TECHNISCHE UNIVERSITÄT WIEN

BioSustain project:

Sustainable and optimal use of biomass for energy in the EU beyond 2020

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The BioSustain Project

- Framework Contract for Impact Assessments and Evaluations (DG Energy)

- Aimed at supporting an impact assessment on the sustainable and optimal use of biomass for energy in the EU beyond 2020.

- **Objective:**

  Developing plausible EU bioenergy supply and demand scenarios for 2030 and assessing the environmental and socio-economic impacts of possible future EU action to ensure bioenergy sustainability post-2020.

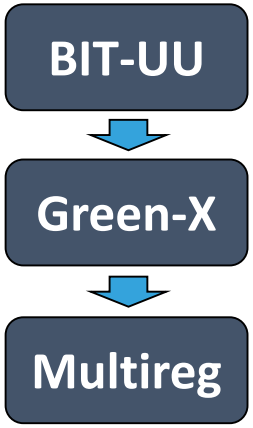
- Final Report & Annexes May 2017

  Hoefnagels, R., I. Kluts, M. Junginger, L. Visser, G. Resch, U. Mantau, L. Pelkmans, und N. Devriendt. „Sustainable and optimal use of biomass for energy in the EU beyond 2020. Annexes of the Final Report“, 2017.
  https://ec.europa.eu/energy/sites/ener/files/documents/biosustain_annexes_final.pdf

GENERAL MODELLING APPROACH

- **Detailed quantitative assessment of bioenergy use within the EU28 up to 2030**, analysing deployment by sector/technology and related socio-economic and environmental impacts

- Identified *potentials & costs for bioenergy supply* combined with *trends concerning biomass demand for material use* serve as basis for the modelling works



Three models with complementary skills are used:

- **Biomass Intermodal Transport model** (Utrecht University) (**BIT-UU**)
  → Incorporate logistics/trade of biomass feedstock into/within the EU
- **Green-X** (TU Wien) conducts scenarios of RES use in the energy sector and the role of bioenergy, analysing the policy impact
- **MULTIREG** (Ruetter+Partner) analyses socio-economic impacts of bioenergy use

Baseline scenario – main input

Input from the EC 2016 reference scenarios, PRIMES EuCo27 & EuCo30

Based on PRIMES	Based on Green-X database	Defined for this assessment
Primary energy prices	Renewable energy technology cost (investment, fuel, O&M)	Renewable energy policy framework
Conventional supply portfolio and conversion efficiencies	Renewable energy potentials	Reference electricity prices
CO_2 intensity of sectors	Biomass trade specification	
Energy demand by sector	Technology diffusion / Non-economic barriers	
	Learning rates	
	Market values for variable renewables	

Baseline scenario – policy setting

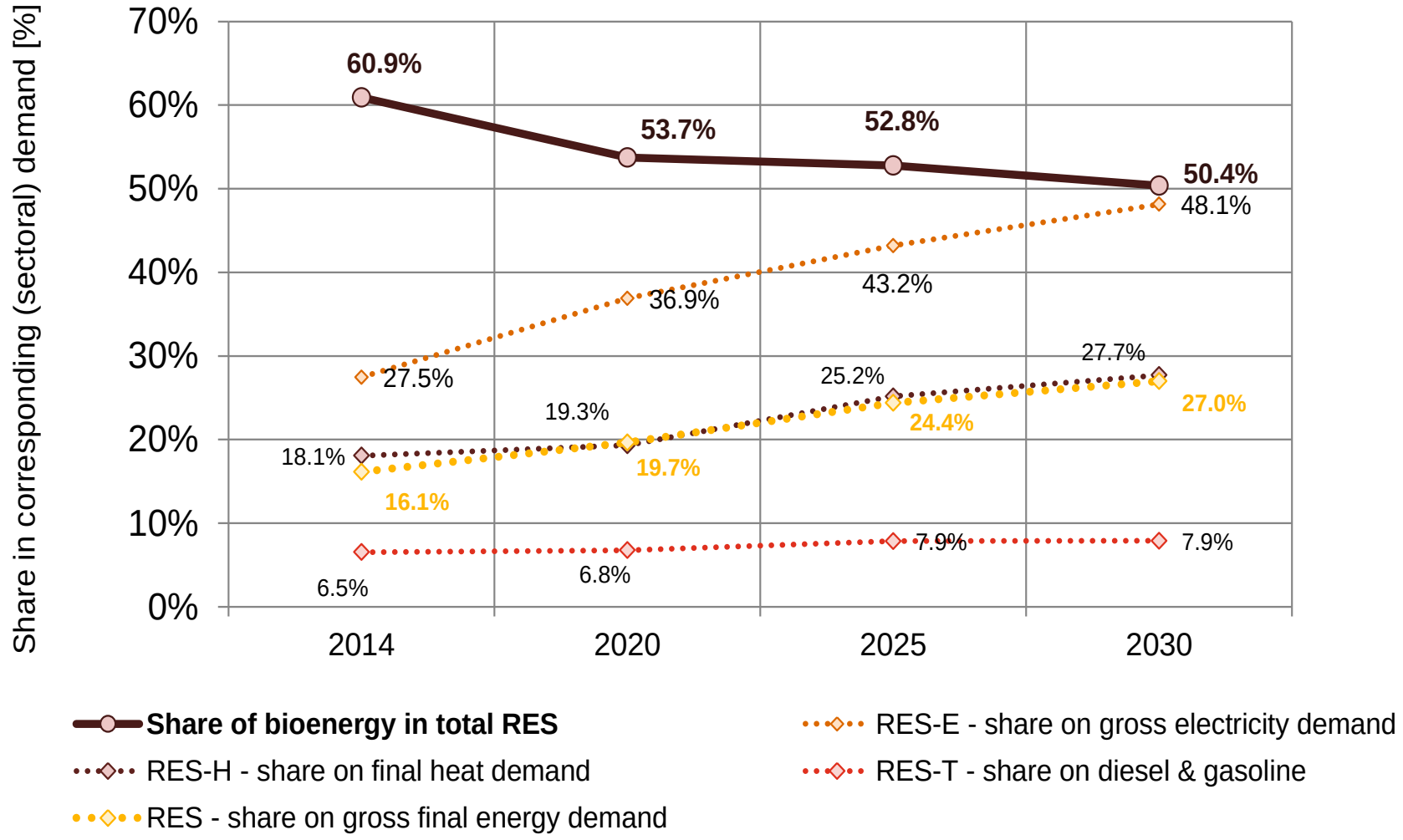
- RES policy scenario

- In accordance with the EC Common Energy Policy agreement on 2030 energy and climate targets
  - 40% GHG reduction comp. to 1990
  - At least 27% RES
  - At least 27% energy efficiency improvement, comp. to 2007. (EUCO27) (raise to 30% calculated in EUCO30)

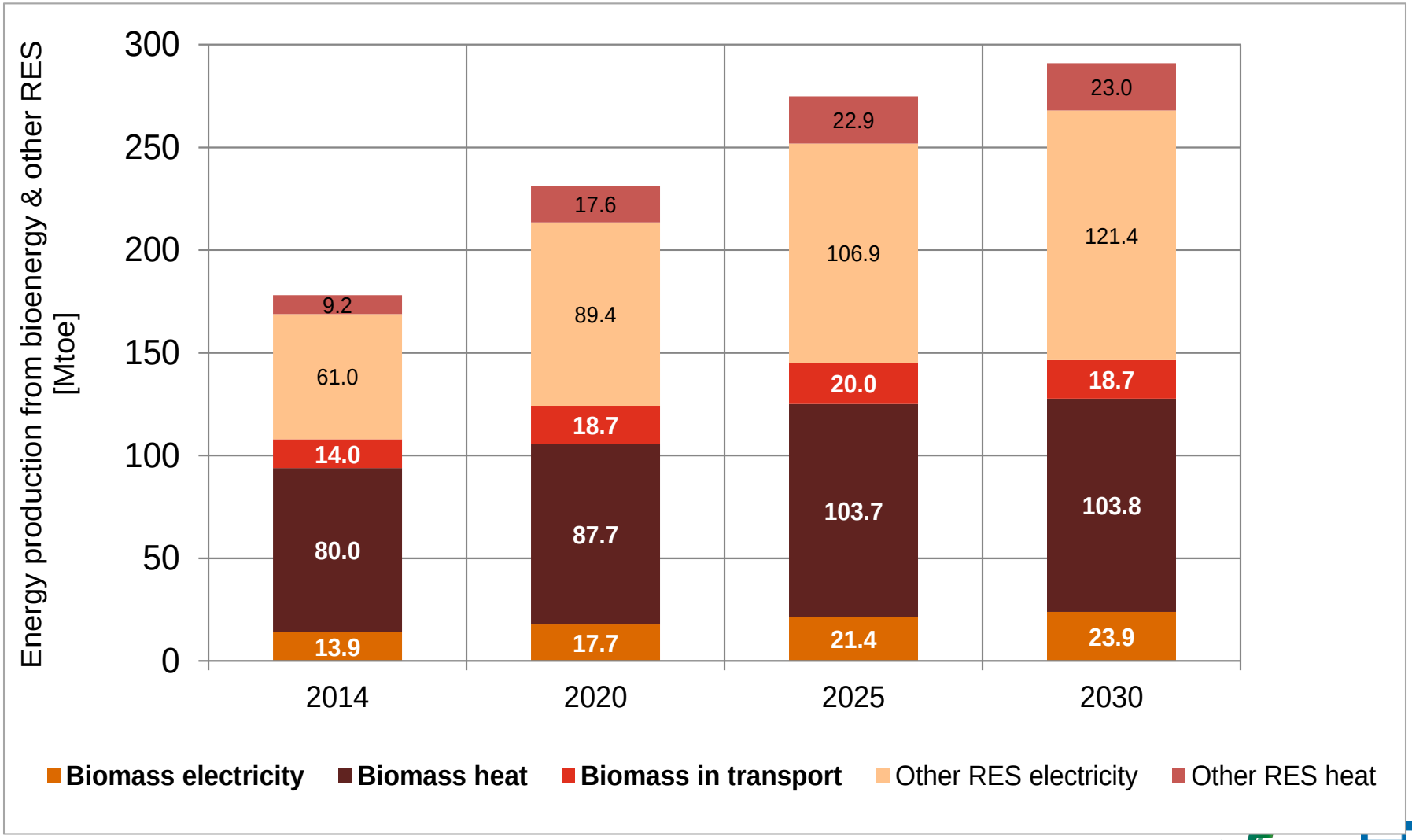
- RED (2009/28/EC): Binding sustainability criteria for biofuels for transport and bioliquids used in other sectors

- ILUC amendment (2015/1513/EU): cap on the amount of food or feed based biofuels (7%)

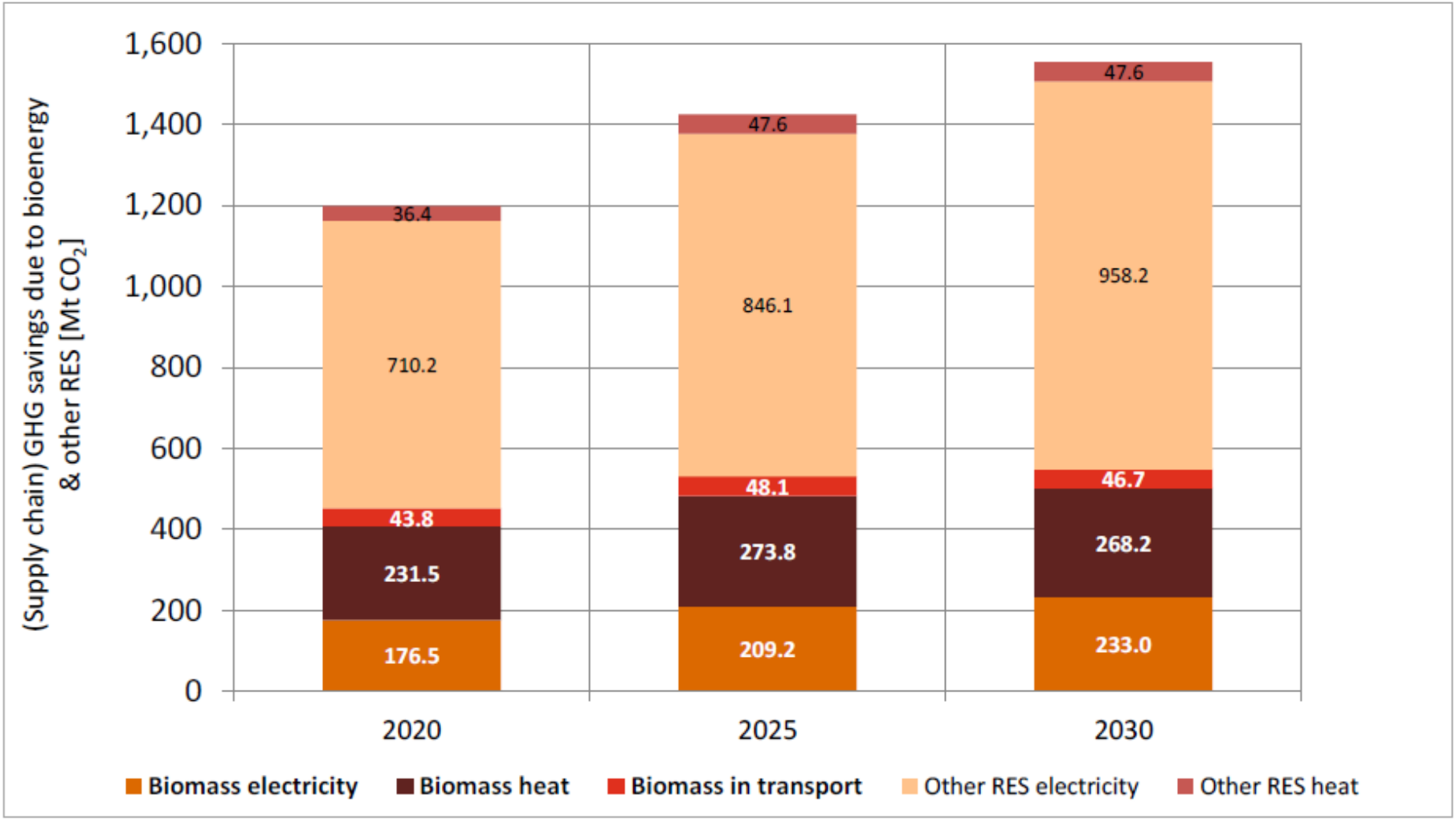
RES share of gross final demand



Final RES and bioenergy demand



Direct GHG savings due to RES use (avoidance of fossil fuels)



The five policy options for EU action

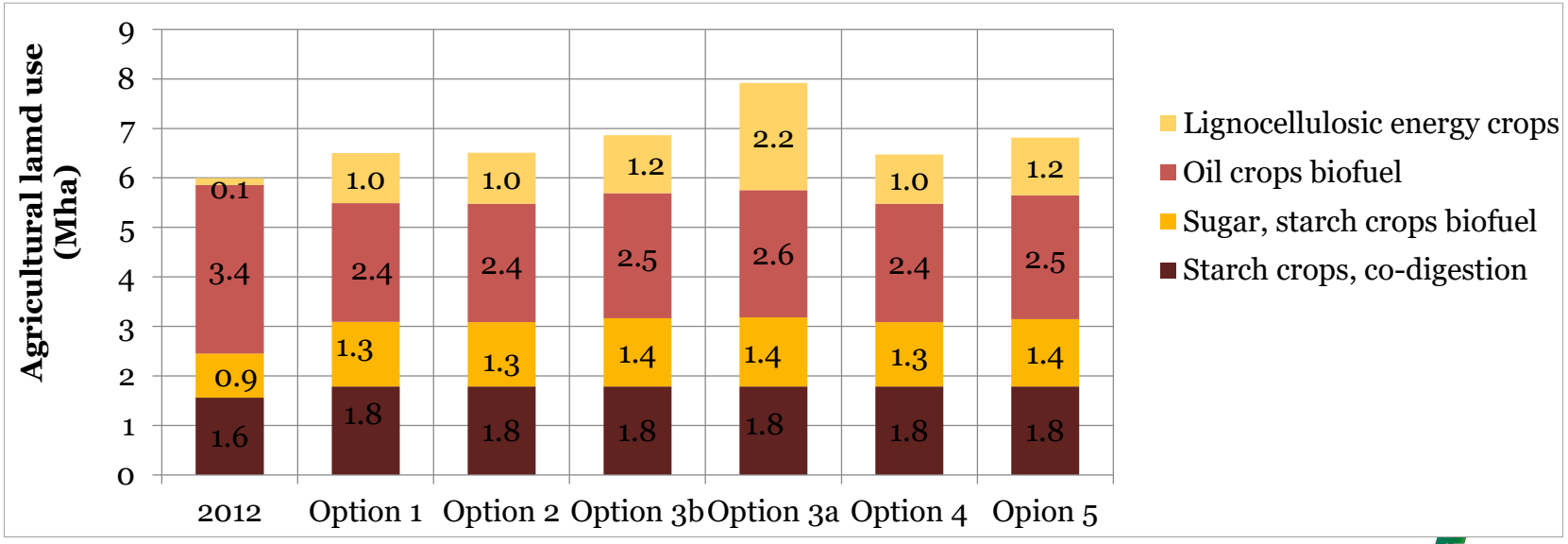
Option	Policy action
Option 1	• Current situation, e.g. sustainability criteria for biofuels and bioliquids. • No additional EU action on biomass for heat and power.
Option 2	• Biofuels as in Option 1 • Sustainability criteria extended to solid biomass and biogas for heat and power. • The land criteria and cross-compliance rules for agricultural biomass are identical to the criteria for biofuels and bioliquids. • Threshold for GHG savings of heat and power applications: 70% (large scale plants, base case: 4-5 MW thermal biomass input).
Option 3a	• Similar to Option 2 (land criteria for agricultural biomass and GHG saving criteria). • For forestry biomass, land criteria are replaced by a new criterion on Sustainable Forest Management (SFM) (all forest biomass used for energy generation should demonstrate compliance through SFM certification).
Option 3b	• The SFM criterion is applied through a risk-based approach • Evidence of compliance with SFM standards would be gathered at national or sub-national level, when not available, operators would be required to provide evidence at the forest holding level).
Option 4	• Criteria of Option 2 • Plus a minimum efficiency standard (base case of 65%) for the conversion of biomass in new large-scale electricity and heat installations.
Option 5	• Criteria of Option 2 • Plus a cap on the use of stemwood for bioenergy at MS level. • Does not cover firewood currently used for residential heating.

Impacts on: Biomass supply and demand (compared to option 1 - baseline)

Policy option 2 EU biomass criteria for heat and power	Policy option 3a SFM certification	Policy option 3b Risk-based approach for forest biomass	Policy option 4 Energy efficiency requirement	Policy option 5 Stemwood cap
0.5% decline in biomass demand	16% decline in biomass demand Strong shift from RES heat to (non-biomass) RES electricity and biofuels Strong decline of forest biomass supply (under modelling assumptions), only partly offset by an increased use of agricultural biomass	3.0% decline of biomass demand Small shift from RES heat to (non-biomass) RES electricity Strong reduction of Extra-EU import of forest biomass (under modelling assumptions)	1.5% decline of overall biomass demand	2.3% decline of overall biomass demand, in particular for heat production from biomass (-4%) Mainly counter-balanced by a growth of (non-biomass) electricity

Impacts on: Land use (compared to option 1 - baseline)

Policy option 2 EU biomass criteria for heat and power	Policy option 3a SFM certification	Policy option 3b Risk-based approach for forest biomass	Policy option 4 Energy efficiency requirement	Policy option 5 Stemwood cap
No additional agricultural land use	Reduced supply of forest biomass results in shift to energy crops (+1.4 Mha)	Reduced supply of forest biomass results in shift to energy crops (+0.4 Mha)	No additional agricultural land use	Reduced supply of forest biomass results in shift to energy crops (+0.3 Mha).



Conclusions of the Biosustain project

- **Option 2** (EU biomass criteria for heat and power): overall the option has minor impact, the 70% GHG threshold is not a limiting constraint
- **Option 3a** (SFM certification) is assumed to limited forest biomass supply substantially. Partial shift to agricultural biomass and to non-biomass electricity (increasing support expenditures with 23%) and higher GHG savings.
- **Option 3b** (risk based approach) leads to strong decline in solid biomass imports and a shift to electricity from other RES and biofuel imports. Support expenditures are 3% higher.
- **Option 4** (energy efficiency req.) reduces biomass demand for electricity with 1.5% and increases biomass heat. No additional GHG savings as a result of higher fossil electricity generation.
- **Option 5** (stemwood cap) leads to a modest decline in biomass consumption (2.3%), partially offset by agricultural biomass and electricity from other RES.

Thank you for your attention!

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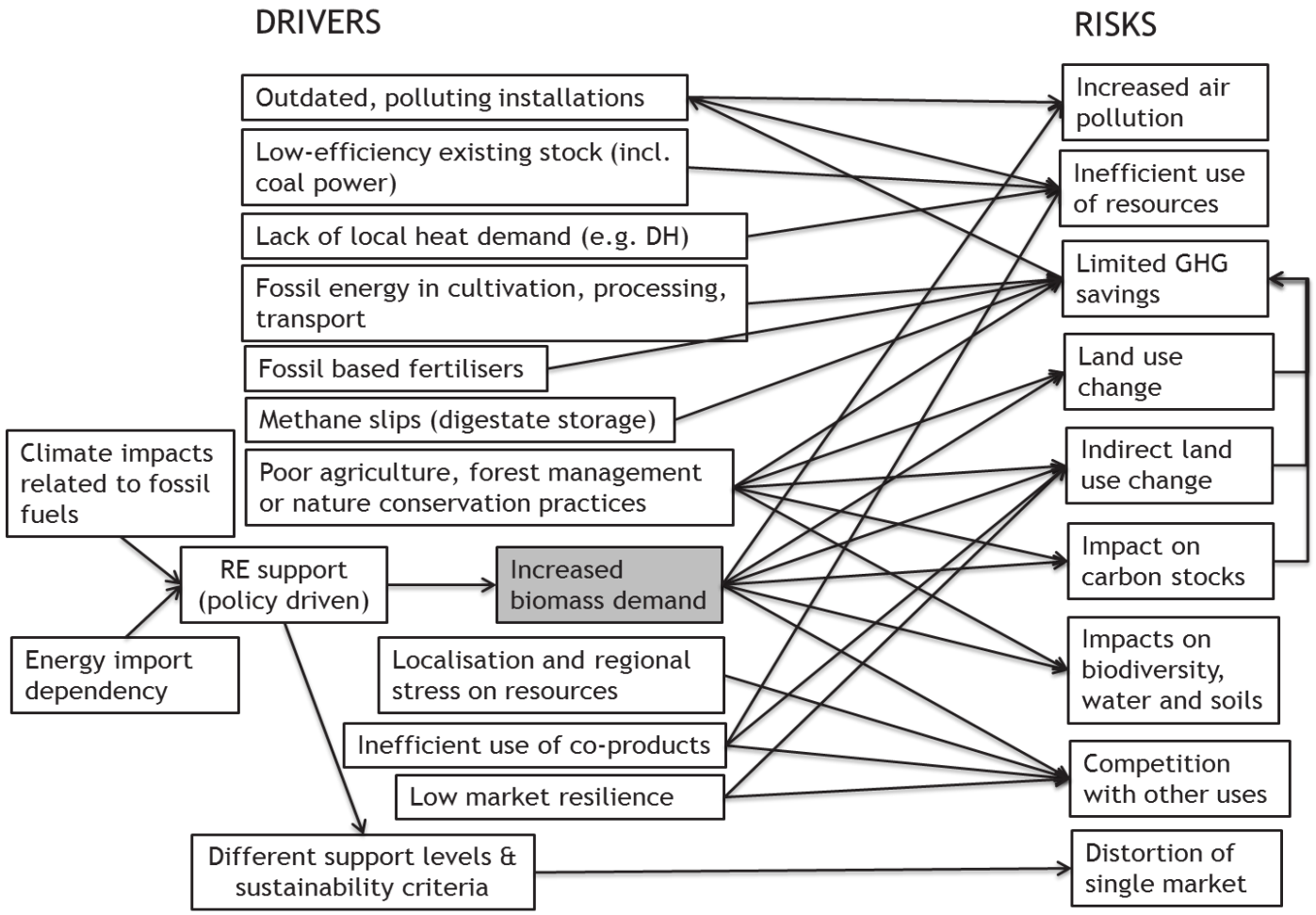
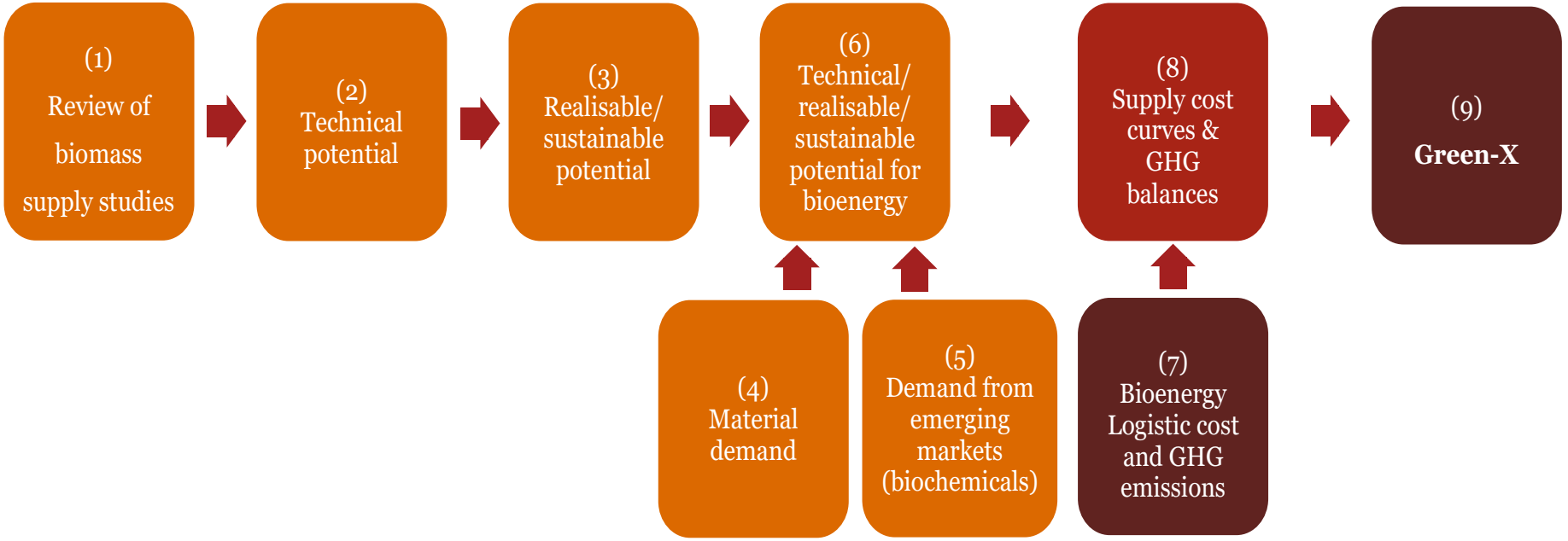
Orig. Photo: Patrick Stargardt

The following risks have been mentioned:

- Poor *greenhouse gas performance* of certain bioenergy pathways, due to:
  - Supply chain greenhouse gas emissions, including emissions related to direct land use change, biomass cultivation, transport and processing;
  - Biogenic emissions related to changes in carbon stock, particularly in forest and soils;
  - Indirect emissions related to displacement effects.
- Impacts of biomass production on *biodiversity, soil and water*;
- Impacts of biomass combustion on *air quality*;
- Low *conversion efficiency* of biomass to electricity;
- *Competition* with non-energy end-use markets;
- Distortion of biomass trade due to diverging national sustainability schemes.

Problem tree for sustainability risks related to solid biomass and biogas for heat and power




(1) Review of biomass supply studies
(2) Technical potential
(3) Realisable/ sustainable potential
(6) Technical/ realisable/ sustainable potential for bioenergy
(8) Supply cost curves & GHG balances
(9) Green-X
(4) Material demand
(5) Demand from emerging markets (biochemicals)
(7) Bioenergy Logistic cost and GHG emissions

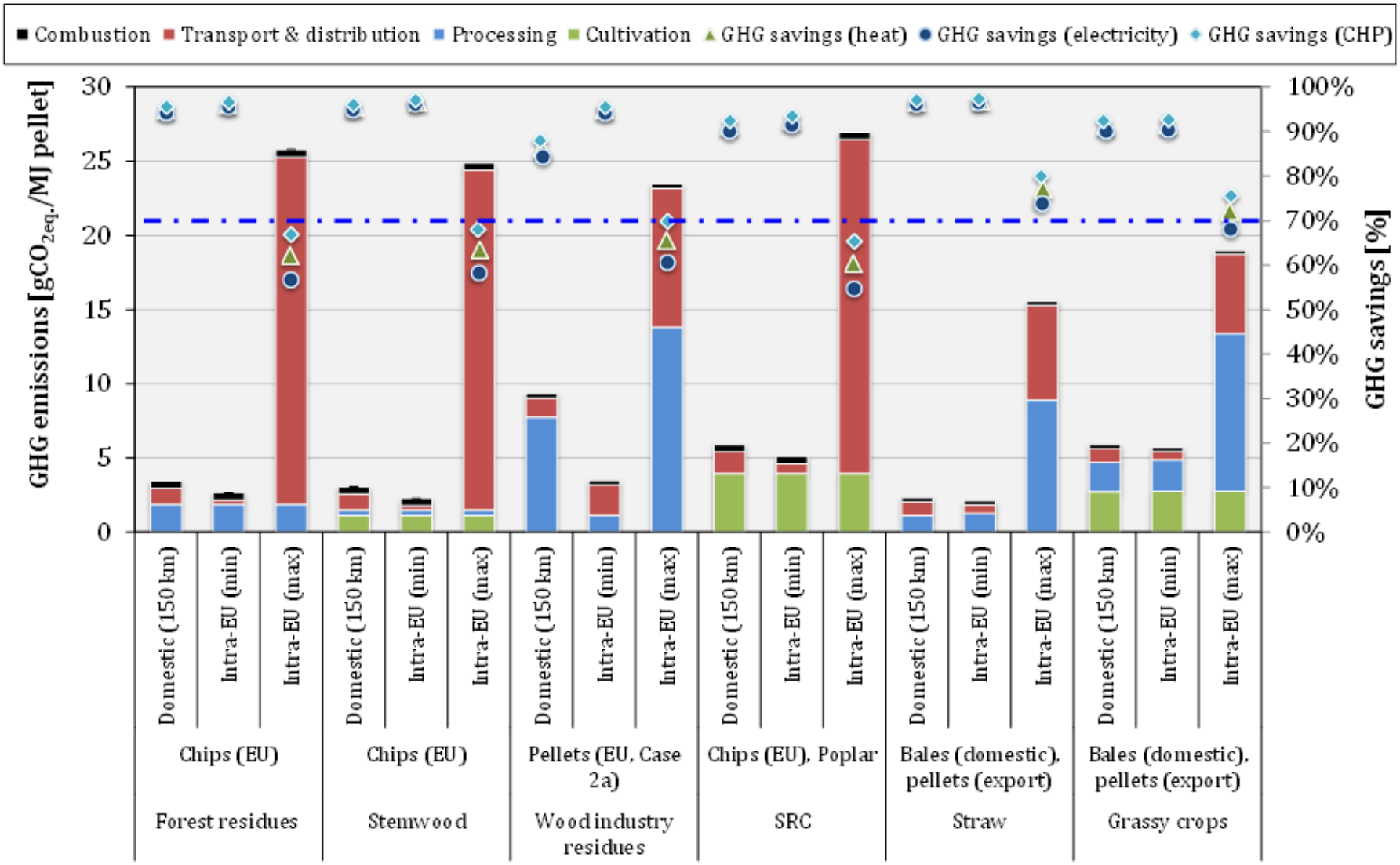
Biomass supply scenarios

- ***Reference***: EU wood availability is given under today's circumstances. Extra-EU solid biomass development follows a BAU trend. Medium export capacity of liquid biofuels to the EU.

- ***Restricted***: EU wood availability under the condition of stronger utilisation restrictions and larger set aside areas. Higher global competition for Extra-EU solid biomass and lack of investments in infrastructure to mobilize alternative woody biomass. Low export capacity of liquid biofuels outside the EU.

- ***Resource***: maximum possible utilisation of wood in the EU under long-term sustainable conditions. Strong development of supply and infrastructure of Extra-EU solid biomass, perennial crops cultivated for export markets. High export capacity of liquid biofuels to the EU.

GHG performance of supply chains



Demand non-energy use

- Based on literature review and recent projects
- Different options of biomass in biochemicals, high growth expected in biopolymers/plastics
- Biopolymer demand estimated in the range of 2 - 3 Mt in EU by 2030
- Projected 2030 biobased raw material demand from chemistry in EU is substantial (5-10 Mtoe), but still much lower than biofuels/bioenergy.
- Mostly **sugar, starch or oil-based** feedstocks *(except specific cellulose based chemicals); s*hift to 2nd gen raw materials (lignocellullose) probably slower than biofuels (*can build on it*)
- Market demand vs production. Substantial part of EU demand may be produced outside Europe (e.g. bio-PET).

BIT-UU → Green-X → Multireg

THE GREEN-X MODEL

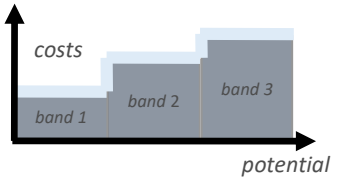
The Green-X approach:

Dynamic cost-resource curves

&

a detailed energy policy representation

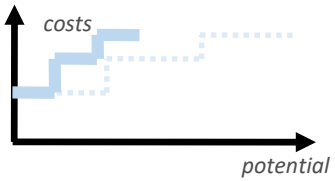
Long-term realisable potentials in year n & corresponding costs at country level by energy technology



Potential

Cost (efficiency)

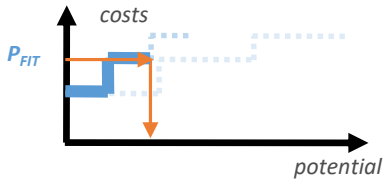
Technology diffusion *('S-curve')*
(non-economic barriers by technology/country)



Technological change
((global) learning curves by technology)

Realisable yearly potentials in year n

Energy policy
(energy prices, support schemes)



Deployment in year n and corresponding costs & benefits

Specific features related to bioenergy use and supply:

"Agricultural products" / Energy crops

- AP1 (rapeseed and sunflower - biodiesel)
- AP2 (sugar beet, maize, wheat, barley - bioethanol)
- AP3 (maize, wheat, barley - whole plant (excl. fruitcake) - lignocellulotic bioethanol)
- AP4 (short rotation coppice poplar, willow - BtL)
- AP5 (miscanthus - BtL)
- AP6 (switch grass, red canary - BtL)
- AP7 (sweet sorghum - BtL)

"Forestry products" / Stem- and Fuelwood

- FP1 (Current use of log wood and wood chips in small-scale systems)
- FP2 (Additional stemwood and bark/residue potential for small-scale use - low cost)
- FP3 (Additional stemwood and bark/residue potential for small-scale use - high cost)

Agricultural residues (incl. waste streams)

- AR1 (straw, other agricultural residues)
- AR2 (used fats and oils (UFO) - BtL)

Forestry residues (incl. waste streams)

- FR1 (black liquor)
- FR2 (Current use of forest residues in large-scale systems)
- FR3 (Additional potential of forestry residues (tradable))
- FR4 (Wood waste (post-consumer wood and industrial residues))
- FR5 (Current use of forestry residues and sawmill by-products for pelletisation)
- FR6 (forestry imports from abroad)

Biogas and Waste

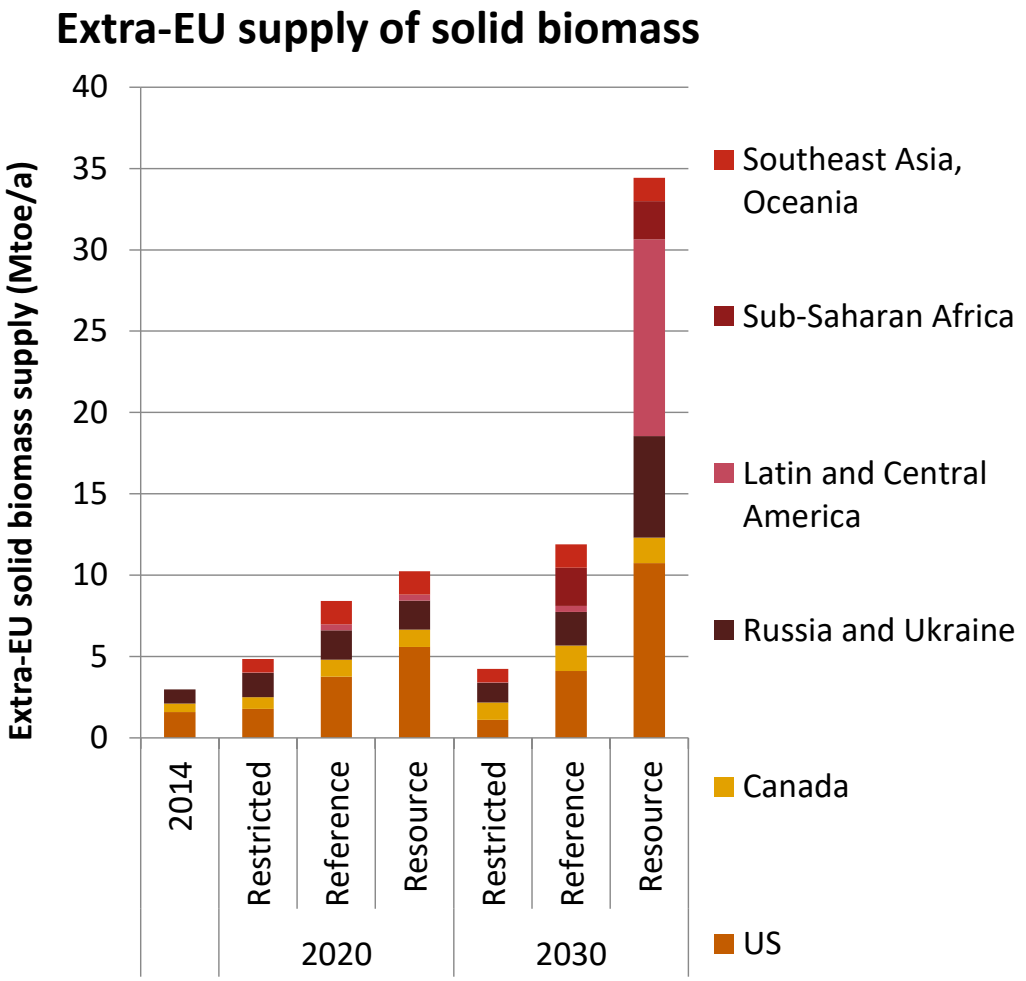
- BW1 (biodegradable fraction of municipal waste)
- BG (agricultural biogas)
- LG (landfill gas)
- SG (sewage gas)

Technology cluster	Corresponding energy sector
Biodiesel refinery	Transport (fuels)
Bioethanol refinery	
Bioethanol+ refinery	
BtL plant	
Small-scale biomass stove using wood fuel	Non-grid connected (decentral) heat
Small-scale biomass heating system using wood chips	
Small-scale biomass heating system using pellets	
Biomass-based district heat plant	Grid-connected heat (excluding CHP)
Small-scale solid biomass power plant (without heat recovery) (below 1 MW)	Electricity (including CHP)
Small-scale solid biomass CHP plant (below 1 MW_e)	
Large-scale solid biomass power plant (above 1 MW_e)	
Large-scale solid biomass CHP plant (above 1 MW_e)	
Cofiring in thermal power plant (without heat recovery)	
Cofiring in CHP plant	
Small-scale MSW incineration (below 10 MW_e)	
Large-scale MSW incineration (above 10 MW_e)	
Biogas plant (without heat recovery) (all sizes)	
Biogas CHP plant (all sizes)	

Extra-EU solid biomass supply scenarios

Source

Region	Source
US Southeast	BioTrade2020+
Brazil	BioTrade2020+
Ukraine	BioTrade2020+
NW-Russia	Pöyry/Diacore
Canada	Pöyry/DiaCore
Sub-Saharan Africa	Biomass Policies
SE Asia/Oceania	Lamers et al 2014



BioTrade2020+

- BAU = Reference
- Optimistic = Resource

Other impact categories

Impacts on: (compared to option 1 - baseline)	Policy option 2 EU biomass criteria for heat and power	Policy option 3a SFM certification	Policy option 3b Risk-based approach for forest biomass	Policy option 4 Energy efficiency requirement	Policy option 5 Stemwood cap
Direct GHG savings	+0.1% GHG savings	+4.4% GHG savings	+1.5% GHG savings	no impact	+1.1% GHG savings
Overall investments and operational costs	+€0.4bln pa increase in CAPEX for RES Combined effect of CAPEX+OPEX of +€0.3bln pa	+€12.7bln pa increase in CAPEX for RES Combined effect of CAPEX+OPEX of +€10.0bln pa	+€2.9bln pa increase in CAPEX for RES, minor impact on OPEX Combined effect of CAPEX+OPEX of +€3.0bln pa	+€1.1bln pa increase in CAPEX for RES Combined effect of CAPEX+OPEX of +€0.6bln pa	+€2.3bln pa increase in CAPEX; OPEX increases Combined effect of CAPEX+OPEX of +€3.2bln pa
Support expenditures/household energy costs	+0.1% (€0.06bln pa) increase of renewable energy support expenditures	+23% (€14.0bln pa) increase of renewable energy support expenditures	+6% (€3.6bln pa) increase of renewable energy support expenditures	+0.3% (€0.2bln pa) increase of renewable energy support expenditures	+4% (€2.2bln pa) increase of renewable energy support expenditures
Gross value added	Value added increase of €0.3bln	Value added increase of €4.8bln	Value added increase of €1.4bln	Value added increase of €0.9bln	Value added increase of €2.1bln
Employment (including SMEs)	4,400 extra jobs SMEs: 3,500 extra jobs	6,000 extra jobs SMEs: 2,000 extra jobs	7,000 extra jobs SMEs: 5,000 extra jobs	3,000 extra jobs SMEs: 2,200 extra jobs	20,000 extra jobs SMEs: 13,000 extra jobs
Administrative costs	Administrative cost estimation on average €30mln pa higher than baseline	Administrative cost estimation on average €55mln pa higher than baseline	Administrative cost estimation on average €22mln pa higher than baseline	Administrative cost estimation on average €43mln pa higher than baseline	Administrative cost estimation on average €43mln pa higher than baseline