International Trends for Bioenergy

Realizing the potential
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Opportunities and constraints

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FOCUS on Forest Engineering 2010
Forest Biofuels: A Green Resource?

Ingwenyama Sports & Conference Resort
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Acknowledgements to colleagues

IEA Bioenergy Task 43 and predecessors

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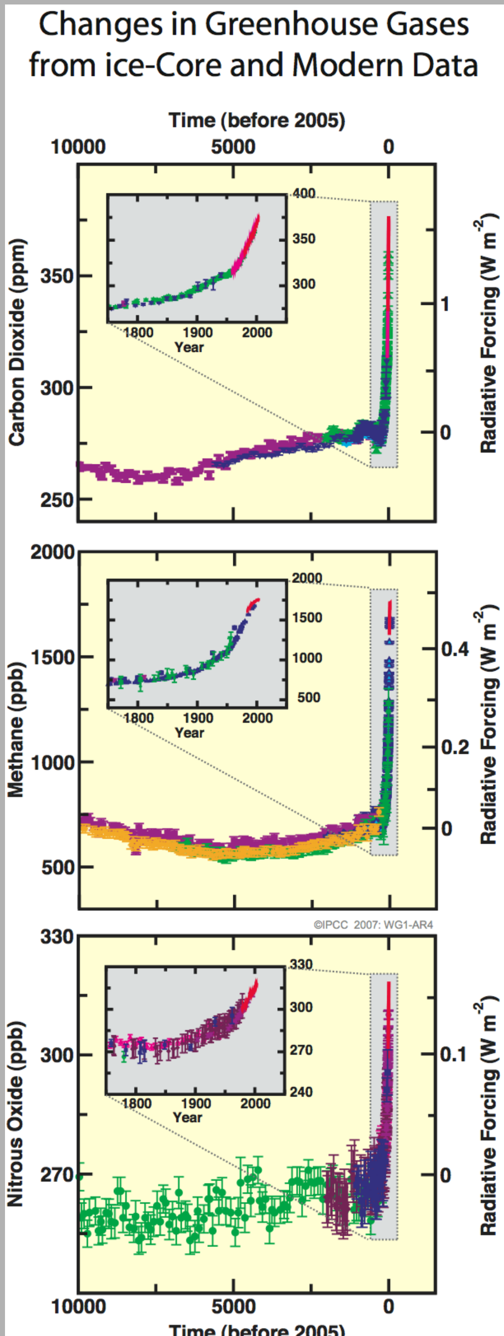
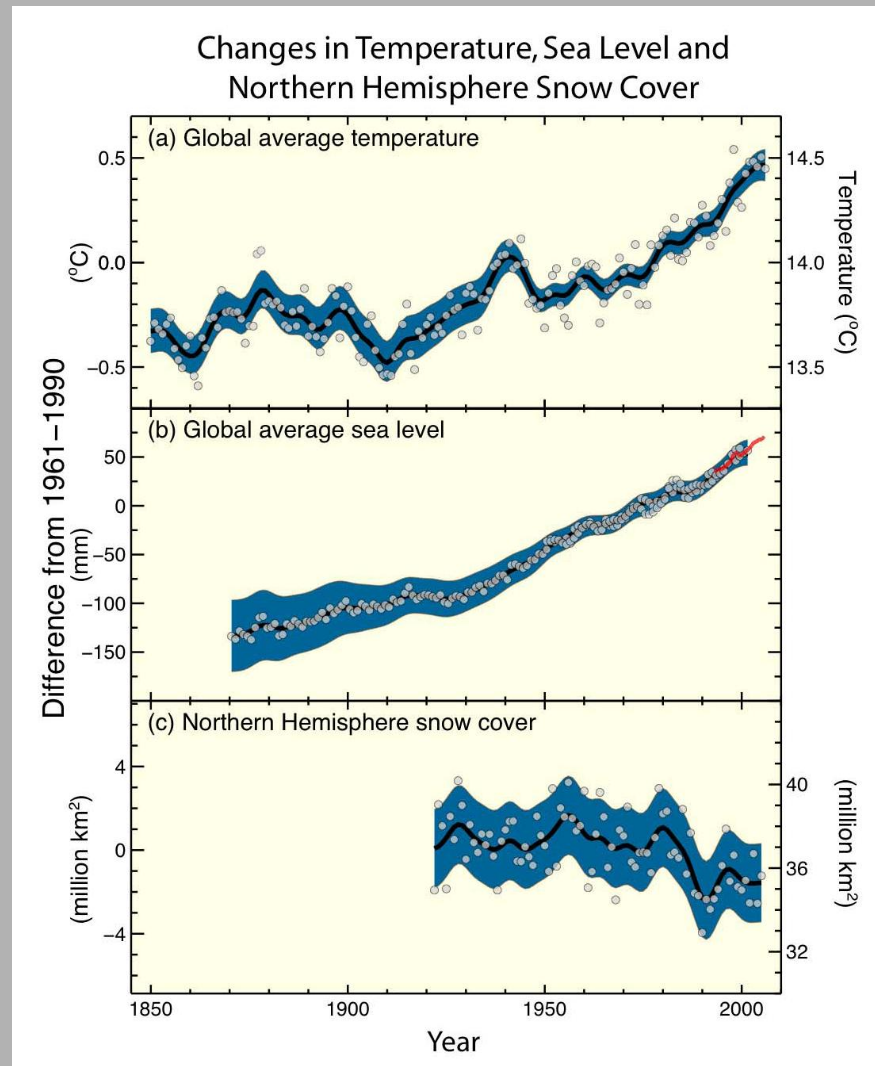
Faculty of Forestry, University of Toronto

Outline

- IEA ETP 2010 global energy projections through 2050
- Describe global and regional patterns of bioenergy use
- Why forest bioenergy?
- Synthesize factors influencing bioenergy deployment
  - Drivers
  - Challenges
- Forest sector opportunities
- Operational challenges
- Opportunities for future collaboration
  - IEA Bioenergy Task 43 – Biomass Feedstocks for Energy Markets
  - COST Action FP0902

Why Bioenergy?
Global climate change





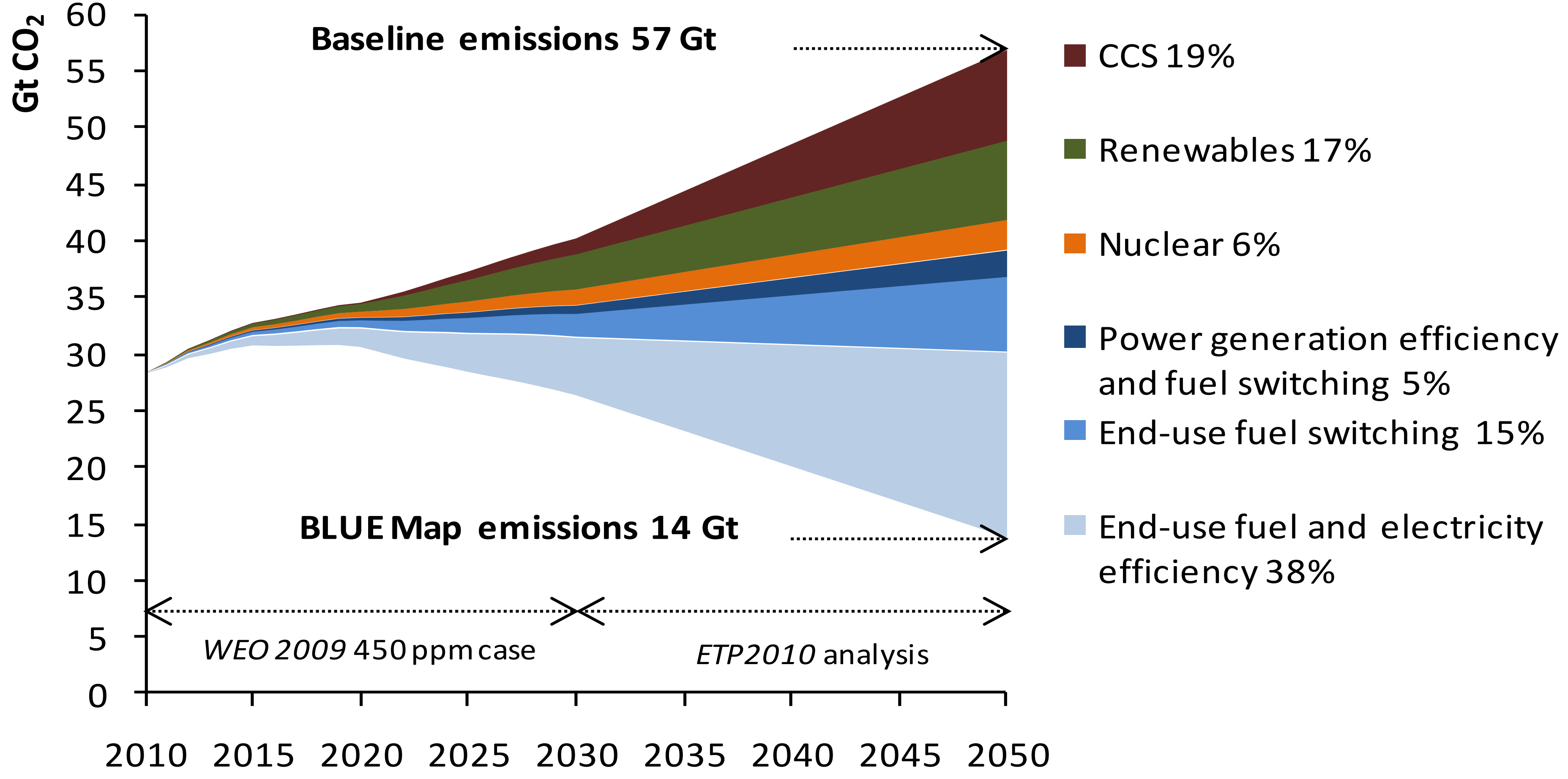
Source: www.ipcc.ch

Background: IEA Energy Technology Perspectives projections as a foundation for roadmap development

- IEA ETP 2010 provides detailed projections of global energy use to 2050, calibrated to World Economic Outlook (WEO) 2009
- ETP BLUE Map scenario depicts a set of pathways to reach a 50% reduction in global energy-related CO_2 by 2050
  - Based on cost-minimization, up to USD 175/ton CO_2 by 2050
  - Uses a back-casting approach to identify pathways and ramp-up rates for different technologies and new fuels
  - Use of bioenergy roughly triples by 2050, biofuels demand in transport increases 10-fold

Source: OECD/IEA 2010

We need a global 50% CO_2 cut by 2050



Source: ETP 2010

- We need a global 50% CO_2 cut by 2050
- A wide range of technologies will be necessary to reduce energy-related CO_2 emissions substantially

Source: OECD/IEA 2010

Biomass use in ETP 2010

- Biomass currently provides around 1100 Mtoe (50 EJ) of primary energy per year
  - 190 Mtoe (8 EJ)/yr of commercial heat and power and 40 Mtoe (1.7 EJ)/yr of liquid transport fuels
  - Traditional biomass accounts for over 800 Mtoe (35 EJ) /yr

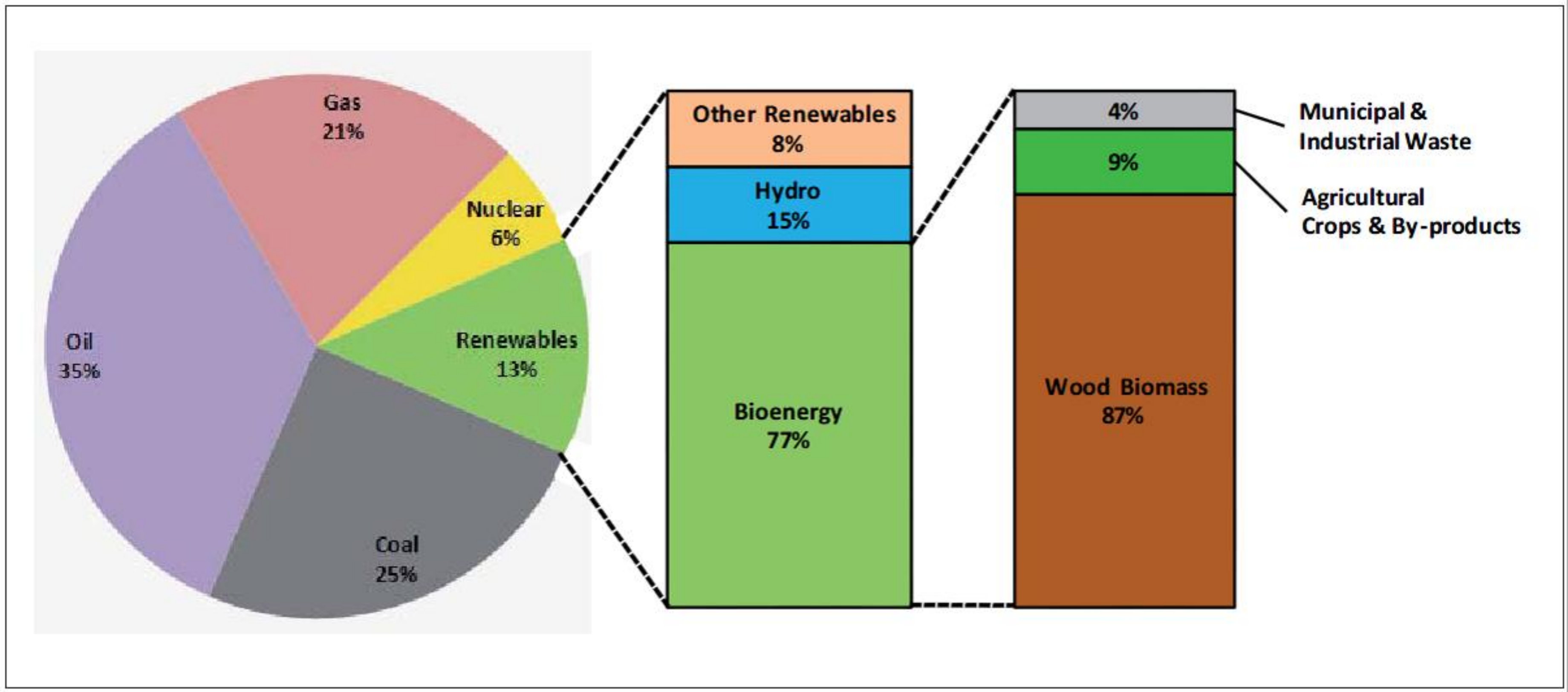
- In BLUE Map scenario biomass use increases to around 3400 Mtoe (140 EJ)/yr in 2050.
  - This will require roughly 7 000 Mt dry biomass
  - between 375-750 Mha* of land needed, if 50% come from crop and forest residues and the rest from purpose grown energy crops

Source: OECD/IEA 2010

*assuming average yield of 5-10 tons (dry)/ha

Global and regional patterns of bioenergy use

Share of bioenergy in world primary energy mix

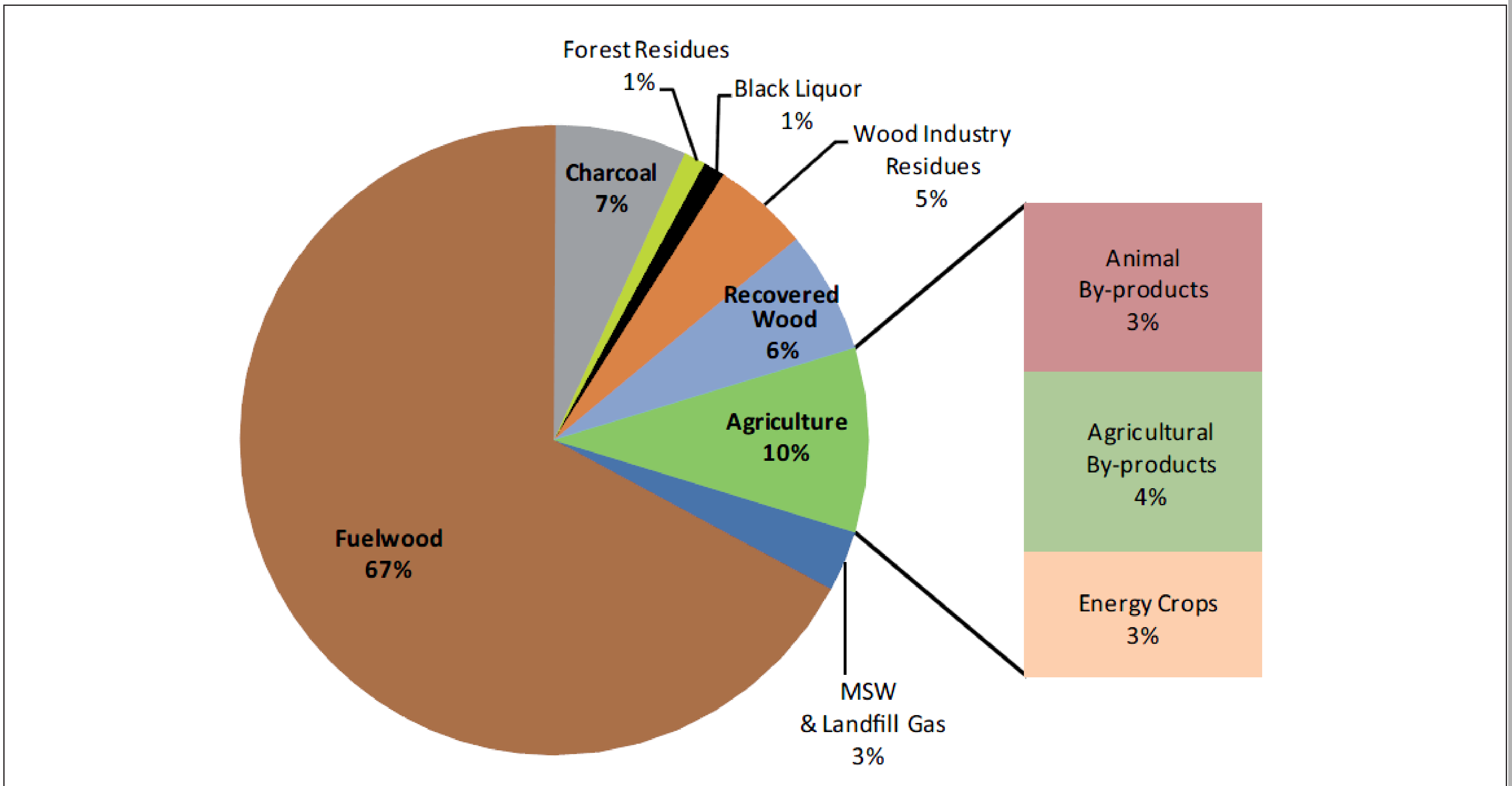


About 72% of woodfuel consumption is in developing countries

IEA Bioenergy: ExCo: 2009:05

Global and regional patterns of bioenergy use

Types of biomass in the primary bioenergy mix

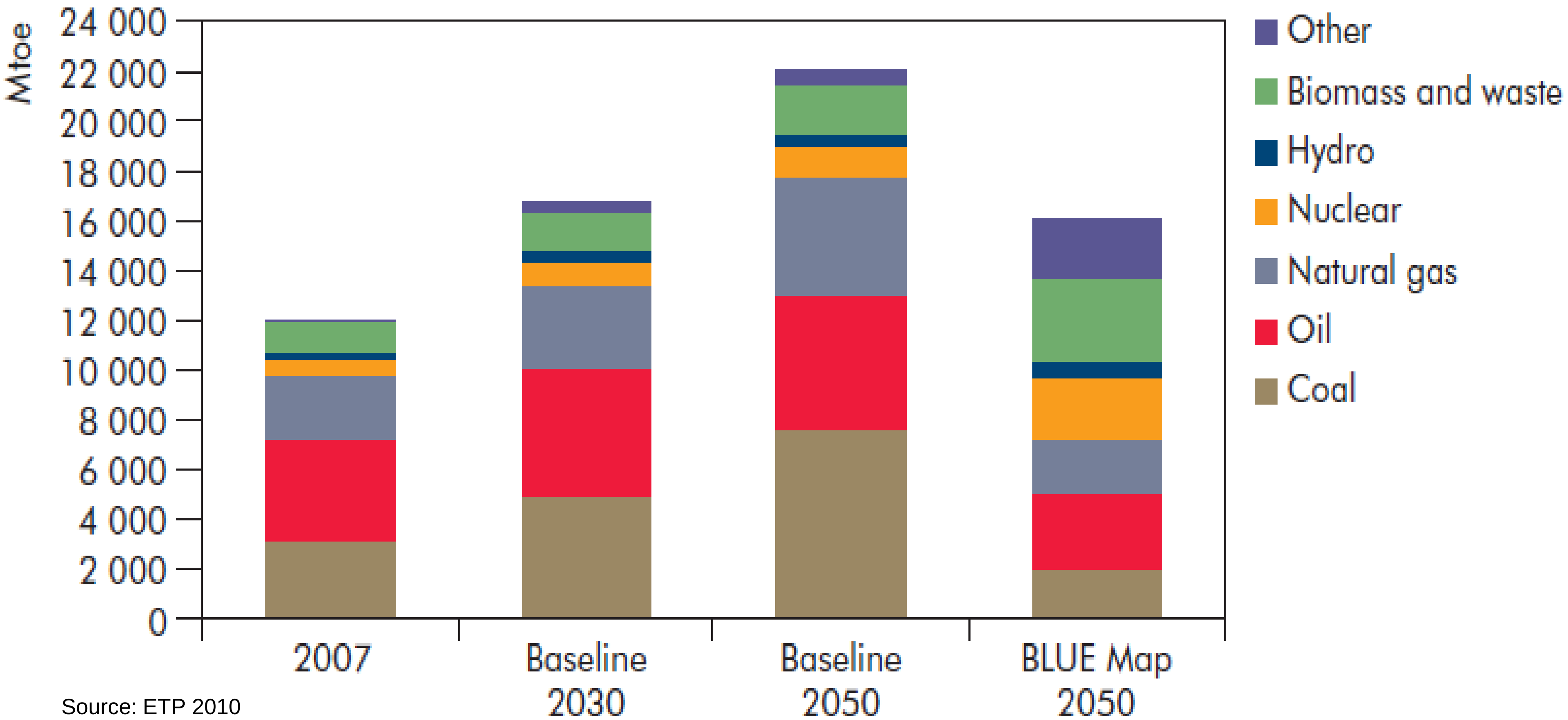


Of 36 EJ woodfuel used in developing countries, 3 EJ is charcoal

Forests are a very important source of bioenergy

IEA Bioenergy: ExCo: 2009:05

World TPES in ETP 2010

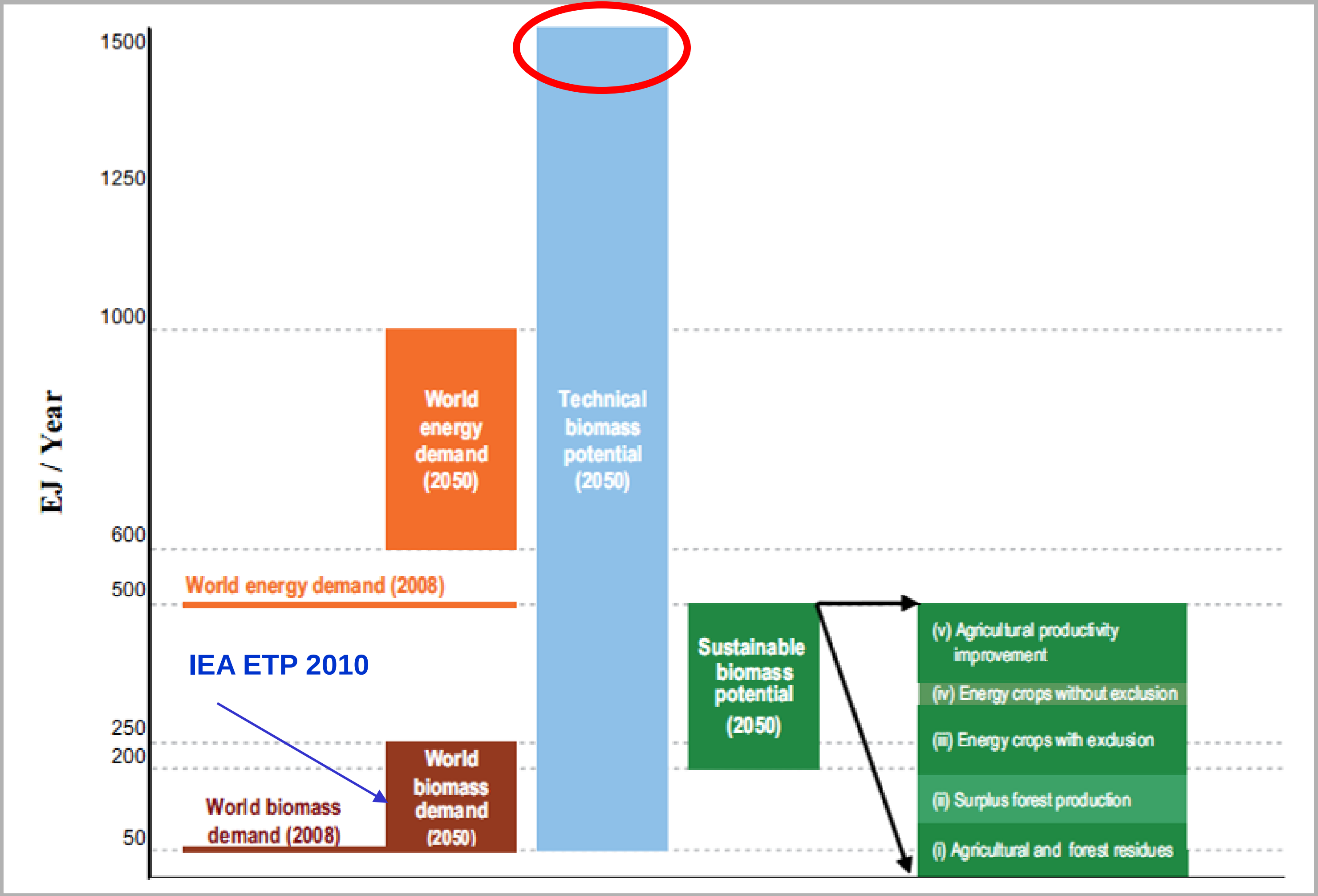


Source: ETP 2010

- Use of biomass increases 3-fold in the BLUE Map scenario, and provides 20% of TPES (140 EJ) in 2050
- Bioenergy accounts for roughly 10% of energy related CO_2 emission reductions in 2050

Source: OECD/IEA 2010

Global potential for bioenergy production to 2050



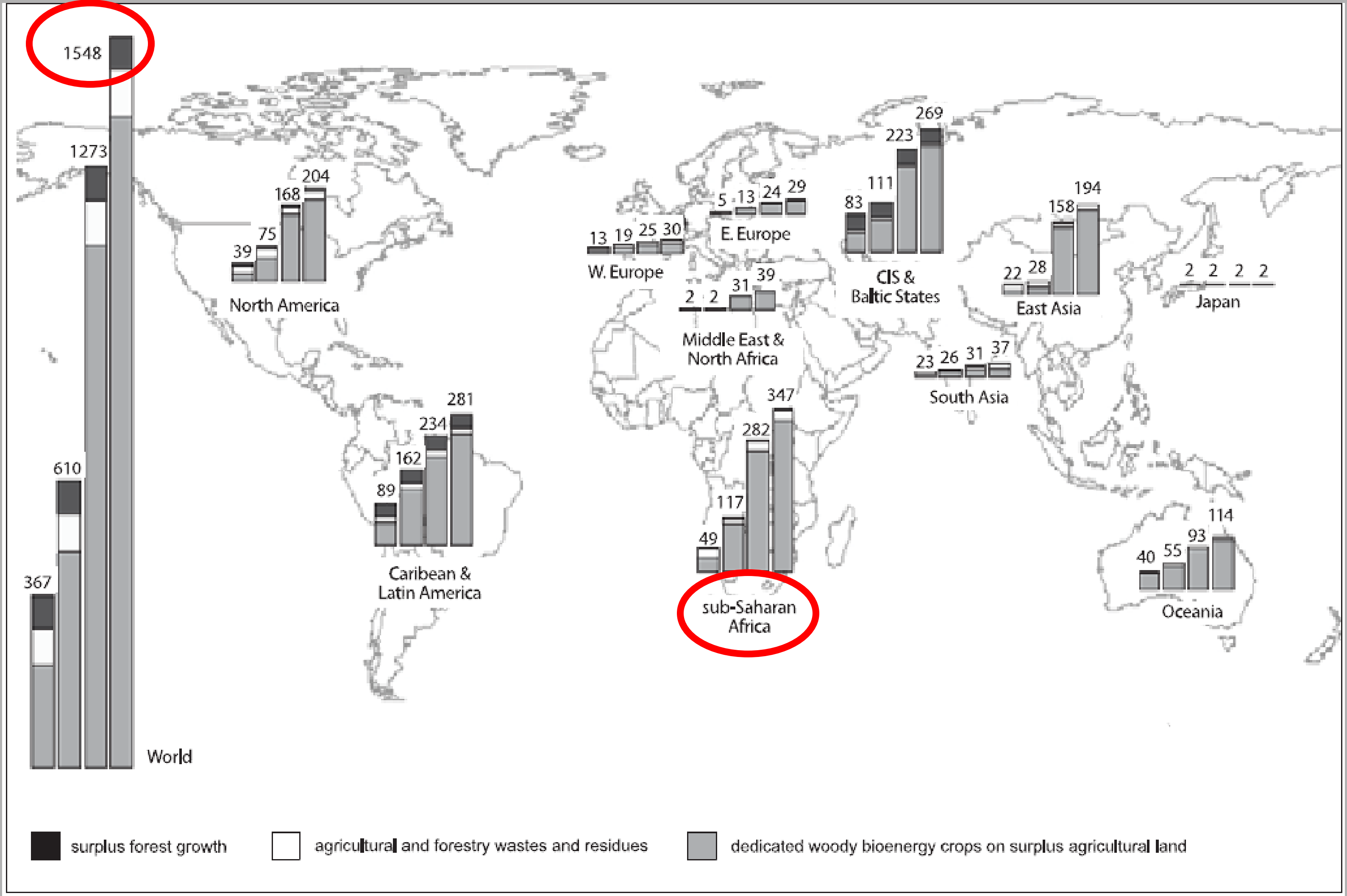
Huge difference between current and potential use of biomass

The range in estimates is an opportunity and a challenge!

IEA Bioenergy: ExCo: 2009:05

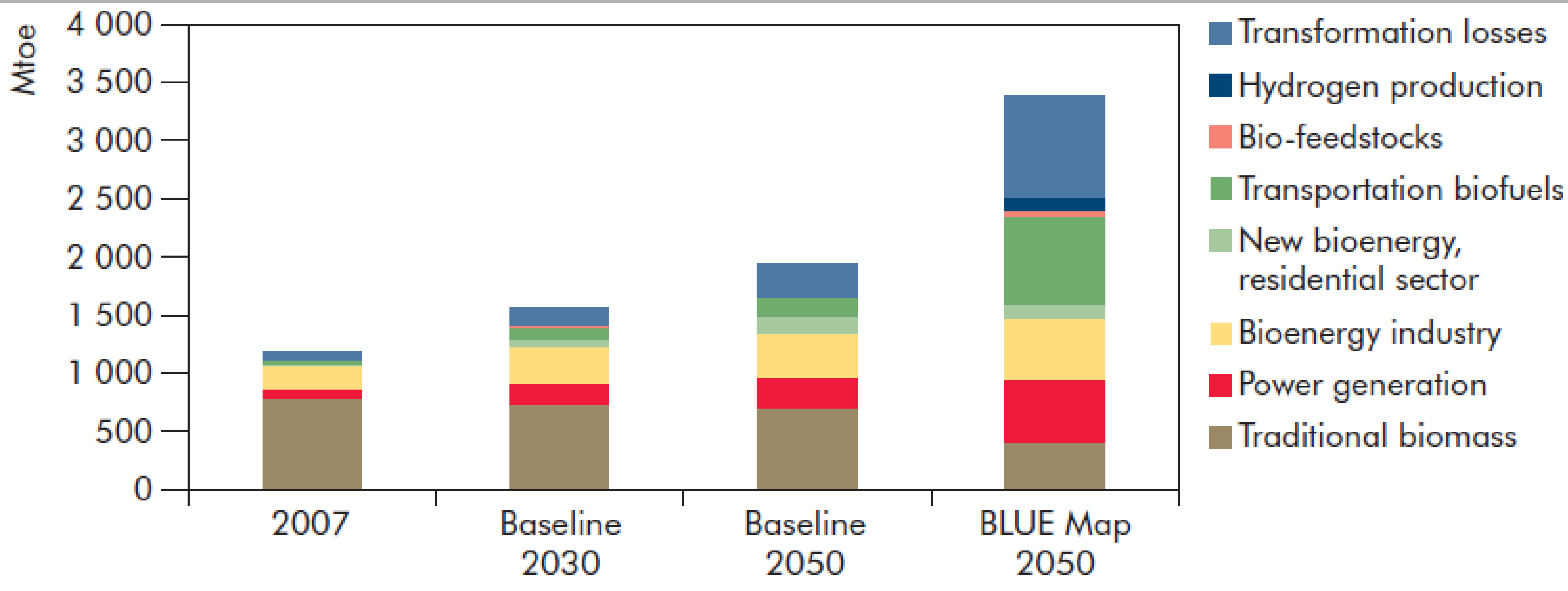
Impact of agricultural productivity gains on total technical bioenergy production potential in 2050 (EJ)

-- 4 scenarios --



Smeets 2007. *In*: IEA Bioenergy: ExCo: 2009:05

Biomass use in ETP 2010



Note: The chart includes transformation losses in the production of liquid biofuels from solid biomass.

Source: ETP 2010

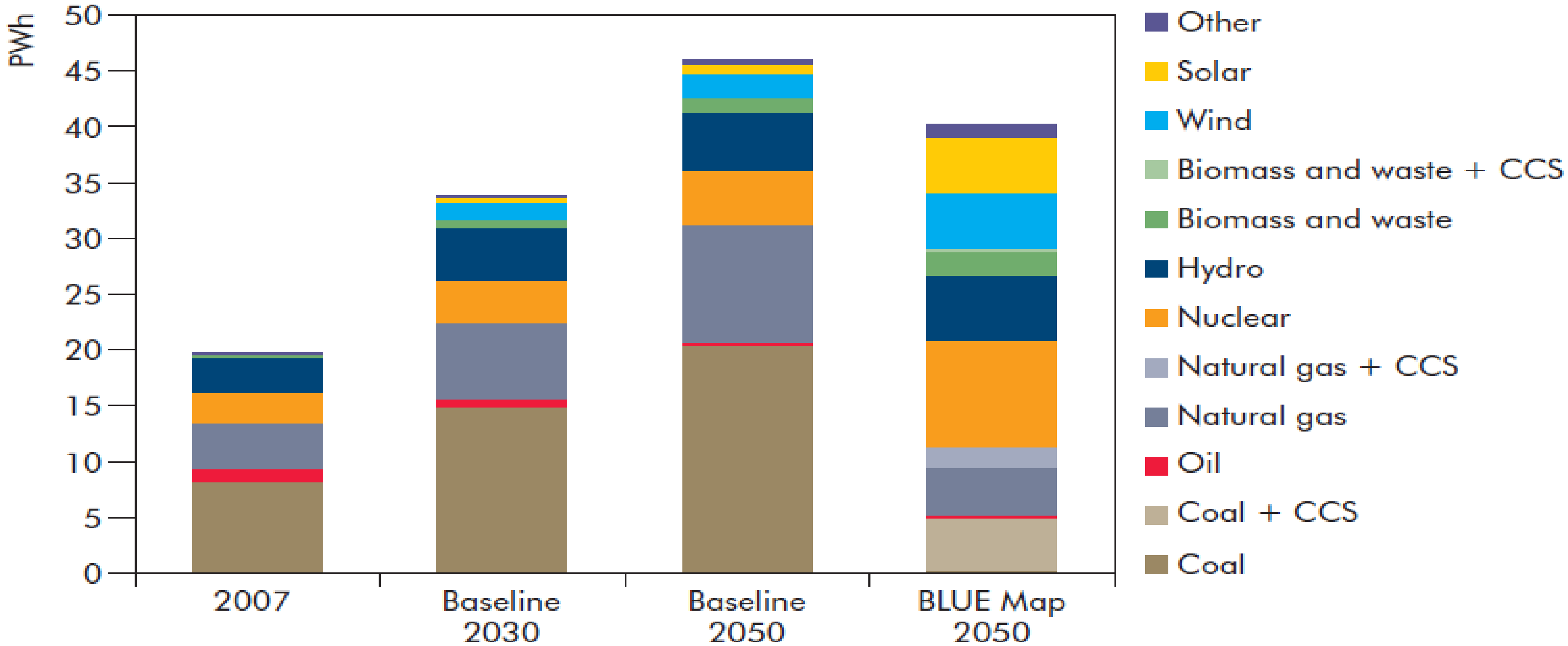
- Modern bioenergy production increases significantly in Blue Map, whereas traditional biomass use is reduced by 2050
- Around 50% of biomass demand in the BLUE Map scenario is for production of biofuels for transport

Source: OECD/IEA 2010

Biomass use in ETP 2010

Electricity sector

Global electricity production by energy source and scenario



Source: ETP 2010

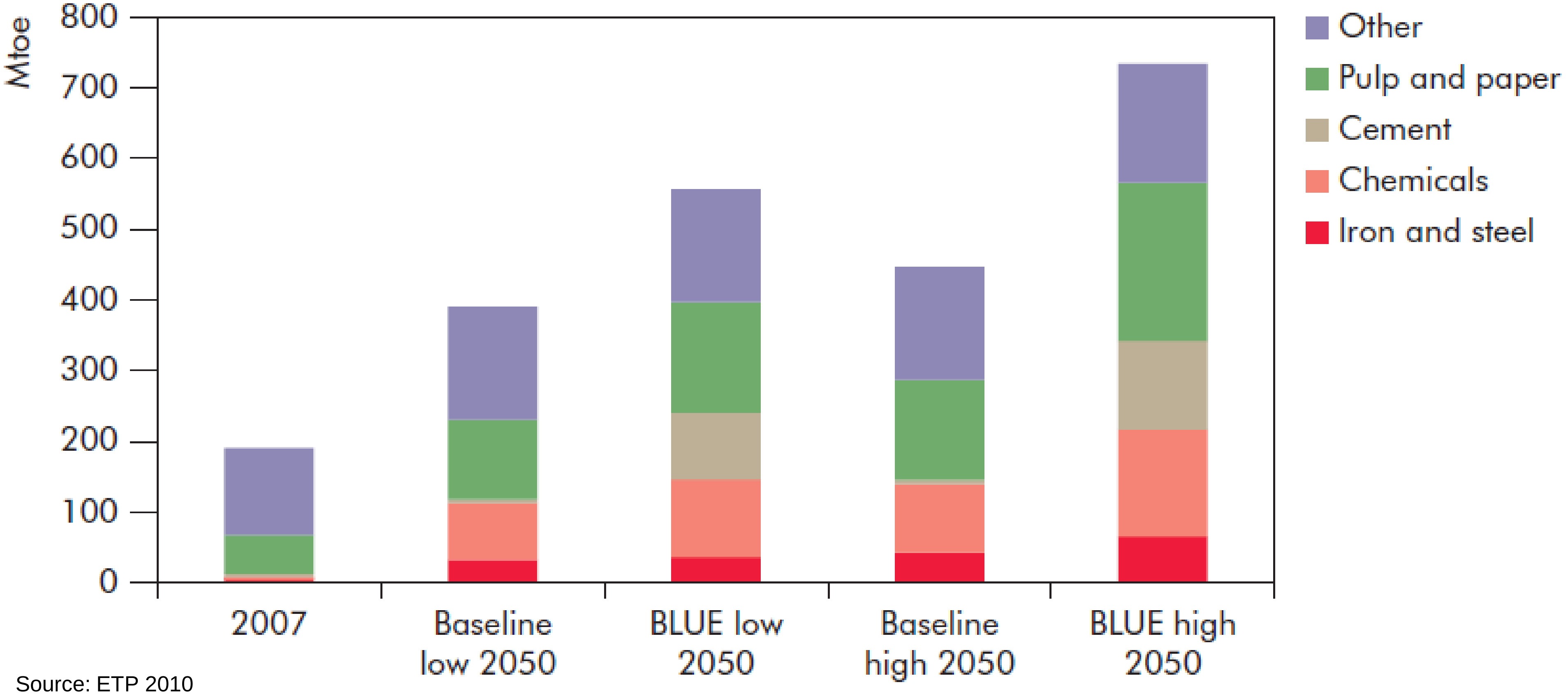
Note: Other includes electricity generation from geothermal and ocean technologies.

- Biomass electricity generation increases significantly and provides 6% (2460 TWh) of total electricity in BLUE Map in 2050
- By 2050, all regions produce at least 50% of their electricity from renewables

Source: OECD/IEA 2010

Biomass use in ETP 2010

Industry



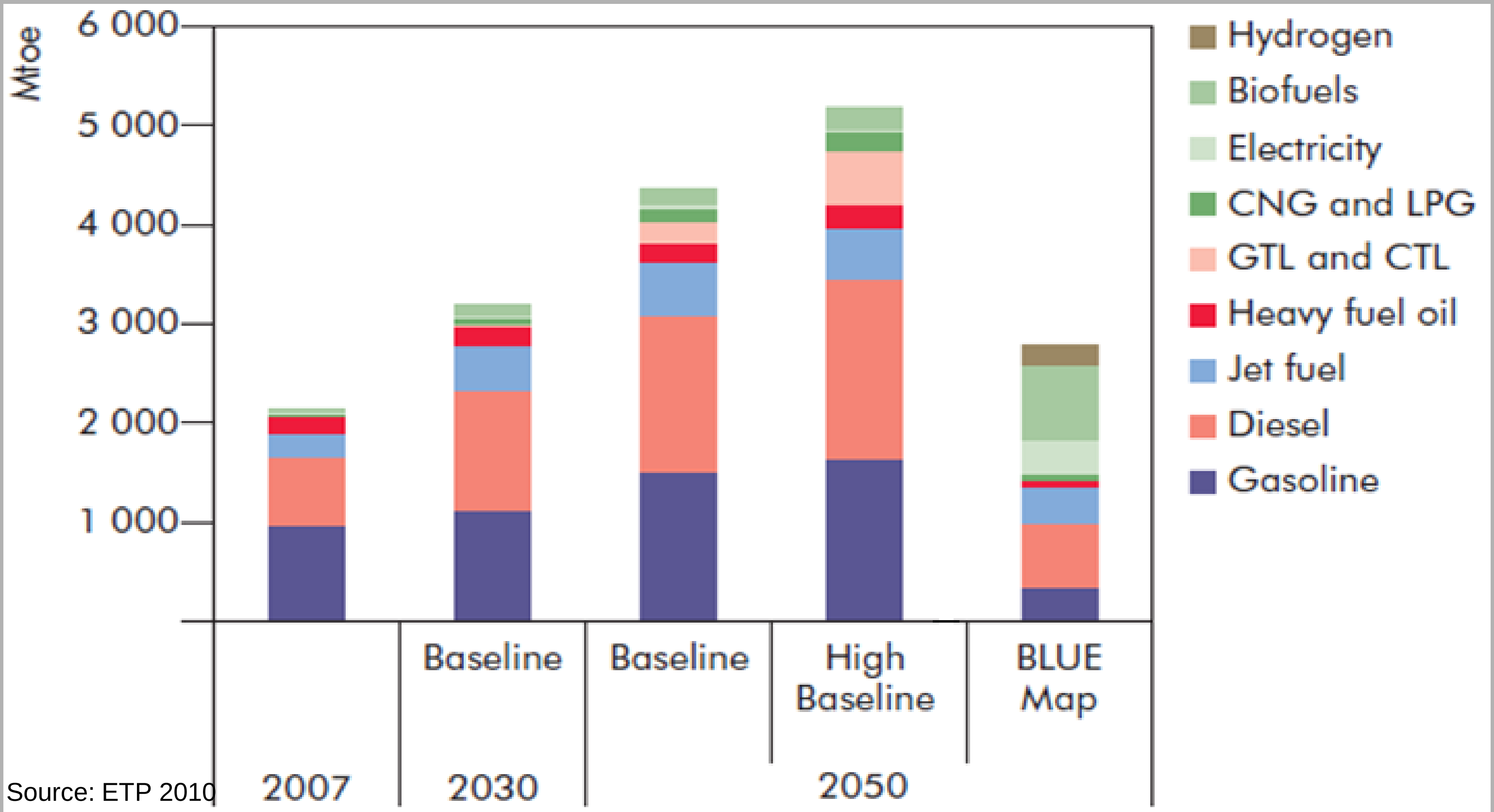
Source: ETP 2010

- By 2050, biomass use in industry reaches between 560 - 730 Mtoe (23-31 EJ), accounting for 12-14% of total industrial energy use in BLUE Map
- Strongest demand growth comes from the chemical industry, followed by cement and iron/steel sector

Source: OECD/IEA 2010

Biomass use in ETP 2010

Transport sector



Source: ETP 2010

- In BLUE Map, transport energy use returns nearly to 2007 level, with more than 50% very low CO_2 fuels
- Total biofuel use in BLUE Map reaches 760 Mtoe (32 EJ) in 2050, with the major share coming from advanced technologies
- Biofuels will be particularly important to decarbonise planes, marine vessels and trucks

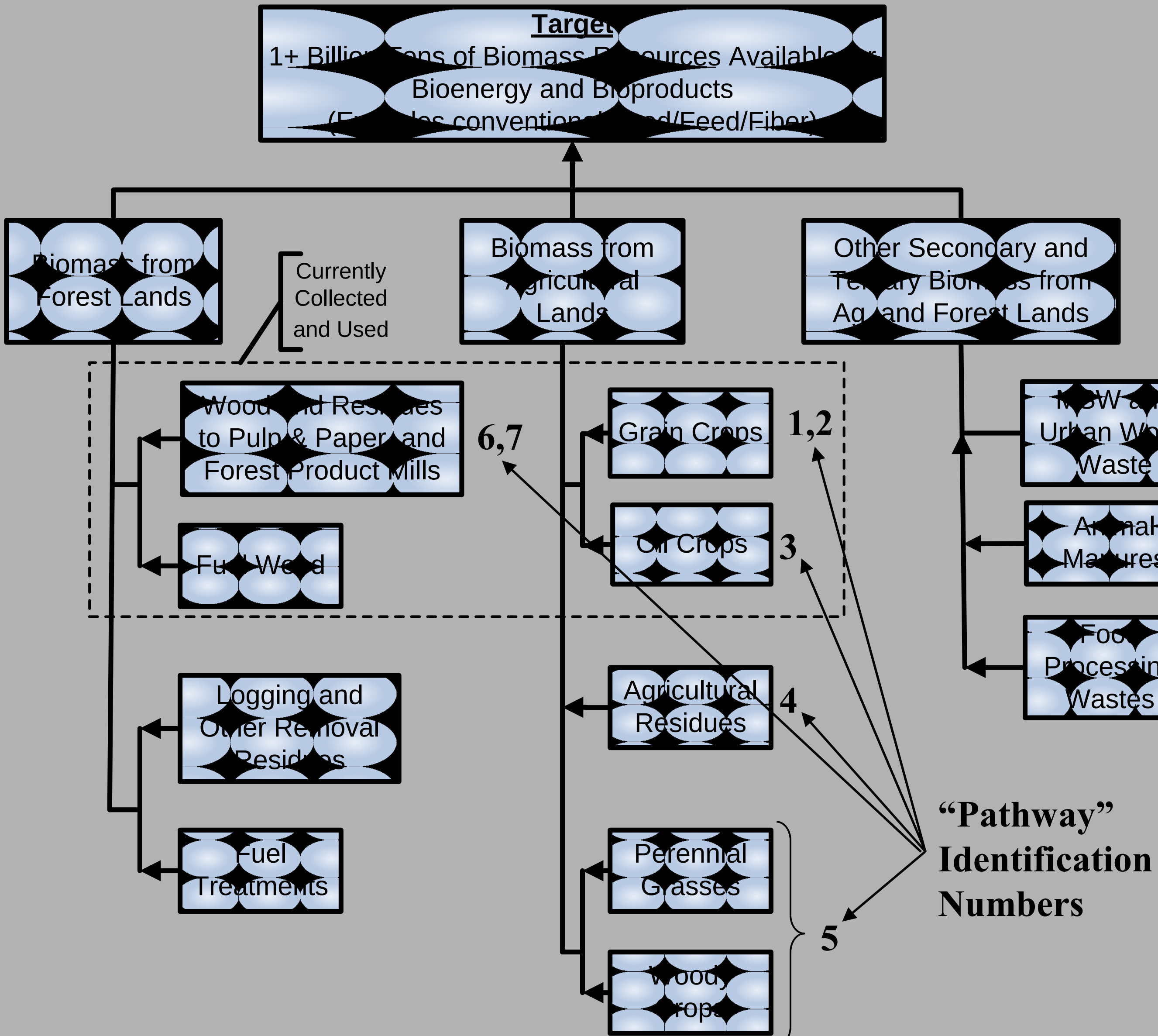
Source: OECD/IEA 2010

The role of roadmaps

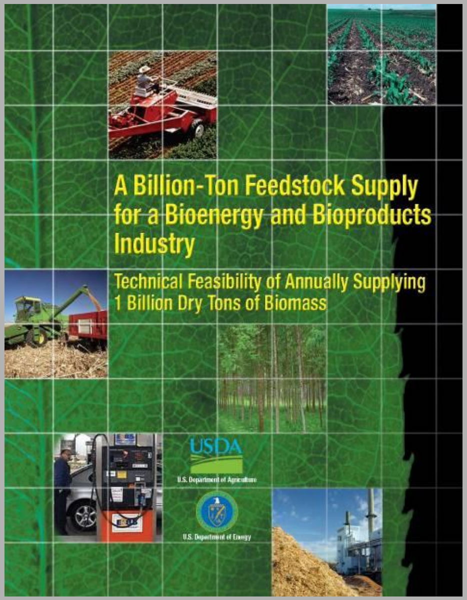
- A global price for carbon is necessary
  - …but by itself insufficient to accelerate the needed energy technology advancements in time
- Greater focus on energy technology policies needed
- Technology roadmaps can support GHG goals by:
  - Identifying and addressing technology-specific barriers
  - Highlighting necessary deployment policies and incentives
  - Directing increased RD&D funding for new technologies
  - Supporting technology diffusion, knowledge sharing among countries

Source: OECD/IEA 2010

Pathway Link to Resource Base

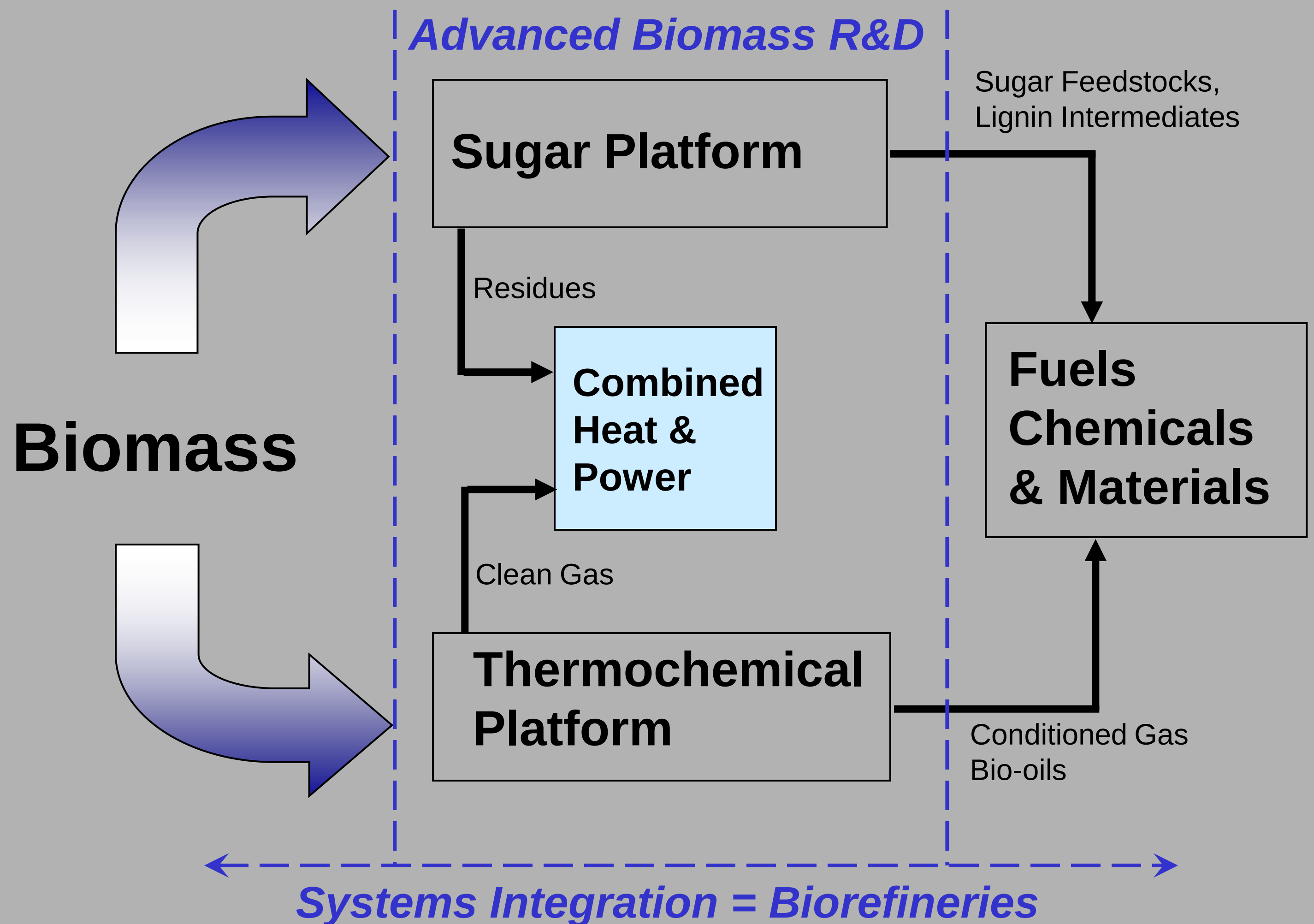


DOE/USDA Billion Ton Vision Paper



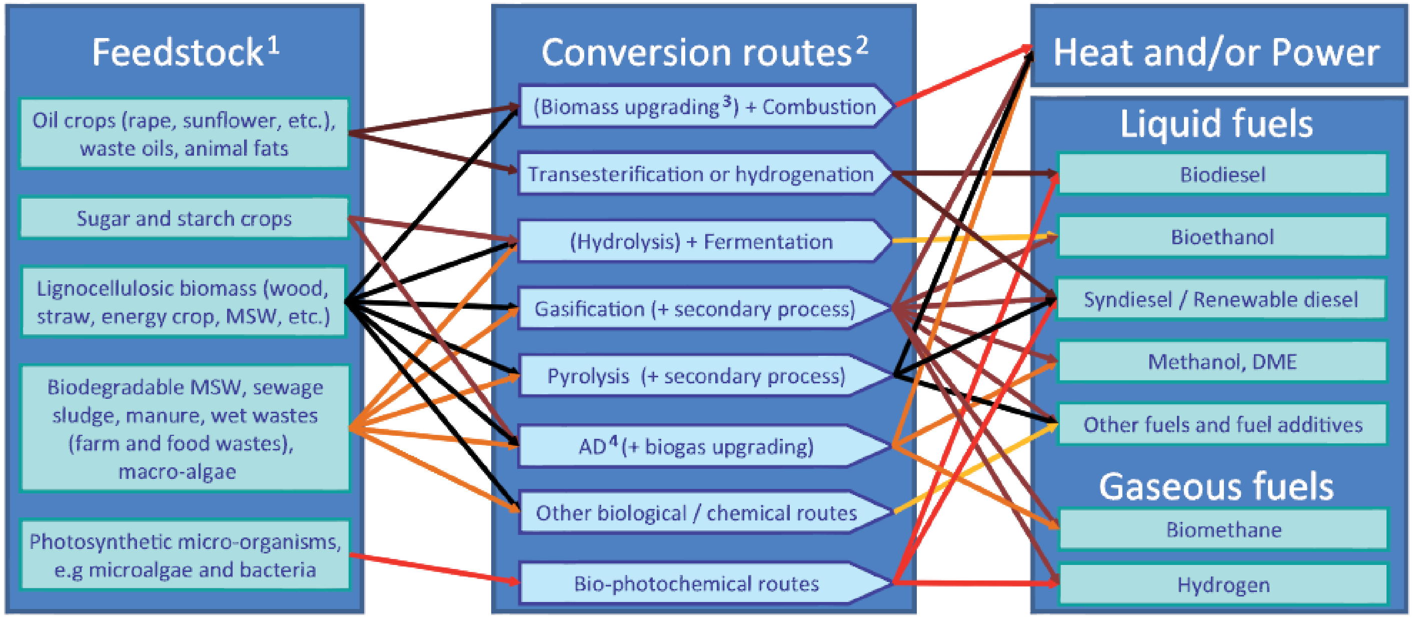
Source: Russo

U.S. Department of Energy
Energy Efficiency and Renewable Energy
Office of the Biomass Program



Source: Russo

Conversion pathways –
feedstocks to bio-based products

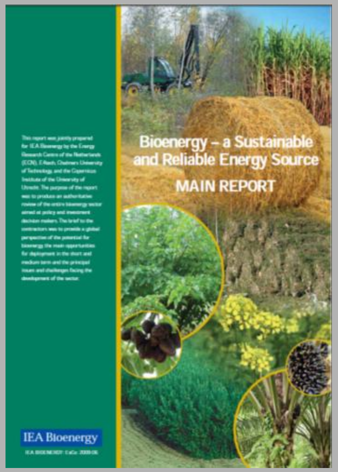


[1] Parts of each feedstock, e.g. crop residues, could also be used in other routes

[2] Each route also gives co-products

[3] Biomass upgrading includes any one of the densification processes (pelletisation, pyrolysis, torrefaction, etc.)

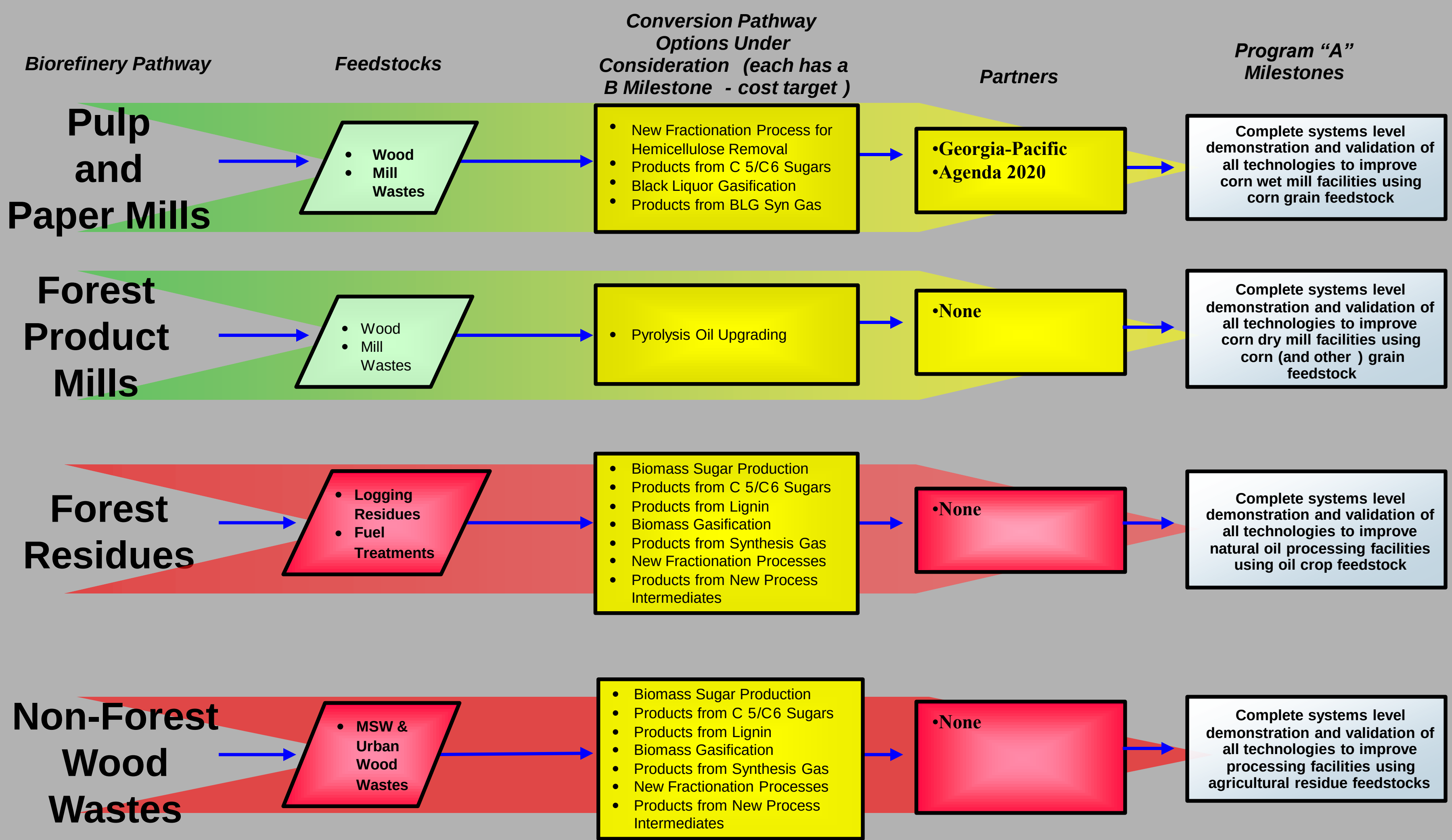
[4] AD = Anaerobic Digestion



IEA Bioenergy: ExCo: 2009:05

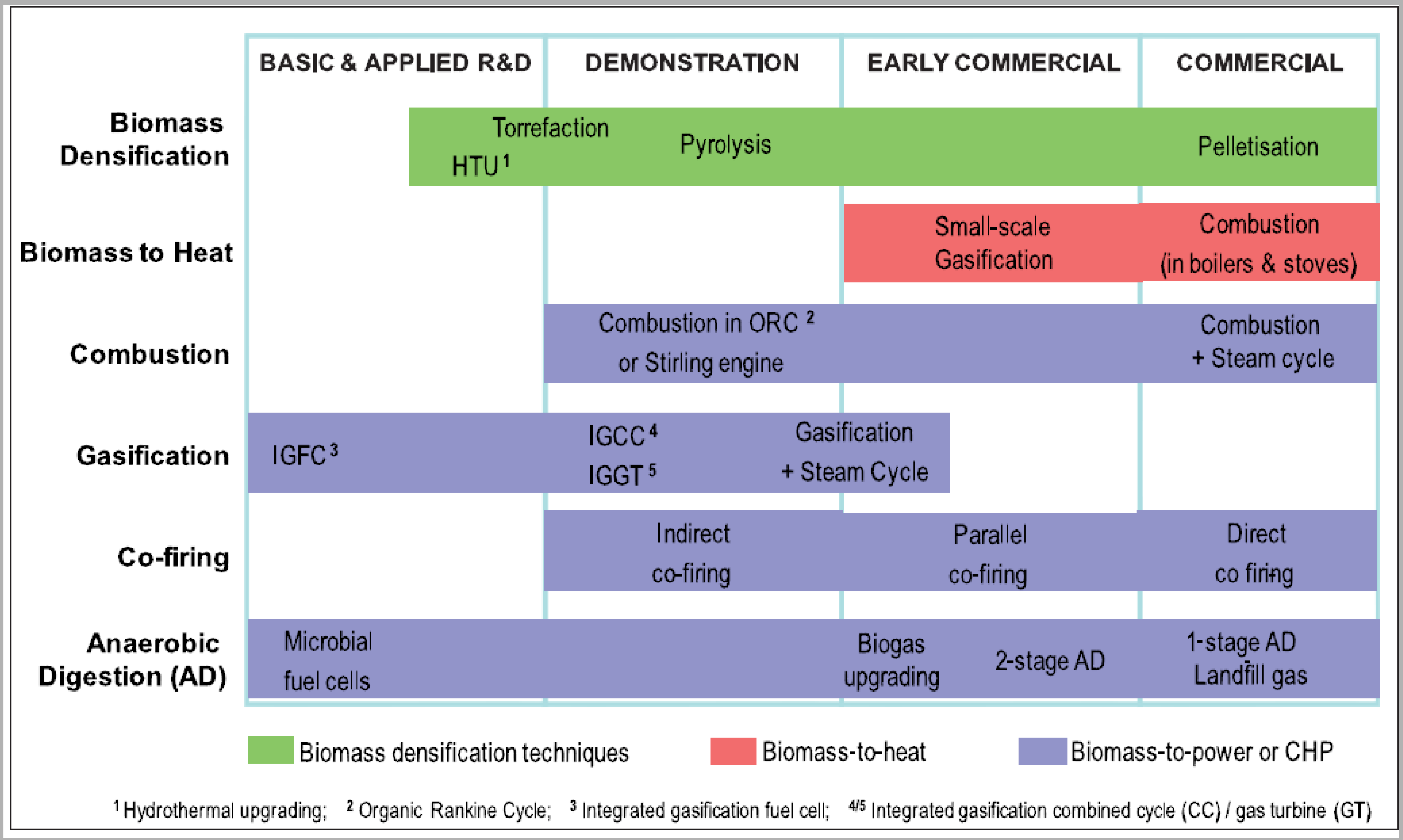
Source: E4tech 2009

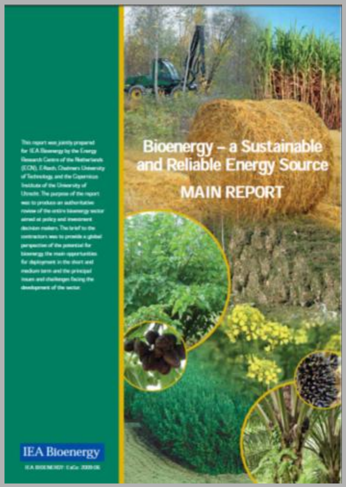
Forest Sector Biorefinery Pathways



Source: Russo

Development status of main technologies – upgrade, heat & power

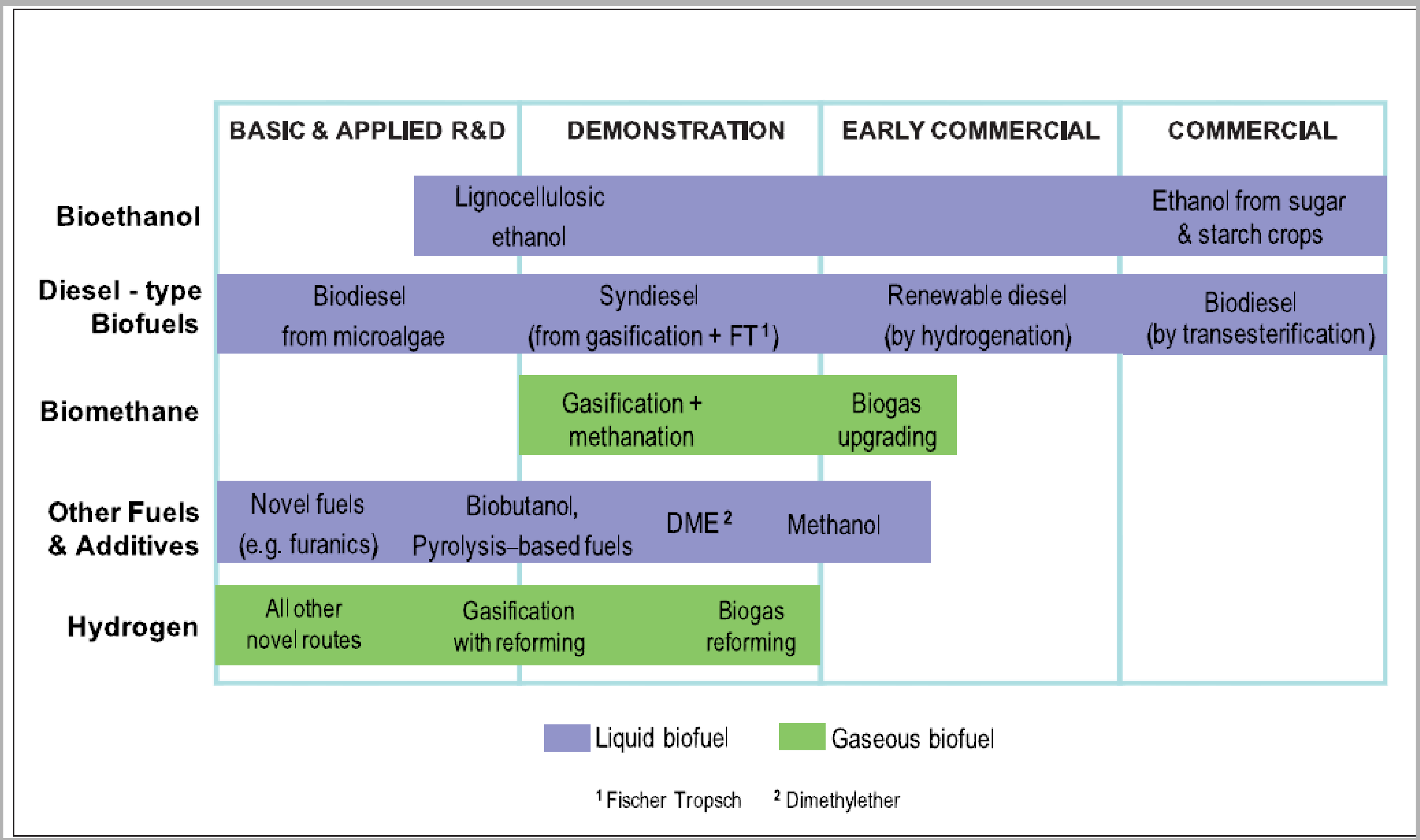


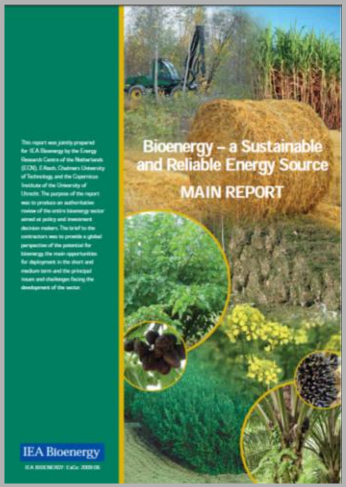


IEA Bioenergy: ExCo: 2009:05

Source: E4tech 2009

Development status of main technologies –
biofuels for transportation

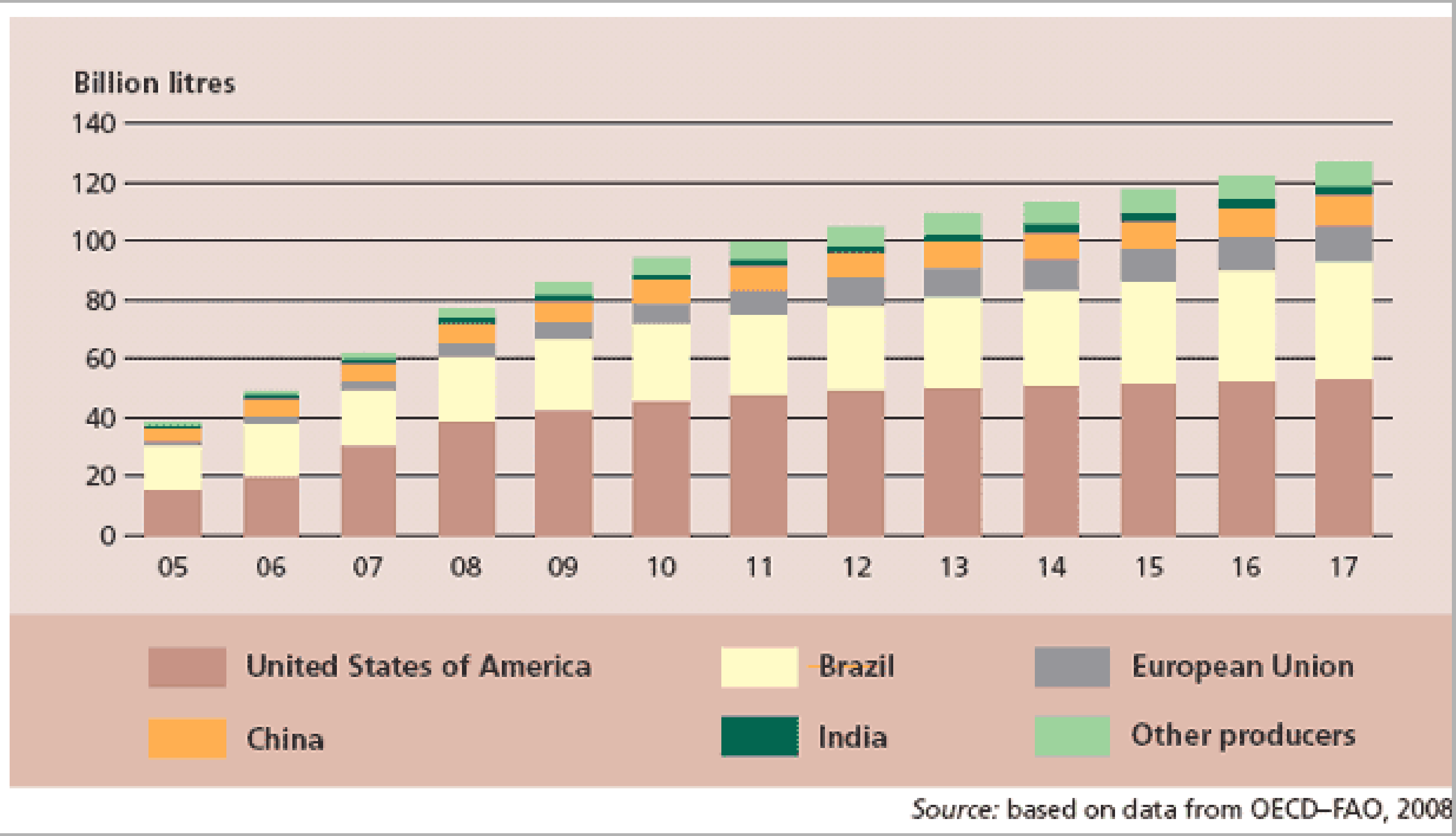




IEA Bioenergy: ExCo: 2009:05

Source: E4tech 2009

Major ethanol producers
with projections to 2017



Source: FAO, The State of Food and Agriculture, Biofuels: Prospects, Risks and Opportunities, 2008.

Bioenergy policies: Targets

Country	Main strategy	Biomass and bioenergy target	Biofuels target
Denmark	Heat, power, CHP, and/or district heating	-	5.75 % share by 2010
Finland		Double to 415 PJ by 2025 from 1995	
Germany		Double power gen. to 25% by 2020 (CHP)	
Netherlands		Double to 200 PJ by 2020 from 2006	
Norway		Double to 100 PJ by 2020 from 2006	
Sweden		50% increase to 576 PJ by 2010 from 2006	
United Kingdom		348 PJ future potential (150 PJ present use)	5% share by 2010
Canada		None	
United States	Ethanol (corn and cellulose)	5% of nation’s power and 25% chemicals by 2030	13% share by 2010, 30% share by 2030

South African bioenergy strategy

The government's 2003 *White Paper on Renewable Energy* set a target of 10 000GWh of energy to be produced from renewable energy sources, mainly from biomass, wind, solar and small-scale hydro, by 2013.

Biofuels Industrial Strategy of the Republic of South Africa
Department of Minerals and Energy
December 2007

"…adopt a short term focus (5 year pilot) to achieve a 2% penetration level of biofuels in the national liquid fuel supply, or 400 million litres pa.

The selected main crops for biofuels development in South Africa are soya, canola, and sunflower for biodiesel and sugar cane and sugar beet for bio-ethanol.

The exclusion of other crops and plants such as maize and Jatropha is based on the food security concerns. Further research is still needed to test usability of these in the country."

Sources:
http://www.energy.gov.za/files/esources/renewables/r_bio.html
http://www.energy.gov.za/files/esources/renewables/biofuels_indus_strat.pdf(2).pdf

Why Forest Bioenergy?

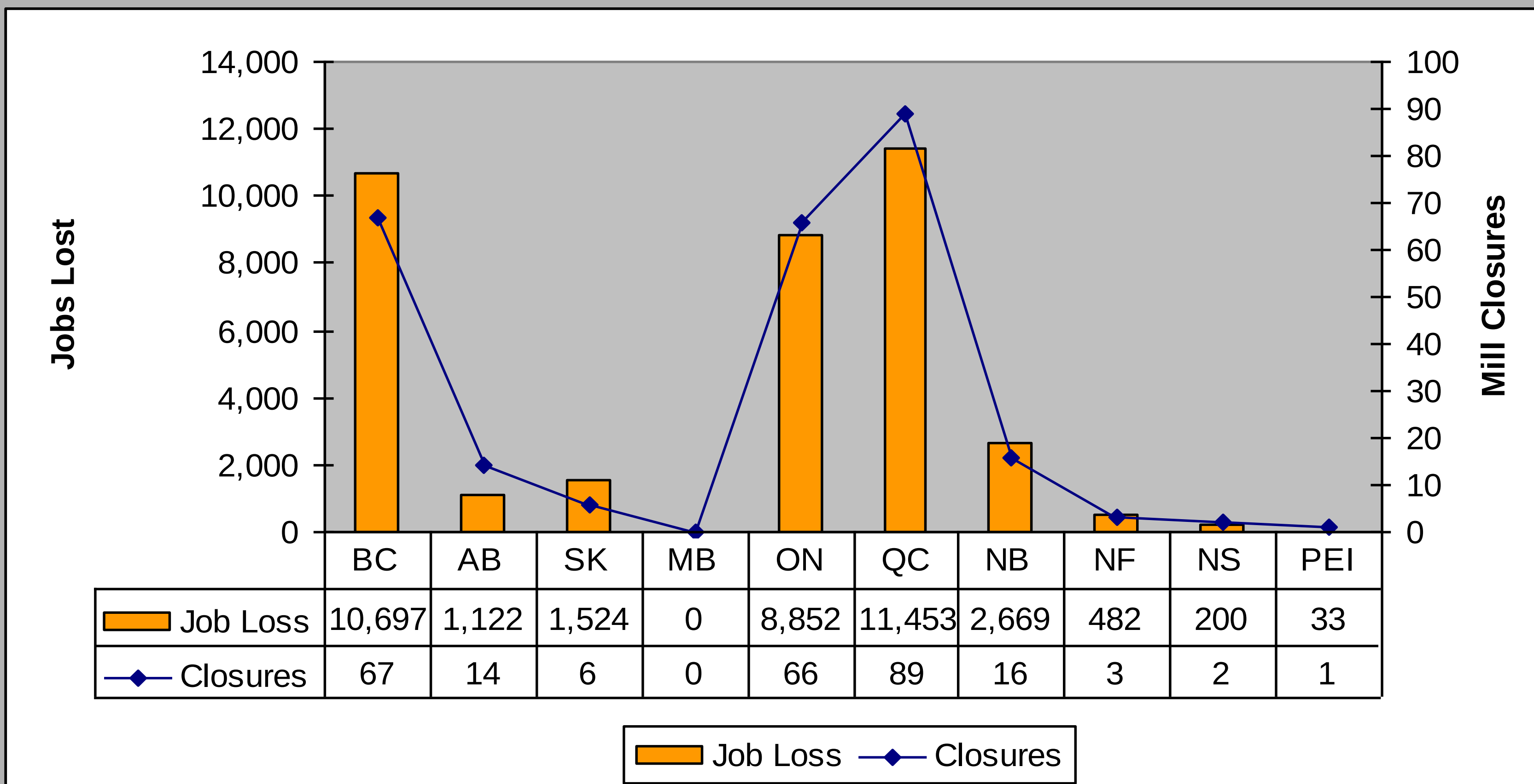
« In the long term, sustainable forest management strategies aimed at maintaining or increasing forest carbon stocks, while producing a sustained yield of timber, fibre, or energy from the forest, will generate the largest sustained mitigation benefit. »

IPCC 2007 ch 9: Forestry, AR4, Group III

Why forest bioenergy?

Sustaining rural economies in the forested areas becomes increasingly challenging due to mill closures and other factors.

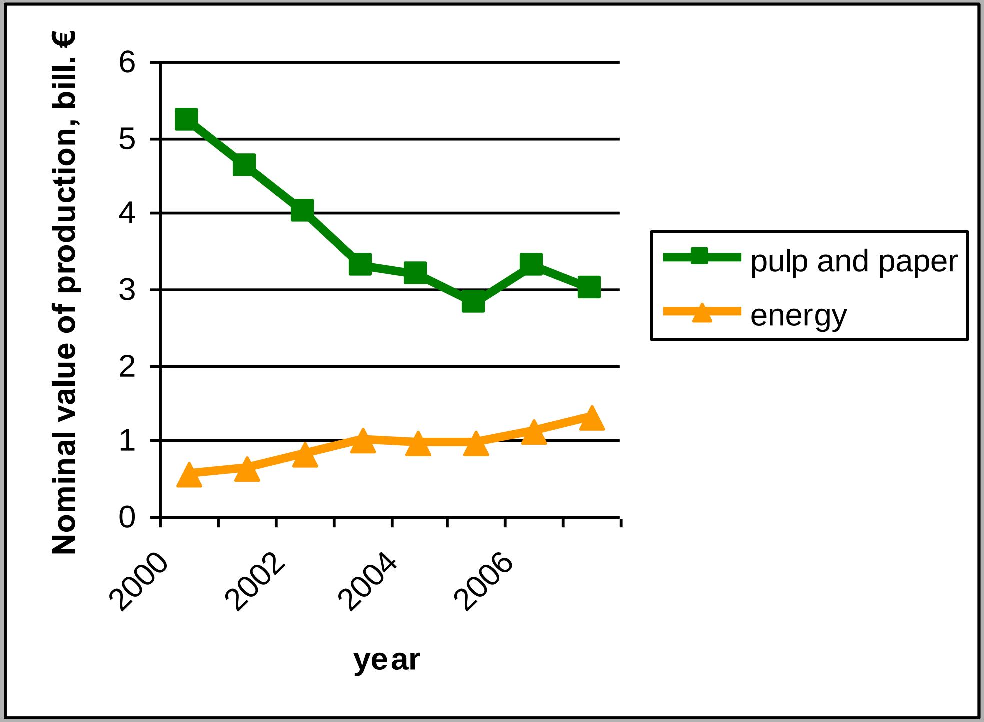
Canada Wide Job Loss Due to Mill Closure
2003 – October 17, 2008



	BC	AB	SK	MB	ON	QC	NB	NF	NS	PEI
Job Loss	10,697	1,122	1,524	0	8,852	11,453	2,669	482	200	33
Closures	67	14	6	0	66	89	16	3	2	1

Benefits of forest biomass in rural areas -- Finland examples

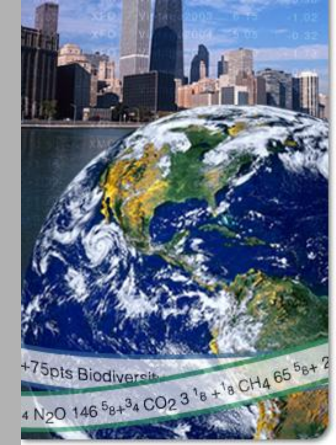
- Structural changes:
  - Global **overproduction** of pulp and paper products
  - Decreasing value of end products in pulp
  - Increasing values of energy products
  - Lack of peat



Decline of demand in traditional forest industry

Asikainen 2009

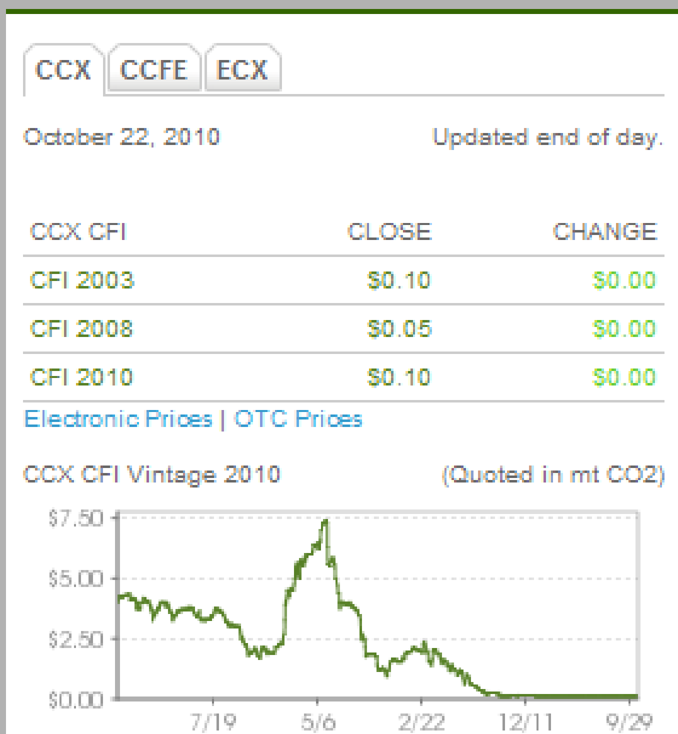
Why forest bioenergy?



Opportunity for valuing environmental services…

Due to concern about global climate change, carbon markets are gradually emerging, yet volatile.

US market, US$/Mg CO_2



CCX | CCFE | ECX

October 22, 2010 — Updated end of day.

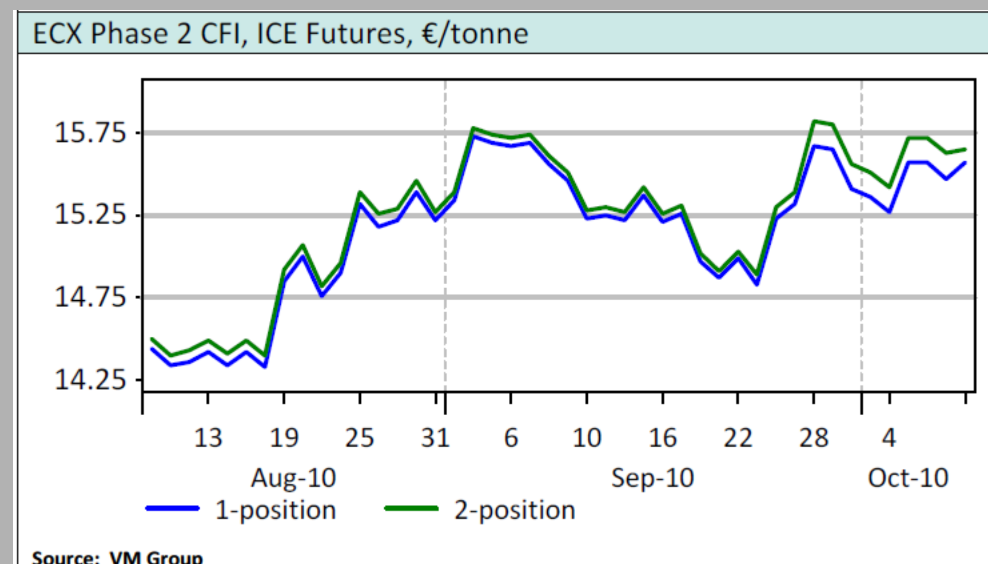
CCX CFI	CLOSE	CHANGE
CFI 2003	$0.10	$0.00
CFI 2008	$0.05	$0.00
CFI 2010	$0.10	$0.00

Electronic Prices | OTC Prices

CCX CFI Vintage 2010 (Quoted in mt CO2)

Source: CCX

European Market, €/Mg CO_2

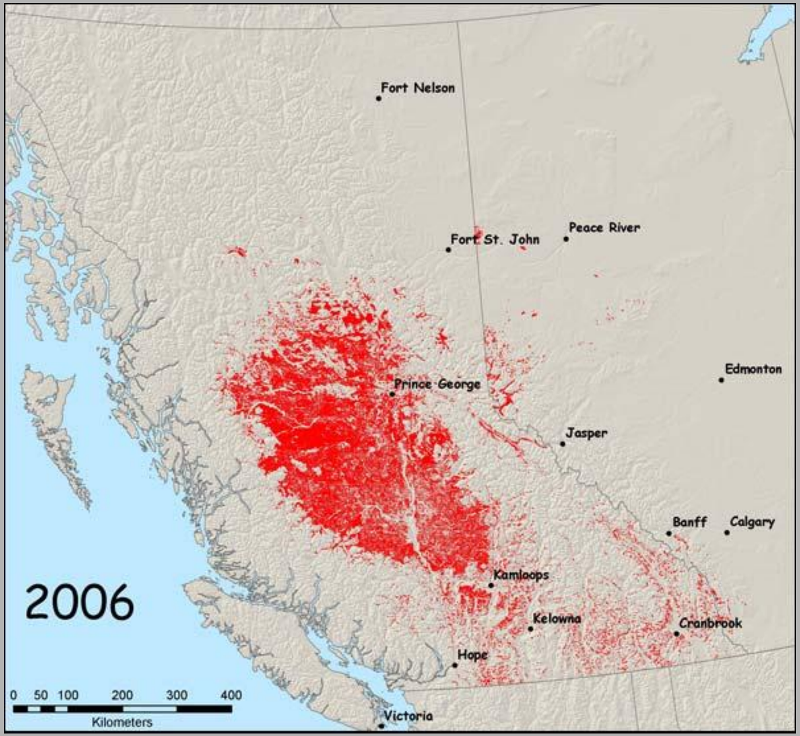


http://www.virtualmetals.co.uk/pdf/ABNCW111010.pdf

Why Forest Bioenergy?

Forest health (e.g. fire, insect, disease)

Mountain pine beetle outbreak in B.C. in 2006



by 2008,

- 50% mature pine dead
- now east of the Rockies

by 2013,

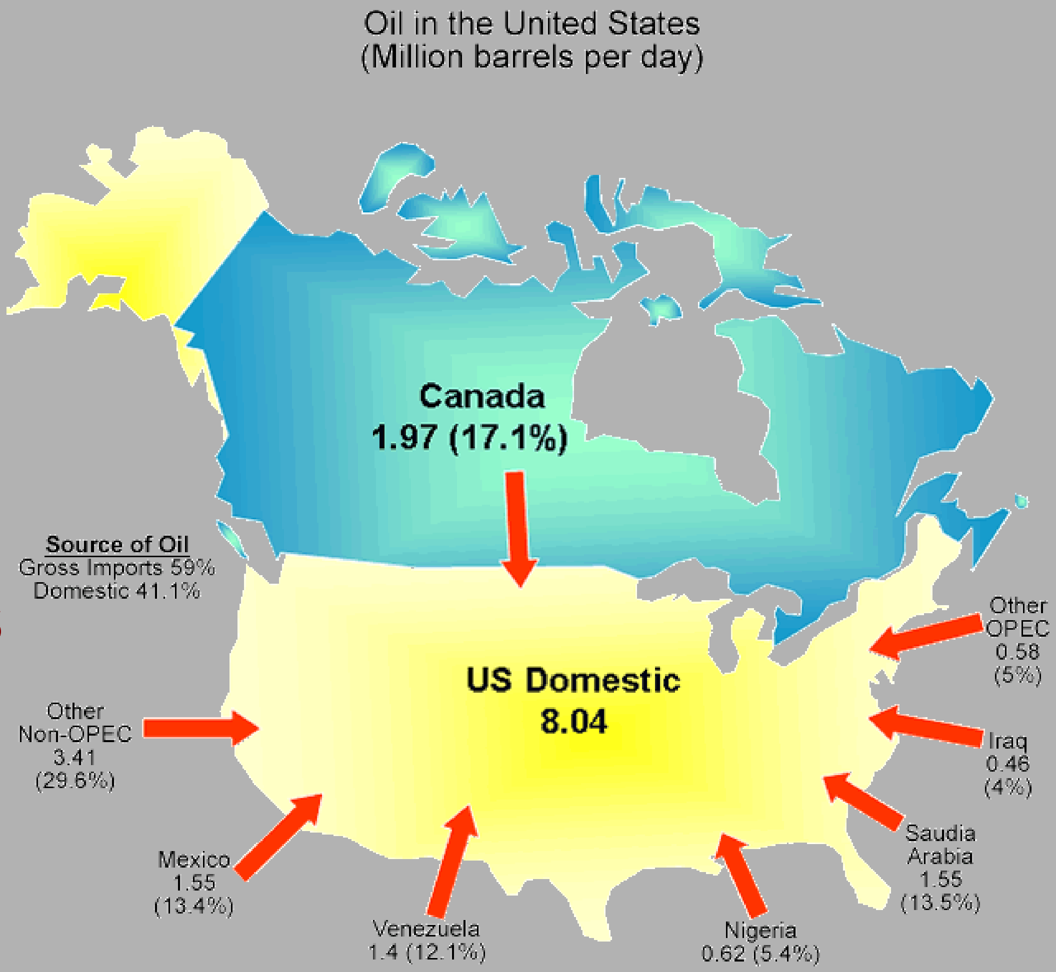
- 80% of mature pine dead

Source: http://mpb.cfs.nrcan.gc.ca/map_e.html

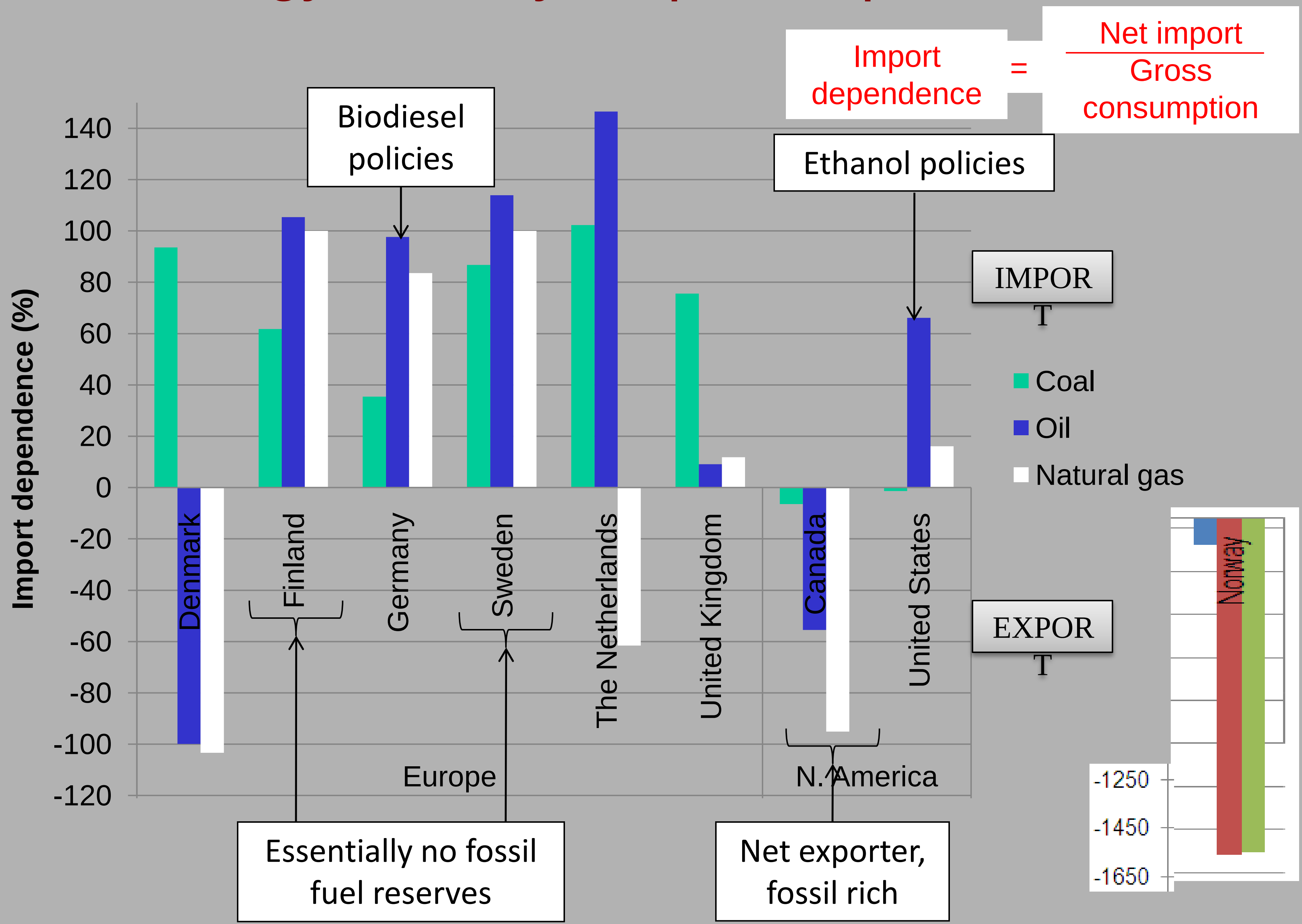
Why Forest Bioenergy?

Energy Security.

- Reduce imports
- Reduce fossil fuel use
- Increase renewable sources
- Increase efficiency



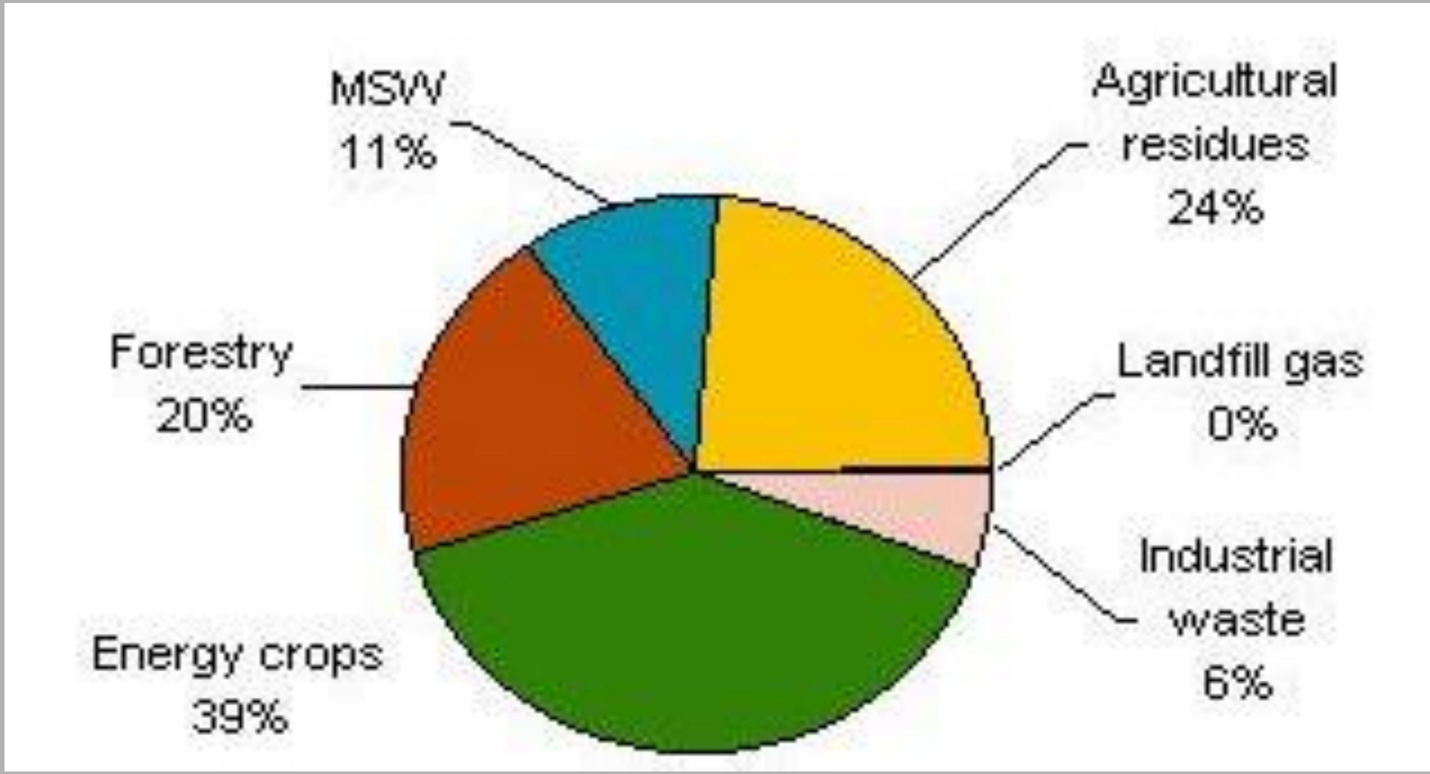
Energy security: Import dependence



Projected biomass resources distribution in EU 15 in 2030

Biomass potential - 4 200 PJ by 2010, 5 000 PJ by 2030

Forests will continue to be an important resource

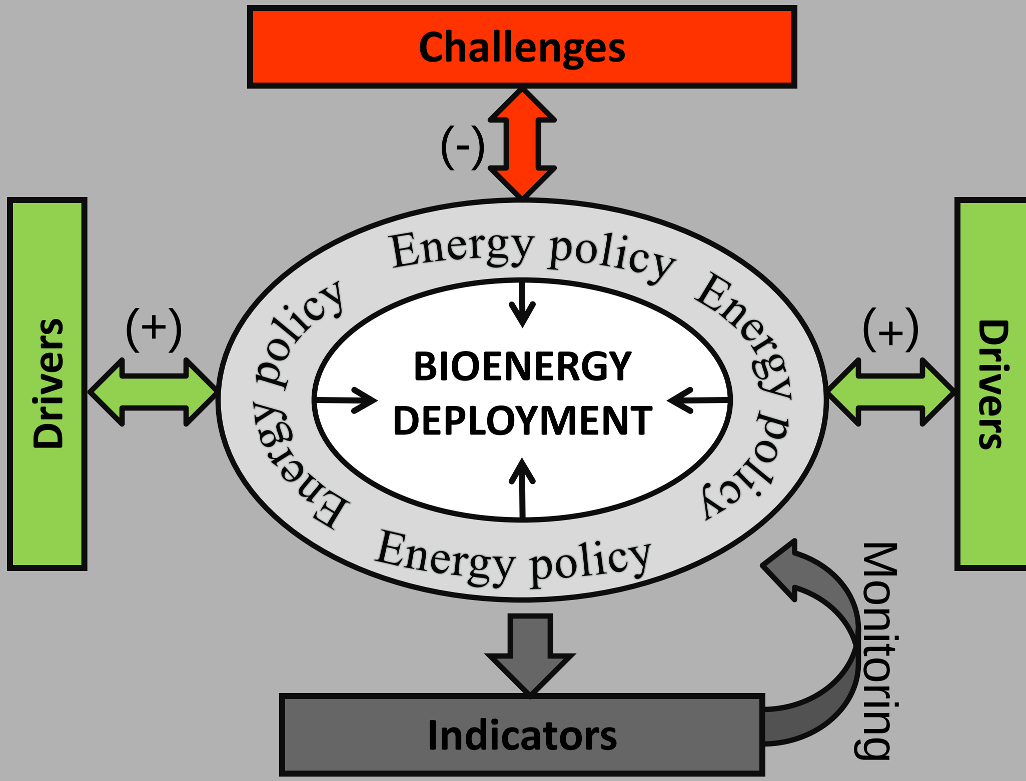


(Jorgensen and van Djik)

If using more forest biomass for renewable energy makes sense, why is deployment so limited?

A bioenergy deployment synthesis model

What lessons come from analysis of drivers, challenges and indicators?



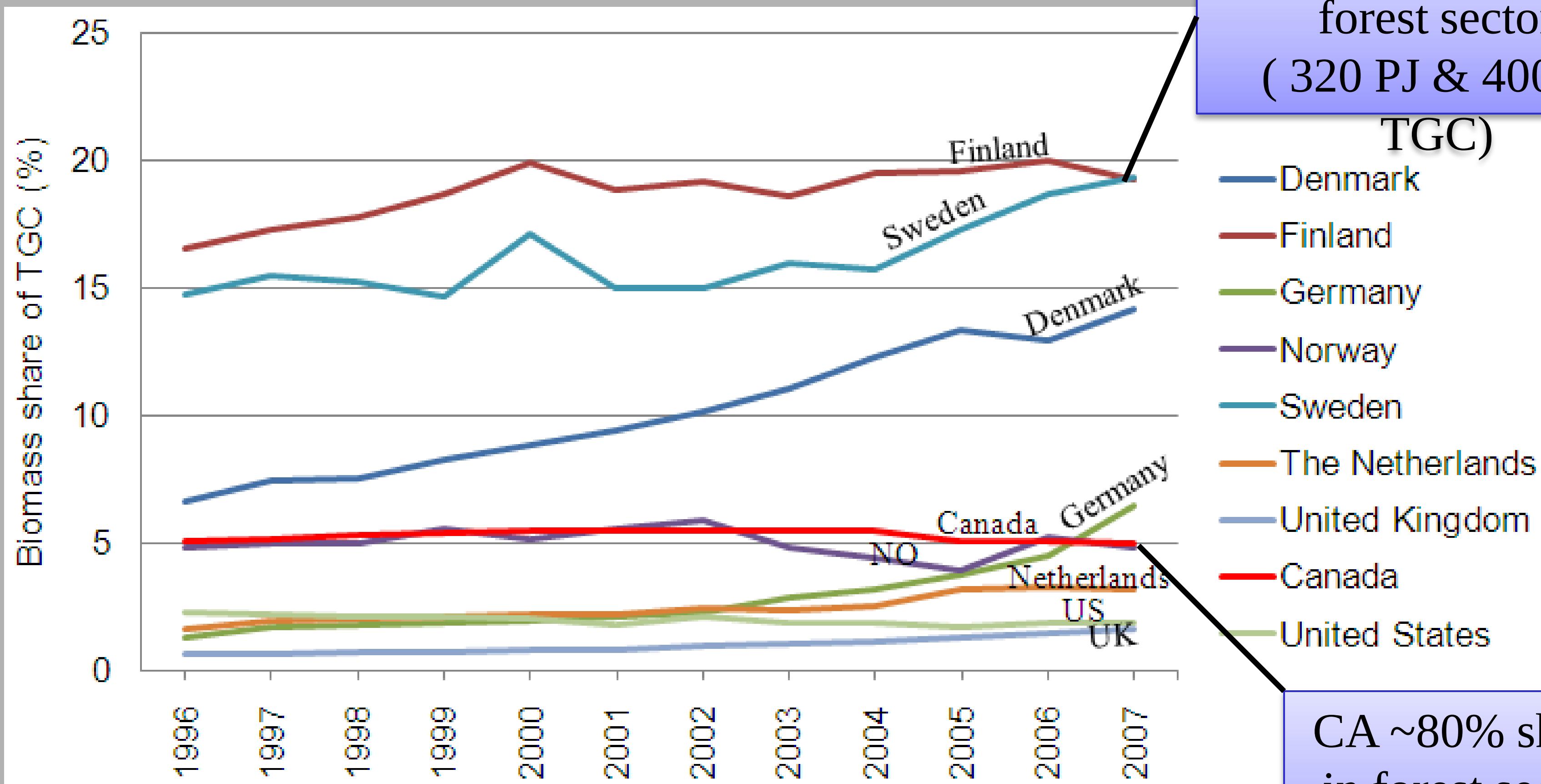
Adaptive framework context

- Policy evolves in response to measures of success or failure

Energy indicators: Biomass share

- Variable biomass shares

FI & SE 80% share in forest sector (320 PJ & 400 PJ TGC)



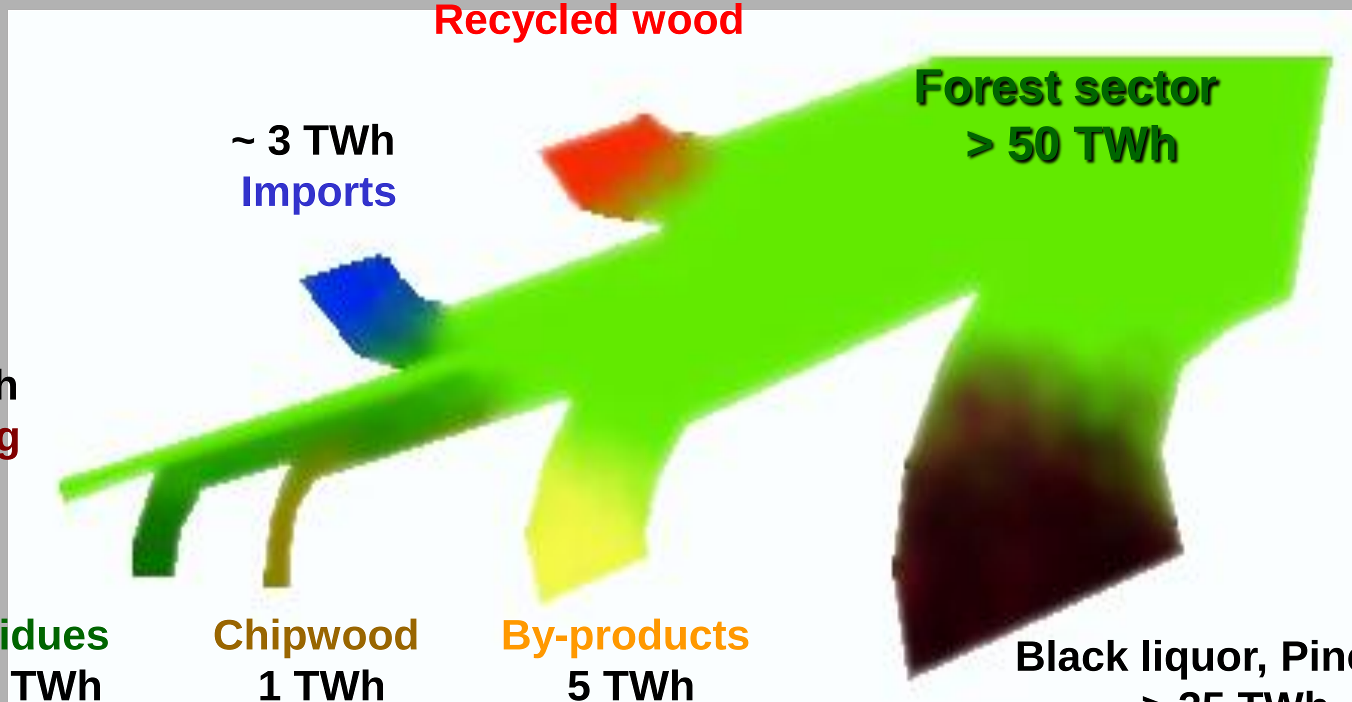
CA ~80% share in forest sector (~600 PJ TGC)

(EIA, 2008; EUROSTAT, 2009)

Forest energy is important in Nordic countries…

Denmark 5, Norway >10, in Sweden and Finland ~25%

Note the importance of manufacturing by-products

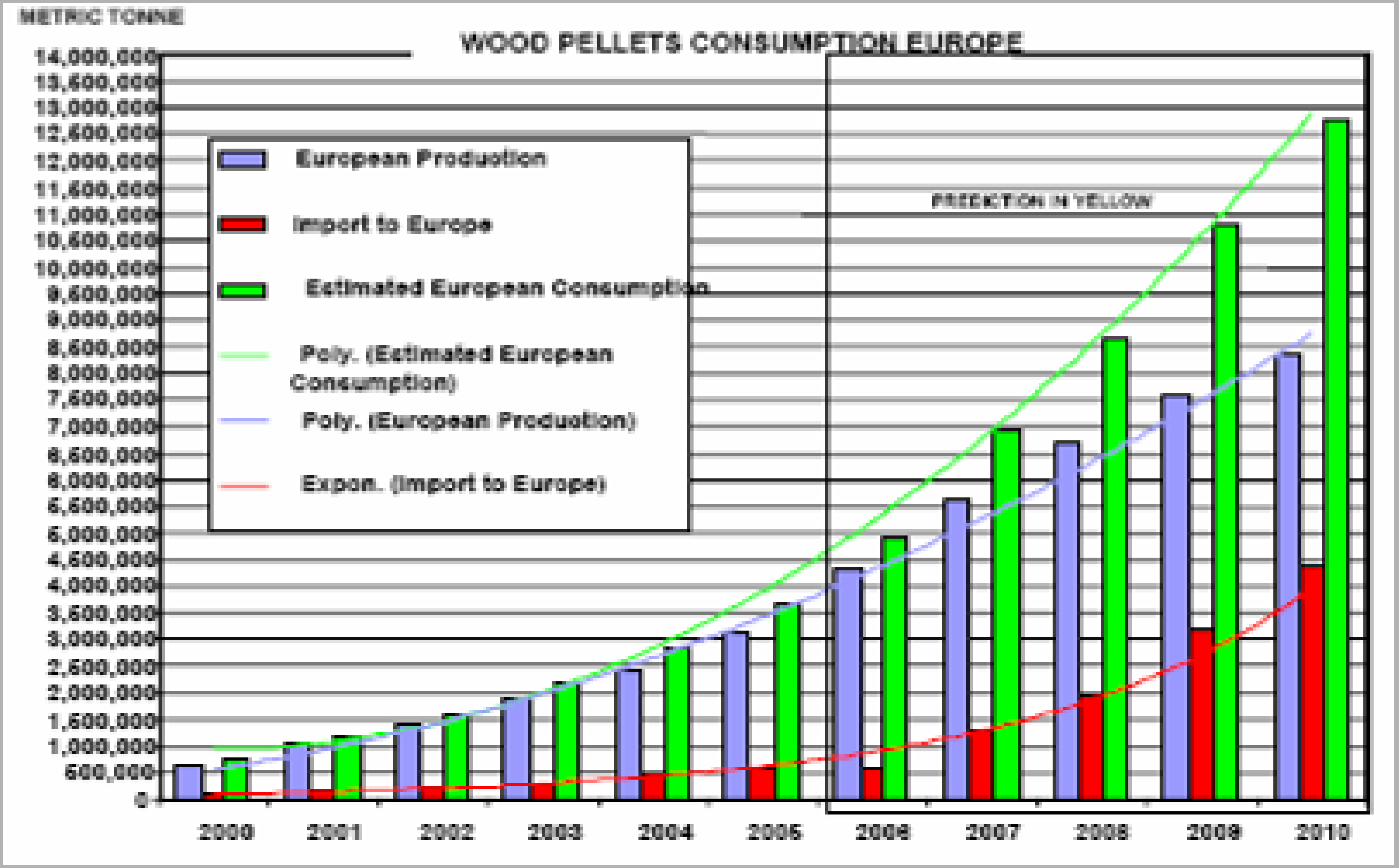


Source: Björheden, 2004

Feedstock supply

- **Challenges**
  - Limited forest resources (NL, UK; <0.05 ha/cap)
  - Growing competition for domestic fibre (FI, SE, CA), and for sawdust (pellets)
  - Expanding wood pellet industry resulting in rising wood fibre costs in Europe
- **Opportunities**
  - More efficient recovery of unused AAC & logging residues (CA, FI, SE, USA, etc.)
  - Shifting fibre use – Small diameter wood (moving away from pulp, SE, FI)
  - Regional opportunities – mountain pine beetle in BC (620 million m^3, up to 1 billion m^3)
  - Increasing import to meet targets (International market)

Increasing trade: Europe



(WPAC)

Global trade in bioenergy feedstocks is developing rapidly

BC wood pellets shipped to Liége, Belgium

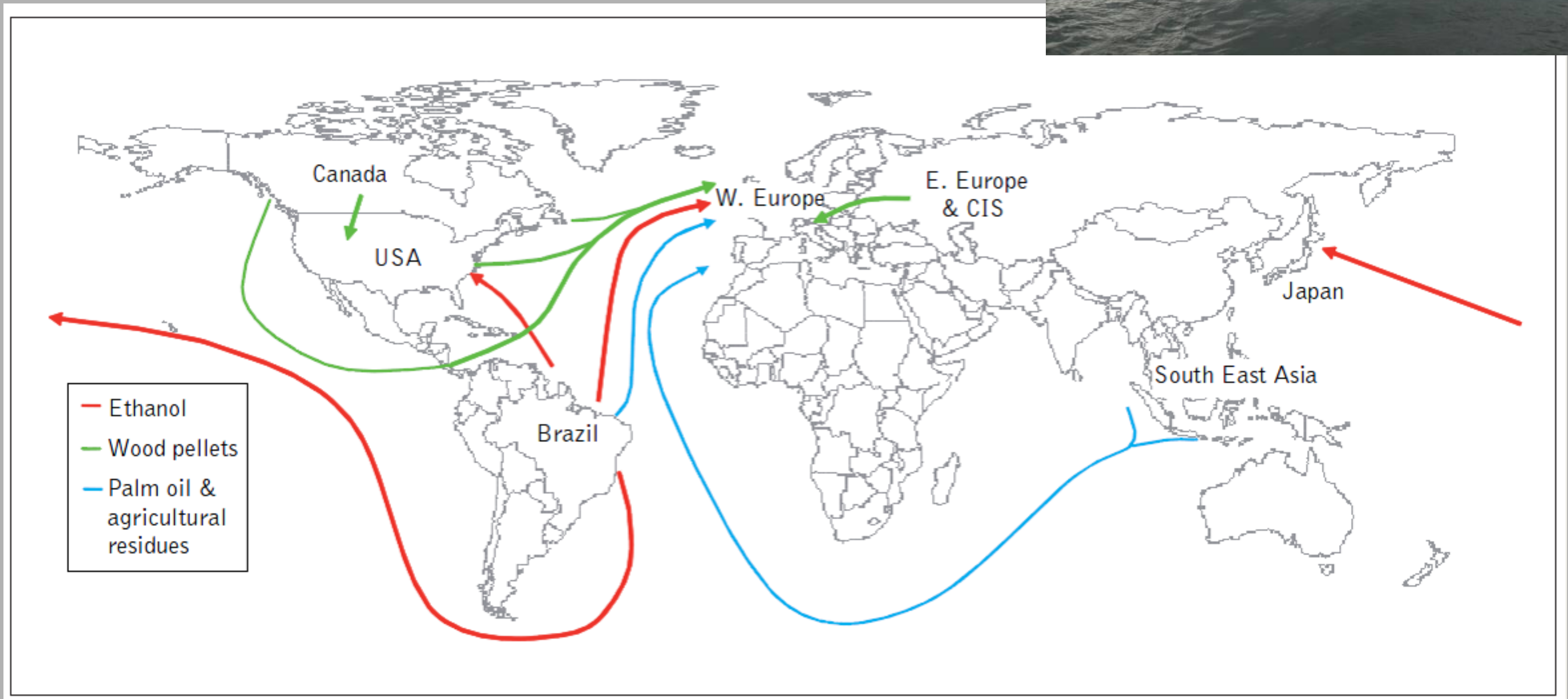


Figure 7: Main international biomass for energy trade routes. Intra-European trade is not displayed for clarity. Source: Junginger and Faaij, 2008.

IEA Bioenergy: ExCo: 2009:05

Conclusions from synthesis model:

- A complex network of drivers and challenges influence energy policy and bioenergy deployment

- Need for clear policy targets and economic incentives

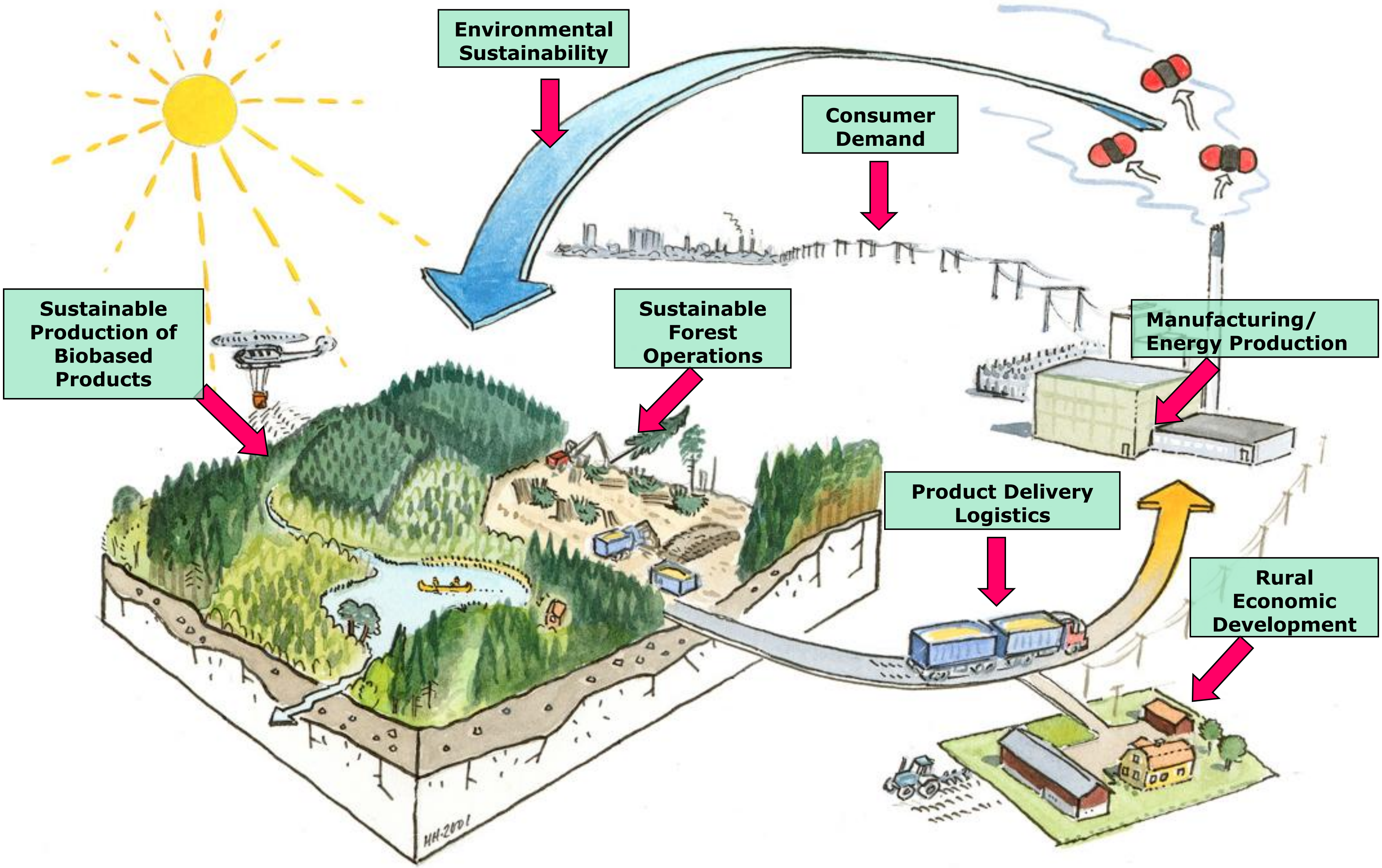
- Trade in woody biomass will probably grow – a key opportunity
  - What operational and logistical scale is most efficient?
  - Suggestion -- forest energy is a local form of energy that also has to be utilized on a local scale
  - Availability analyses must be conducted for a specific plant, and that's where system optimization analysis can play a role

- Cross-sectoral issues are significant:
  - Indirect land use change: Food vs. fuel vs. fibre
  - USA housing starts & CAN forest sector vitality

Assumptions

- **Forests will continue to be a globally important bioenergy feedstock**… can we get greater penetration?
- **The public will demand that forests be managed sustainably... and that bioenergy be sustainable along the whole supply chain** (forest to energy consumer)
- **Concepts of sustainability along the whole supply chain involve complexities of:**
  - **scale (management unit, landscape, regional, global)**
  - **direct and indirect Land Use Change**
  - **cross-sectoral impacts and tradeoffs (food vs fuel vs fibre)**
  - **applying C&I for environmental, social and economic values**

Critical Components of Sustainable Bioenergy Production Systems



Martin Holmer, 2001

IEA Bioenergy Task 31

Can we ensure whole-tree harvesting at landscape-scales is sustainable?

Northern Maine – early 1980s

Weymouth Point, Maine
17-year post-harvest results

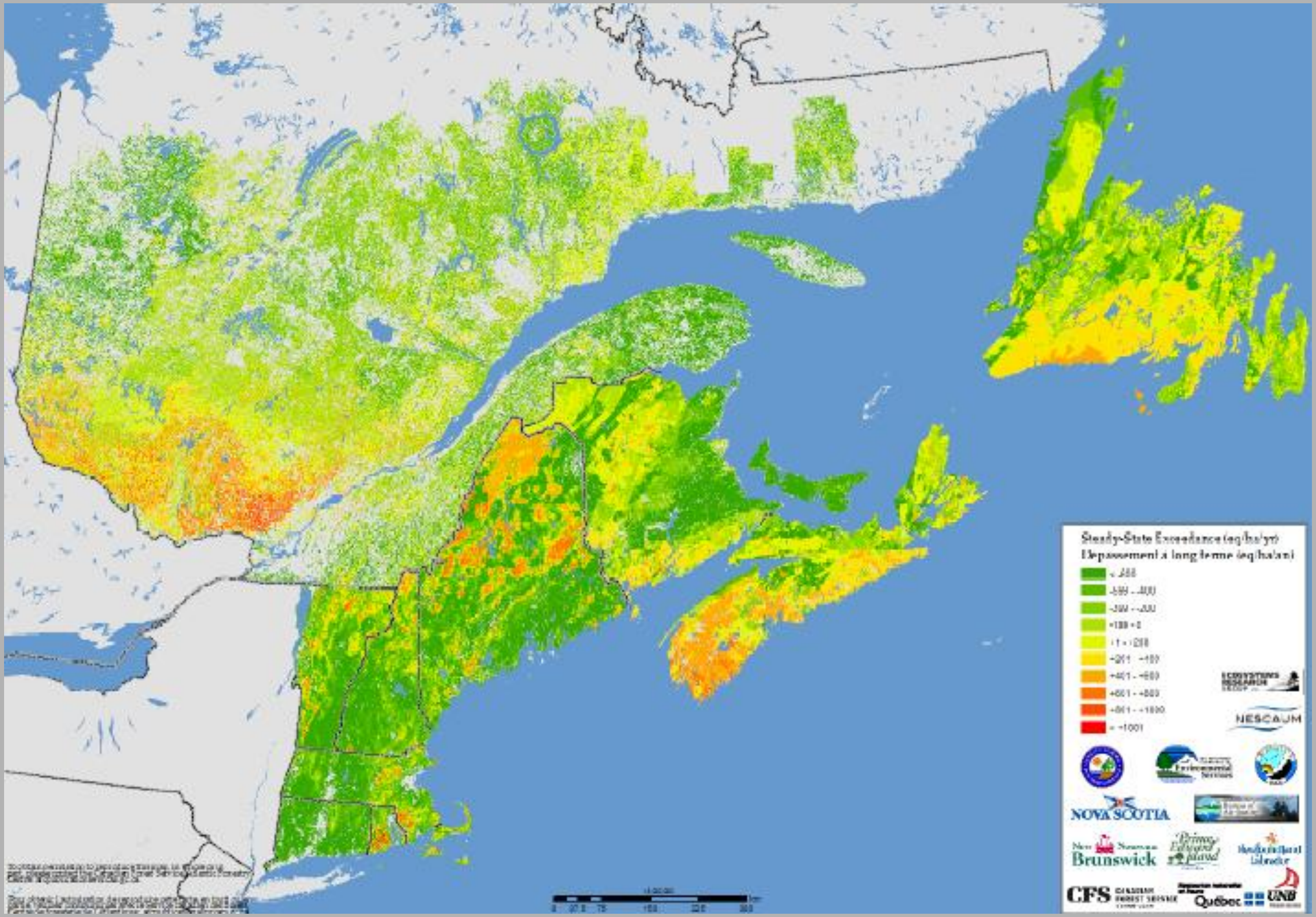
1.
Whole-tree harvesting had not led to depletions of C, N, or the base cations in this low-elevation spruce-fir forest in central Maine 17 years after regeneration.

2.
Acidic deposition may be a concern for exchangeable Mg depletion for this site type. Both the reference and regenerating watersheds had significantly lower forest floor and total soil exchangeable Mg pools than the pre-harvest condition.

3.
At this time, we have a **limited understanding of the potential interactions between increased N deposition, organic matter, and cation cycling over an entire rotation**, as well as for future rotations in northern coniferous forests.

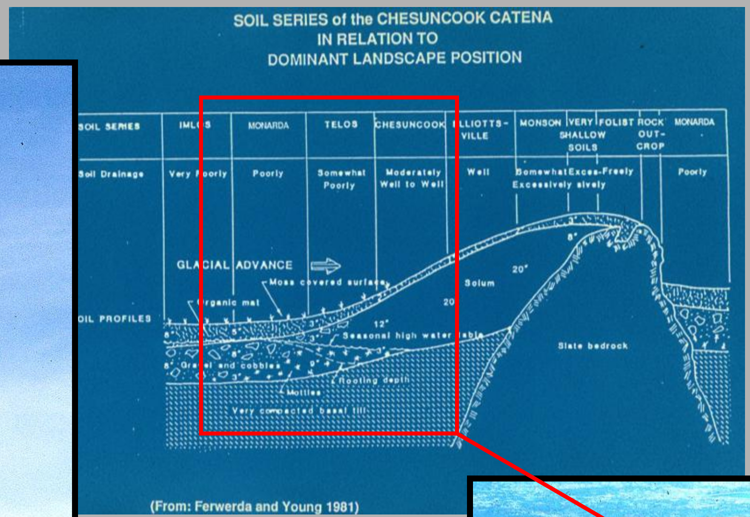
Source: McLaughlin & Phillips 2006
Photo: McCormack

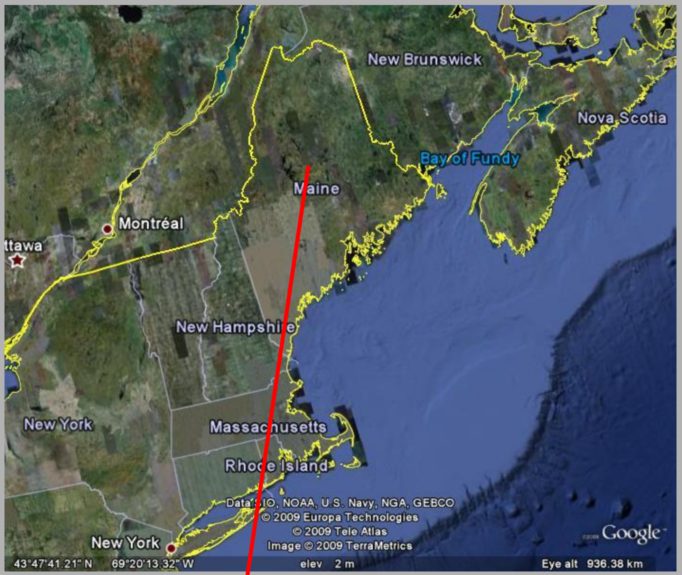
Some provincial concerns seem driven by soil sensitivity to acidic deposition



Source: Arp et al. (2007) for The Committee on the Environment of The Conference of New England Governors and Eastern Canadian Premiers

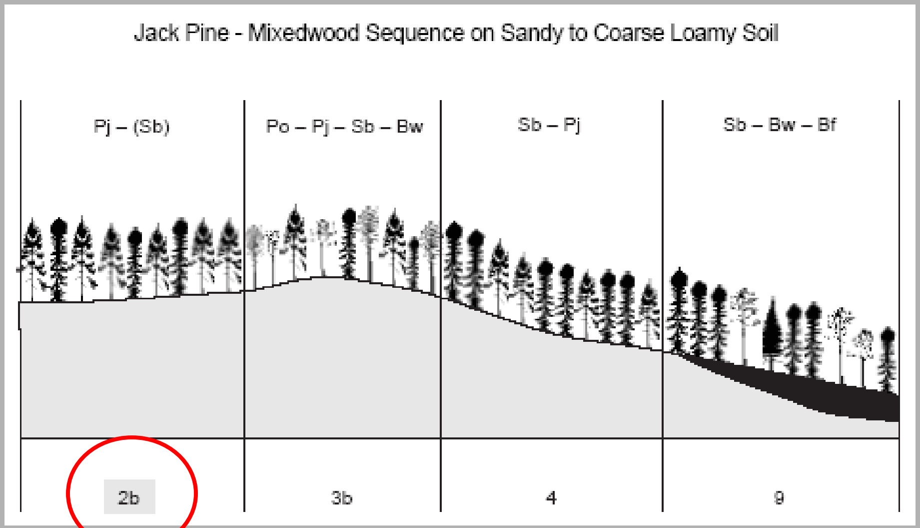
New England guidelines should be site-specific

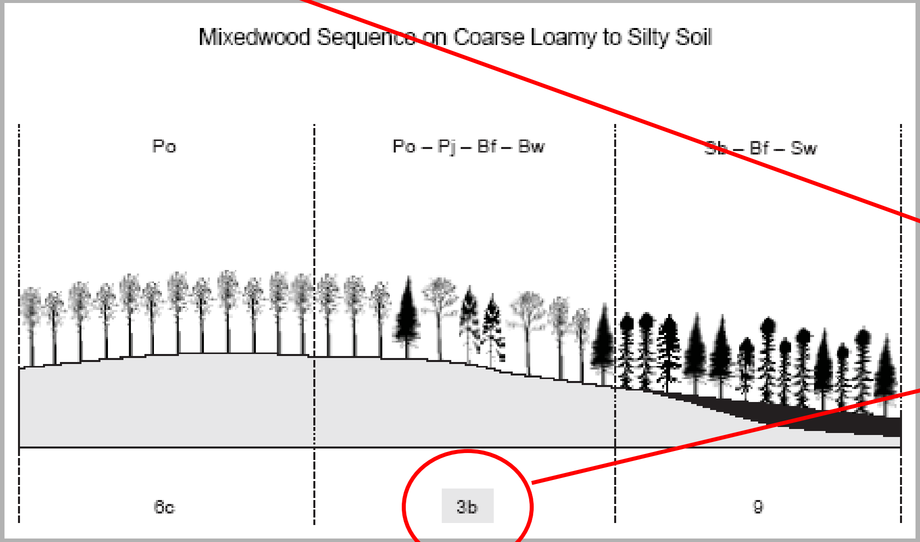


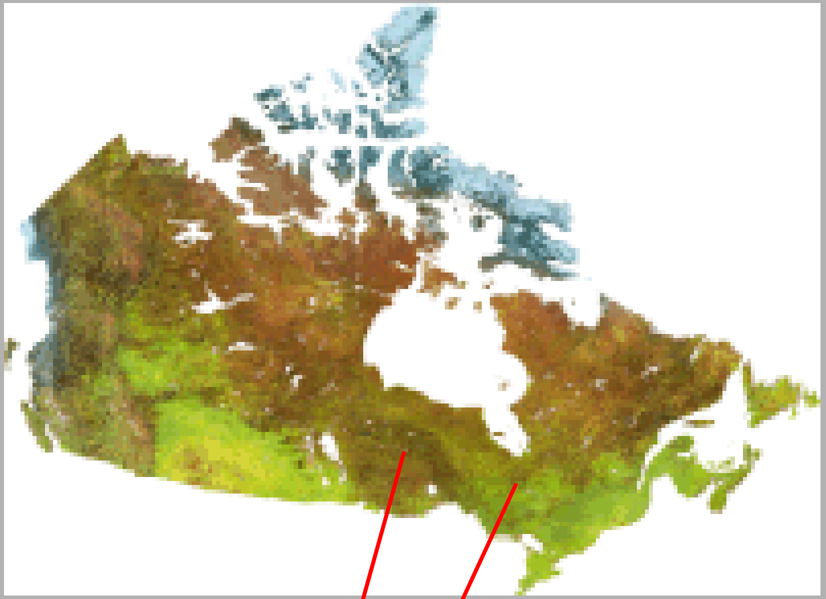


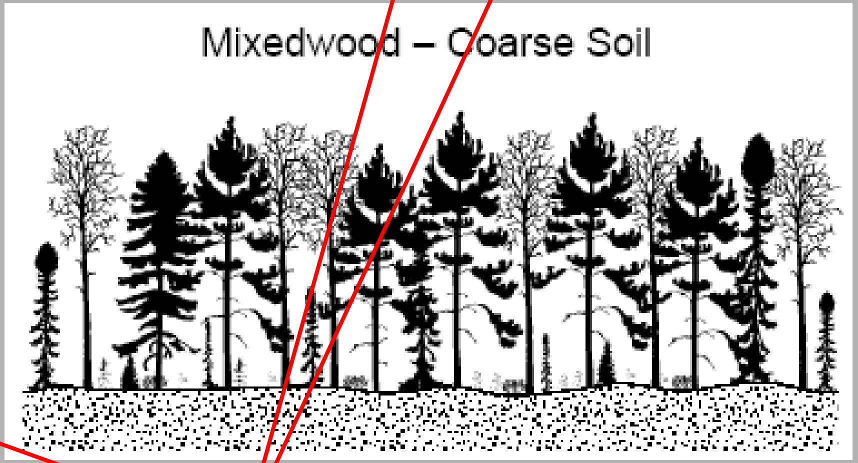
Source: McCormack

Canadian guidelines should be site specific



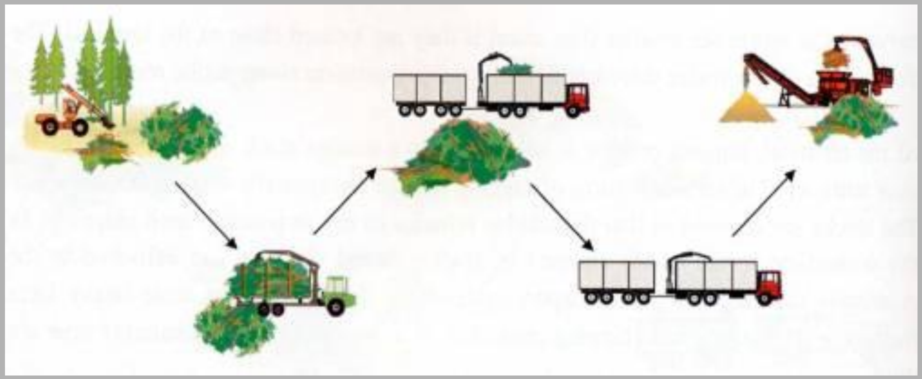


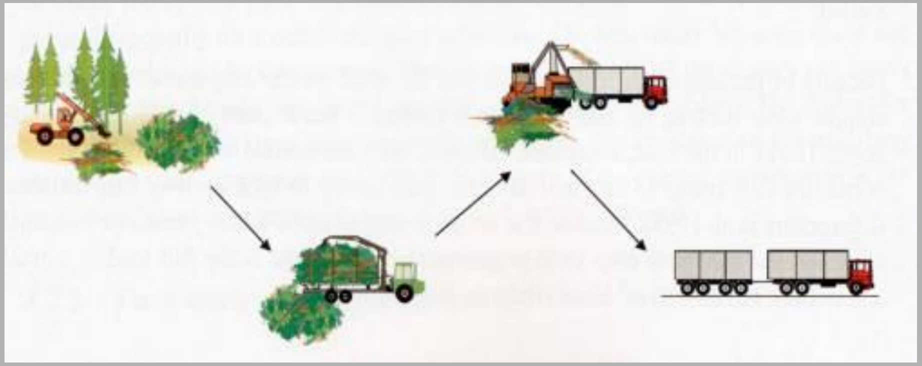


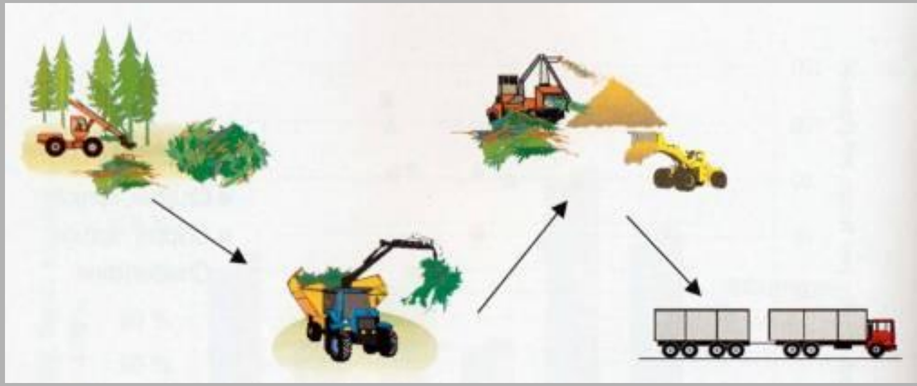


Site type 3b

Sources: OMNR 1997, CFS 2006







Our responsibility & challenge:

Design low-impact systems

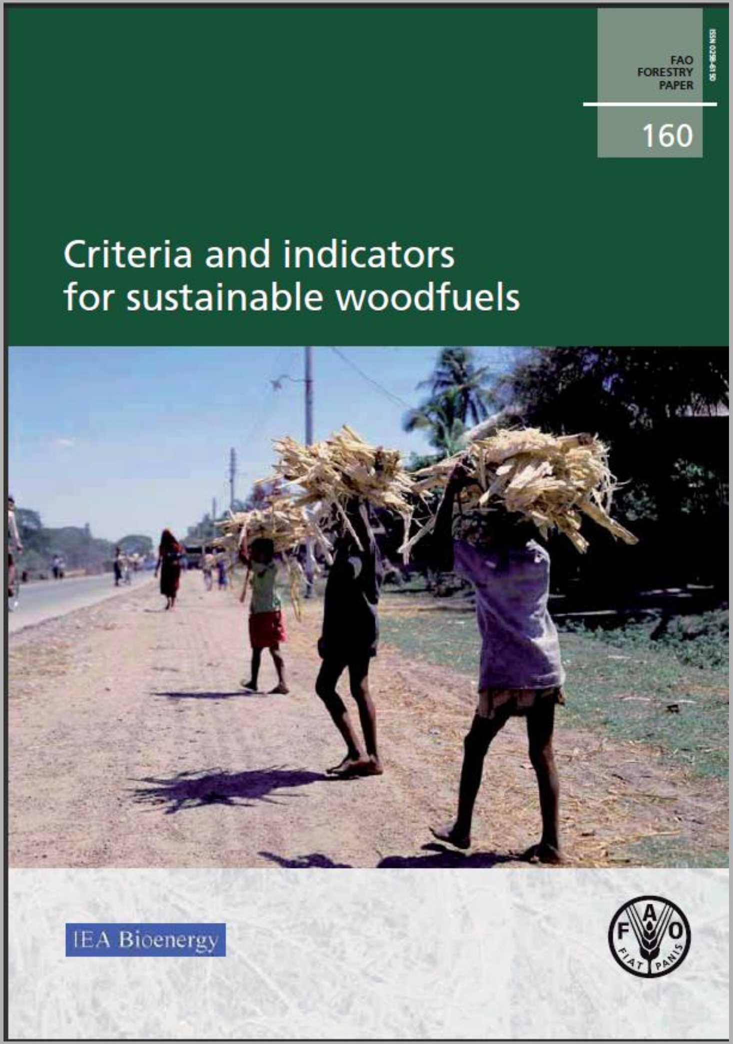
- **Identify risks to soils, water, biodiversity**
- **Identify practices to mitigate risks**

Graphics source:

Courtesy Tapio Ranta, VTT Processes 2002

‘Principles and criteria of sustainable woodfuels’

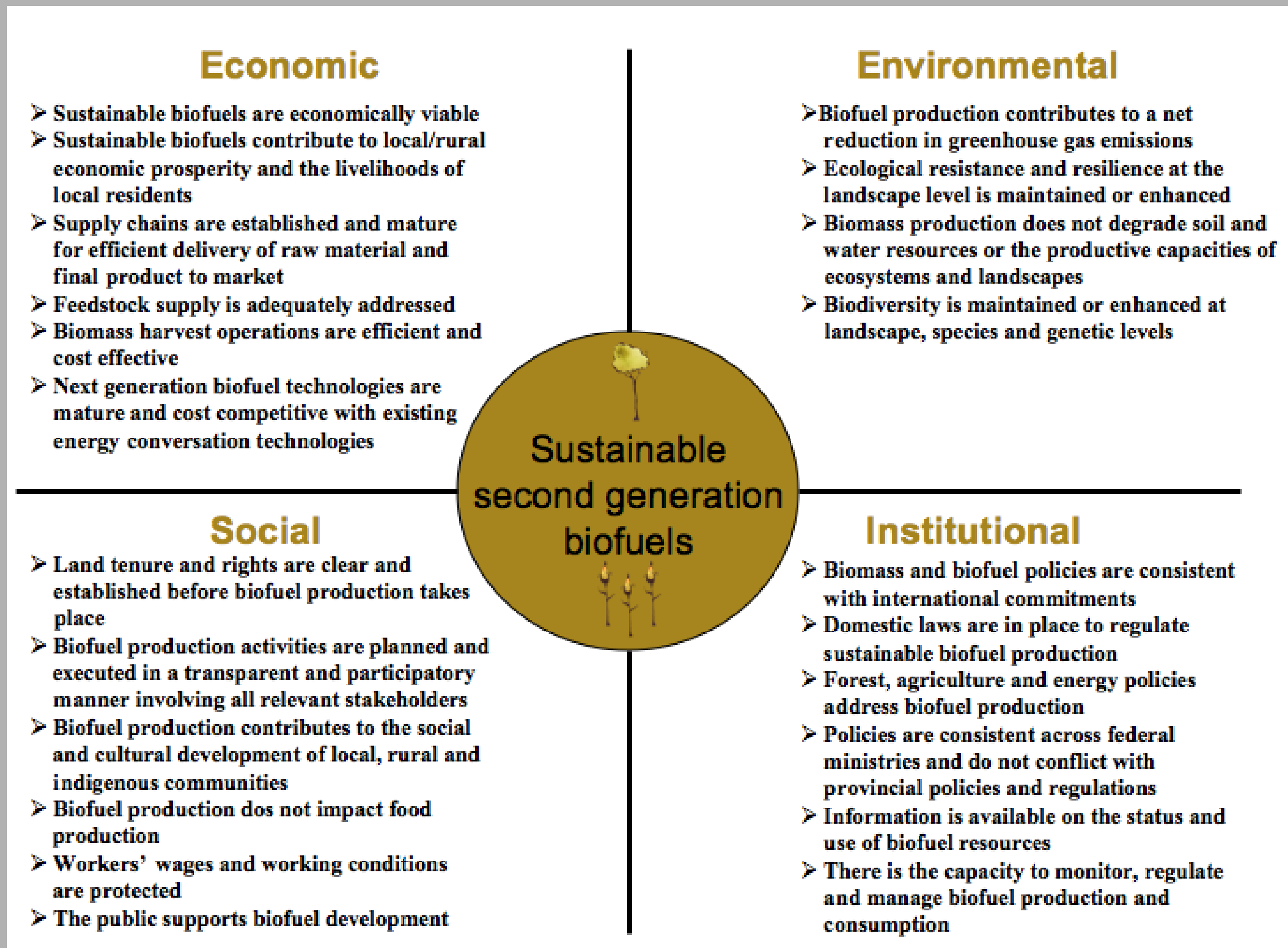
FAO Forestry Paper 160



IEA Bioenergy Task 31 & FAO-Forestry collaboration

www.fao.org/forestry

Principles and criteria of sustainable 2nd generation biofuels



Source: Smith et al. 2009

Pre-commercial thinning

Whole-tree material at roadside

What challenges (technical, non-technical, policy, etc.) must we solve to develop sustainable forest bioenergy production systems?

Logging slash from final harvest

Hybrid poplar

Consider biomass at individual tree and stand levels

Precommercial thinning

Whole-tree material at roadside

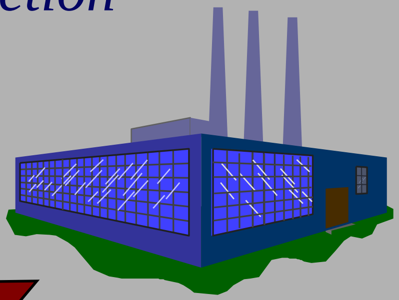
‘Conventional’ forestry and new opportunities

Logging slash from final harvest

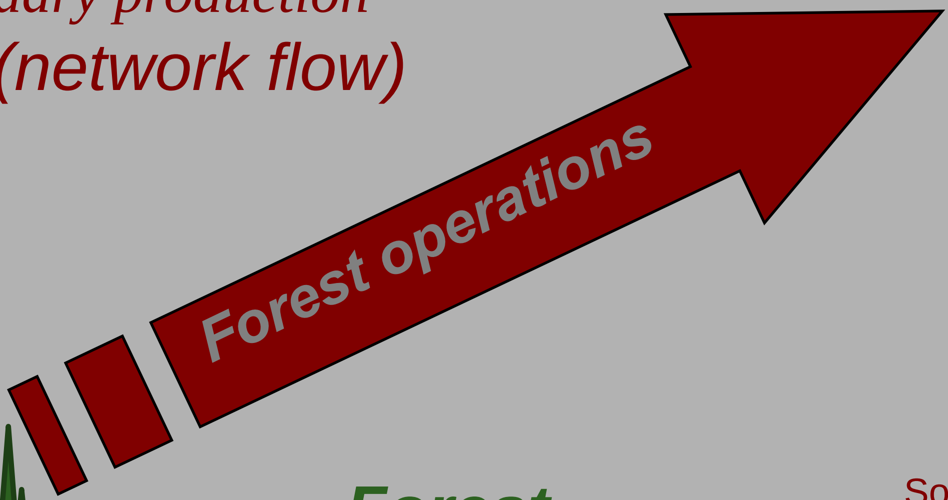
Hybrid poplar energy plantations

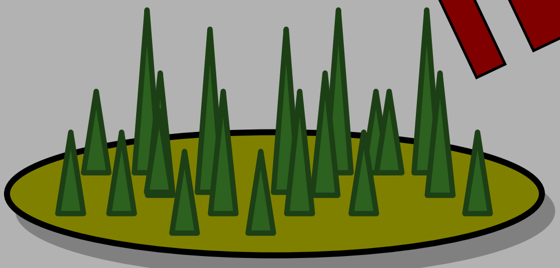
Logistical nature of forestry

Forest industry
Tertiary production
Points



Forest operations & transports
Secondary production
Lines (network flow)

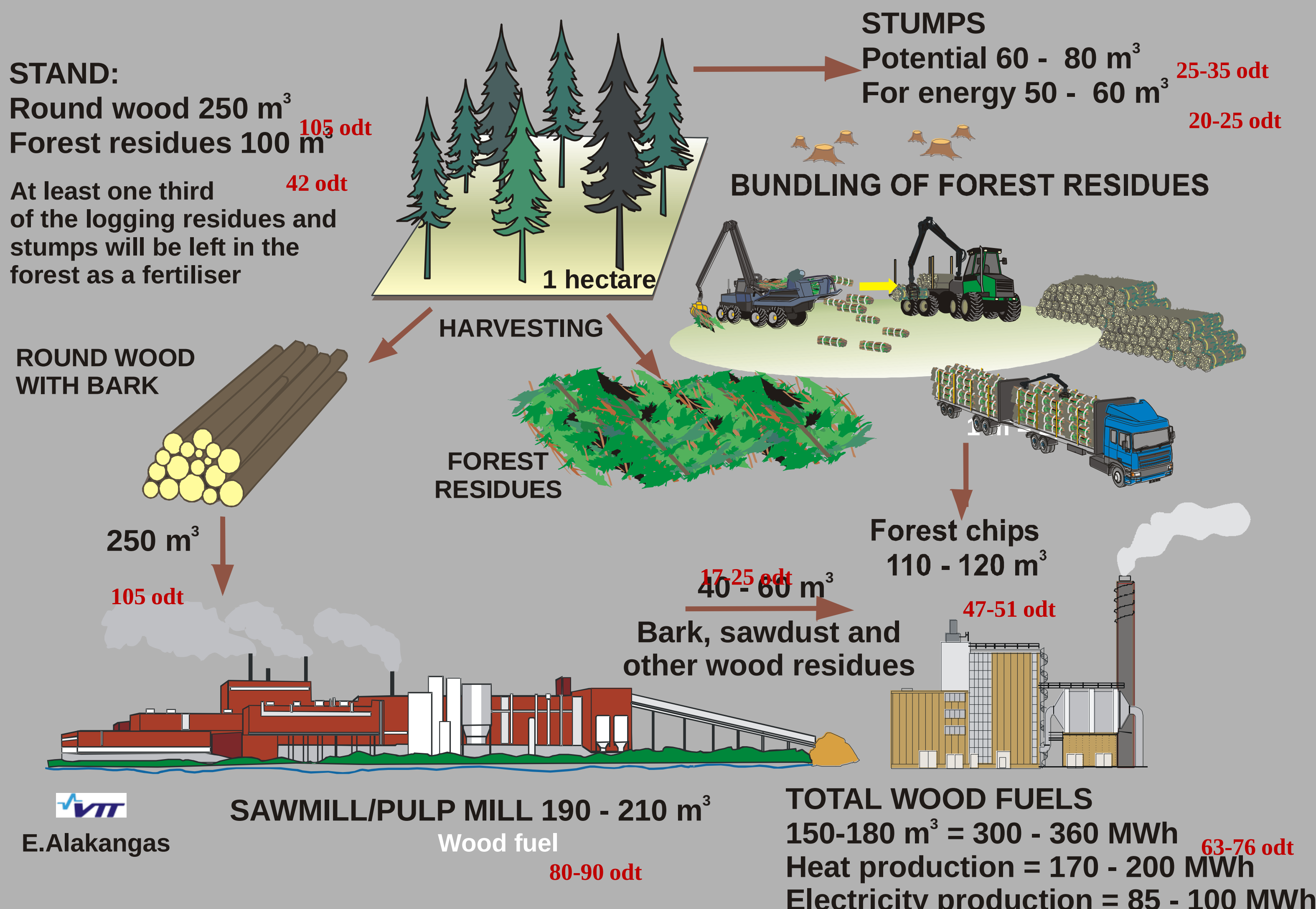




Forest
Primary production
Areas

Source: Björheden

Requires efficient integration



Operational & Supply Chain Analysis

Complex system elements

- **Annual need** for forest fuels and other fuels
- **Annual availability** of forest fuels
  - Fuel mix (residues, small trees, stumps)
  - Harvesting conditions
  - Transport distances in the forest/on road network
- Roadside **landing capacities**
- **Location of plant** (centre of a town or in the sub urban area)?
- Size of plant yard (**storage**)?
- **Dominant technology** to produce heat (combustion/gasification)
- Need for **GIS**-based availability and **cost analysis**

- Total cost of the supply system

Fuel quality optimization through

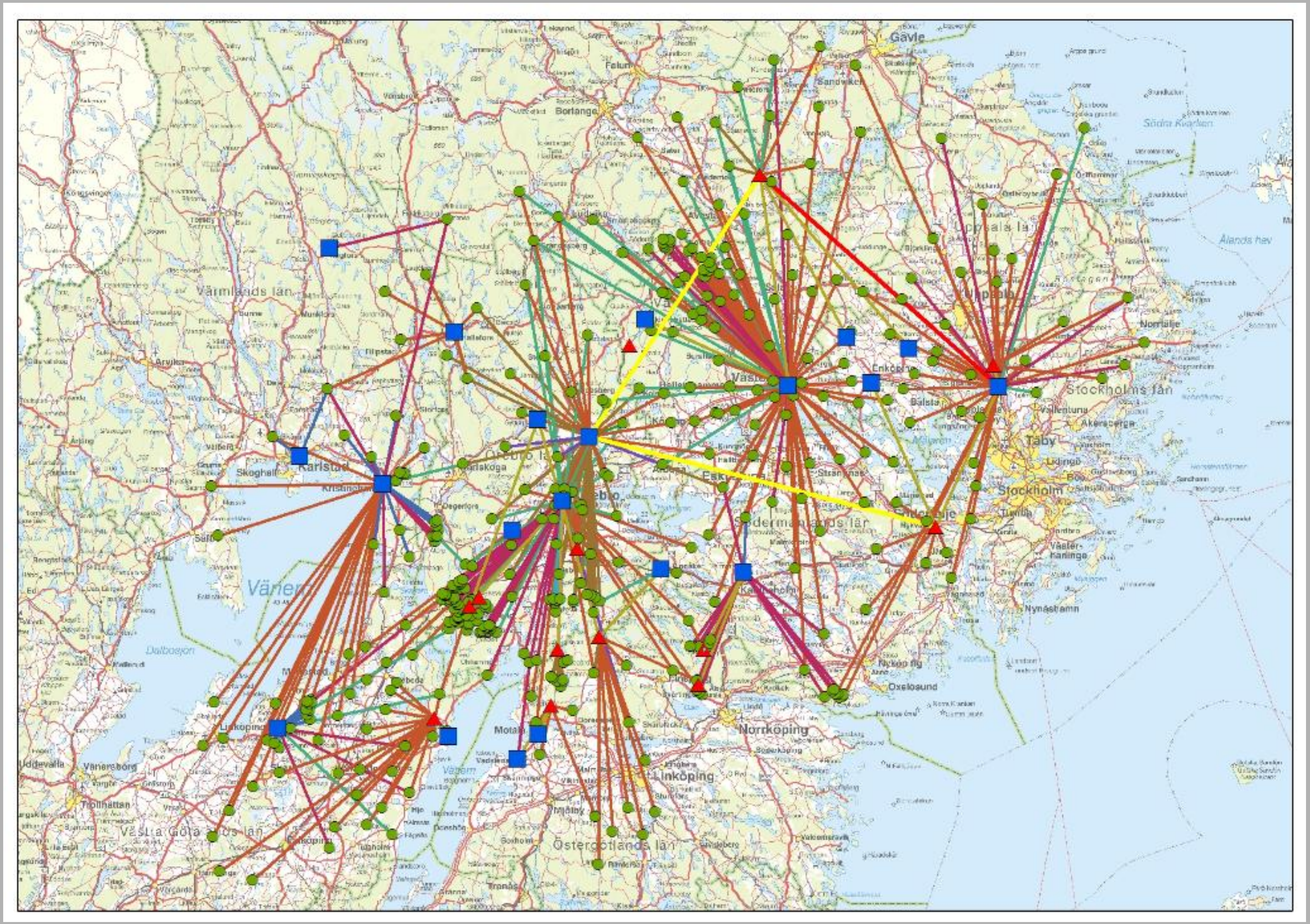
- Optimized supply chains
- Optimized storage management
- Right material to the right customer

Optimized supply chains:

Small scale systems in Central Europe

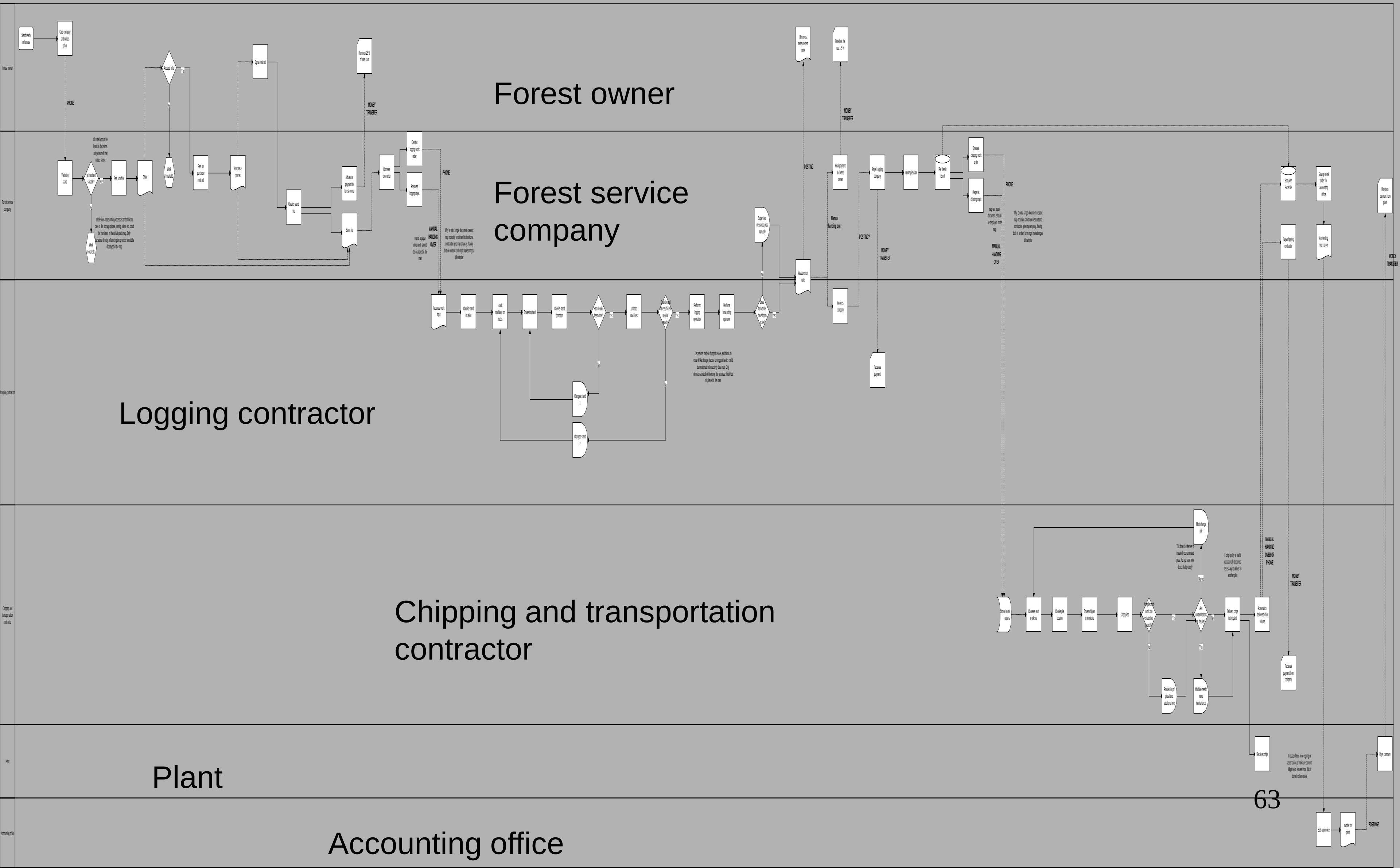



All flows of assortments – Swedish case

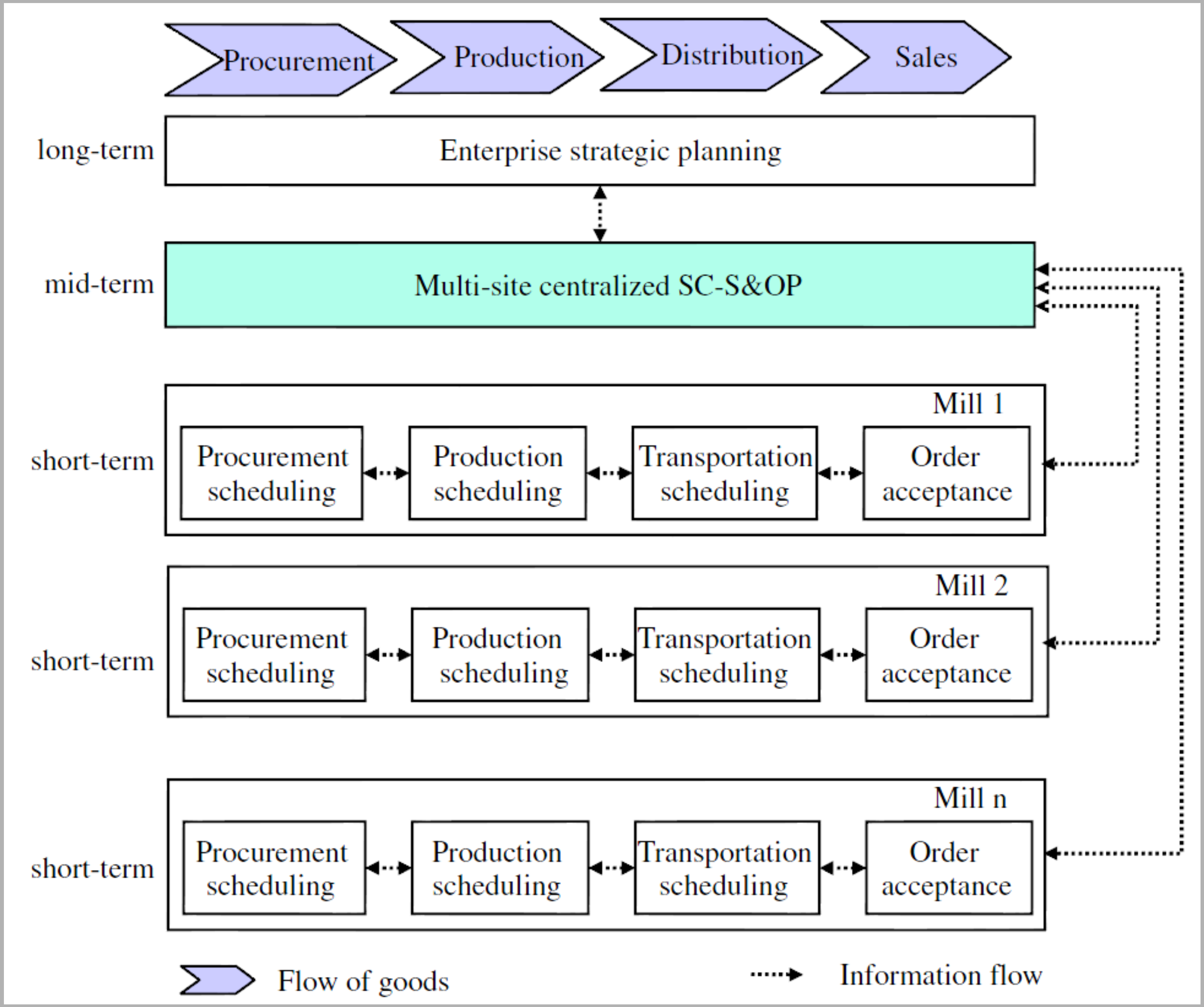


Source: Filsberg et al. 2010

Optimized storage mgmt: Process mapping



Supply chain planning matrix



Source: Feng et al. 2008

Building teams -- opportunities for collaboration

International networks

- **IEA Bioenergy** -- www.ieabioenergy.com

- **IEA Bioenergy Task 43 --**
  Biomass Feedstocks for Energy markets
  www.ieabioenergytask43.org

- **COST Action FP0902 --** Development and harmonisation of new operational research and assessment procedures for sustainable forest biomass supply

Canadian research network

- **FPInnovations/NSERC forest initiative**
  Value Chain Optimization Network
  www.reseauvco.ca/en/home/

Opportunities for collaboration

IEA Bioenergy Task period 2010-2012
www.ieabioenergytask43.org

Supply-chain, Operations and Technological Assessments

- Antti Asikainen and Dominik Röser, Finnish Forest Research Institute (METLA), Finland.

- Bruce Talbot, Norwegian Institute of Forest Research and Danish Centre for Forest, Landscape & Planning.

COST Action FP0902

Development and harmonisation of new operational research and assessment procedures for sustainable forest biomass supply

Dominik Röser
Finnish Forest Research Institute, Metla





Objective:

To harmonize forest energy terminology and methodologies of forest operations research and biomass availability calculations thereby building the scientific capacity within forest energy research and supporting the technology transfer of the forest biomass procurement chain and sustainable forest management.

COST Action FP0902 linkages

Forest-Based Sector
Technology Platform

Biofuels
Technology Platform

EFORWOOD
Sustainability Impact Assessment
of the Forestry-Wood Chain

FPInnovations

bee
Biomass Energy Europe

IUFRO
The Global Network for
Forest Science Cooperation

EUROPEAN FOREST INSTITUTE
ATLANTIC EUROPEAN REGIONAL OFFICE – EFIATLANTIC

IEA Bioenergy
Task 43: Biomass Feedstocks for Energy Markets

THANK YOU!

Questions?

Faculty of Forestry

UNIVERSITY OF TORONTO

IEA Bioenergy

Task 43: Biomass Feedstocks for Energy Markets

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