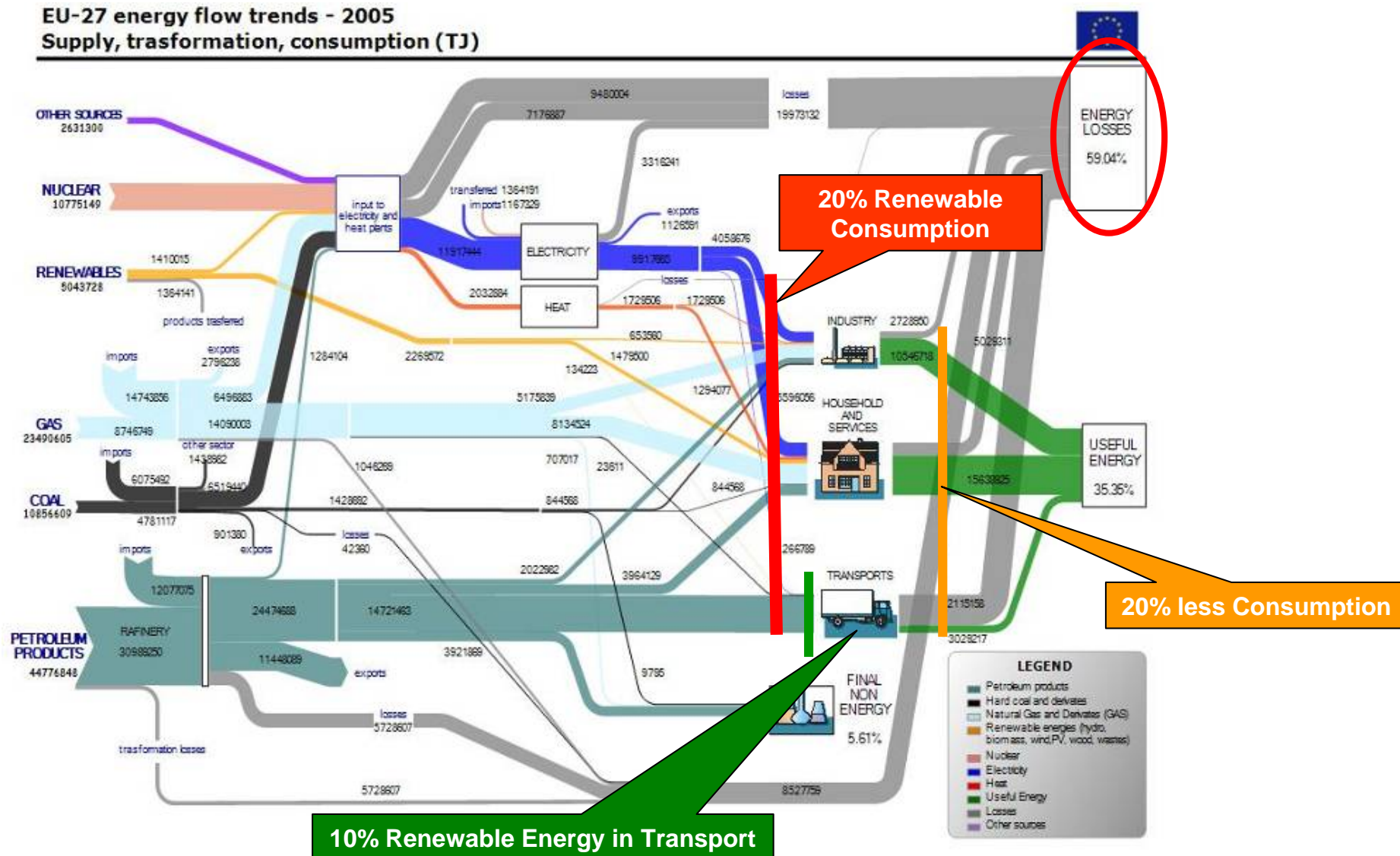
- save 20% of total primary energy consumption compared to baseline

- 20%



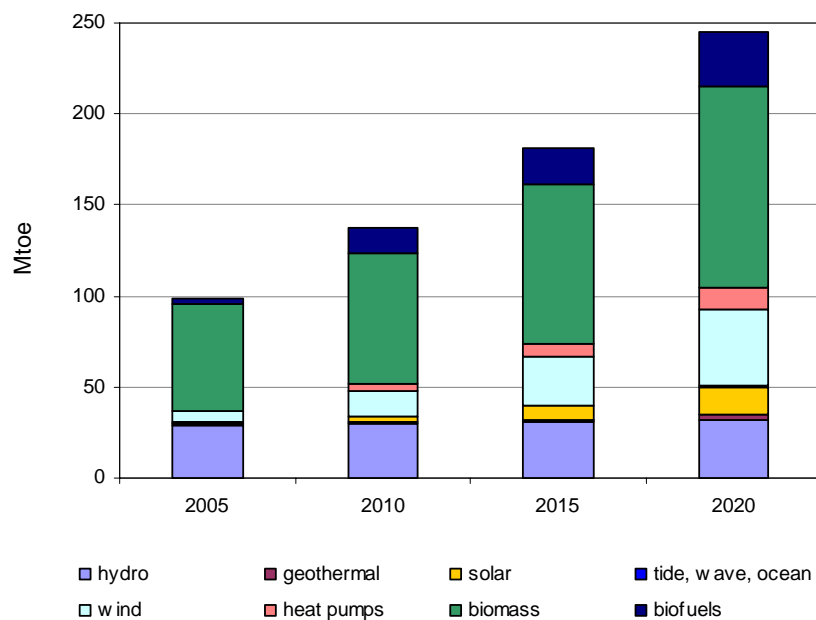
The EU 2020 targets in the Energy Flow

EU-27 energy flow trends - 2005
Supply, transformation, consumption (TJ)

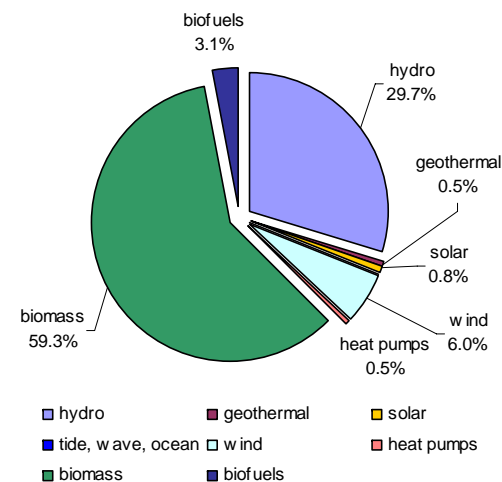


Renewable final energy consumption in the EU

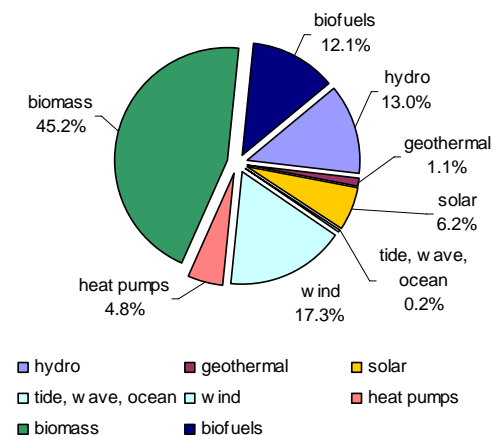
Renewable final energy consumption in the EU



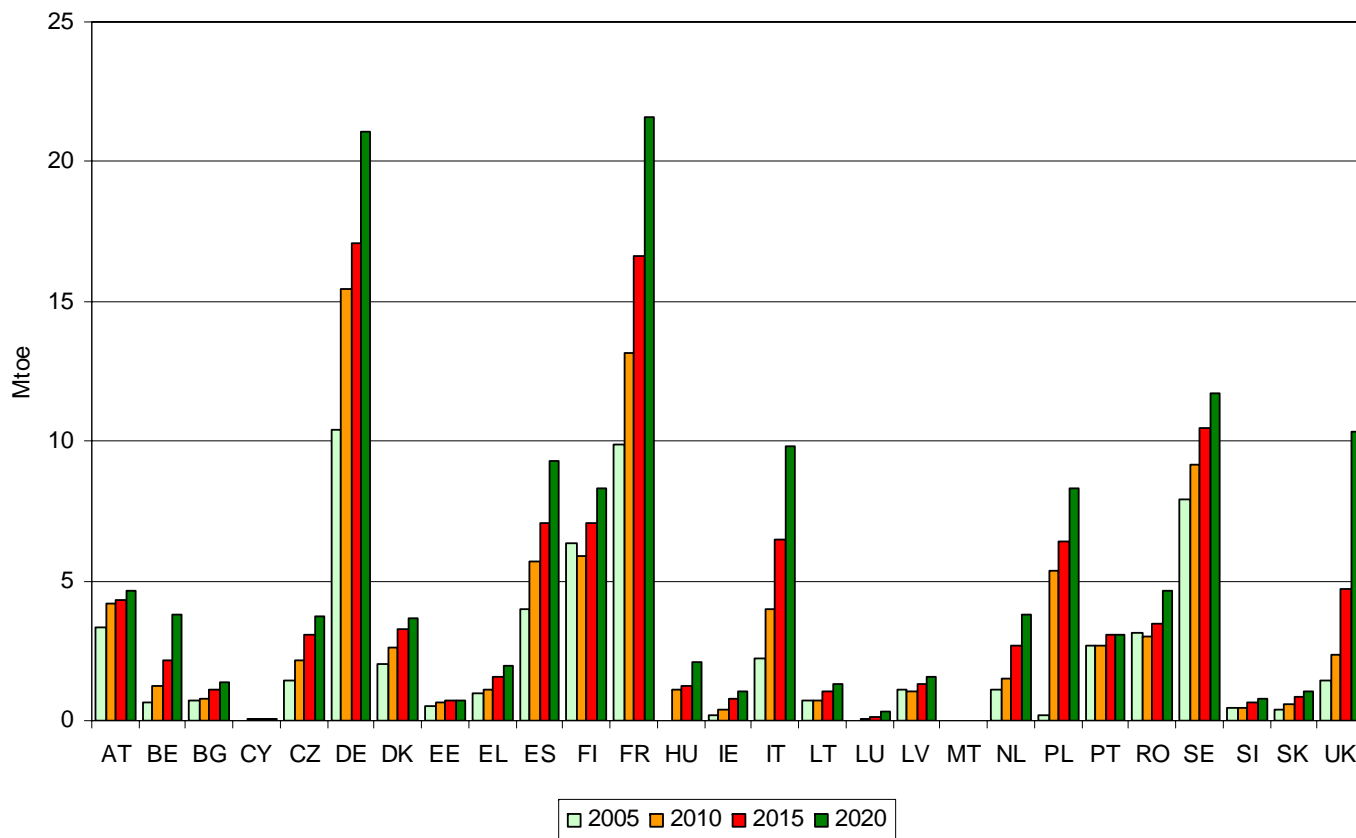
Final renewable energy consumption in 2005



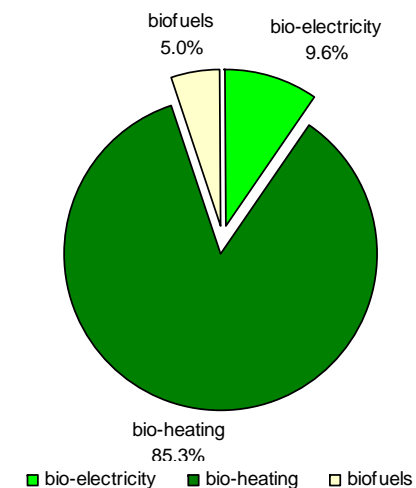
Final renewable energy consumption in 2020



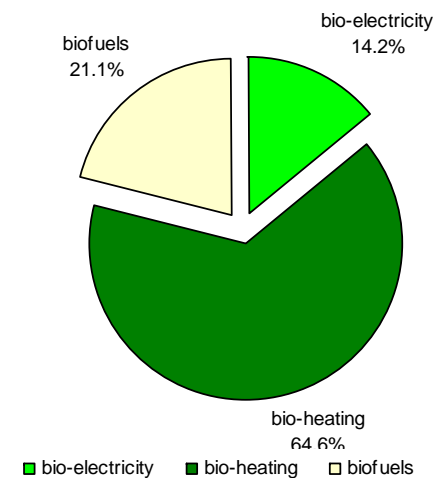
Final energy consumption of biomass in the EU



Final energy consumption of biomass in the EU in 2005



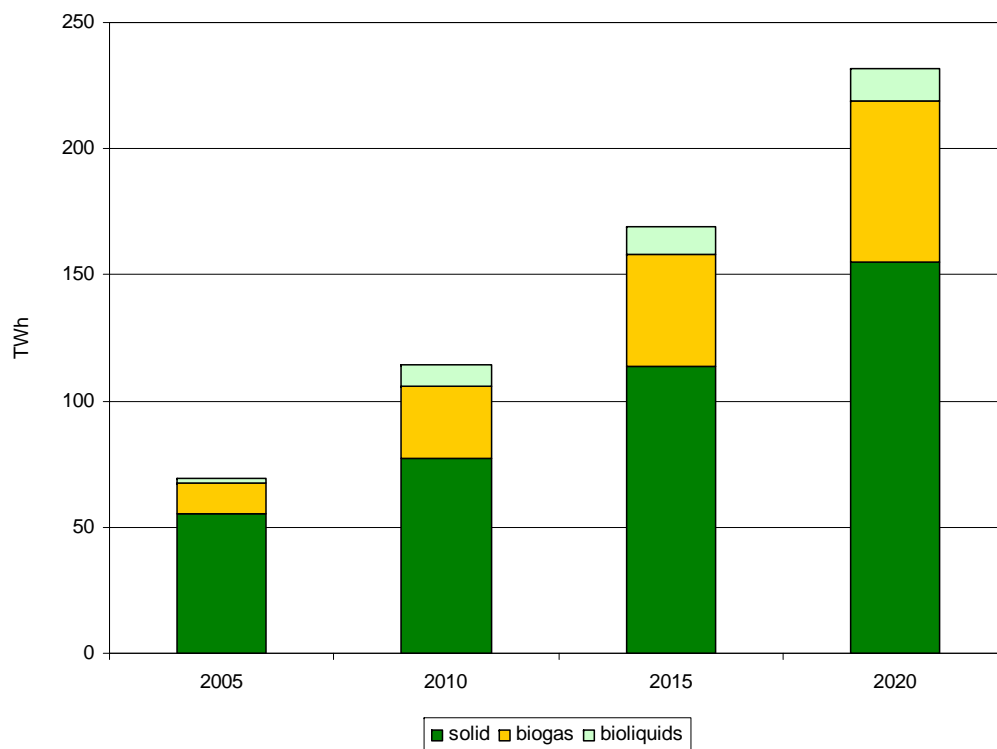
Final energy consumption of biomass in the EU in 2020



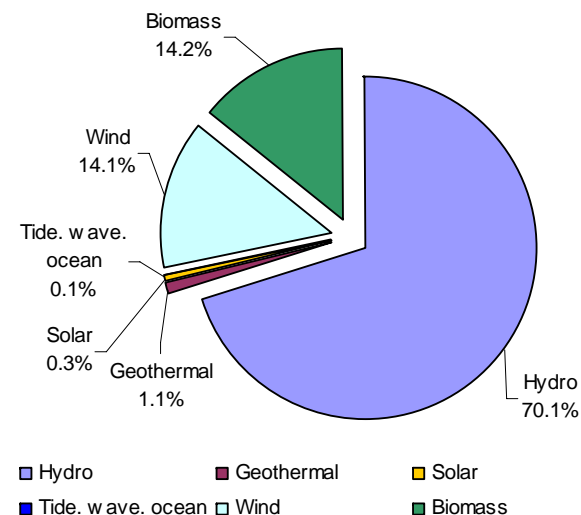
Biomass contribution to RES targets in the EU

- biomass electricity

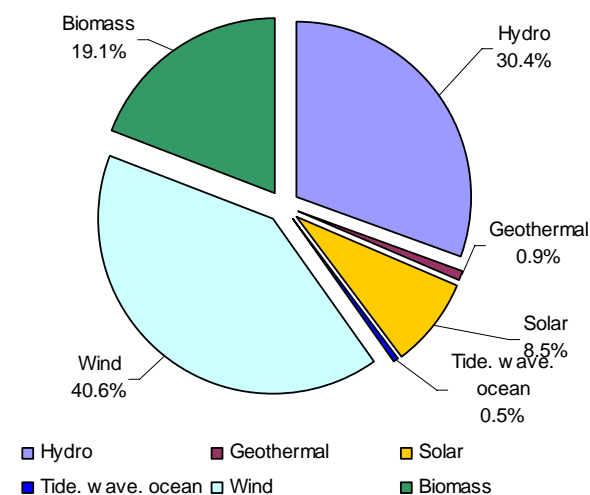
Biomass contribution to electricity production



Renewable electricity in 2005



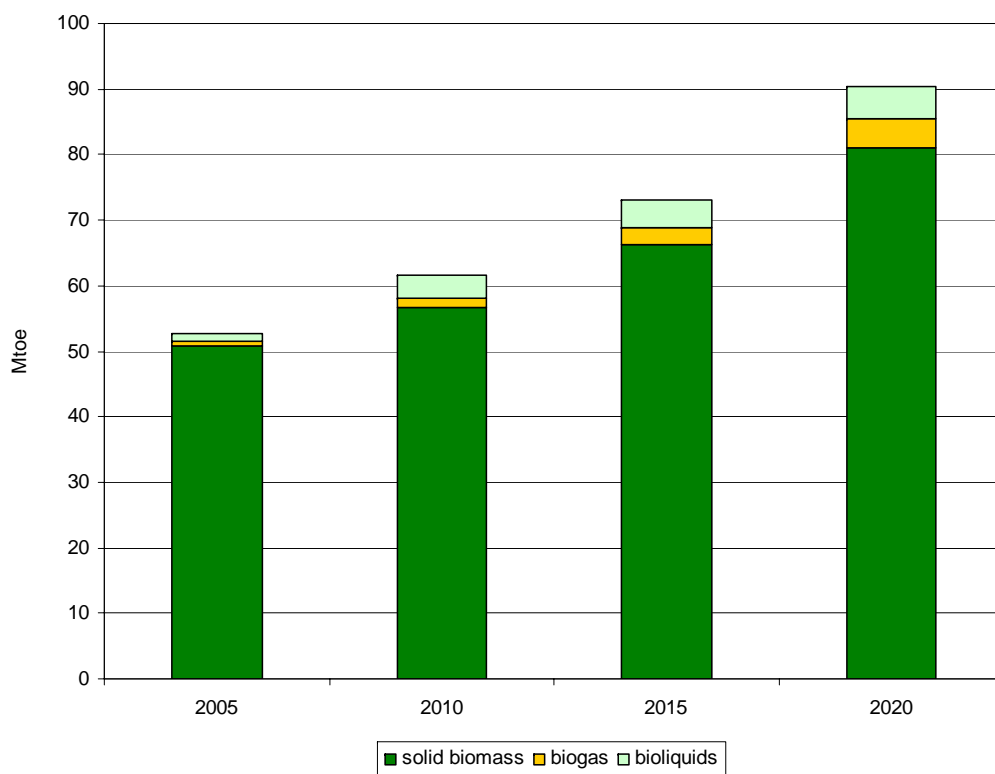
Renewable electricity in 2020



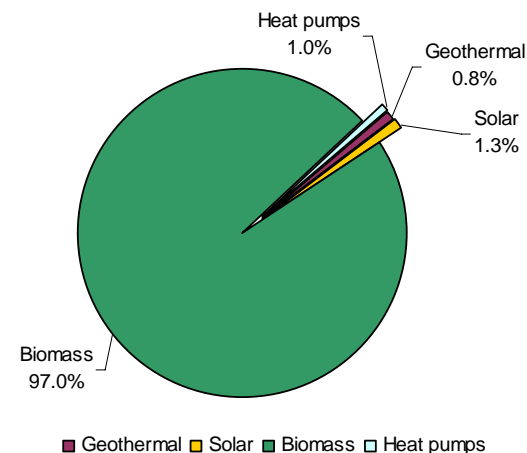
Biomass contribution to RES targets in the EU

- biomass heating& cooling

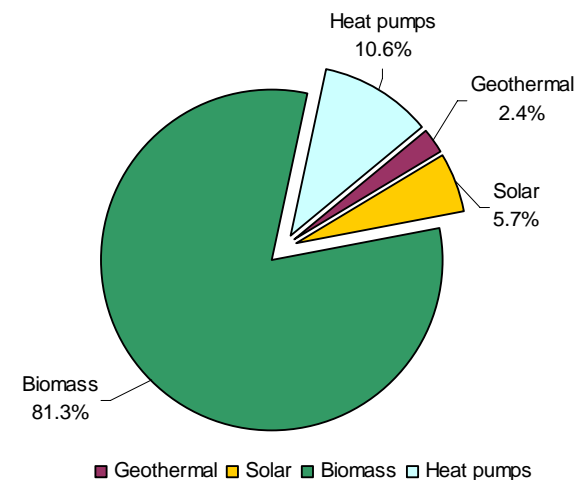
Biomass contribution to heating and cooling in the EU27 in 2020



Renewable heating and cooling in 2005

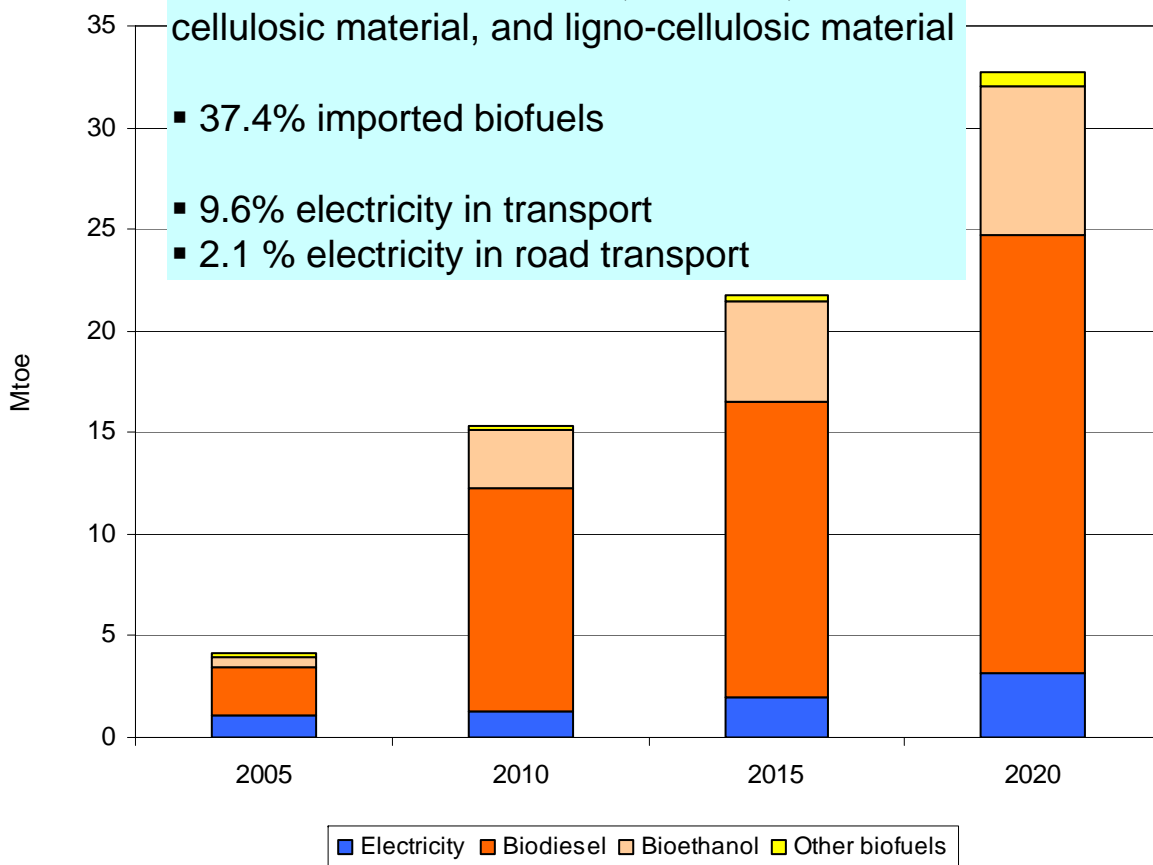


Renewable heating and cooling in 2020

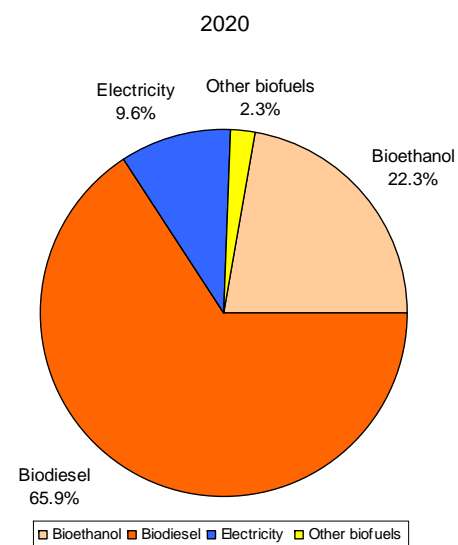
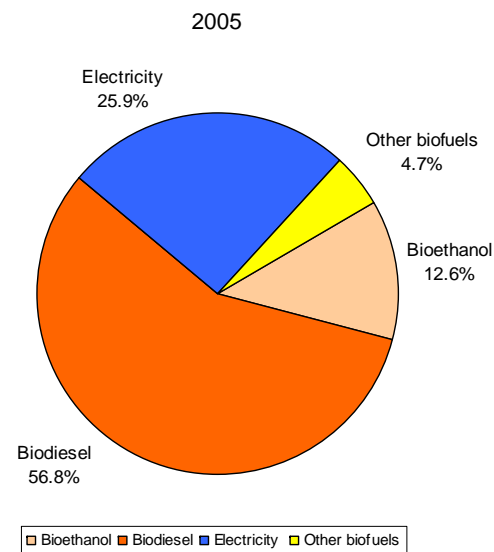


Renewable energy in transport in the EU

- 72.9% biodiesel
- 24.6% bioethanol
- 9.0% biofuels from waste, residues, non-food cellulosic material, and ligno-cellulosic material
- 37.4% imported biofuels
- 9.6% electricity in transport
- 2.1 % electricity in road transport

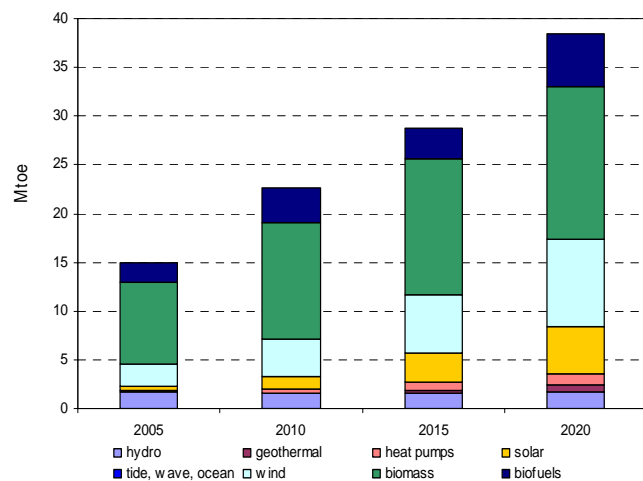


Data sources: National Renewable Action Plans (NREAPs)

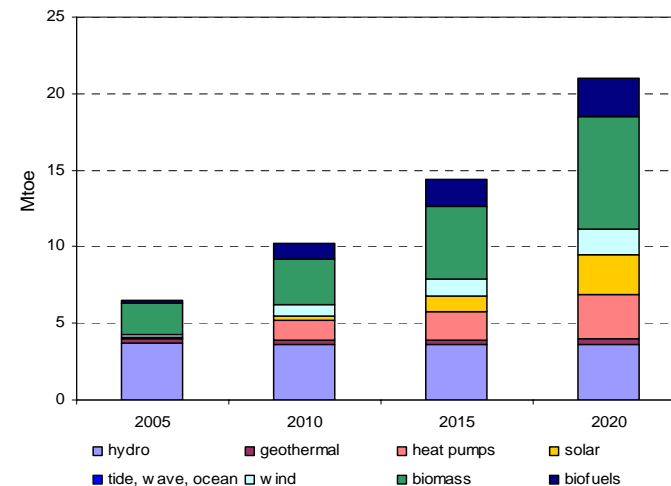


Some examples

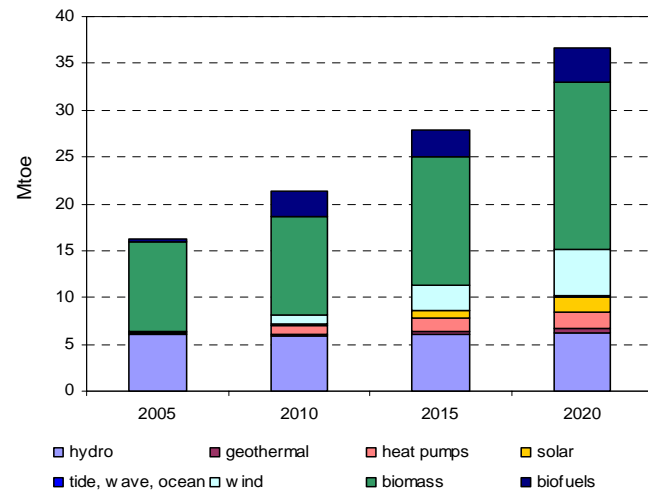
Renewable final energy consumption in Germany



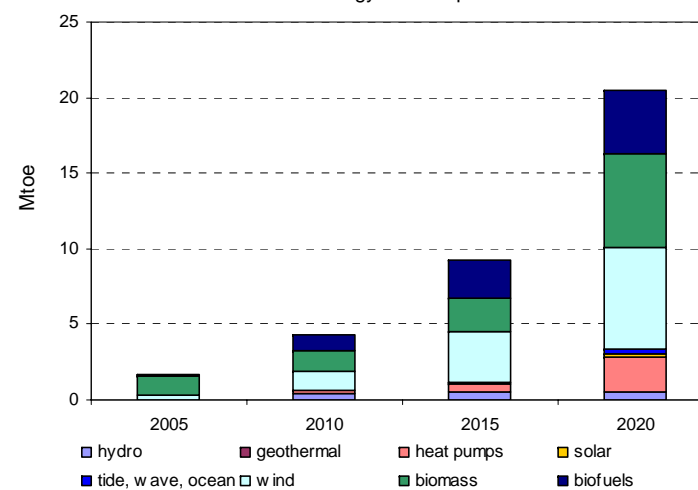
Renewable final energy consumption in Italy



Renewable final energy consumption in France



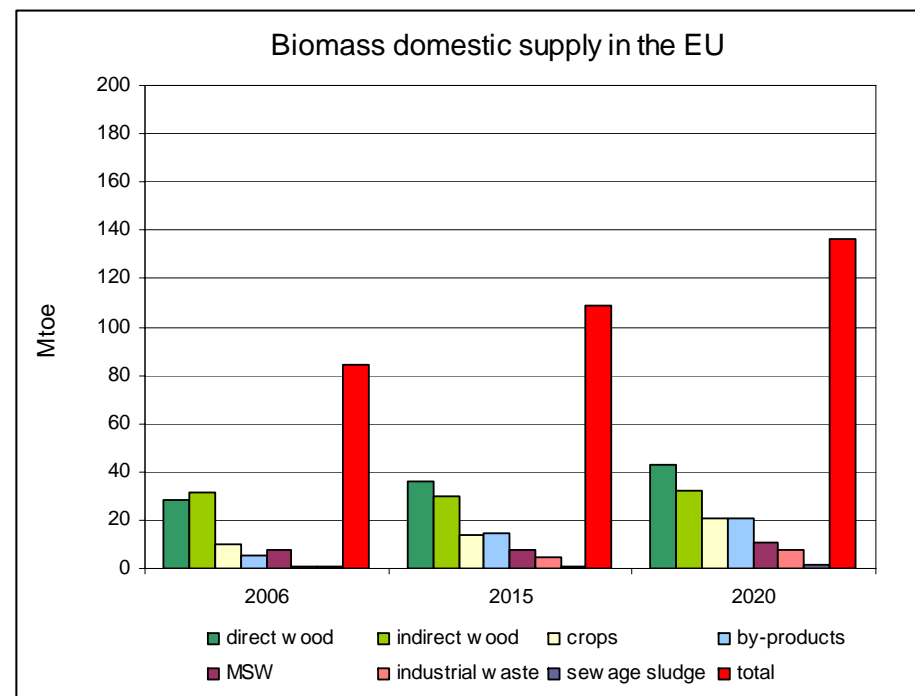
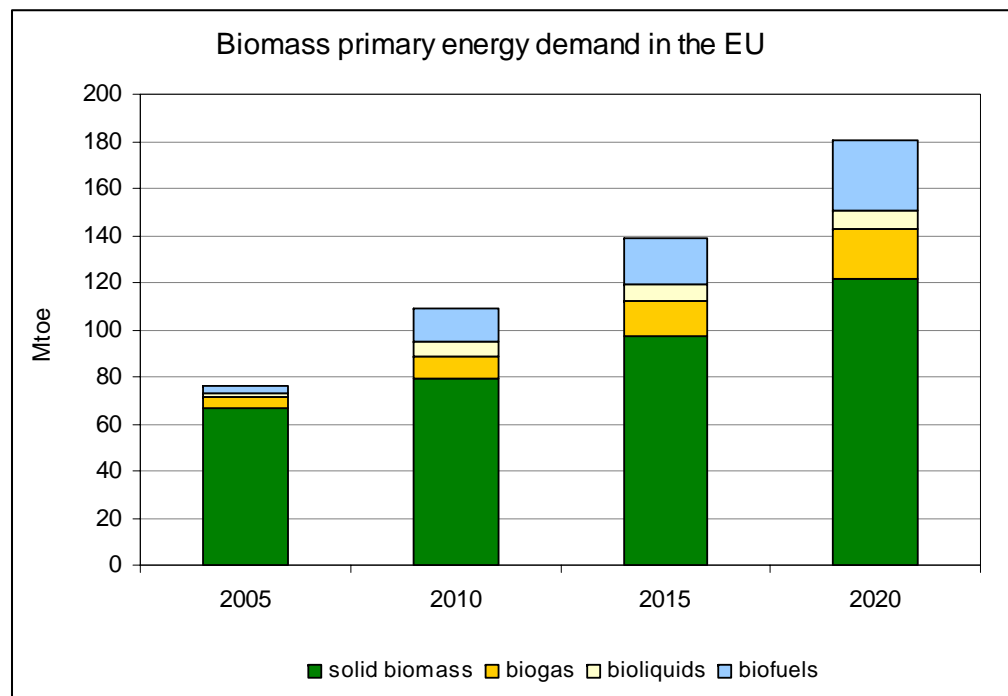
Renewable final energy consumption in the UK



NREAPs – Biomass domestic supply

Is there enough biomass to reach these targets?

- better mobilisation
- energy crops
- waste and residues
- imports from abroad

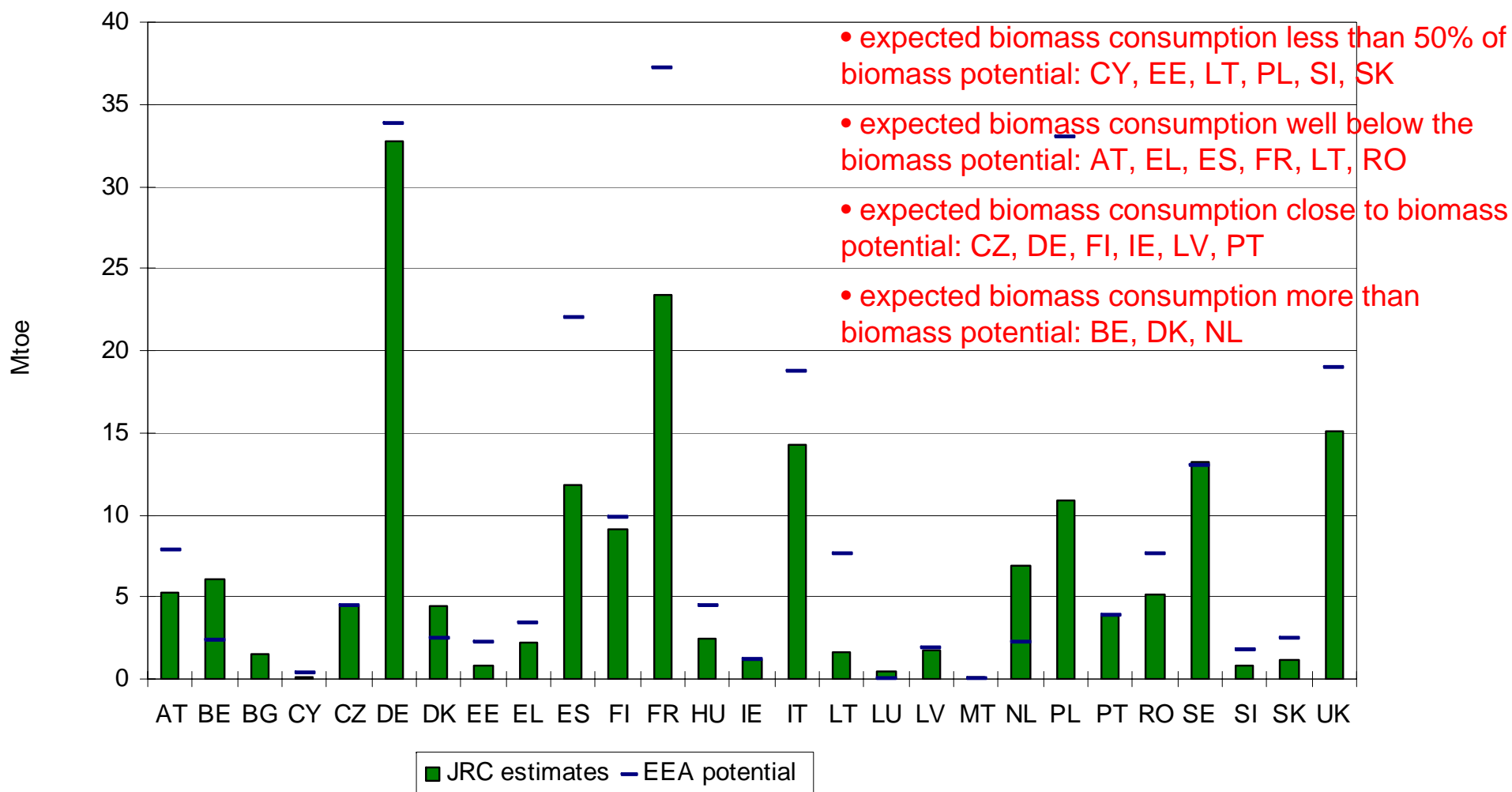


Data sources: National Renewable Action Plans (NREAPs)

2005 - actual data according to the NREAPs

2010-2020 – projections according to the NREAPs

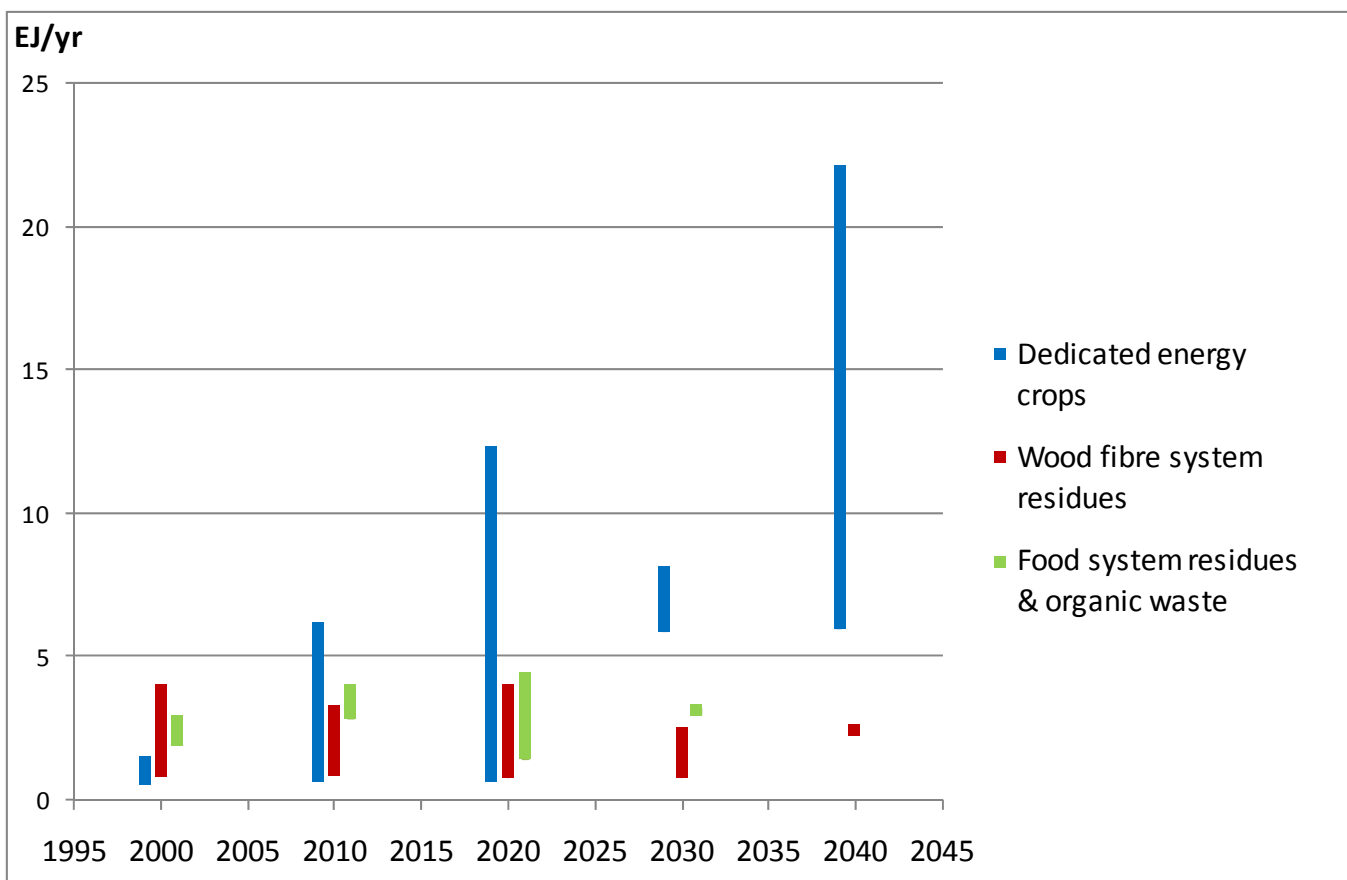
Expected biomass consumption and biomass potential in 2020



Sources: JRC estimates based on the NREAPs projections
EEA environmentally compatible biomass potential

Biomass Resources

Estimated total biomass energy potentials for EU27



Large variability and uncertainty of the results....

And what about the costs ?

Biomass Resource Assessments

Theoretical potential: the maximum amount of terrestrial biomass which can be considered theoretically available for bioenergy production within fundamental bio-physical limits.

The technical potential: the fraction of the theoretical potential which is available under the regarded techno-structural framework conditions and with the current technological possibilities (such as harvesting techniques, infrastructure and accessibility, processing techniques), also taking into account spatial confinements due to other land uses (food, feed and fibre production) as well as ecological (e.g. nature reserves) and other non-technical constraints.

Environmental potential: the fraction of the theoretical potential which meets certain environmental criteria, related to biodiversity, soil and water protection.

Economic potential: the share of the technical potential which meets criteria of economic profitability within the given framework conditions.

Implementation potential: the fraction of the economic potential that can be implemented within a certain time frame and under concrete socio-political framework conditions, including economic, institutional and social constraints and policy incentives.

Sustainable potential: the fraction of the theoretical potential which contains multiple environmental, economic and social aspects.

Biomass Resource Assessment

Resource focussed

- Statistical methods
- Spatially explicit methods
- Cost-supply methods

Demand driven

- Energy and economic modelling methods

Combined Integrated assessments

Because biomass resources are SPARSE and/or IRREGULAR, a careful potential evaluation should be geographically based

Biomass Resource Assessment methodology

Basic databases

Eurostat: crop statistics (NUTS 2)
National statistics and surveys
Corine Land Cover Map
Forest Cover Map

Specific data bases:

Biomass-productivity map (JRC)
M3-Crops Data (McGill University)
Map of protected areas
Digital elevation model
Climate zones

Other coverage:

Administrative boundaries
Road network map – Teleatlas
Natural gas transmission network

Restrictions, thresholds

- sustainable removal rates
- terrain slopes
- distances to roads

Logistics

- harvesting
- transport

Biomass costs

- harvesting
- collection
- transport

GIS

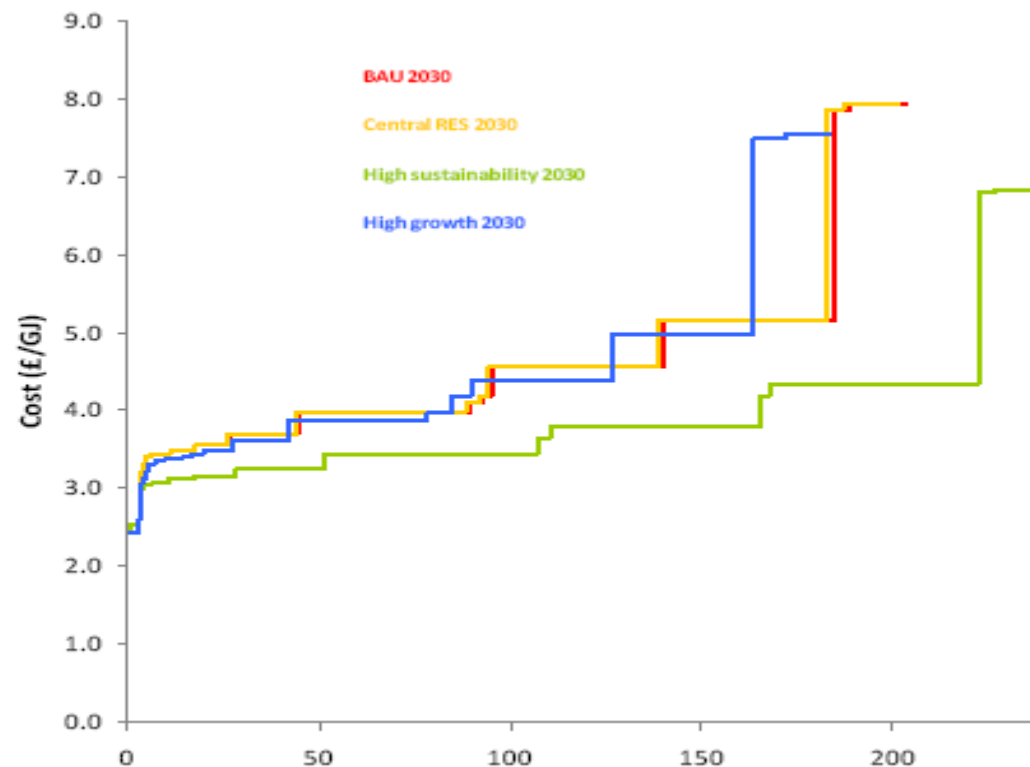
Mapping biomass resources

Availability

GIS provides map based visualization and modelling tools

Cost-supply assessment

- The amount of energy resource that can be used depends on the costs the users are ready to pay → you need cost-supply curves.



GIS-based assessment of crop residues in the EU

Actual production

- annual crop production
- crop yields
- residue to yield ratios

Environmental constraints

- organic matter content
- water retention capacity
- sensitivity to erosion

>> sustainable removal rates

Competitive use

- livestock raising in regions

Availability for energy

Suitability for energy generation

- suitability maps
- localization/optimization



GIS-based assessment of crop residues in the EU

Data/Tools

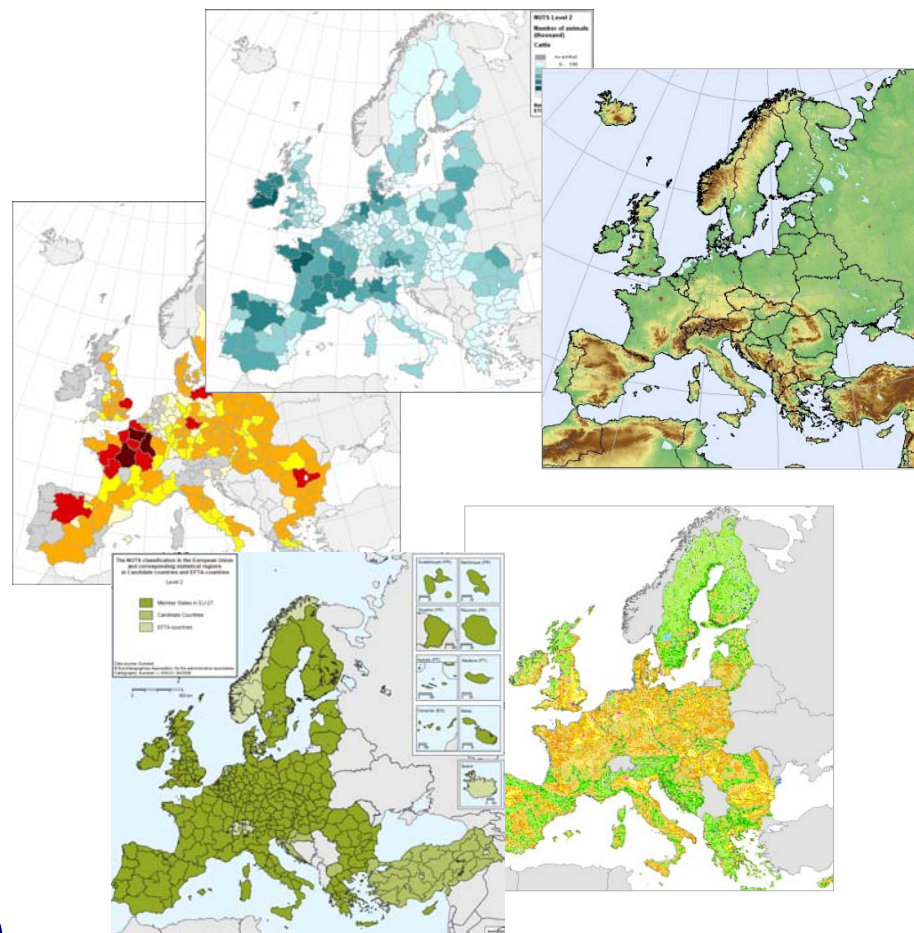
Eurostat (NUTS2 regions), year 2000-2009

- agricultural crops
 - wheat, barley, rye, oat, maize, rice, rapeseed and sunflower
- land use
- livestock use

GIS data

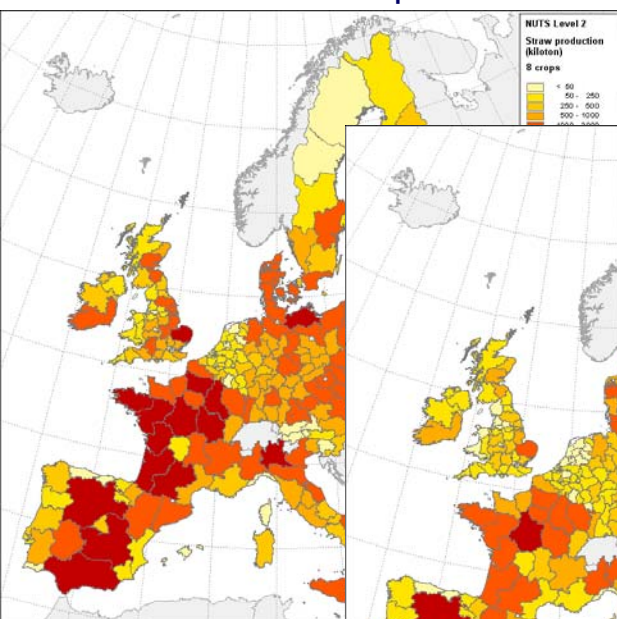
- GISCO (the Geographical Information System at the Commission)
- CORINE Land Cover 2000
- land cover (M3)
- soil productivity (JRC)

Geographical Information System (GIS)

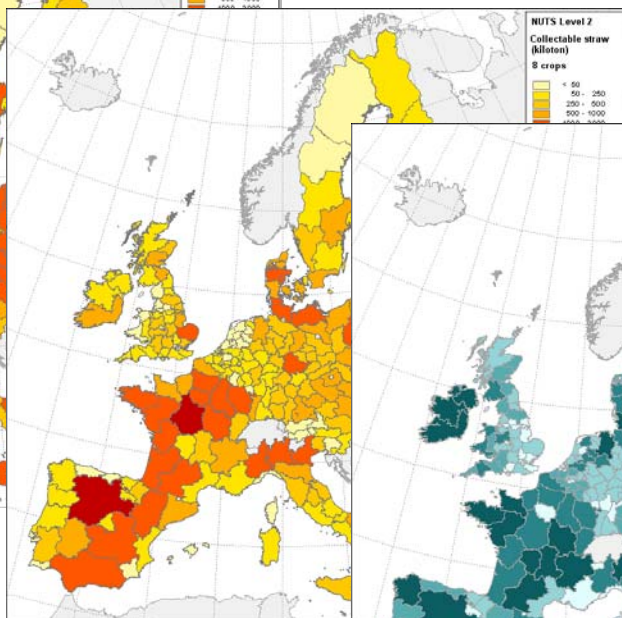


GIS-based assessment of crop residues in the EU

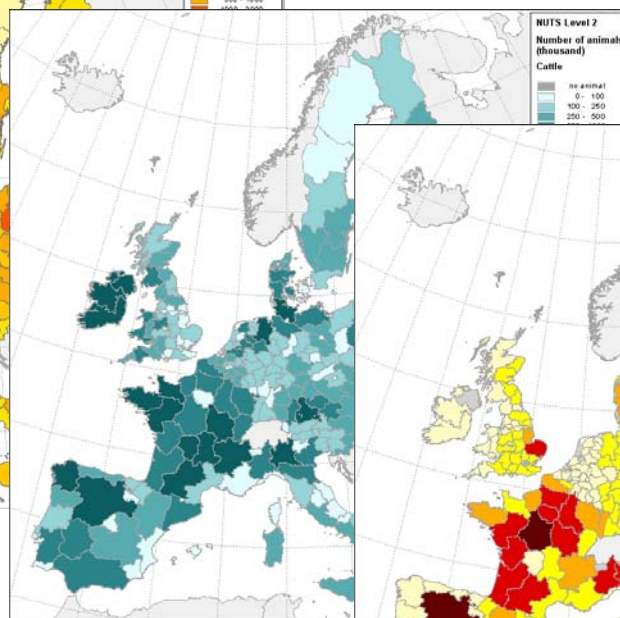
Straw production



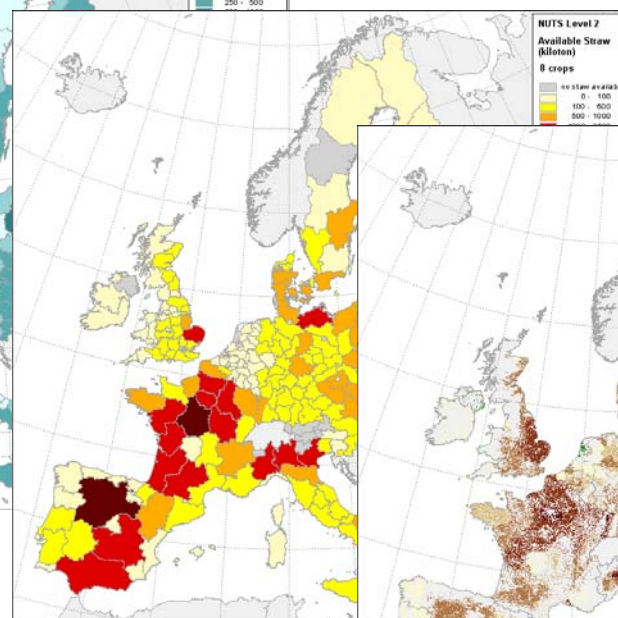
Collectable straw



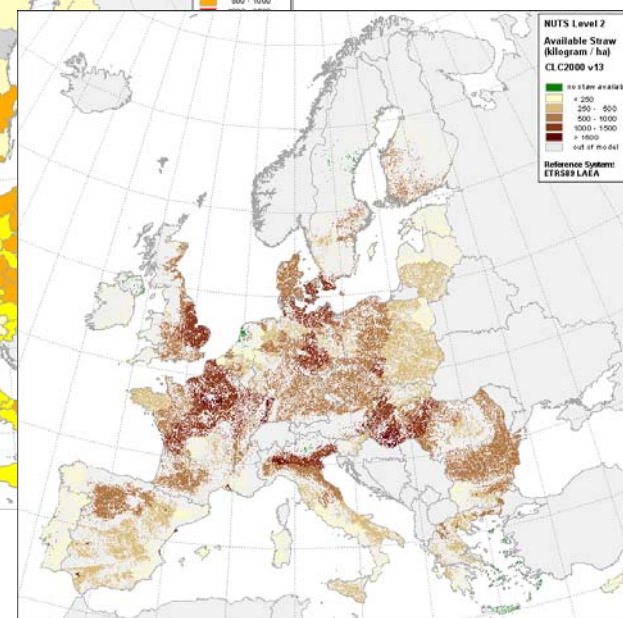
Competitive uses



Straw available for energy



Straw density

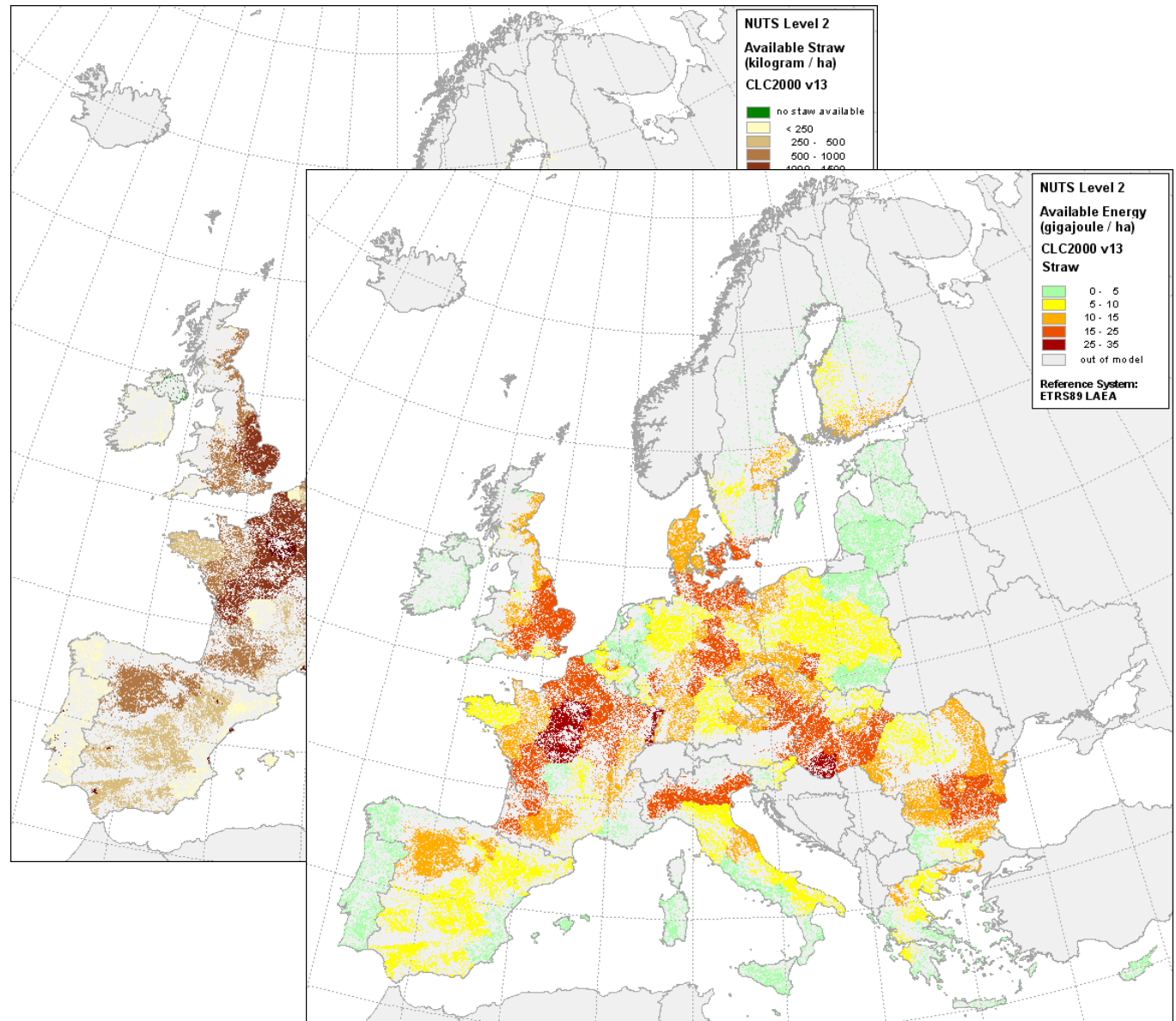
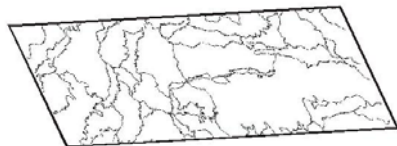
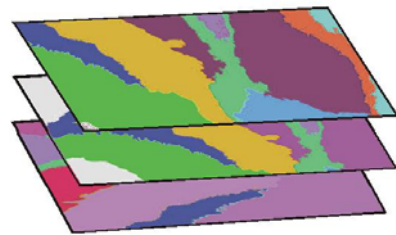


Data disaggregation and Land allocation

Available straw distributed
on the basis of:

- Land use (CORINE)
- Land cover (M3-Crops Data McGill University)
- Soil productivity (JRC)
- Climatic zones

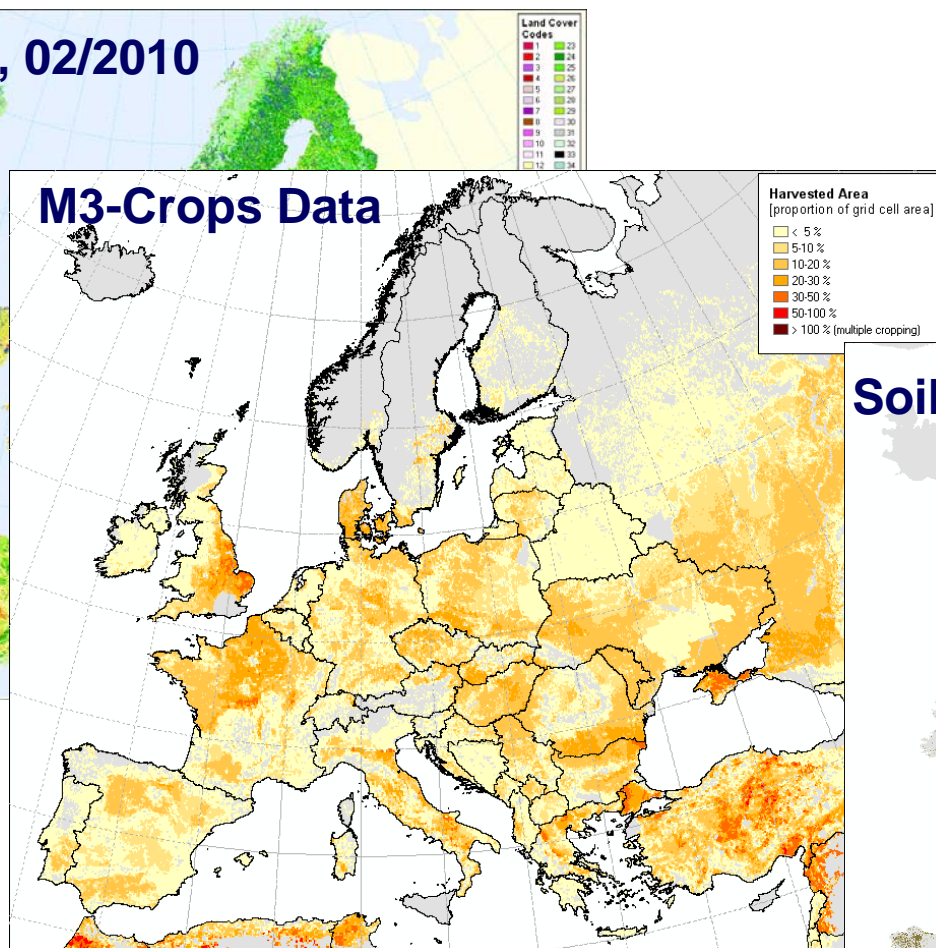
- Resolution: 1km x 1km



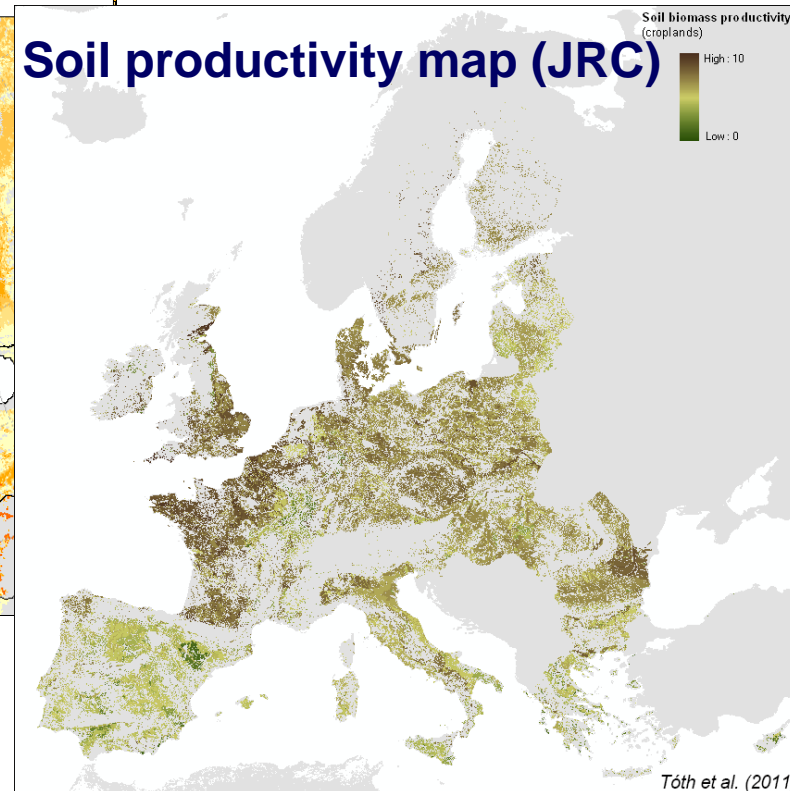
Data disaggregation and Land allocation

Code Land cover type
C2000 Ver. 13, 02/2010

Code	Land cover type
1	Continuous urban fabric
2	Discontinuous urban fabric
3	Industrial or commercial area
4	Road and rail networks and associated land
5	Port areas
6	Airports
7	Mineral extraction sites
8	Dump sites
9	Construction sites
10	Green urban areas
11	Sport and leisure facilities
12	Non-irrigated arable land
13	Permanently irrigated land
14	Rice fields
15	Vineyards
16	Fruit trees and berry plantations
17	Olive groves
18	Pastures
19	Annual crops associated with permanent crops
20	Complex cultivation patterns
21	Land principally occupied by agriculture, with significant areas of natural vegetation
22	Agro-forestry areas
23	Broad-leaved forest
24	Coniferous forest
25	Mixed forest
26	Natural grasslands
27	Moors and heathland
28	Sclerophyllous vegetation
29	Transitional woodland-shrub
30	Beaches, dunes, sands
31	Bare rocks
32	Sparsely vegetated areas
33	Burnt areas
34	Glaciers and perpetual snow
35	Inland marshes
36	Peat bogs
37	Salt marshes
38	Salines
39	Intertidal flats
40	Water courses
41	Water bodies
42	Coastal lagoons
43	Estuaries
44	Sea and ocean



Data source: Harvested Area and Yields of 175 crops (M3-Crops Data), Monfreda et al. (2008), "Farming the planet: 2. Geographic distribution of crop areas, yields, physiological types, and net primary production in the year 2000", Global Biogeochemical Cycles, Vol.22, GB1022, doi:10.1029/2007GB002947.

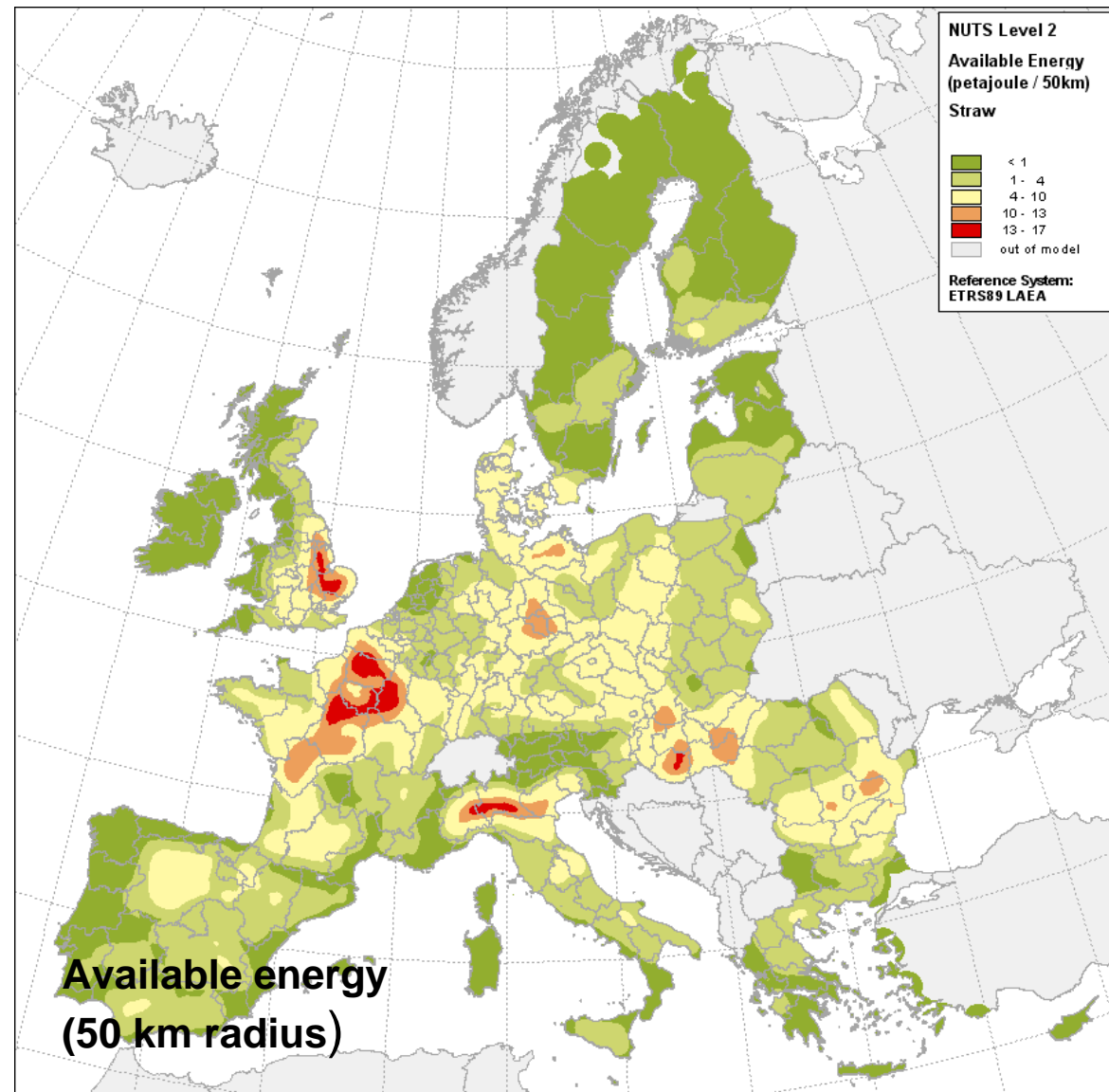


GIS-based assessment – straw plants location

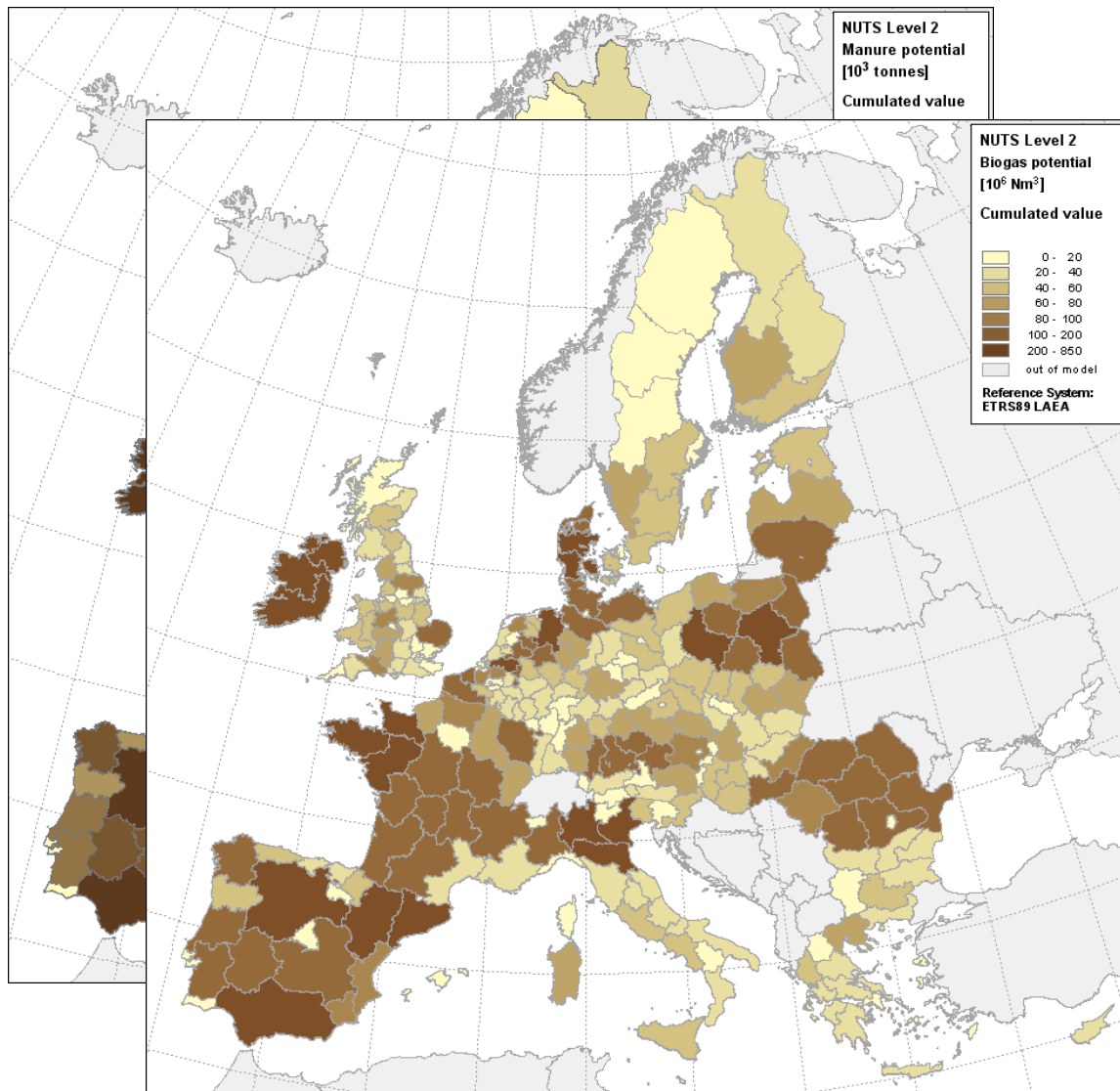
Suitability map for localization power plants

Main areas with important available straw resources

How many plants are possible to
be built, and where, given the
actual geographical distribution of
the straw resource?



Mapping of available biogas in the EU



Livestock Information

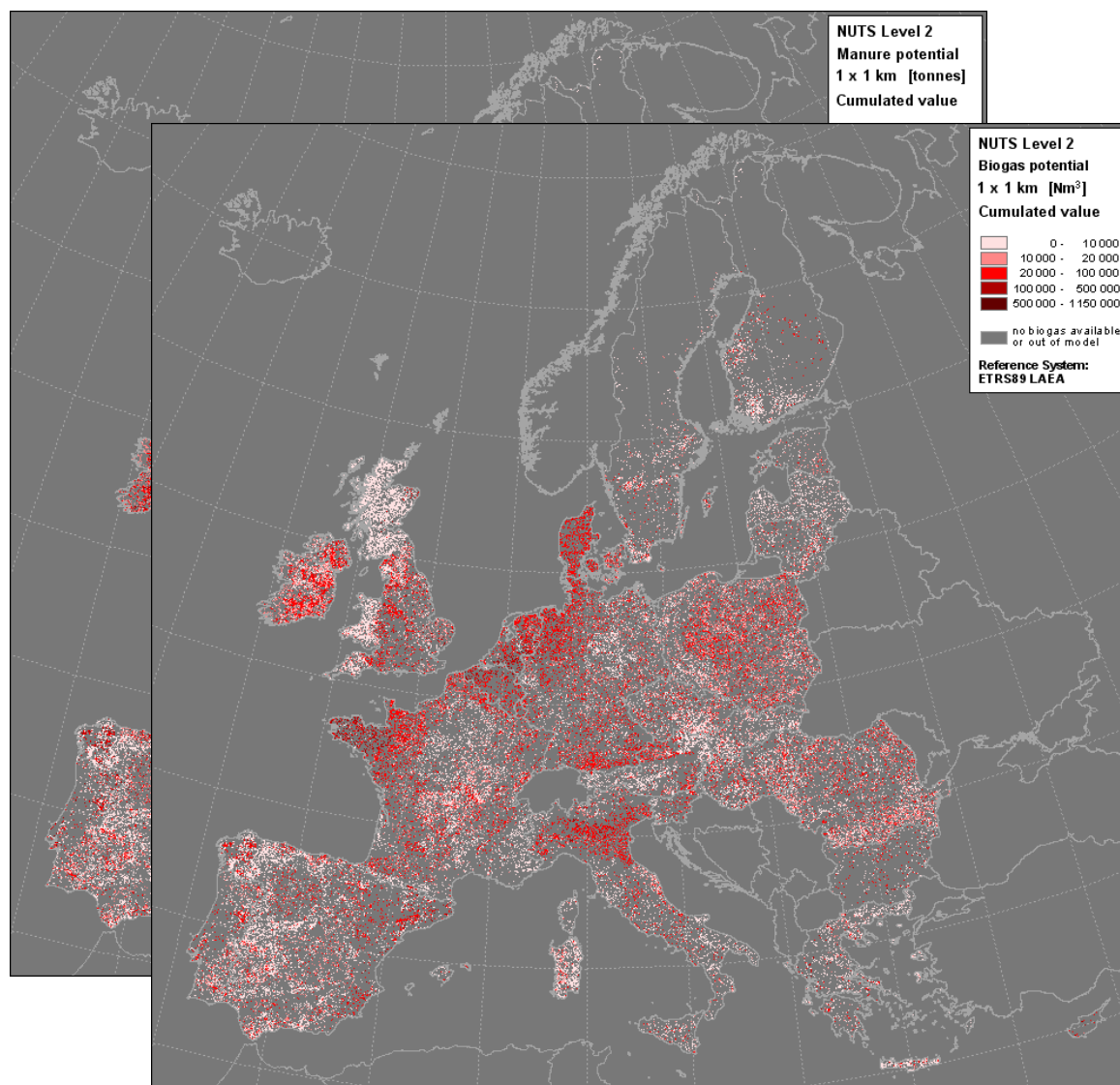
- type
- number
- confinement period
- wastewater, bedding & other waste volumes

Feedstock information

- feedstock composition (DM, OM)
- gas yields (biogas, methane)



Mapping of available biogas in the EU

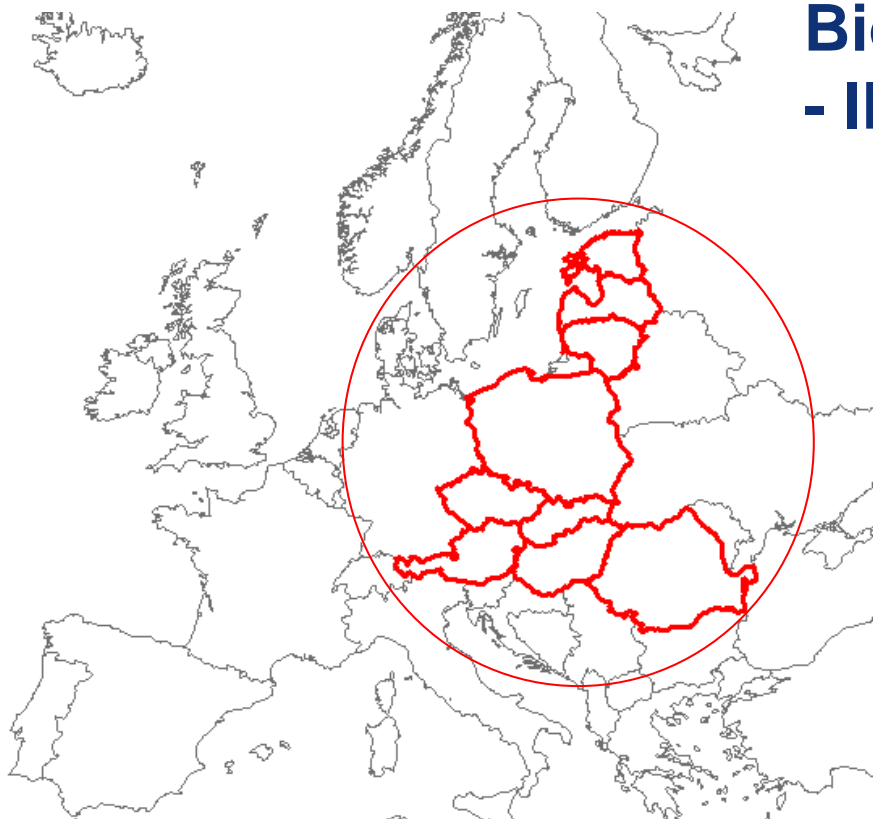


**Spatial allocation according to the
distribution of livestock in Europe**

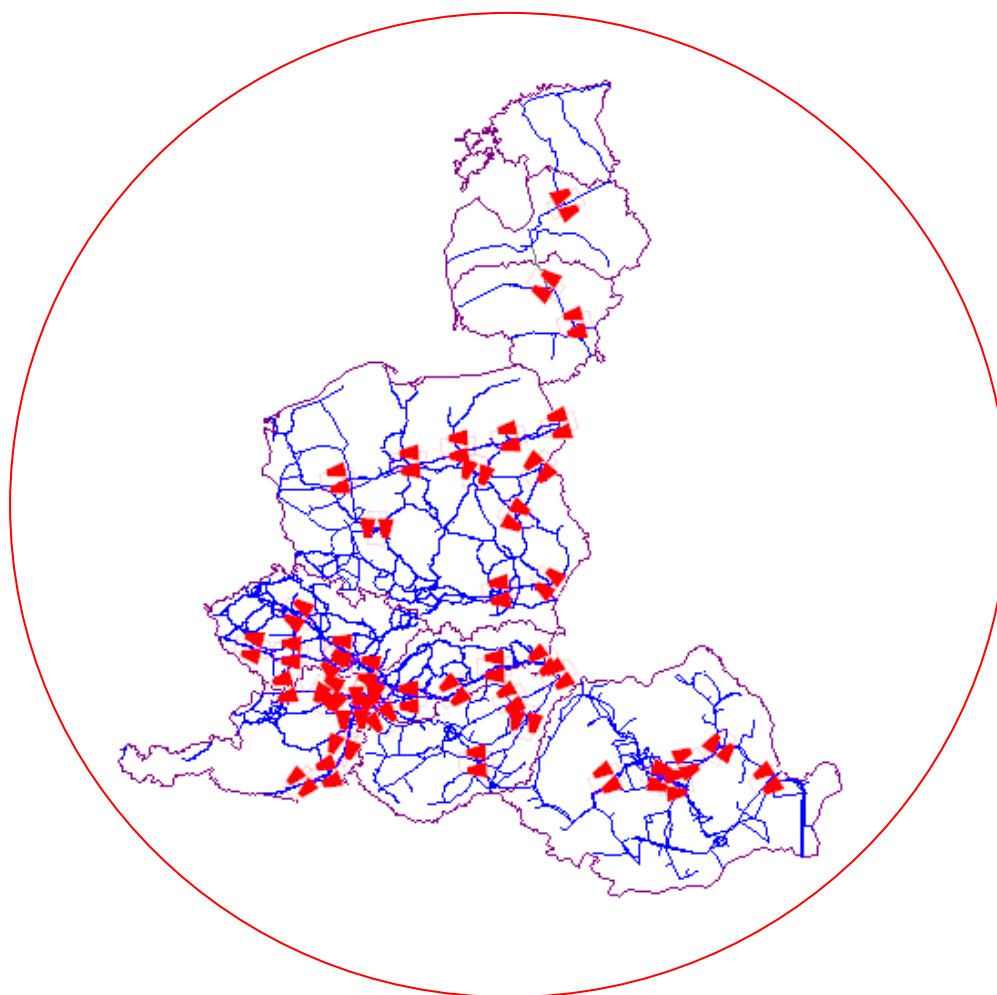
Source of livestock density based on the data developed by Neumann et al. 2009.

Data source: Neumann, K., Elbersen, B.S., Verburg, P.H., Staritsky, I., Perez-Soba, M., de Vries, W., Rienks, W.A. Modelling the spatial distribution of livestock in Europe, *Landscape Ecol* (2009) 24:1207–1222, DOI 10.1007/s10980-009-9357-5

Biogas integration into natural gas grid - IET gas model



Compressor station



GIS-based assessment of forest residues in the EU

Resource assessment depends on:

- Natural capital
- Topography
- Infrastructure
- Nature conservation
- Mechanisation options
- Costs
- Labour costs
-



GIS-based assessment of forest residues in the EU

National Forest Inventory data

- Forest area
- Growing stock
- Net annual increment
- Annual fellings

Technical constraints

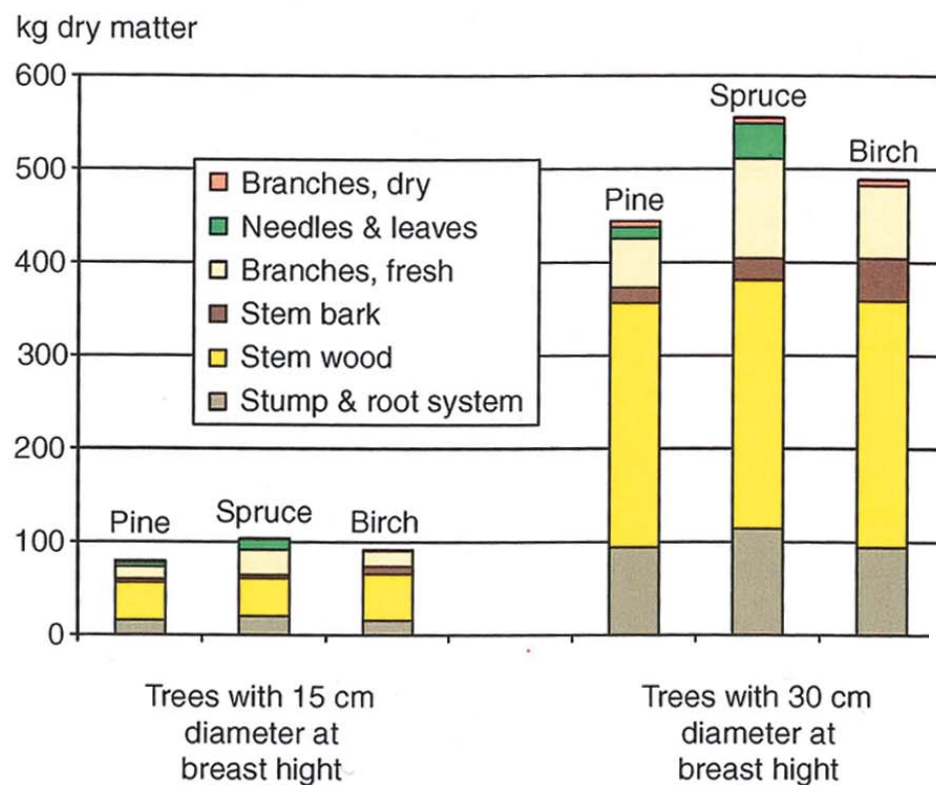
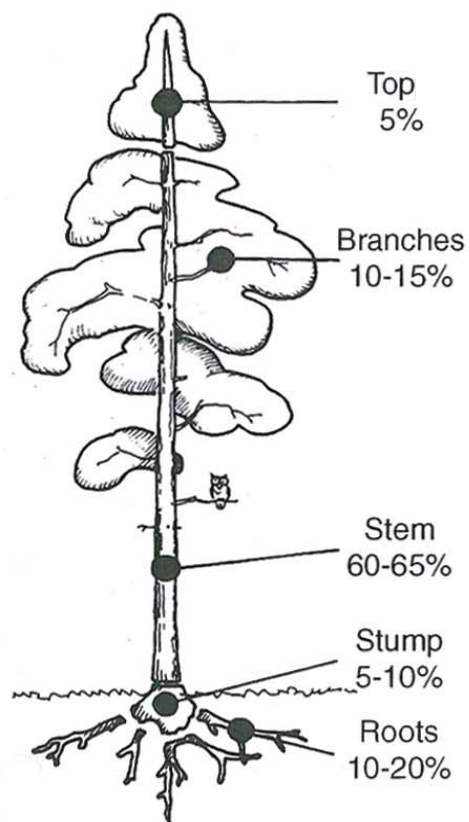
- infrastructure accessibility
- topography
 - elevation
 - slope

Environmental constraints

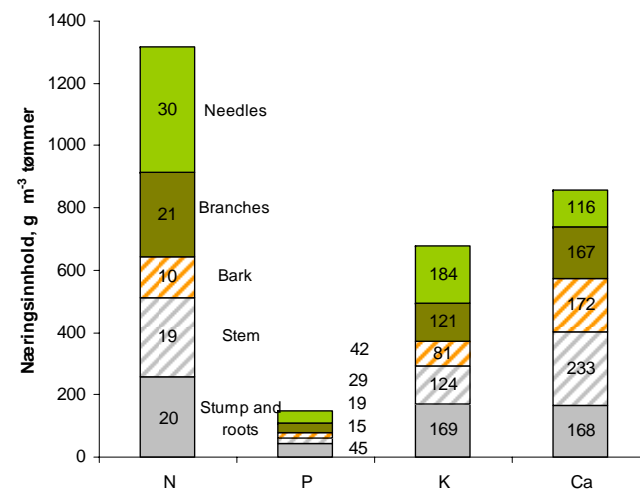
- biodiversity
 - dead wood
 - protected areas
- soil protection /soil erosion
 - soil type
 - elevation
 - slope
- protected areas



How much biomass is available after cutting down the trees?



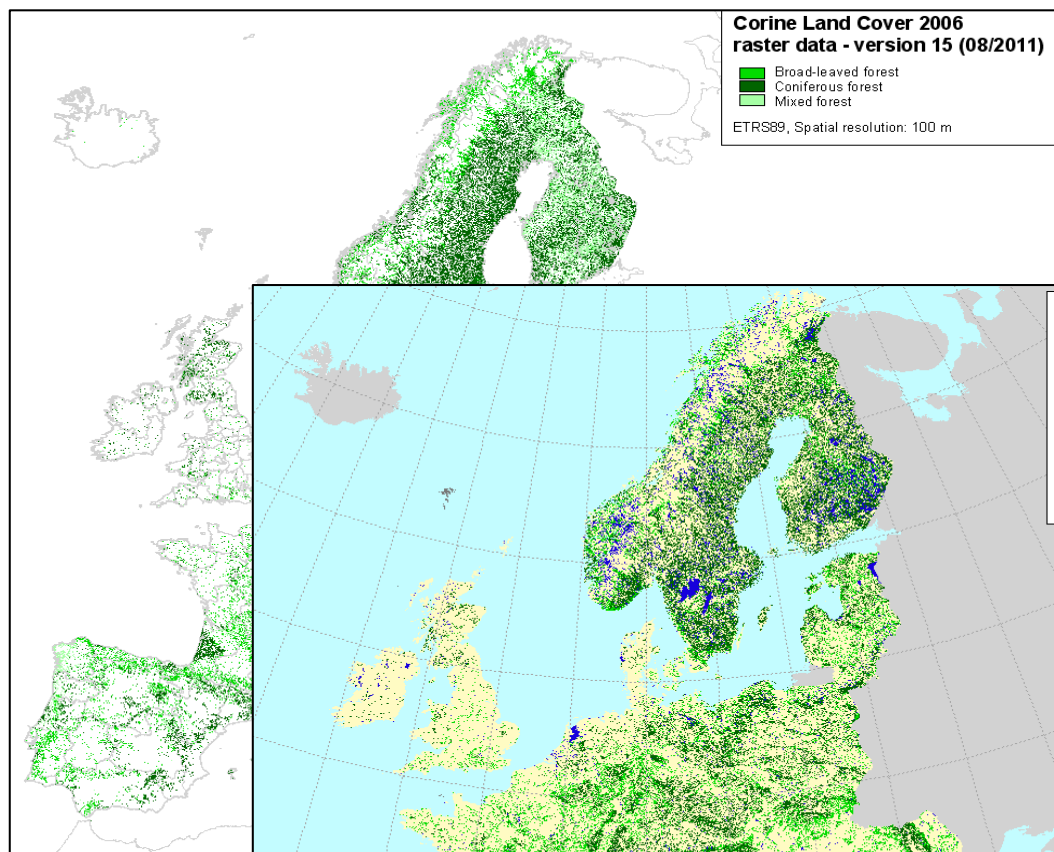
Nutrient distribution in trees



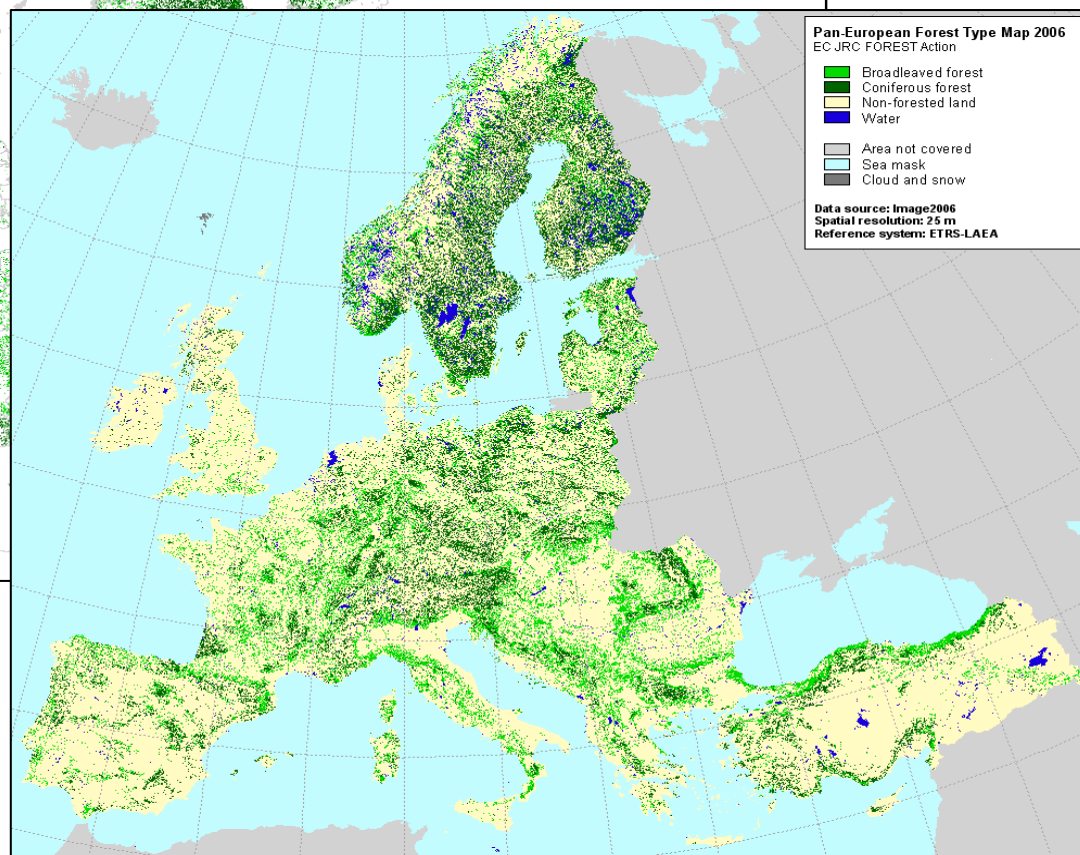
Source: G Melin, www.swebio.se

Input Data for Mapping forest resources

- **Corine Land Cover (EEA-2000 v.13, 2010, EEA-2006 v.15, 2011)**



- **Pan-European Forest Type JRC, Forest-2006**



Input Data for Mapping forest resources

Forest species

JRC Project GHG AFOLU – 2000

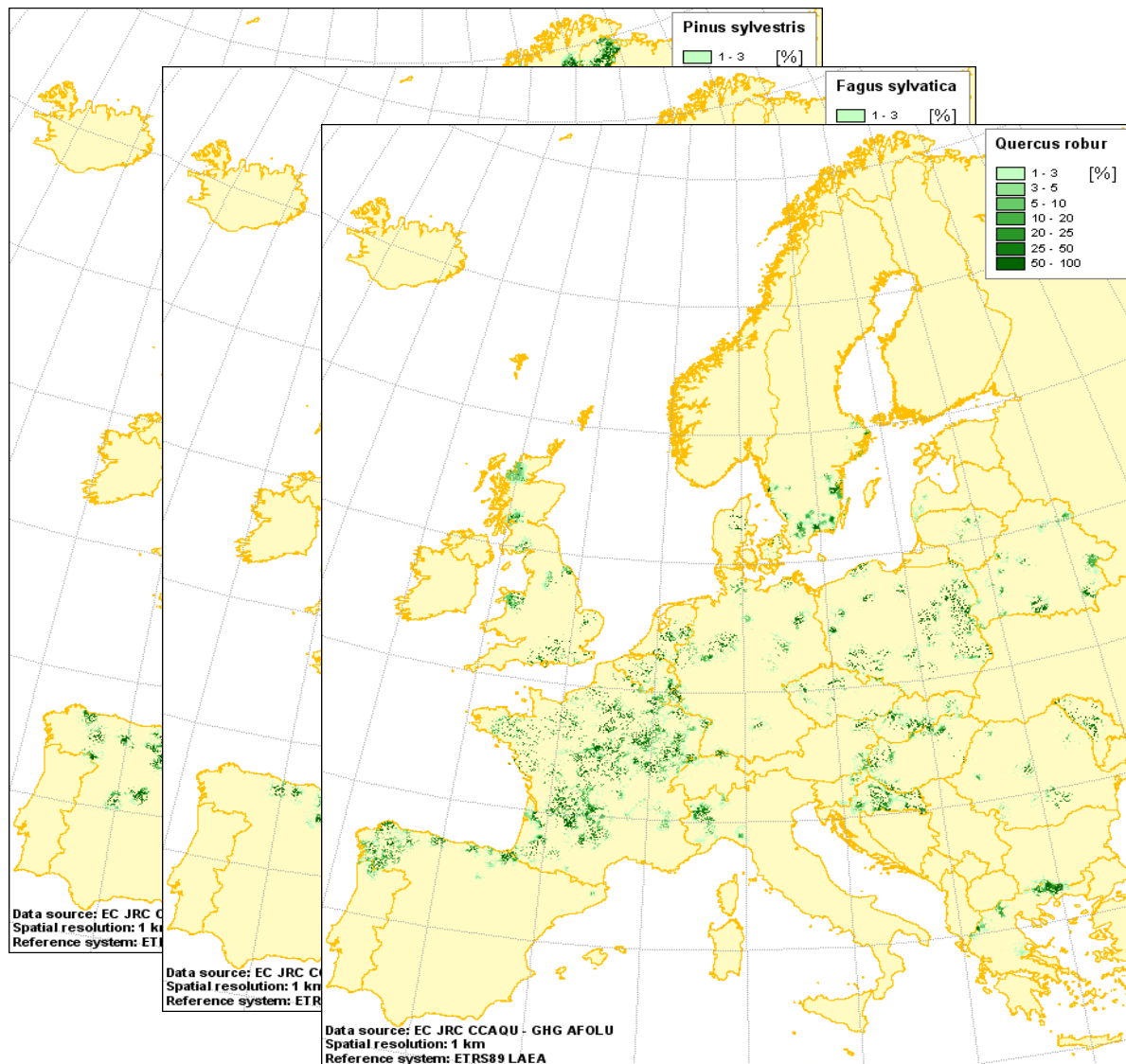
Pinus sylvestris (Scots pine)

Fagus sylvatica (Beech)

Quercus robur (Common oak)

Gridded data of forest species in 1 km spatial resolution

abi_alba	Abies alba	euc_spec	Eucalyptus sp.	pin_leuc	Pinus leucodermis	que_pube	Quercus pubescens
abi_bon	Abies balsamifera	fag_moes	Fagus moesiaca	pin_mugo	Pinus mugo	que_pyre	Quercus pyrenaica
abi_ceph	Abies cephalonica	fag_ore	Fagus orientalis	pin_nigr	Pinus nigra	que_robu	Quercus robur
abi_gran	Abies grandis	fag_sylv	Fagus sylvatica	pin_pina	Pinus pinaster	que_rotu	Quercus rotundifolia
ace_camp	Acer campestre	fra_ang	Fraxinus angustifolia	pin_pine	Pinus pinea	que_rubr	Quercus rubra
ace_mons	Acer monspessulanum	fra_exc	Fraxinus excelsior	pin_radi	Pinus radiata	que_sube	Quercus suber
ace_opal	Acer opalus	fra_orm	Fraxinus ornus	pin_stro	Pinus strobus	que_troj	Quercus trojana
ace_plat	Acer platanoides	ile_aqu	Ilex aquifolium	pin_sylv	Pinus sylvestris	rob_pseu	Robinia pseudacacia
ace_spec	Acer sp.	jug_nigr	Juglans nigra	pin_unci	Pinus uncinata	sal_alba	Salix alba
aln_cord	Alnus cordata	jug_regi	Juglans regia	pis_lent	Pistacia lentiscus	sal_capr	Salix caprea
aln_glut	Alnus glutinosa	jun_comm	Juniperus communis	pis_tere	Pistacia terebinthus	sal_cine	Salix cinerea
aln_inca	Alnus incana	jun_oxy	Juniperus oxycedrus	pla_ore	Platanus orientalis	sal_elea	Salix eleagnos
aln_viri	Alnus viridis	jun_phoe	Juniperus phoenicea	pop_alba	Populus alba	sal_spec	Salix sp.
arb_andr	Arbutus andrachne	jun_thur	Juniperus thurifera	pop_cana	Populus canescens	sor_aria	Sorbus aria
arb_uned	Arbutus unedo	lar_deci	Larix decidua	pop_hybr	Populus hybridus	sor_aucu	Sorbus aucuparia
bet_pend	Betula pendula	lar_kae	Larix kaempferi	pop_nigr	Populus nigra	sor_dome	Sorbus domestica
bet_pube	Betula pubescens	lau_nobi	Laurus nobilis	pop_trem	Populus tremula	sor_torm	Sorbus torminalis
bux semp	Buxus sempervirens	mal_dome	Malus domestica	pru_avu	Prunus avium	tax_bacc	Taxus baccata
car_betu	Carpinus betulus	ole_euro	Olea europaea	pru_padu	Prunus padus	thu_spec	Thuja sp.
car_orie	Carpinus orientalis	ost_carp	Ostrya carpinifolia	pru_sero	Prunus serotina	til_cord	Tilia cordata
cas_sati	Castanea sativa	oth_broa	Other broadleaves	pse_menz	Pseudotsuga menziesii	til_plat	Tilia platyphyllos
ced_atla	Cedrus atlantica	oth_coni	Other conifers	pyr_comm	Pyrus communis	tsu_spec	Tsuga sp.
ced_deod	Cedrus deodara	phi_lati	Phillyrea latifolia	que_cerr	Quercus cerris	uim_glab	Ulmus glabra
cer_sili	Cercis siliquastrum	pic_abi	Picea abies	que_cocc	Quercus coccifera	uim_laev	Ulmus laevis
cer_silq	Cerastion silqua	pic_sitc	Picea sitchensis	que_fagi	Quercus faginea	uim_mino	Ulmus minor
cer_avel	Corylus avellana	pin_brut	Pinus brutia	que_frai	Quercus frainetto		
cup_semp	Cupressus sempervirens	pin_cana	Pinus canariensis	que_fruc	Quercus fructosa		
eri_arbo	Erica arborea	pin_cemb	Pinus cembra	que_ilex	Quercus ilex		
eri_mani	Erica manipoliflora	pin_cont	Pinus contorta	que_macr	Quercus macrolepis		
eri_scop	Erica scoparia	pin_hale	Pinus halepensis	que_patr	Quercus patraea		



Source: Köble R. and Seufert G. (2001)

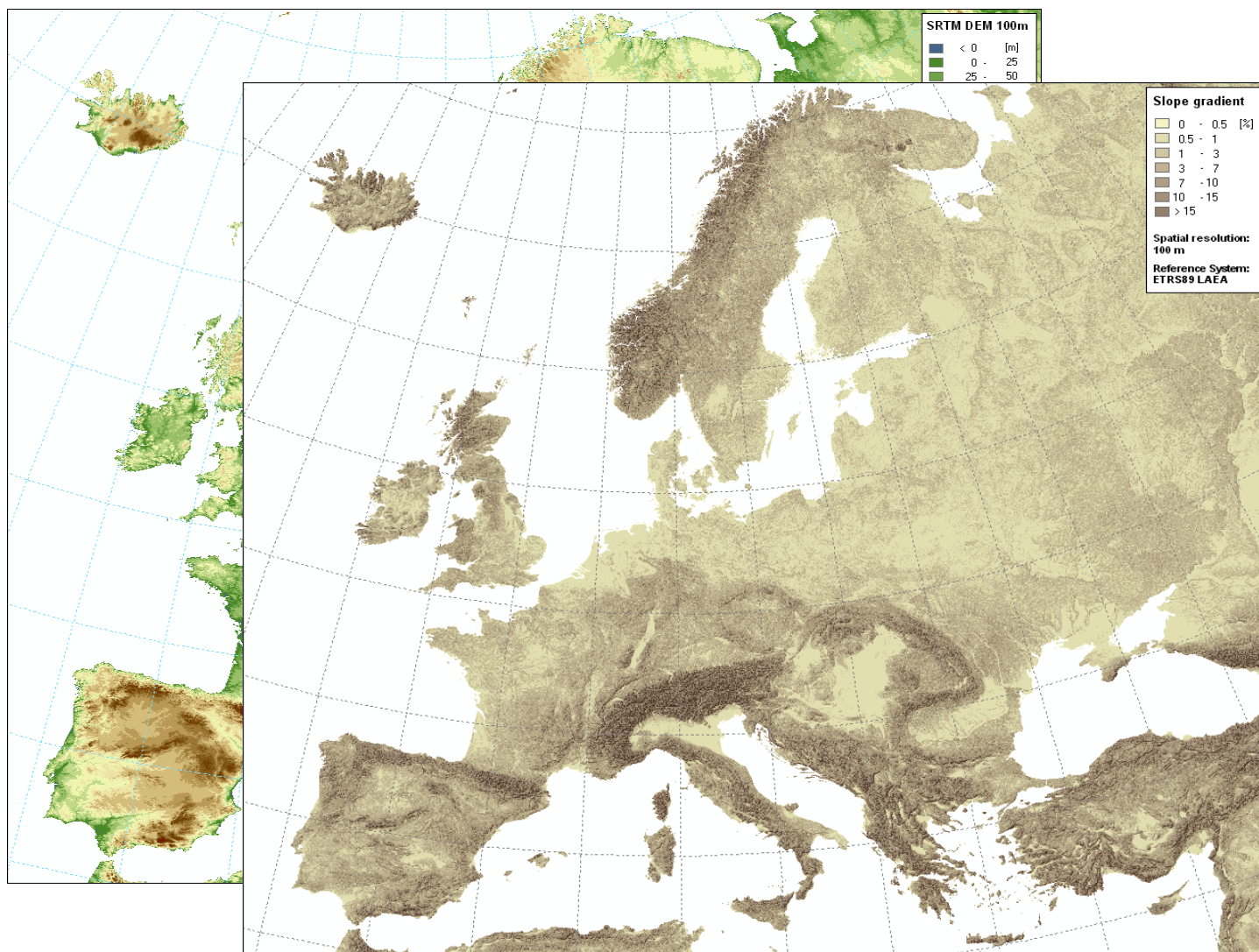
Input Data for Mapping forest resources

Digital Elevation Model

Spatial resolution: 100 m

Slope gradient map

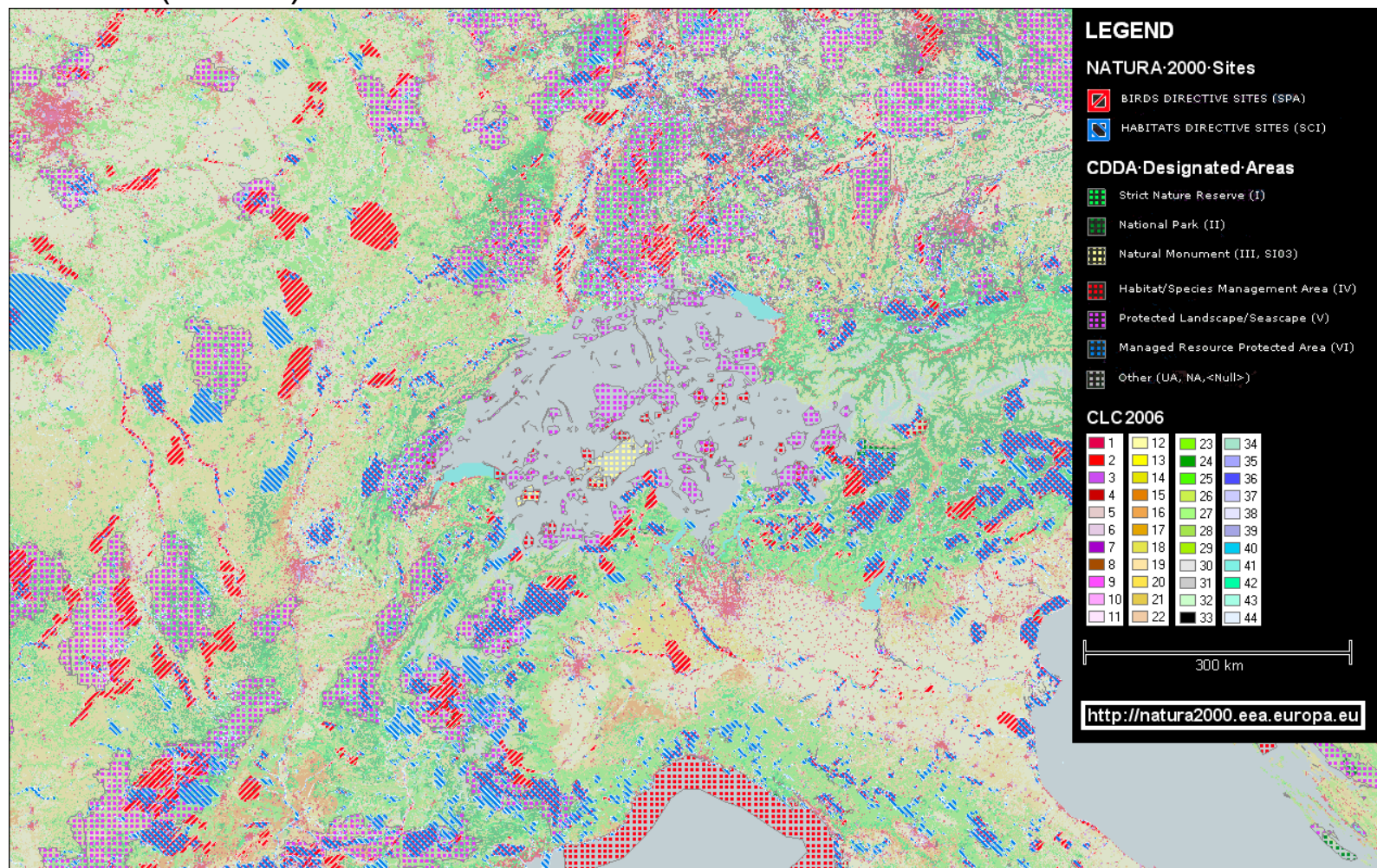
Spatial resolution: 100 m



Data source: Consortium for Spatial Information (CGIAR-CSI) <http://srtm.csi.cgiar.org>

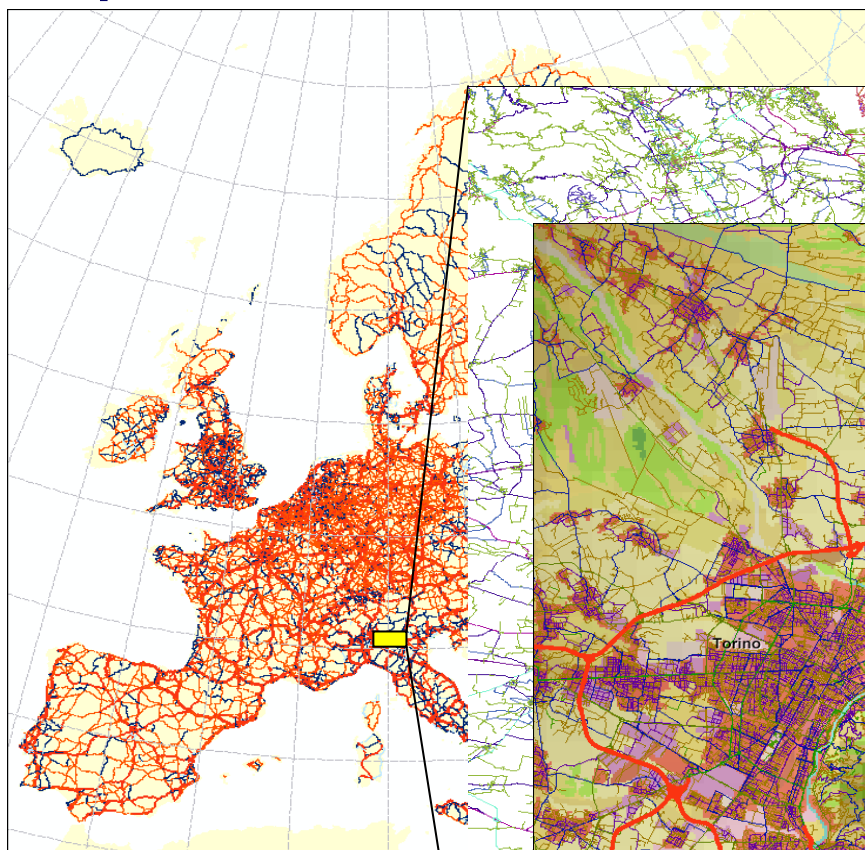
Protected areas

- NATURA 2000
- Nationally designated areas (CDDA)

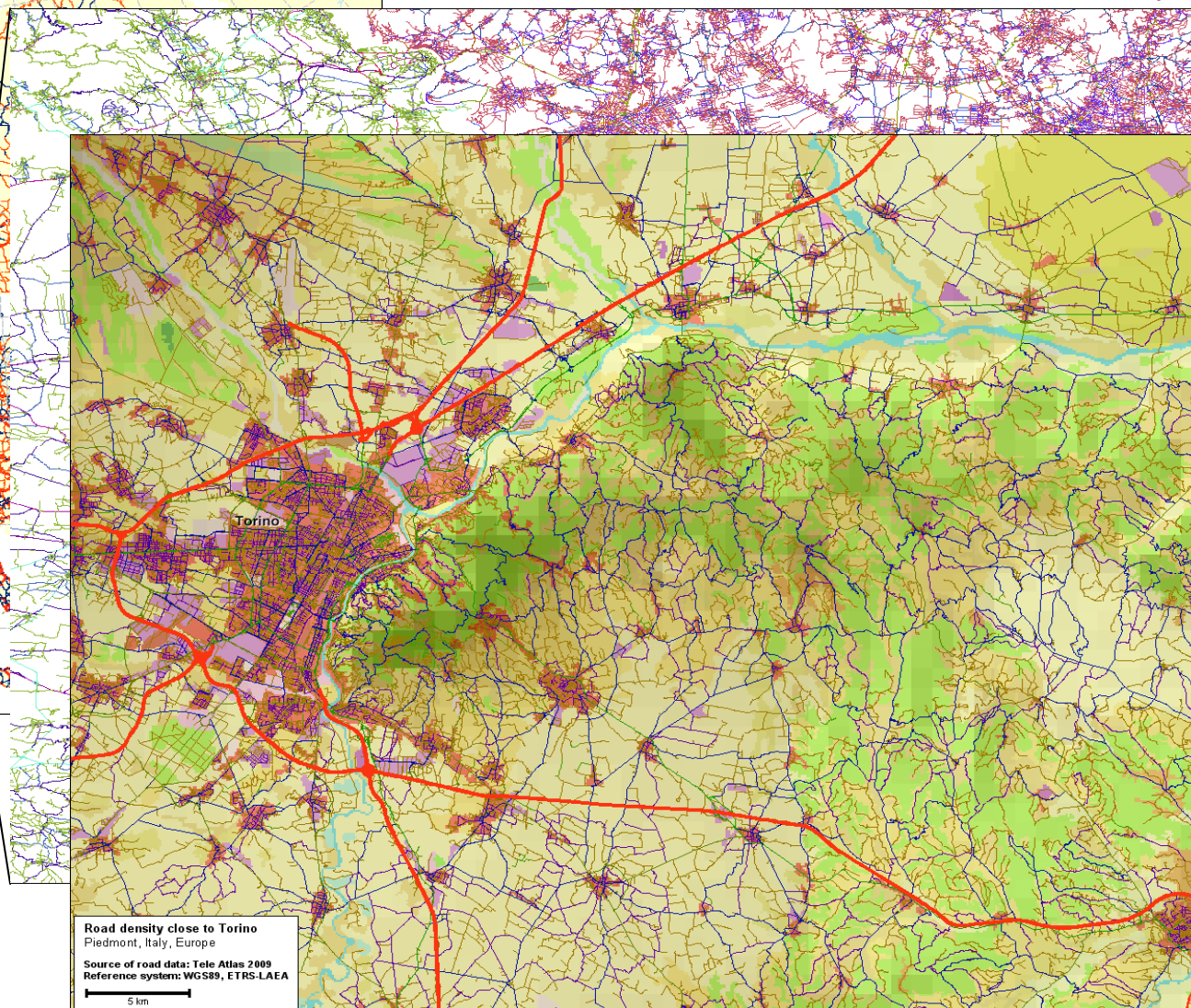


Roads in Europe

Tele Atlas 2009



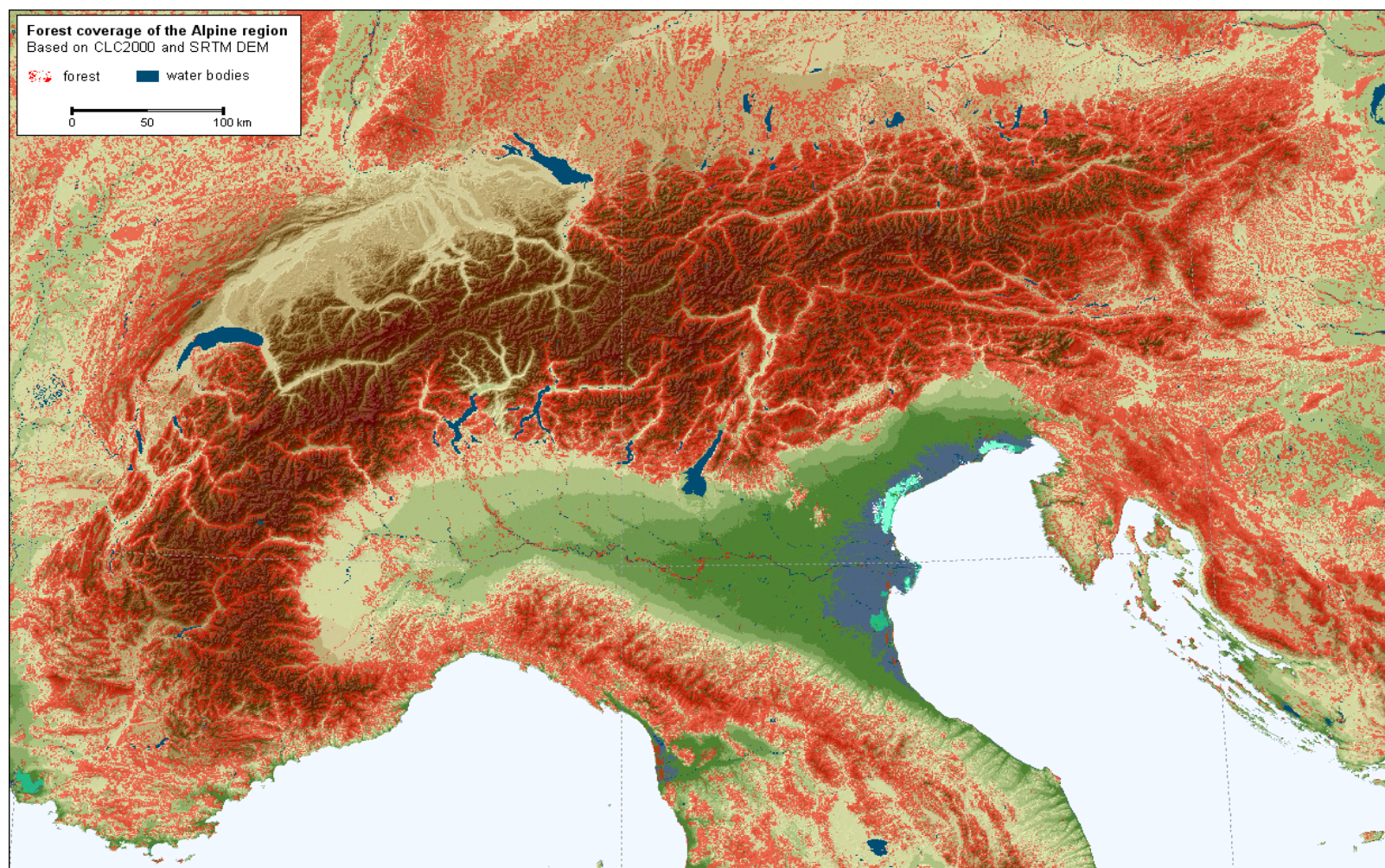
Roads in Piedmont and Lombardy



Roads in Europe – Torino

Forest coverage of the Alpine region

Spatial resolution: 100 m



Thank you for your attention!

Nicolae Scarlat

**European Commission
Joint Research Centre
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