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Sustainable energy supply: Trade-offs in energy transition process

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Introduction

- **Megatrends:**

  Climate change

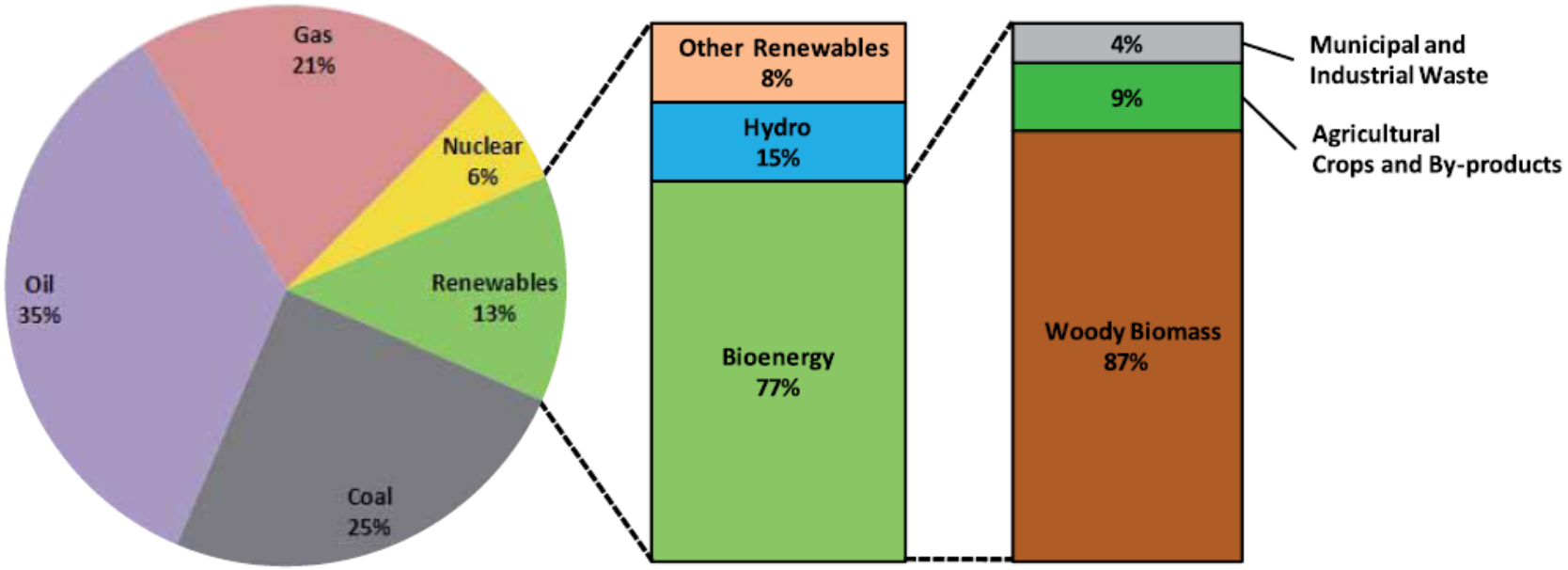
  Energy crisis

  Urbanization

- **Energy transition**

  Sustainable supply and consumption

Introduction



Share of bioenergy in the world primary energy mix

Source: based on IEA, 2006; and IPCC, 2007

Introduction

➢ Two definitions

Biomass consists of any organic matter of vegetable or animal origin.

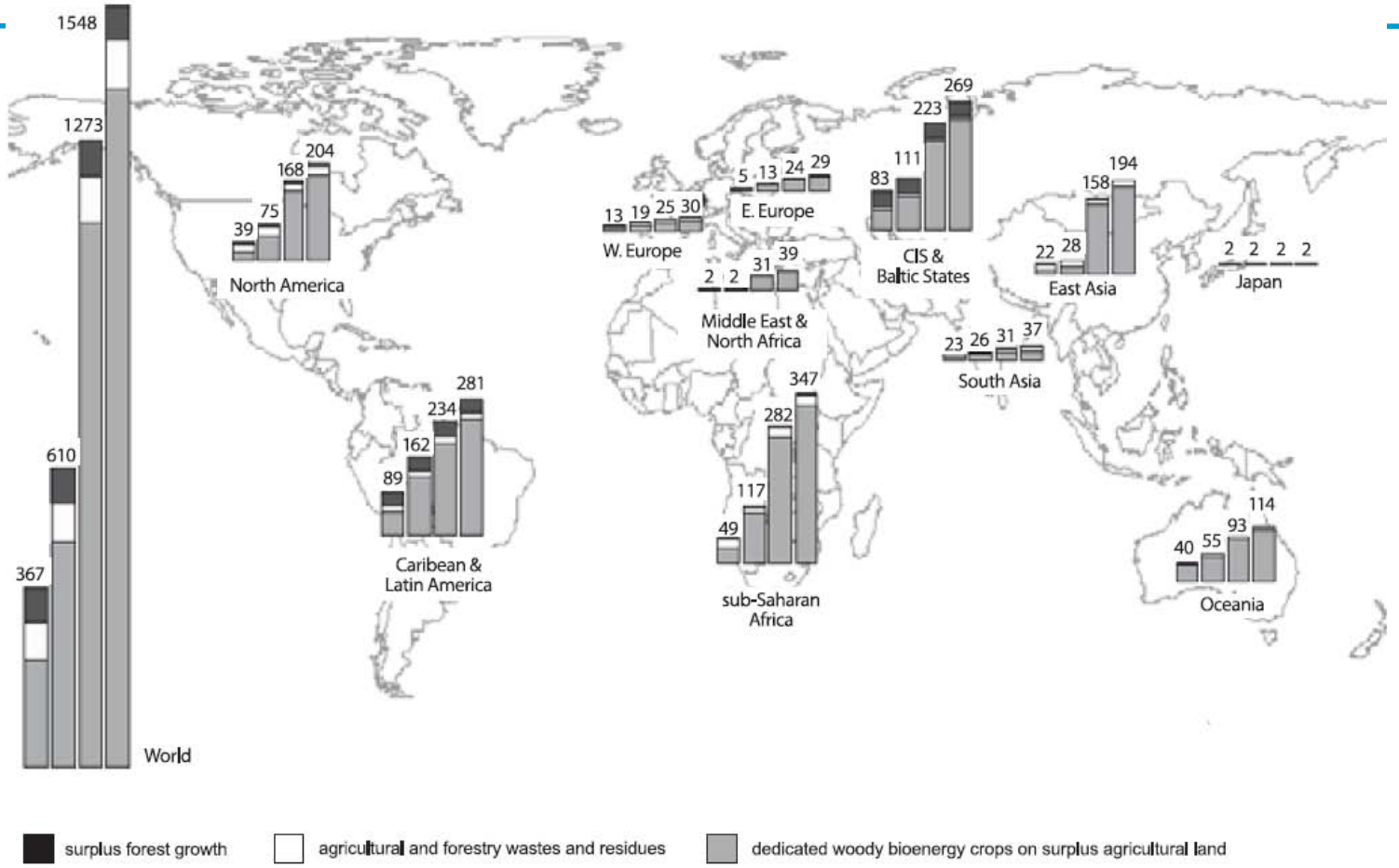
Biomass energy is solar energy stored in the chemical bonds of carbon and hydrogen chains as a result of photosynthesis or the metabolic activity of organisms.

Biomass Yields of Food and Lignocellulosic Crops

Crop	Crop yield (fresh tonne/ha/yr)	Net Energy yield in fuel (GJ/ha/ yr) [3]	By-products
Conventional energy crops [1]			
Wheat	5.1	~ 15	Straw
Corn	9.2	19- 37	Stover, straw, DDGS
Sugar-beet	58.5	~ 111	Sugar-beet pulp
Sugar-cane	73.1	84-152	Bagasse, tops and leaves
Soy beans	2.7	12-13	Glycerine, seed cake
Palm oil (fresh fruit bunches)	19.2	~ 140	Palm kernel shells, PFAD, glycerine
Rape seed	2.9	28	Glycerine, seed cake
Jatropha seeds	4-7	~ 40	Seed cake
Lignocellulosic energy crops [2]			
Woody crops, e.g. poplar, willow, *Eucalyptus*	10 – 15	90-110	
Perennial herbaceous crops, e.g. *Miscanthus*, switchgrass, reed canary grass	10 – 30	140 – 230	
Prairie grasses (low-input system, degraded lands)	3 – 6	18-28	

Sources: 1. Yields based on Sims et. al. (2006), EEA (2007), Berndes (2001) Tilman et al., (2006) and Smeets (2008) ; 2. Sims et al., (2006) for wheat, corn, sugar-beet and rape seed, Smeets et al., (2008) for sugar-cane, Donato and Huerga (2007) for soy, Wicke et al., (2008) for palm oil, Berndes (2001) & Fischer et al., (2007) for lignocellulosic energy crops, Tilman et al., (2006) for corn and prairie grasses.

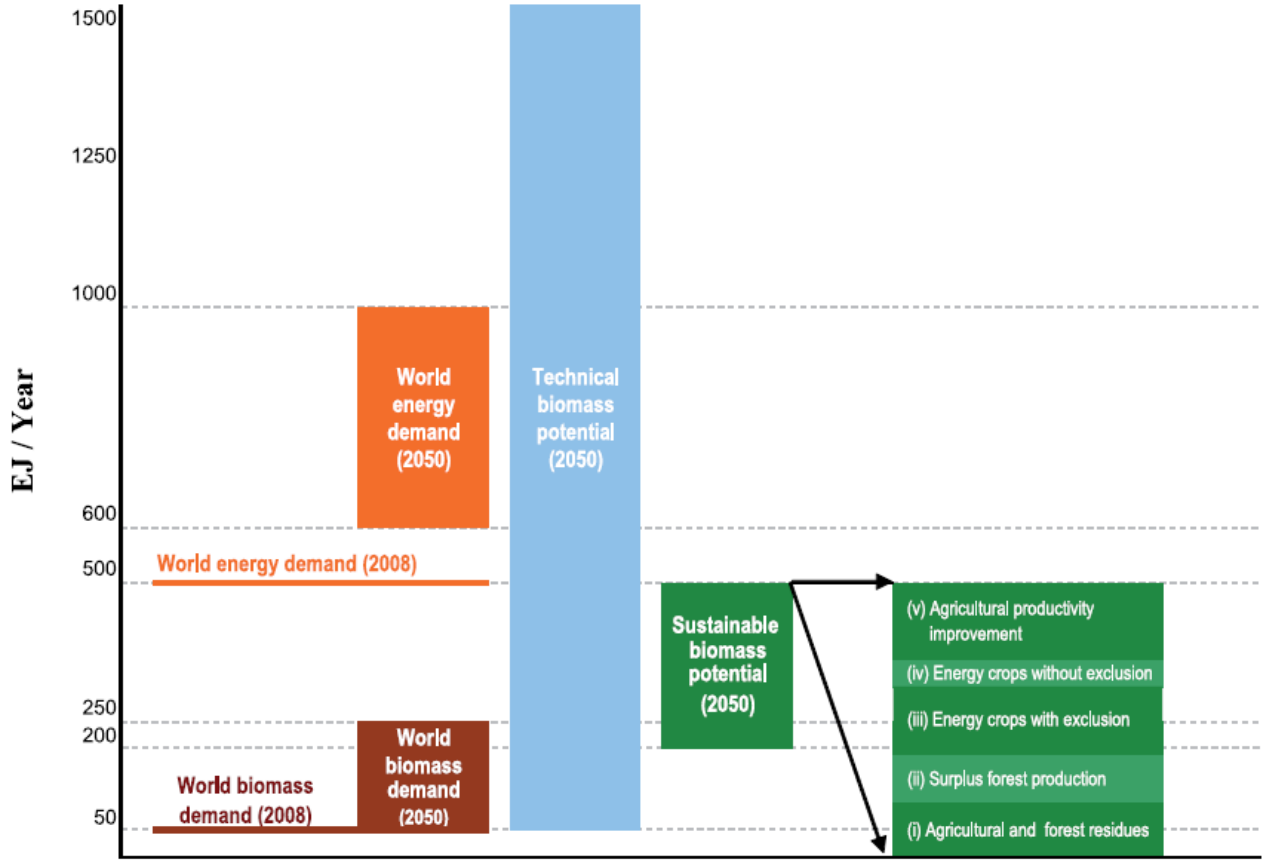
Biomass potential



Impact of different scenarios for agricultural productivity improvement on total technical bioenergy production potential in 2050

Source: Smeets, 2008

Biomass potential

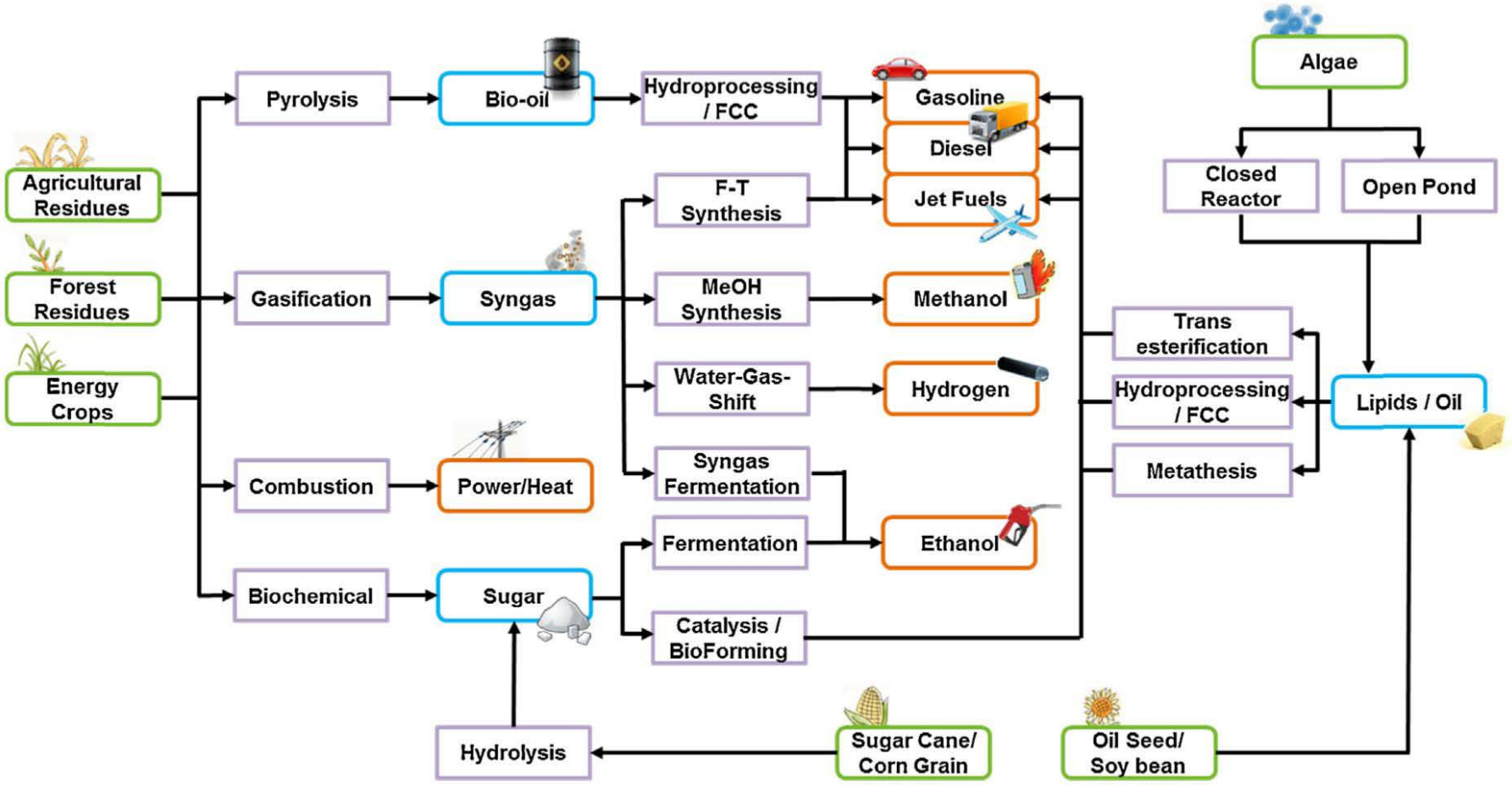


1 EJ = 10^{18} Joules (J)
= 10^{15} kilojoules (kJ)
= 24 million tonnes of oil equivalent (Mtoe)

Technical and sustainable biomass supply potentials and expected demand for biomass

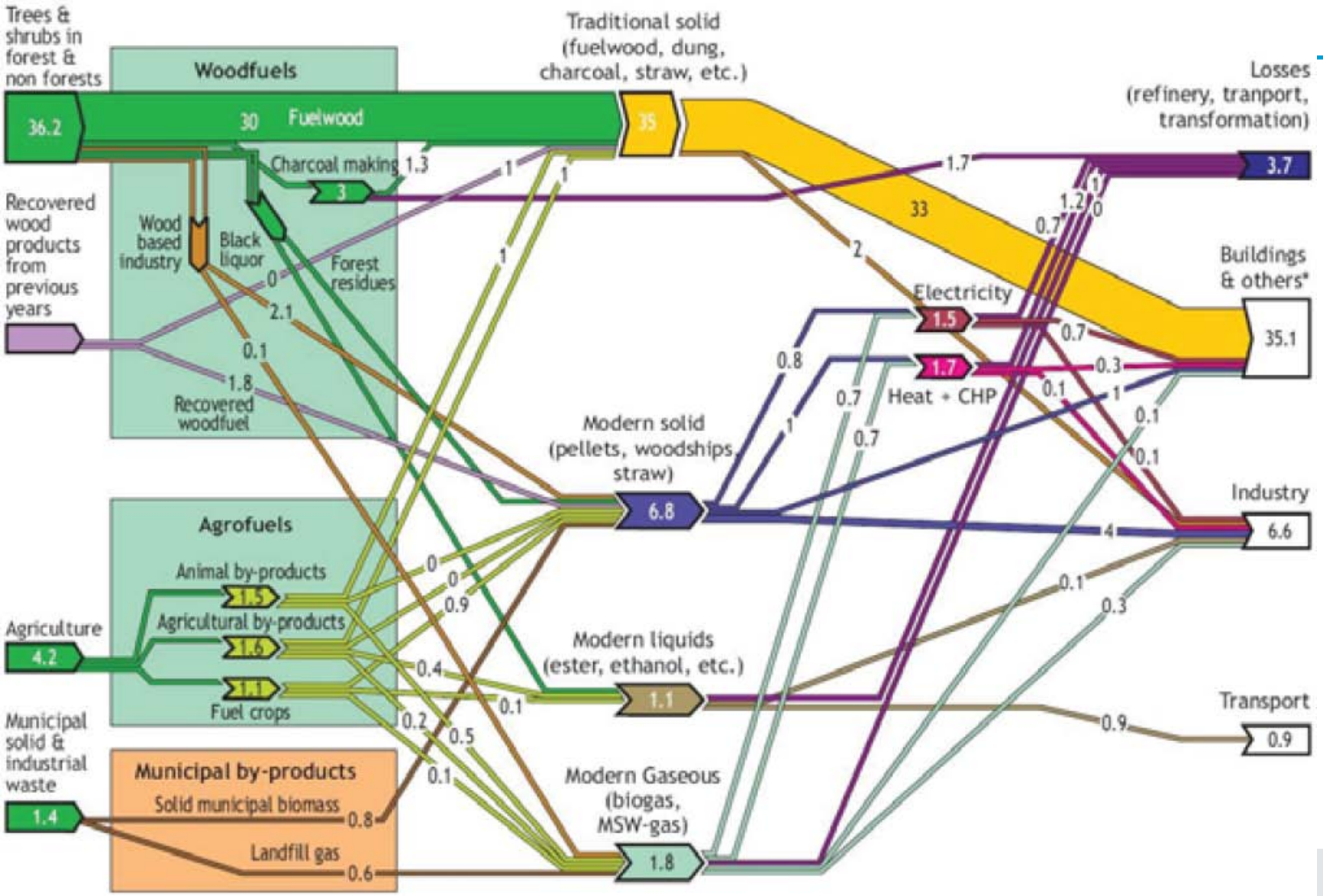
Source: Adapted from Dornburg et al. (2008) based on several review studies

Biomass sources and conversion pathways



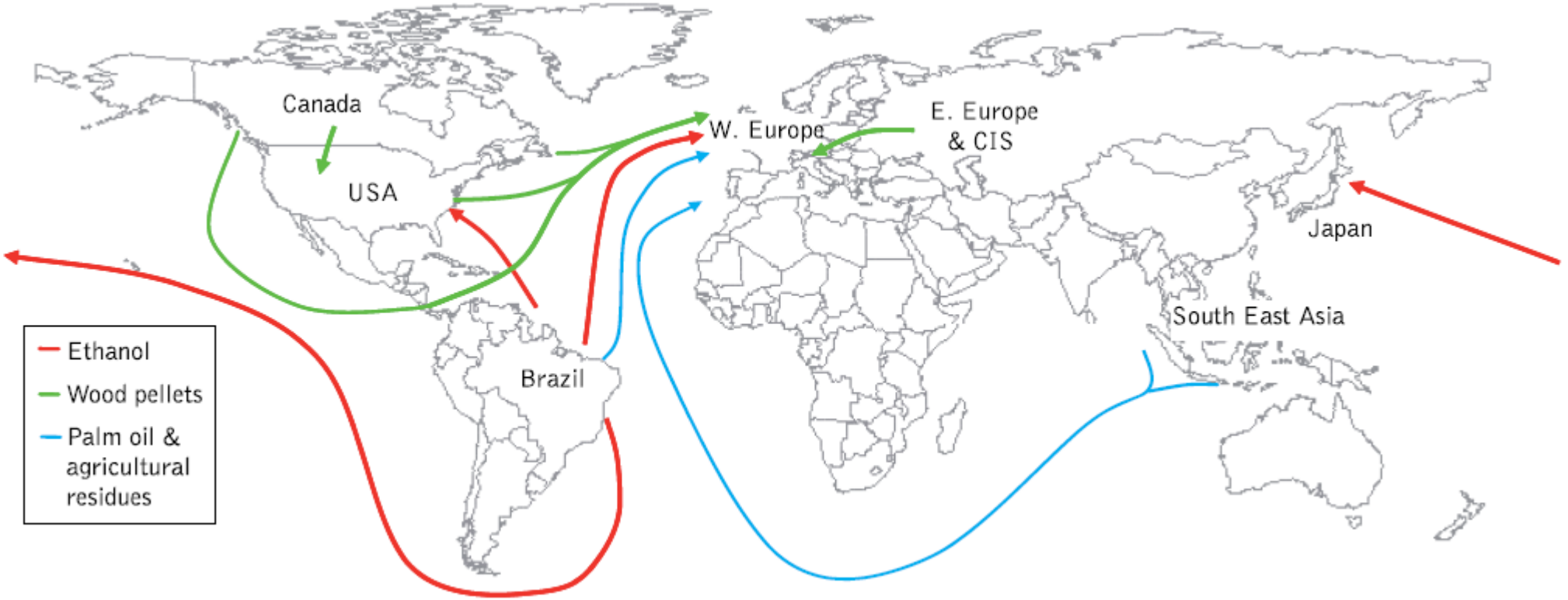
(Source: Yue, you e tal., 2014)

Bioenergy flows into final application (EJ/)



Source:
IPCC, 2007

Cycle of Bioenergy industry



Main international biomass for energy trade routes

(Source: Junginger and Faaij, 2008)

Estimated scope of international biomass trade

	PJ	Million tonnes
Ethanol	160	6
Biodiesel	>90	>2.4
Fuelwood	40	3
Charcoal	20	0.9
Wood pellets	45	2.6
Palm oil	>60	>1.6
Direct trade	**>380**	**>16.7**
Industrial round wood	480	50
Wood chips and particles	150	16
Indirect trade	630	66
Total	**>1000**	**>83**

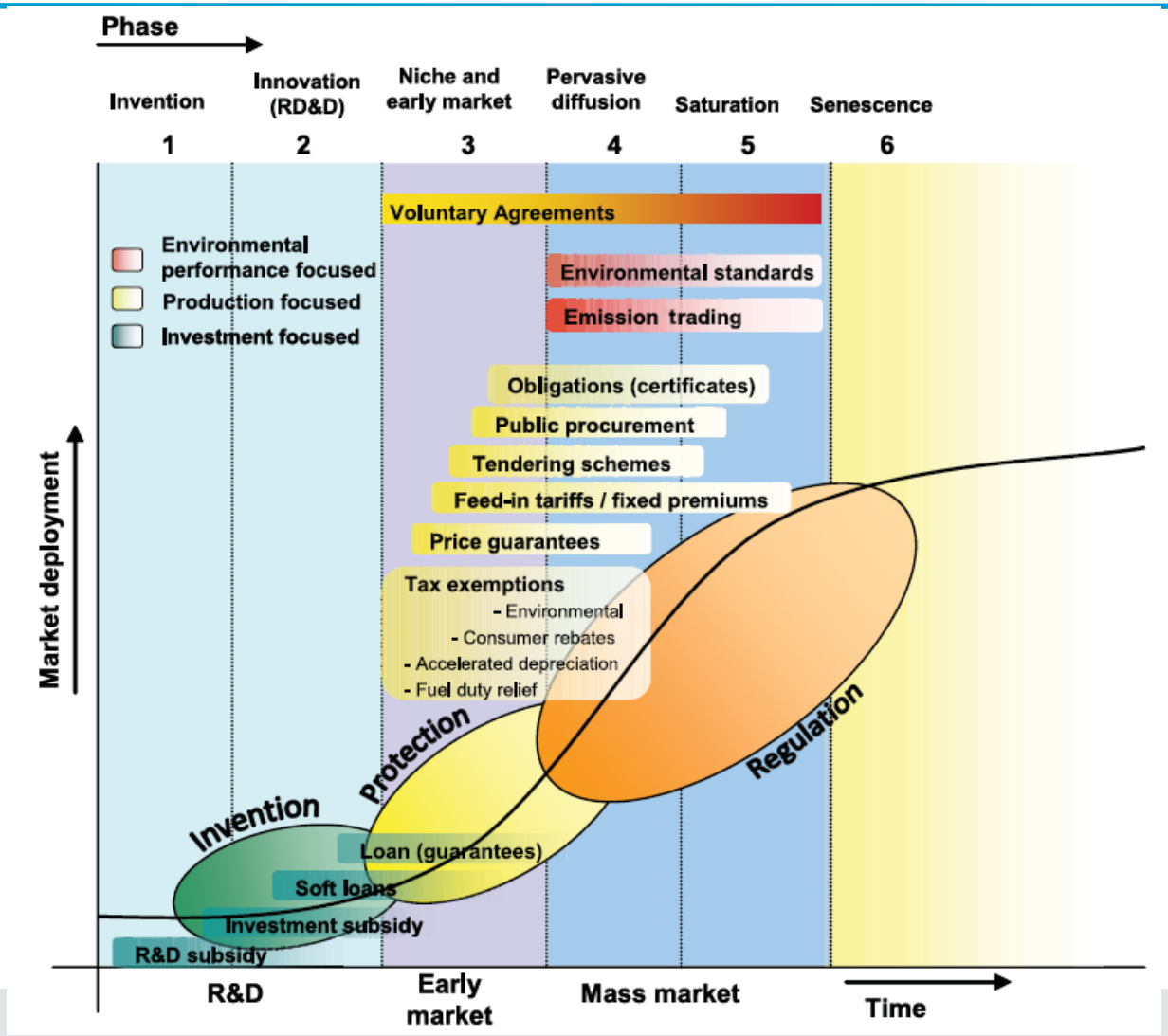
Source: adapted from Heinimö and Junginger, 2009

Key motivations for bioenergy policy

Country	Objectives						
	Climate change	Environment	Energy security	Rural development	Agricultural development	Technological progress	Cost effectiveness
Brazil	X	X	X	X	X	X	
China	X	X	X	X	X		
India			X	X		X	X
Mexico	X	X	X	X		X	
South Africa	X		X	X			
Canada	X	X	X			X	
France	X		X	X	X		
Germany	X	X		X	X	X	X
Italy	X		X		X		
Japan	X	X			X	X	
Russia	X	X	X	X	X	X	
UK	X	X	X	X			X
US		X	X	X	X	X	
EU	X		X	X	X	X	

Source: GBEP, 2007

Policy instruments for each technology development stage



Source: Adapted from Ros et al., 2006

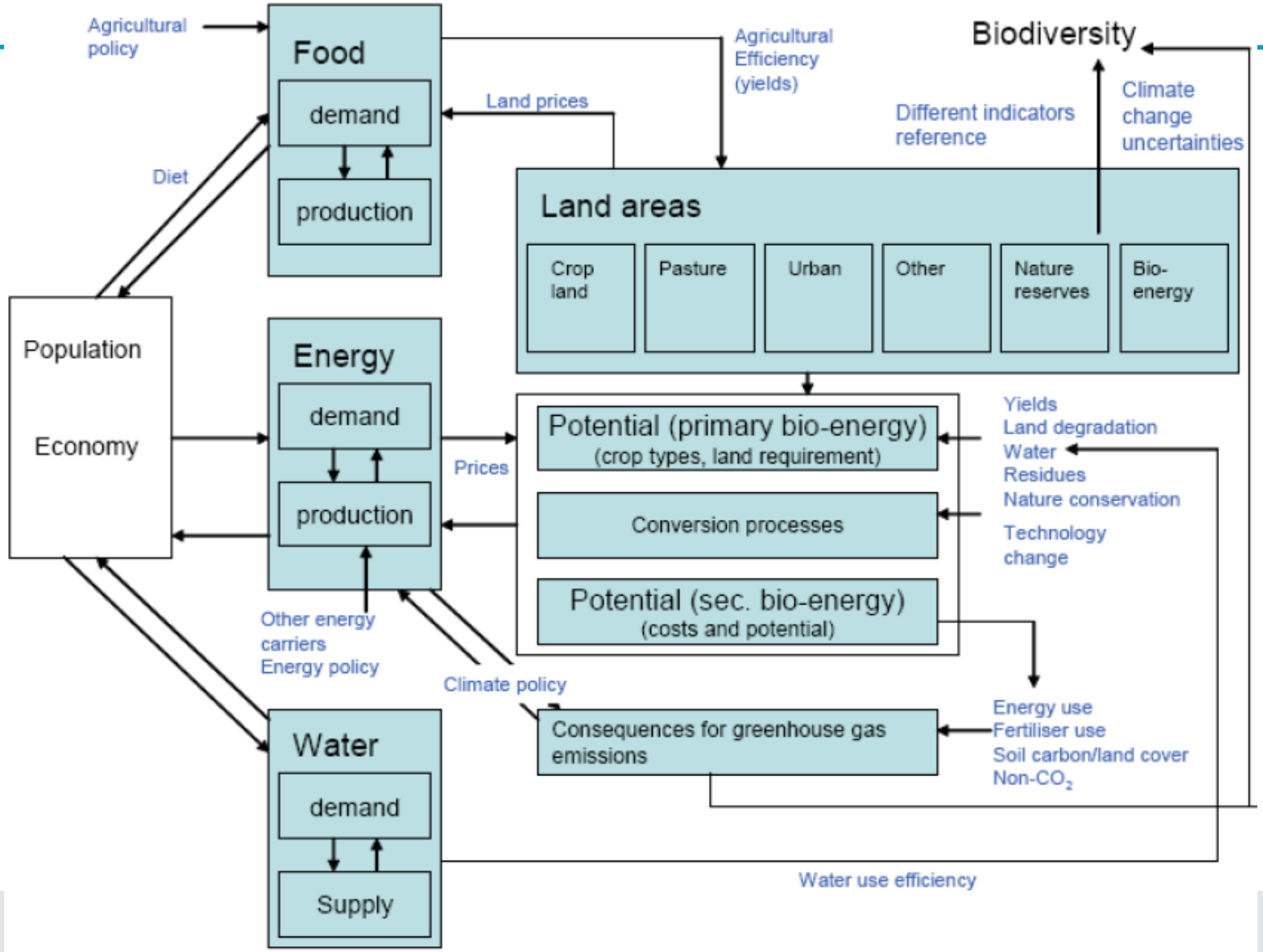
Policy mix

Country	Energy Policy							
	Binding targets/ Mandates[1]	Voluntary targets[1]	Direct incentives[2]	Grants	Feed-in tariffs	Compulsory grid connection	Sustainability criteria	Tariffs
Brazil	E,T		T					Eth
China		E,T	T	E,T	E,H	E,H		n/a
India	T,(E*)		E	E,H,T	E			n/a
Mexico	(E*)	(T)	(E)			(E)		Eth
South Africa		E,(T)	(E),T					n/a
Canada	E**	E**, T	T	E,H,T				Eth
France		E*,H*,T	E,H,T		E			As EU below
Germany	E*,T		H	H	E	E	(E,H,T)	As EU below
Italy	E*	E*,T	T	E,H	E	E		As EU below
Japan		E,H,T				E		Eth, B-D
Russia		(E,H,T)	(T)					n/a
UK	E*,T*	E*,T	E,H,T	E,H	E		T	As EU below
USA	T	E**	E,H,T	E,T	E			Eth
EU	E*,T	E*,H*,T	T	E,H,T		E	(T)	Eth, B-D

E: electricity, H: heat, T: transport, Eth: ethanol, B-D: biodiesel

Source: GBEP, 2007

Key relationships relevant to bioenergy projects implications



Source: Dornburg et al., 2008

Bioenergy and policy objectives

Debate:

Should we develop the bioenergy industry or not?

Bioenergy and policy objectives

Debate rules:

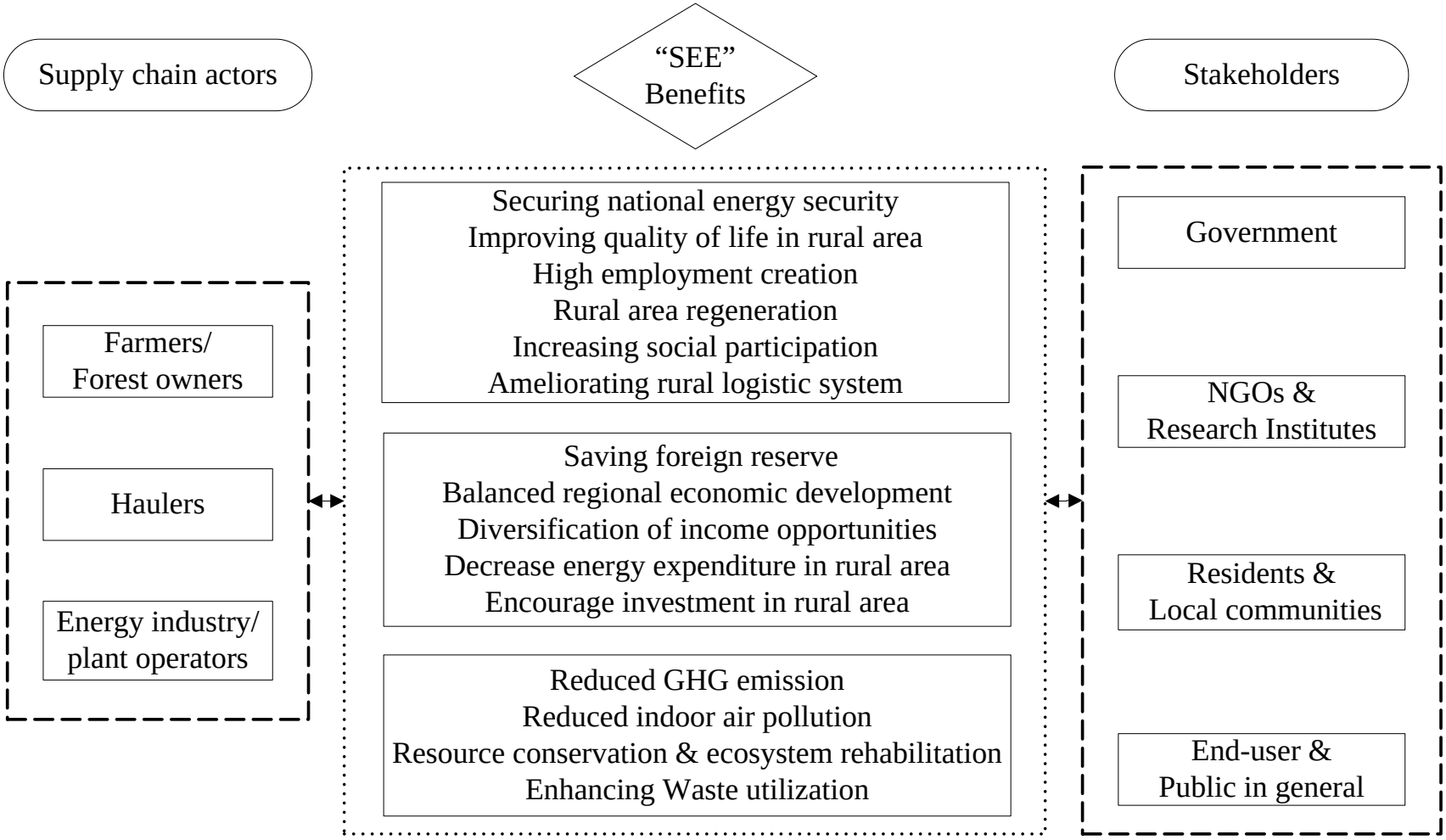
Role play: 6 persons in each group (chair speaker, farmer, bioenergy plant operator, food consumer, energy consumer, governor)

Topic: “SEE” analysis

Procedure:

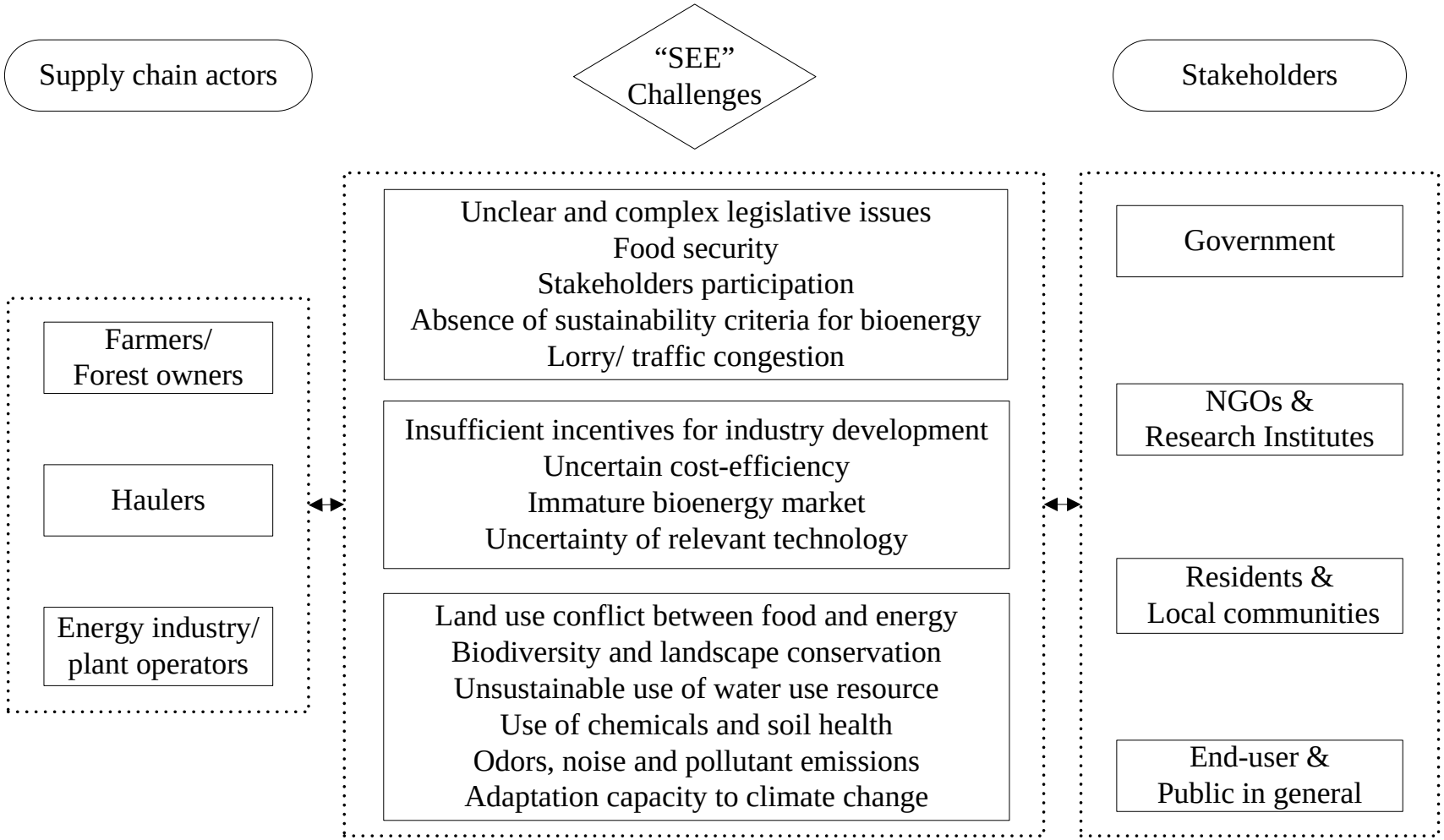
1. State positions: chair speakers in both teams present the constructive arguments
2. Free debate: 5 following debaters play their roles
3. Conclusion: chair speakers restate their arguments

"SEE" benefits



Source: Shu, 2016

"SEE" challenges



Source: Shu, 2016

Key Characteristics of Several Biomass Sustainability Certification Initiatives

Check list	Green Gold Label	Electrabel Label	Government (BE)	RTFO (UK)	NTA 8080 (NL)	RSPO	RED (EU)	RSB
Type of biomass	All biomass for heat and electricity	All biomass for heat and electricity	All biomass for heat and electricity	Biomass for biofuels	All biomass	Palm oil	Biomass for biofuels	Biomass for biofuels
Status	Certification in implementation, also in development	Certification in implementation, also in development	Green certificates linked to GHG / energy criteria	Implemented since 2008	Principles developed, testing phase C&I (pilot studies)	Principles developed, testing phase C&I (pilot studies)	Standards developed; detailed design through 2009.	In development
GHG and/or energy balance	+ (included in GGLS8)	+	+	+	+	+	+	+
Biodiversity	+	-	-	+	+	+	+	+
Competition with food	-	-	-	-	+	-	-	+
Leakage	-	-	-	-	-[35]	-	-	+
Economic well-being	-[36]	-	-	+	+	+	-[37]	+
Welfare / social criteria	-	-	-	+	+	+	- [37]	+
Environmental criteria	+	+	-	+	+	+	- [37]	+
Type of system[38]	Track-and-trace Sourcing	Track-and-trace Sourcing	Cooperation with e.g. Electrabel, SGS	Meta-standard	Track-and-trace, mass balance or book and claim, currently under consideration.	Track-and-trace, mass balance or book and claim	Mass balance	Not yet determined
Organisation	Established by company Essent, now open for 3rd parties	Label is developed by company Electrabel	Government provides Green Certificate based on criteria compliance	Administered by Renewable Fuels Agency, a UK government body	Initiated by government, organisational structure in process	Roundtable with stakeholders in palm oil production	Evolving – probably mixture of government and private schemes.	Roundtable with multi-stakeholder participation
Verifier	Control Union	SGS	Independent 3rd party verification	Independent 3rd party verification	Requirements not yet determined	Verifier working group (in progress)	Independent 3rd party verification	Not yet determined
Relation to national policies	Stimulated by policy	Required by law	In regional policy (in development)	Embedded in national policy	NTA 8080 will be coupled to subsidy (only) for biomass for heating and electricity	On voluntary basis	Will be embedded in national policies	Not yet determined
(Plans to) make use of existing systems	FSC, 'Organic' certification	Yes (e.g. FSC)	See Electrabel	Yes – meta-standard approach	Will apply e.g. FSC, and GGL	Makes use of existing systems	Will make use of existing systems	Yes – meta-standard approach

Source: van Dam et al., (2008) updated to July 2009

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