Biomass-to-energy

Environmental Priorities

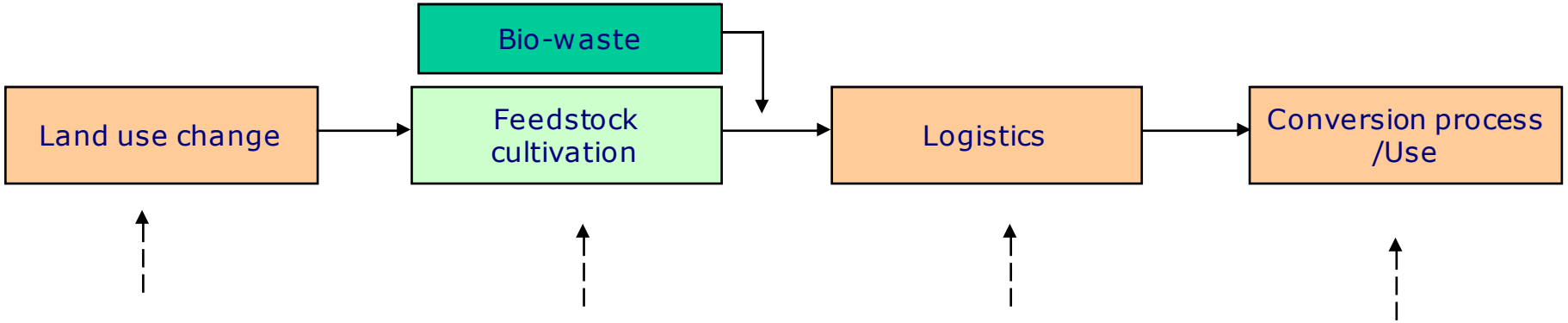
"Reality check on bioenergy targets"
19-20 May 2008

Ayla Uslu
European Environment Agency

Presentation overview

- What are the net environmental benefits of different types of bioenergy use?
- Application of LCA (GHG emissions) to analyse those benefits and the outstanding issues?

Biomass-to-energy pathways



- Clearing of land
- Soil carbon change
- Burning of biomass

Risk matrix:

- erosion
- soil compaction
- nutrient inputs groundwater
- nutrient inputs in surface water
- pesticide pollution of soils and water
- water abstraction
- "increased fire risk"
- diversity of crop types,intensification of protected areas

- Fossil fuel energy use
- Exhaust gas emissions
- Env. Impacts of increased logistics

- Conversion efficiency
- Emissions to air
- Water discharge

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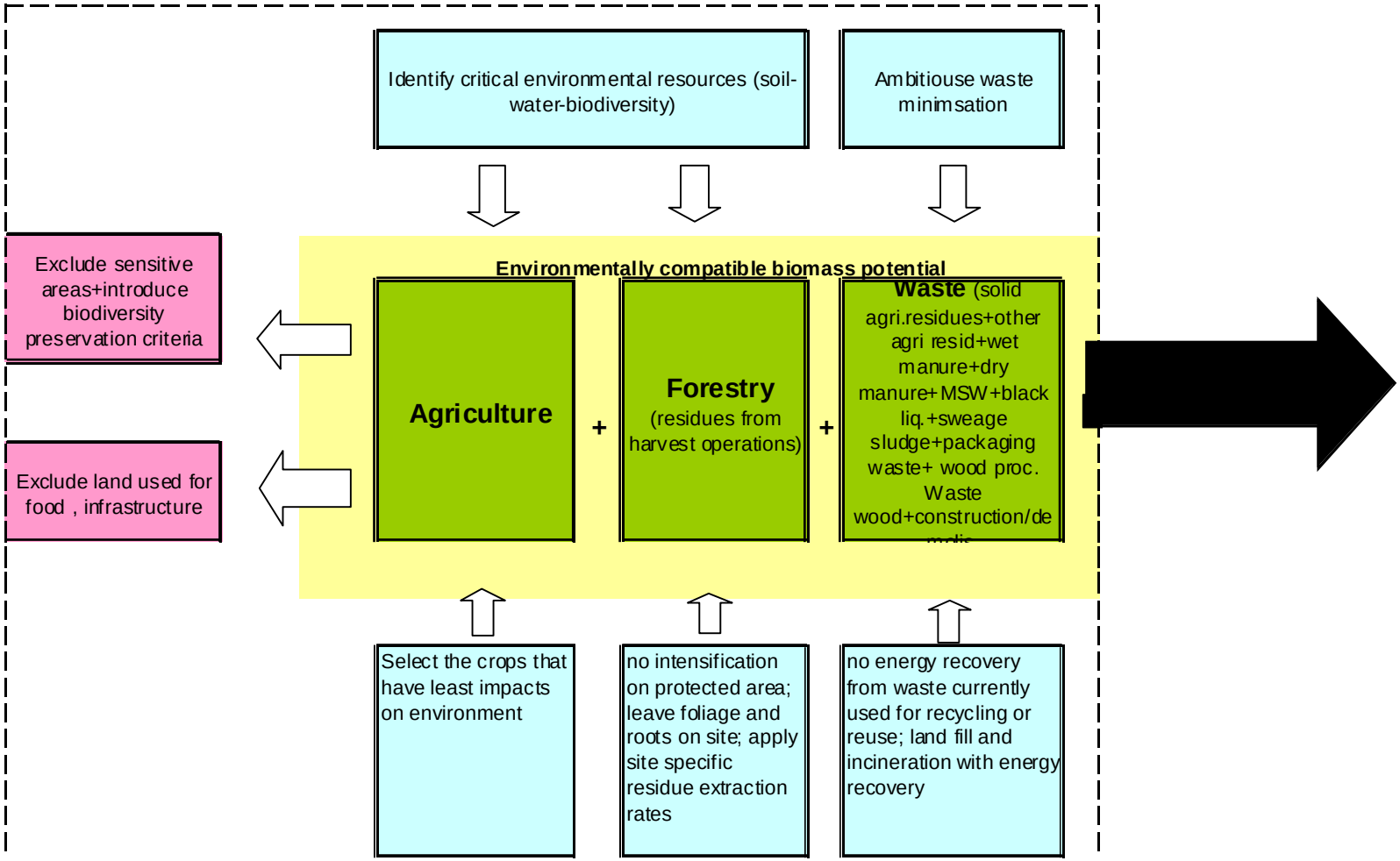
Bioenergy potential-EEA, 2006



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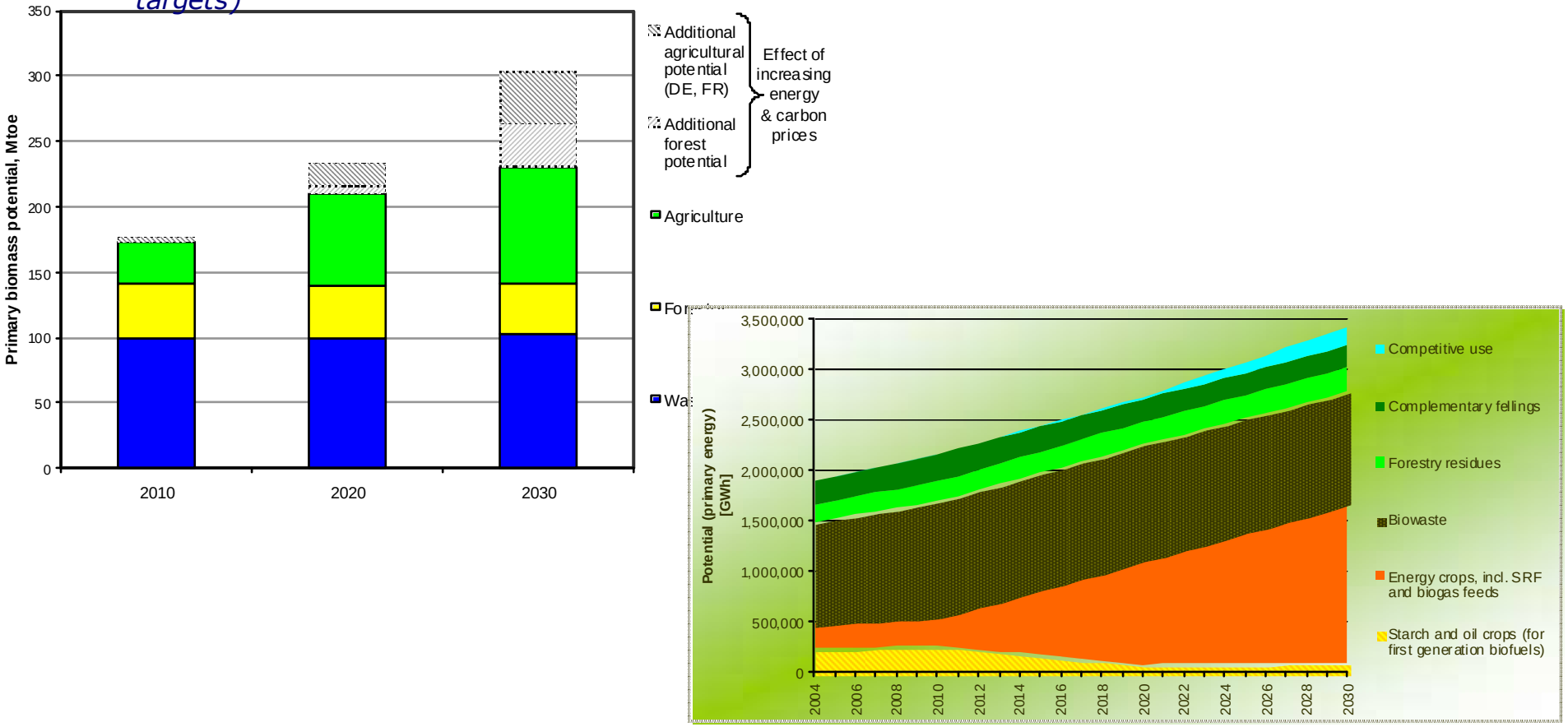
EEA, 2006-How much bioenergy can Europe produce without harming the environment ?

Project aim: Determine the bioenergy potential that

- *causes no additional pressure on farmland and forest biodiversity and soil and water resources*
- *Respects other environmental objectives (organic farming, waste minimisation, climate targets)*



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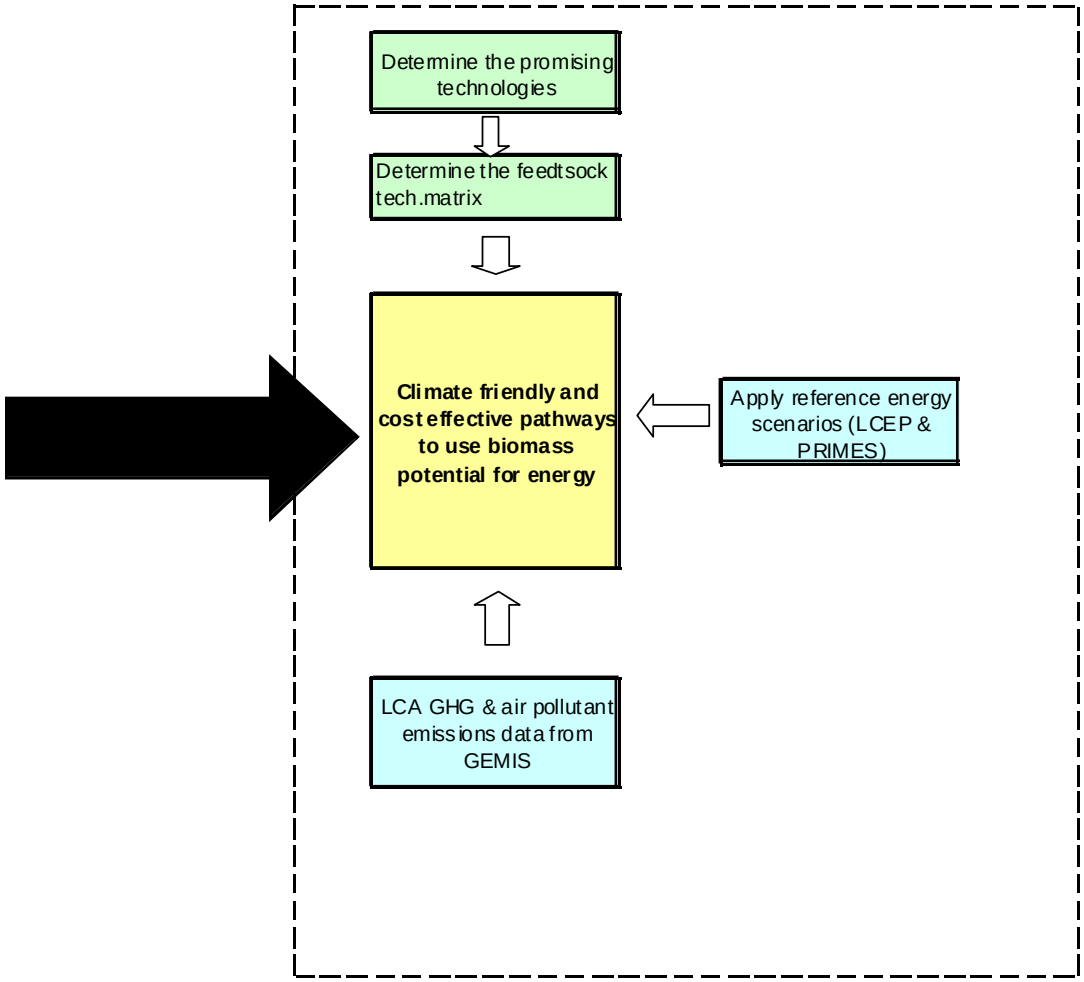
Which technologies can exploit the environmentally-compatible potential?

- Heat and electricity production are better suited to use solid biomass, perennials, biogas etc.
- Environmentally-friendly crop mixes favour perennials and low-impact, high yield crops
  - → 1st generation biofuel production has limited potential
  - → Sugar beet and oilseed rape appear not so favourable
- 2nd generation biofuel technologies are promising from an environmental perspective (BTL, biogas, ethanol+) as they can use ligno-cellulosic material:
  - Can use low-impact, high yield crops and grass cuttings as input
  - Allows the use of the important bioenergy potential from forestry and waste, incl. by-products from agriculture

……..how to use this potential?

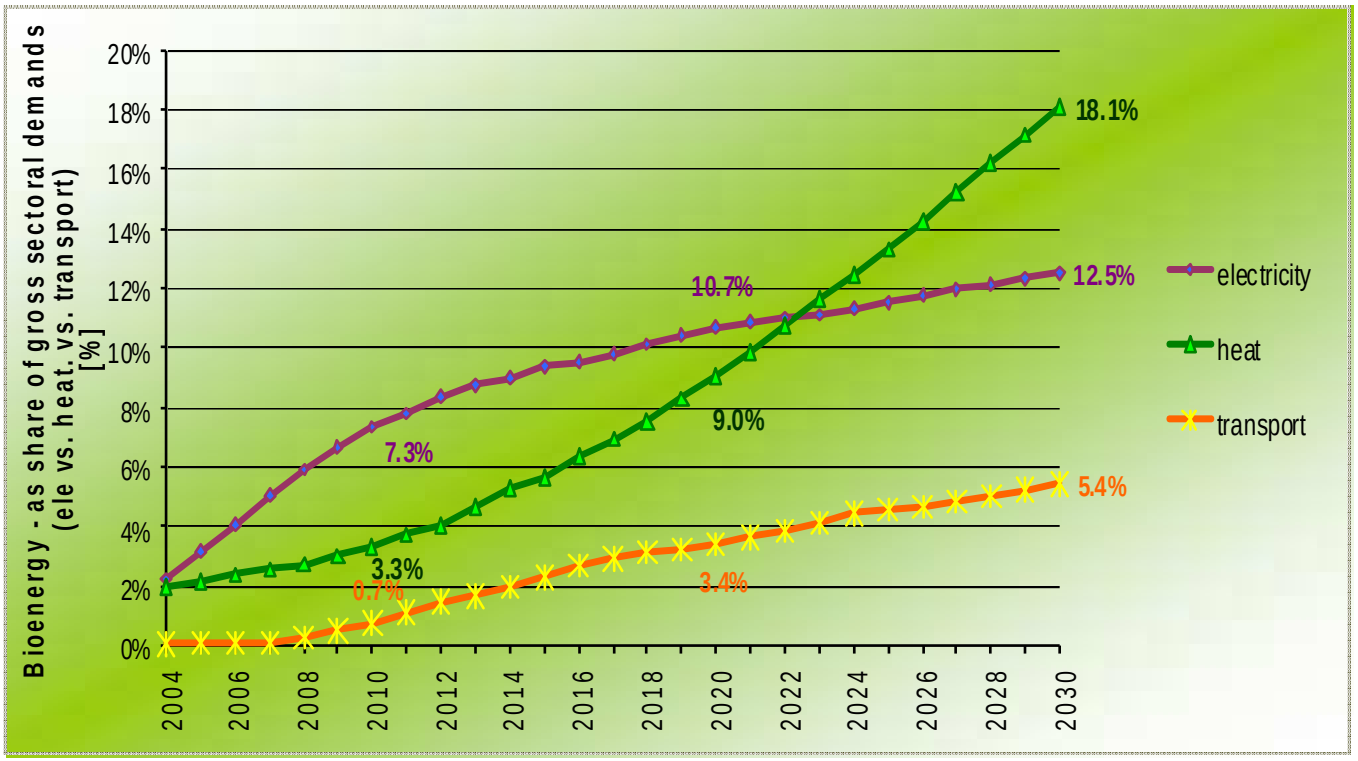


Limitations to this study:

Due to the availability of modelling tools and the complexity of guaranteeing sustainability of large scale biomass/biofuel production in other world regions and the uncertainties around them, ***the focus is given to the EU domestic bioenergy resources****. Direct and indirect land use effects of large scale global bioenergy production on the environment and bioenergy GHG balances are therefore not assessed*

Exploiting Europe's bioenergy potential-Preliminary results

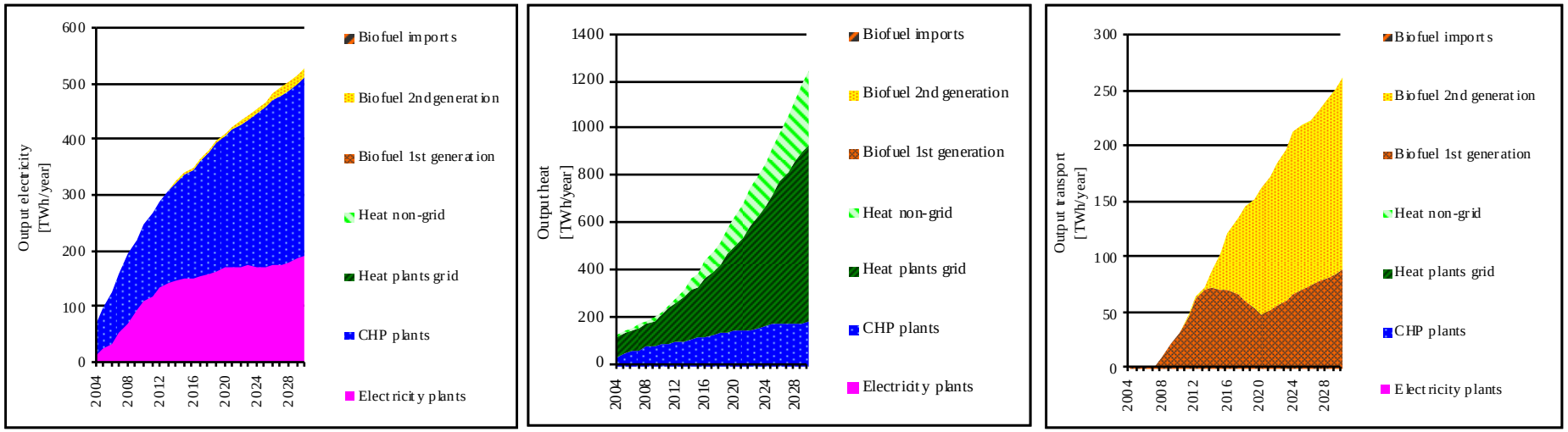
Bioenergy deployment as a share of gross sectoral demands (electricity, heat and transport).



10.5% of total primary energy consumption (7.7% of final energy consumption) in 2020 and 15.9 %(13% of final energy consumption) by 2030

Preliminary results

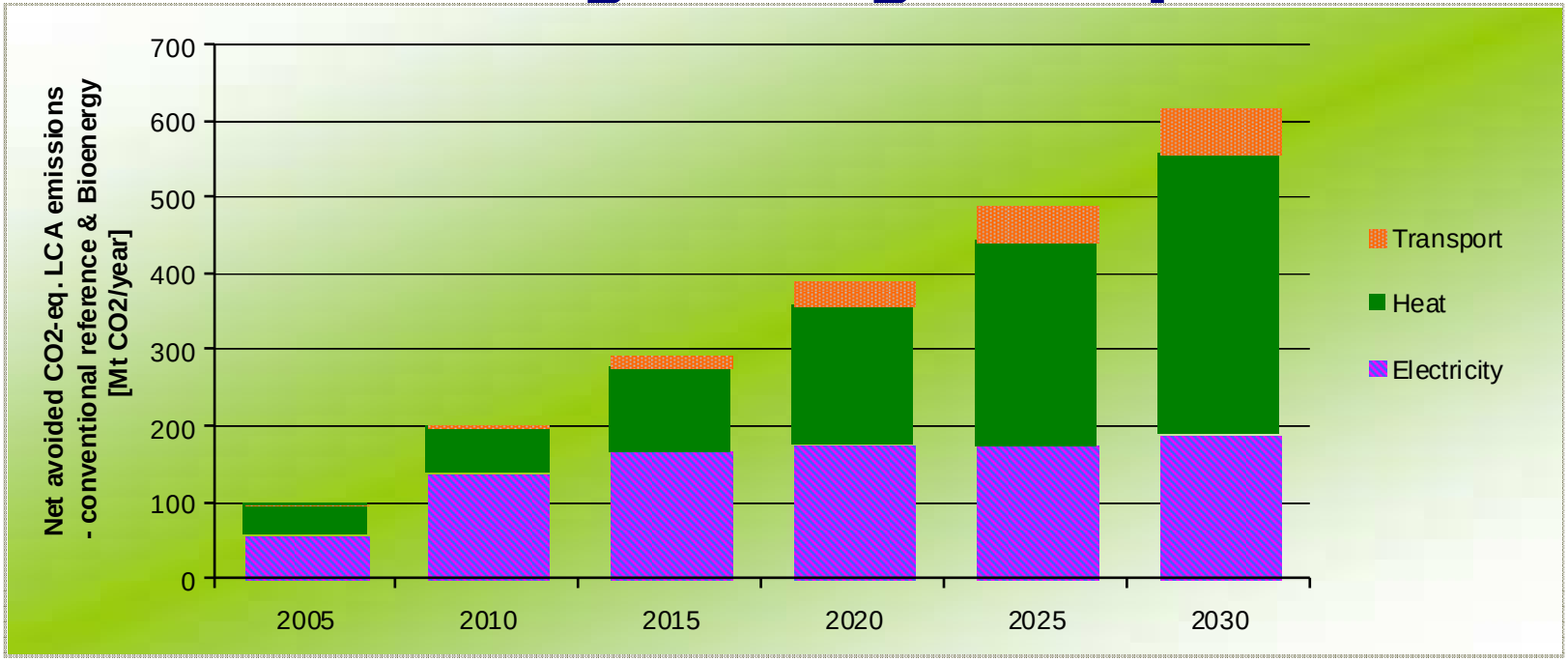
Breakdown of electricity, heat and biofuel generation into technology clusters



By 2030 the bioenergy allocated to district and decentralised heating systems and CHP is 1660 TWh(fuel input), approximately 49% of the total bioenergy used.

Preliminary results

Climate change mitigation potential



Sector	Net avoided greenhouse gas emissions (in kg CO_2-eq/MWh)					
	2005	2010	2015	2020	2025	2030
Power generation	264	274	246	214	195	187
CHP - Electricity & Heat	166	150	138	130	119	119
District heat	258	265	261	263	265	266
Decentralised heat	265	263	265	265	263	261
Transport	68	57	84	122	128	138
Average overall	201	194	180	179	177	184

Preliminary results

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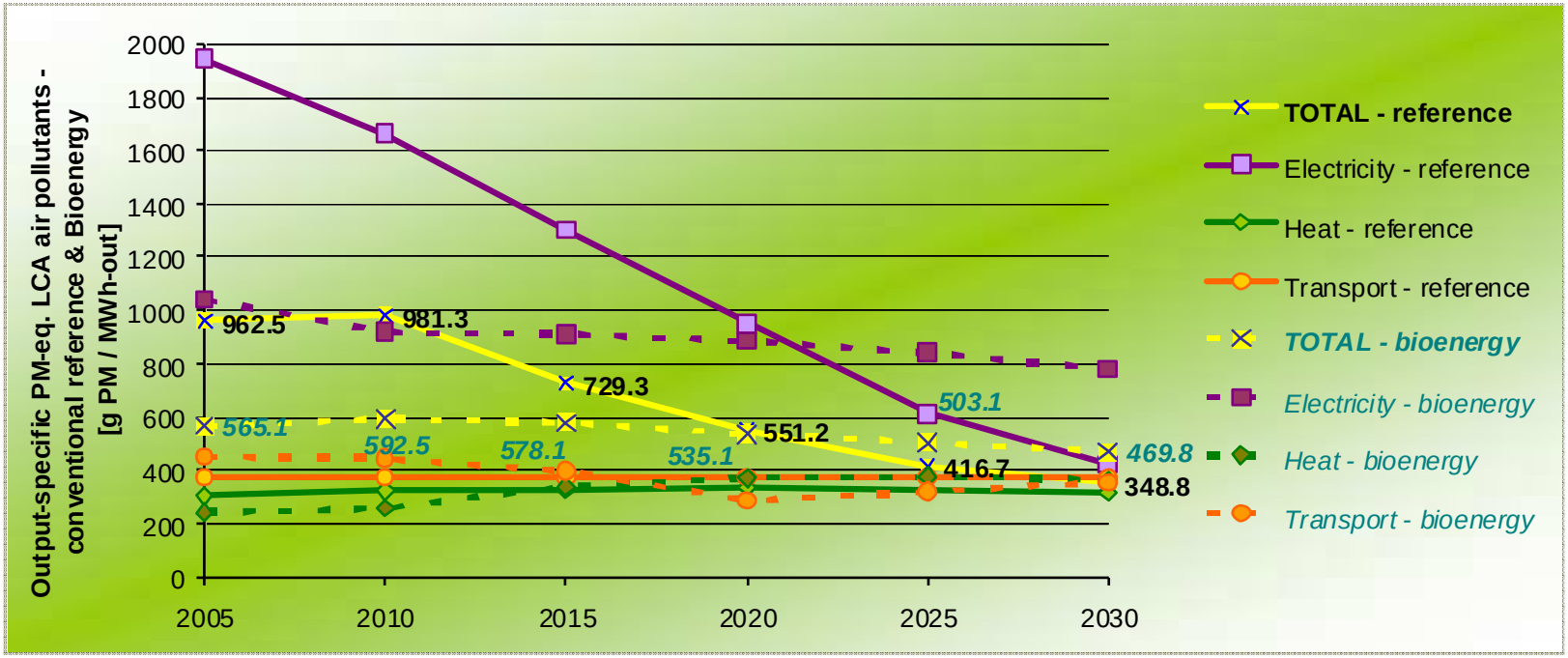
Air pollutant emissions from different sectors of bioenergy and the conventional energy economy, per unit of energy



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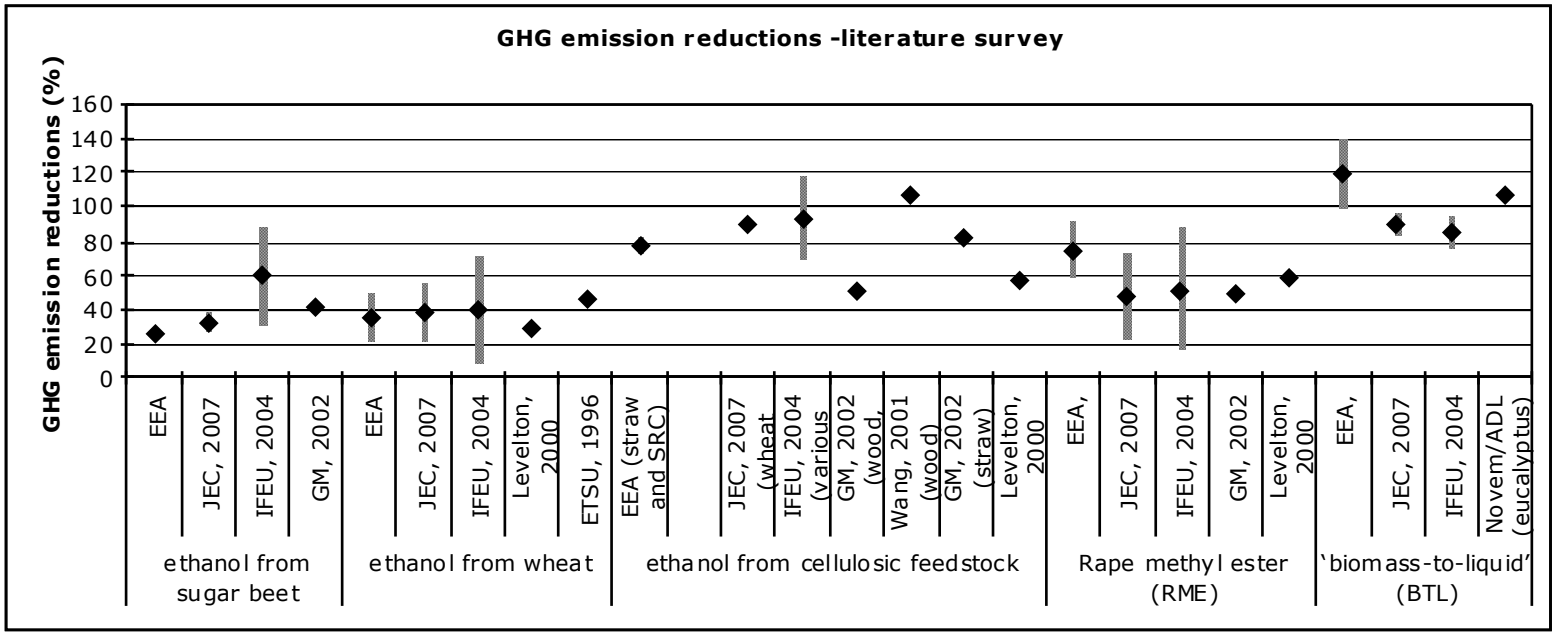
LCA GHG emissions-literature survey

Biomass-to-biofuel



Draft results – work in progress

Conclusions

- Substantial biomass potential to support ambitious renewable energy targets taken into account environmental considerations and significant amounts of GHG emission savings when the potential is exploited (up to 600Mtons)
- Detailed environmental guidelines need to become an integral part of planning processes at all levels of decision making (European, national, regional)
- There is considerable potential for synergies between an increased bioenergy production and nature conservation and biodiversity
  - Cuttings from grassland: bioenergy & maintaining biodiversity rich grassland and landscape diversity
  - Growing bioenergy crops on intensive farmland (e.g. double cropping) can result in reduced environmental pressure (lower nutrient input, enhanced crop diversity, less use of heavy machines, structural elements)

Project contributors

- European Topic Centre Air and Climate Change:
  - Institute for Applied Ecology (Öko-Institut)
  - Netherlands Environmental Assessment Agency
- European Topic Centre Biodiversity
  - European Forest Institute
- AEA-Technology in collaboration with
  - Wageningen University & Research, Alterra
  - Vienna University of Technology (in collaboration with Fraunhofer Institute ISI)

Thank you very much for your attention!

- http://reports.eea.europa.eu/eea_report_2006_7/en
- http://reports.eea.europa.eu/technical_report_2007_12/en
- http://www.eea.europa.eu/pressroom/speeches/unintended-effects-the-need-for-a-proper-assessment-framework-for-agrofuels

- Feedstock-technology matrix

Feedstock - Technology - Matrix		Agricultural biomass																		Biowaste															Forestry		
		rape seeds	sunflower seeds	maize corn	wheat corn	barley/ triticale corn	grass cuttings	maize whole plant	triticale whole plant	wheat whole plant	2-culture opt.	2-culture red.	SRC poplar	SRC willow	miscanthus	reed canary grass	giant reed	switch-grass	sweet sorghum	solid agr. resid.	wet manure (large farms)	wet manure (small farms)	other agr. resid.	dry manure (large farms)	dry manure (small farms)	food proc. resid.	wood proce. resid.	MSW (not to landfill recyling or compost)	MSW (to landfill)	MSW (composted)	sewage sludge	black liquor	demolition wood	pack-aging waste wood	house-hold waste wood	Forest residues	Complementary fellings	Competitive use
Electricity & CHP	Biogas / Landfill gas / Woodgas CHP plant (gas engine) - small to large-scale units			X	X	X	X				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X
	[1] Woodgas CHP plant (fuel cells - MC or SO)												X	X																						X	X	X
	Gas-fired CHP plant - small-scale units																			X												X				X	X	X
	Gas-fired power plant - small-scale units																			X												X				X	X	X
	Woodgas CHP plant (gas engine - fixed bed) - small-scale units												X	X						X												X				X	X	X
	Woodgas CHP plant (micro gas turbine - fixed bed) - small-scale units												X	X						X												X				X	X	X
	CHP plant based on gasified miscanthus (gas engine - with circulating fluitized bed combustion)												X	X	X	X	X	X		X												X						
	Cofiring in a (natural) gas-fired combined cycle power plant			X	X	X	X				X	X	X	X	X	X	X	X			X		X	X		X				X	X				X	X	X
	Local CHP plant for wood chips												X	X																			X	X	X	X	X	X
	Local CHP plant for wood chips based on ORC												X	X																			X	X	X	X	X	X
	Cofiring (forestry: 10%, straw: 5%) in a coal-fired CHP plant (steam turbine (back pressure) with FBC)												X	X						X													X	X	X	X	X	X
	Cofiring (forestry: 10%, straw: 5%) in a new coal-fired power plant (steam turbine with FGD)												X	X						X													X	X	X	X	X	X
	Local CHP plant for straw																			X																		
	Local CHP plant for straw based on ORC																			X																		
	CHP plant based on rapeseed oil (diesel engine) - small to large-scale units	X	X																																			
	CHP plant based on RME (diesel engine) - small to large-scale units	X	X																																			
	MSW incineration plant																											X										
Heat (incl. district heating)	Residential central heating systems for wood chips - small to large-scale units												X	X																			X	X	X	X	X	X
	Local heating plant for wood chips - small to large-scale units												X	X	X	X	X	X															X	X	X	X	X	X
	Wood pellet heating system with stirling engine																										X											
	Residential central heating systems for wood pellets - small to large-scale units																										X											
	Local heating plant for wood pellets - small-scale units																										X											
	Local heating plant (gasifier) for straw - small to large scale units																			X																		
	Local heating plant for straw - large-scale units																			X																		
Transport	Biodiesel plant (FAME)	X	X																																			
	Bioethanol plant (EtOH)			X	X	X													X																			
	[1] Advanced bioethanol plant (EtOH+)							X	X	X									X	X																		
	[1] BtL from gasifier												X	X	X	X	X	X		X																X	X	X

[1] *Technology / Feedstock assumed to be available after 2(*

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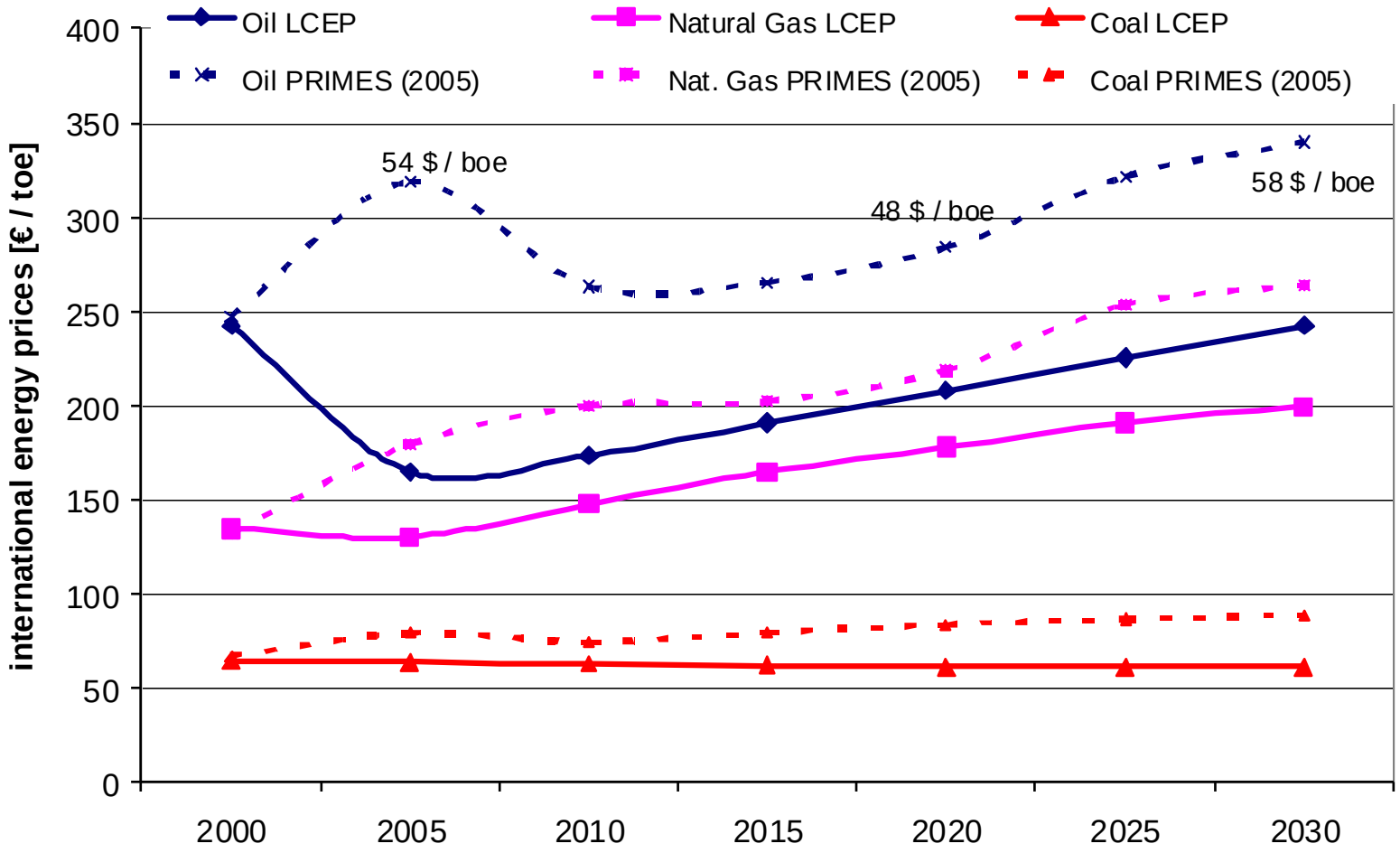
- Electricity
  - Co-firing: Biomass is added to the conventional fuel (coal) as a percentage of < 5% straw or 10% wood. Attention is given to the availability of appropriate filters in these plants.
  - CHP: Plant sizes from 1 to 20 MWel are distinguished, as are those fed with biogas, wood and various waste streams. CHP co-firing also includes gas-CHP fed with a mix of natural gas and biogas after a series of pre-treatment processes.
- Both types of electricity generation are based on almost all biomass resources – forestry, energy crops and waste streams.
- Heat, non-grid
  - Pellets
  - Wood chips
- Both mainly based on forestry, selected energy crops and wood-based waste streams.
- Heat, grid-connected
  - Heat plants
  - CHP
- Both based on various biomass resources – forestry, energy crops and waste streams.



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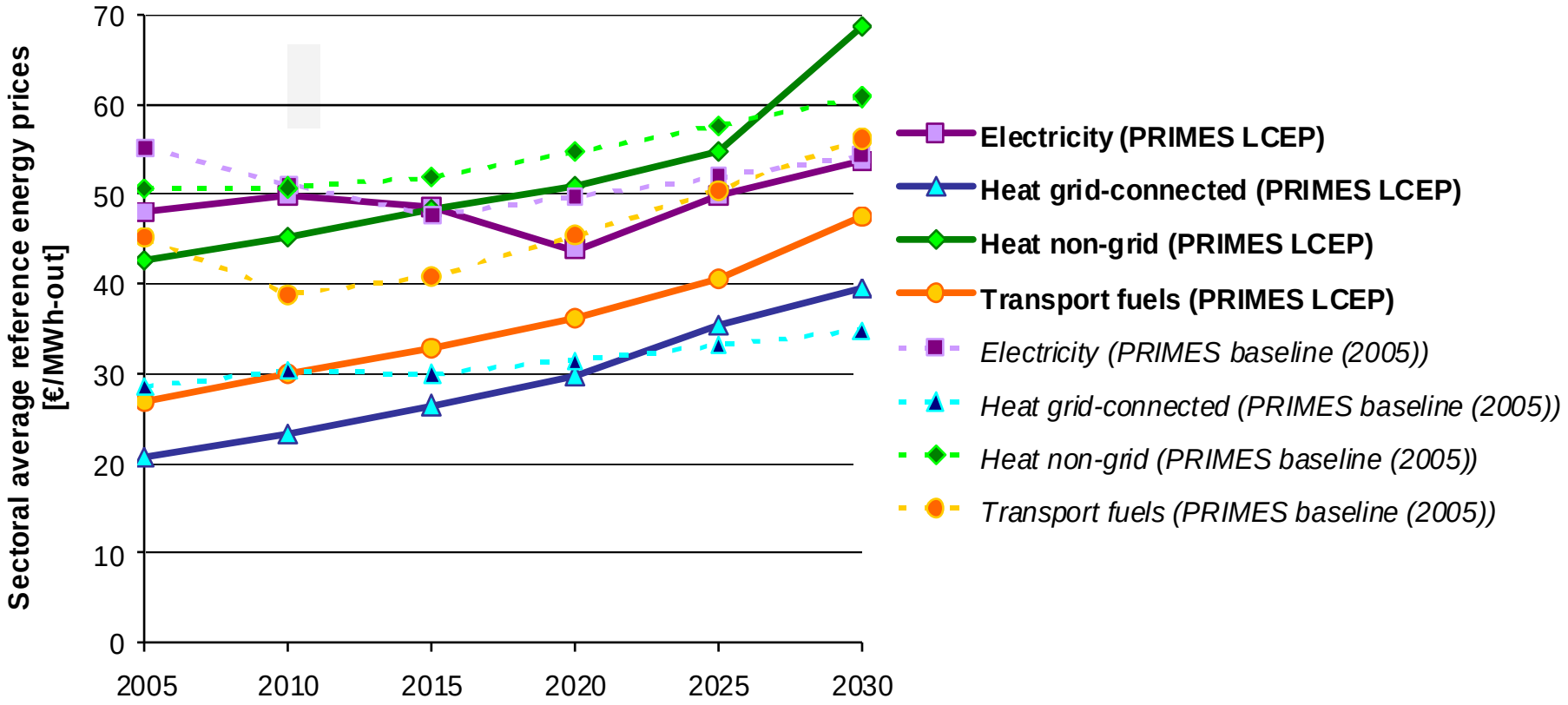
Development of European average sectoral reference energy prices Source: based on (PRIMES, 2004 & 2005)



Energy consumption parameters Source: based on (PRIMES, 2004 & 2005)

PRIMES LCEP		2005	2010	2020	2030
Gross inland consumption	Mtoe	1708	1750	1800	1811
Gross ele demand	TWh	3155	3426	3900	4236
Gross heat demand	Mtoe	582	595	604	599
Gross transport fuel demand	Mtoe	362	383	411	416

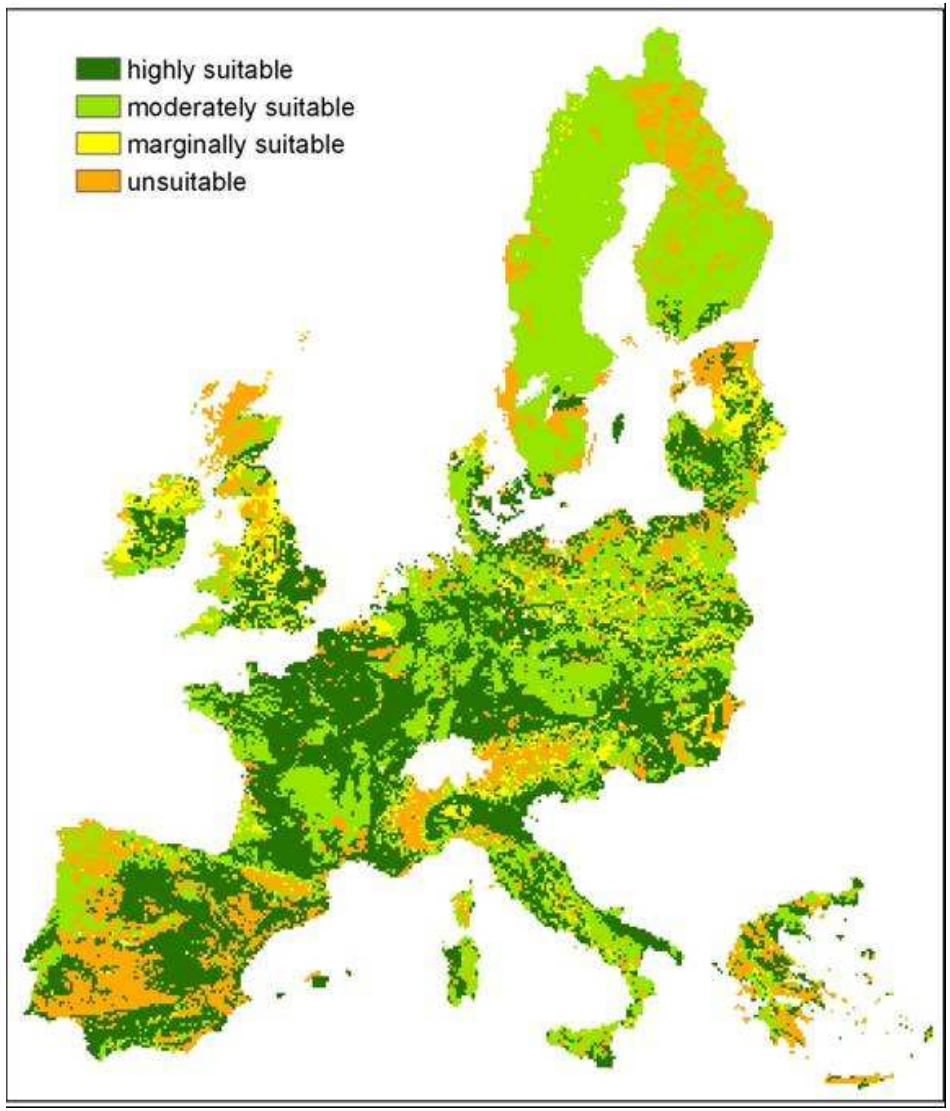
PRIMES (2005)		2005	2010	2020	2030
Gross inland consumption	Mtoe	1741	1811	1885	1899
Gross ele demand	TWh	3207	3509	4030	4392
Gross heat demand	Mtoe	590	616	650	656
Gross transport fuel demand	Mtoe	354	374	399	396

Environmental assumptions

- At least 30% of agricultural land is retained under environmentally oriented farming.
- Important types of extensive farming, including grassland areas, are maintained.
- 3% of intensively farmed land is set aside as ecological compensation areas by 2030.
- Bioenergy crops with low environmental pressure are favoured.
- Current protected forest areas are maintained and the area of protected forest is increased by 5% in each country.
- Forest residue removal is adapted to local site conditions. Foliage and roots are not removed.
- At least 5% of the deadwood is left in all forests.
- Ambitious waste management strategies are applied

"Environmental" considerations forest residues

- roots and foliage remain in the forest
- sustainable nutrient balance (soil database)
  - soil type
  - base saturation
- soil erosion
  - steepness
  - elevation
- soil compaction
  - peat land
  - soil water regime
- No intensification on protected areas (intrinsic)



Forestry scenarios

EFISCEN model (European Forest Information Scenario Model):

- market demand driven model
- baseline data and projections (FAO and OECD) → determines the forest residues potential
- MAX scenario (maximum sustainable harvest scenario → determines the complementary fellings/residues
  - + protected areas: reduced area by 5 %
  - + deadwood: reduced area/mass by 5 %

agricultural biomass: "environmental framework"

Aim: no additional pressure on farmland biodiversity and soil & water resources due to bioenergy production

- 30% of Utilized Agricult. Area from 'environmentally orientated' farming in every MS in 2030:
  - high nature value farmland
  - organic farming
- set-aside 3 % of intensively used farmland for nature conservation
- grass-land not to be transformed into intensive agricultural land (Cross-compliance, soil carbon)
- no conversion of other land to UAA

Biowaste scenarios

BaU scenario

- Energy/production projections from PRIMES baseline scenario
- Agricultural projections from CAPSIM Animlib scenario

Environmentally enhanced scenario

- Energy/production projections from PRIMES LCEP scenario
- Agricultural projections from CAPSIM Animlib scenario, plus modifications for increased organic share
- Greater waste reduction, reduced landfill, enhanced recycling and composting
- MSW projections from EEA ETC Waste and Material Flow

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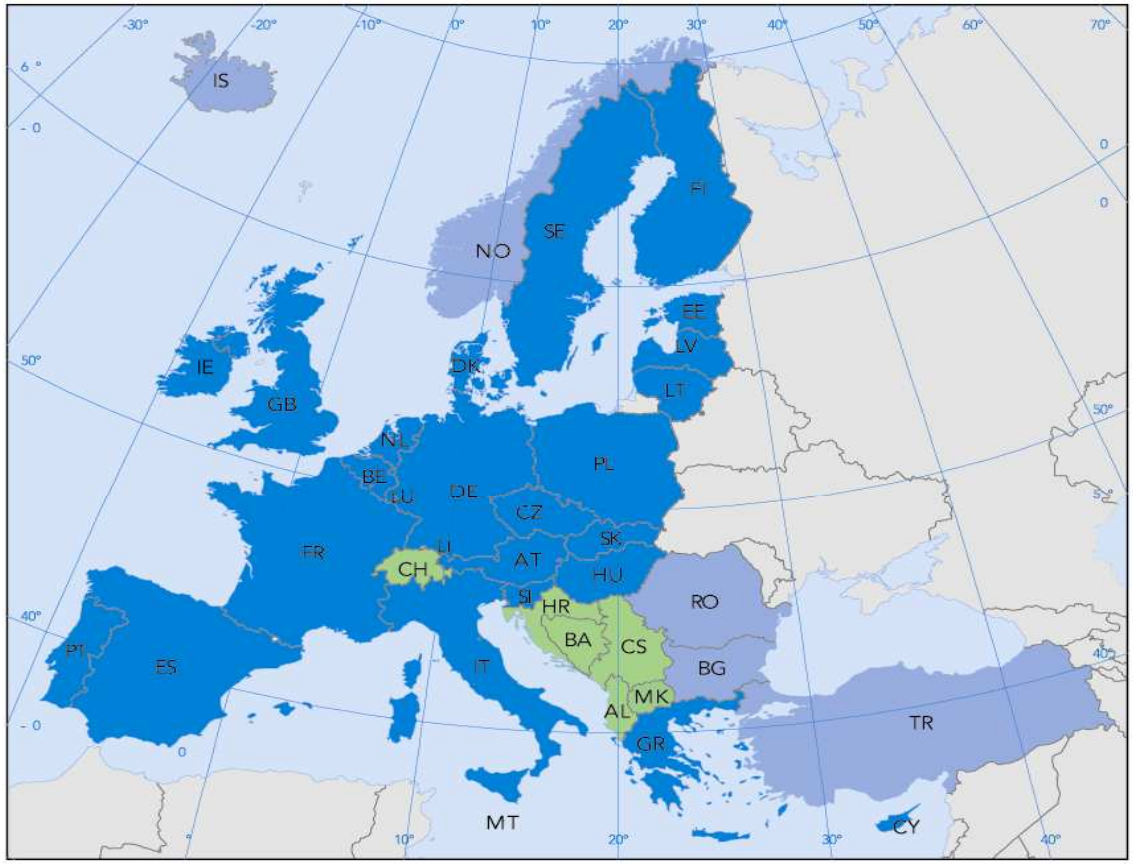

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Conclusions 2

Pressures on land use, nature protection and biodiversity can be **minimised** if

- no intensification of use in protected areas & HNV farmland
- no transformation of grassland into arable land
- careful selection of bioenergy crops regarding their impacts
- forestry residue removal adapted to soil suitability
- Complementary fellings respect protected area & deadwood

and **synergies** created:

- Bioenergy production can reduce environmental pressure compared to intensive farmland
- Cuttings from grass land can deliver bioenergy and contribute to nature conservation
- Forest residues removal can contribute to reduce fire risk
- more controlled waste management
- substantial emissions of GHG avoided