Biomass In Canada
--
A renewed opportunity for Operations Research

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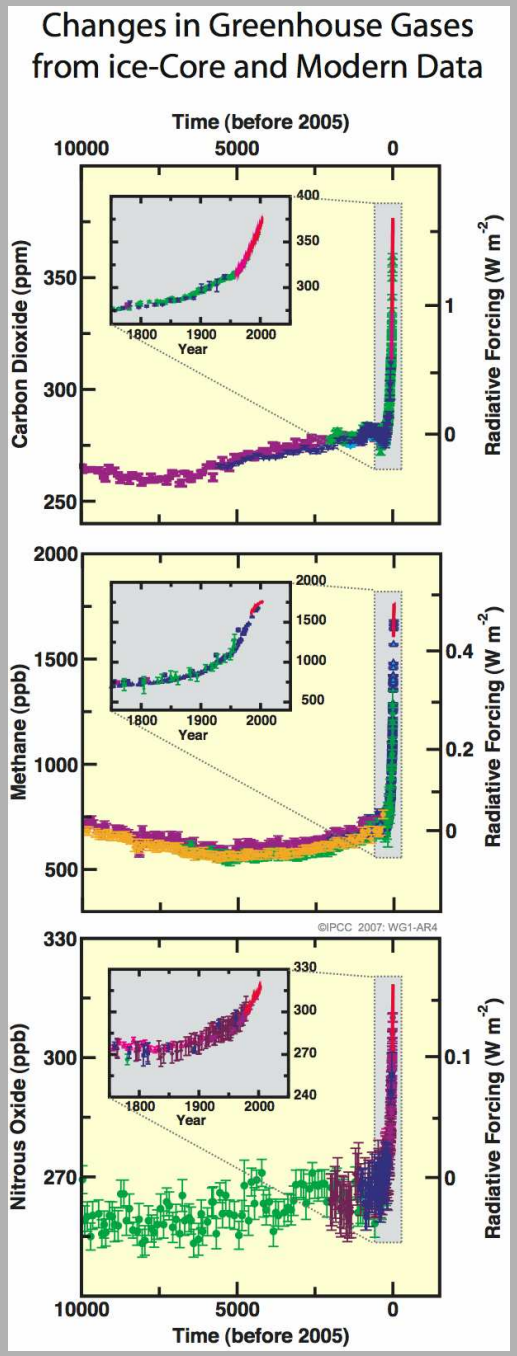
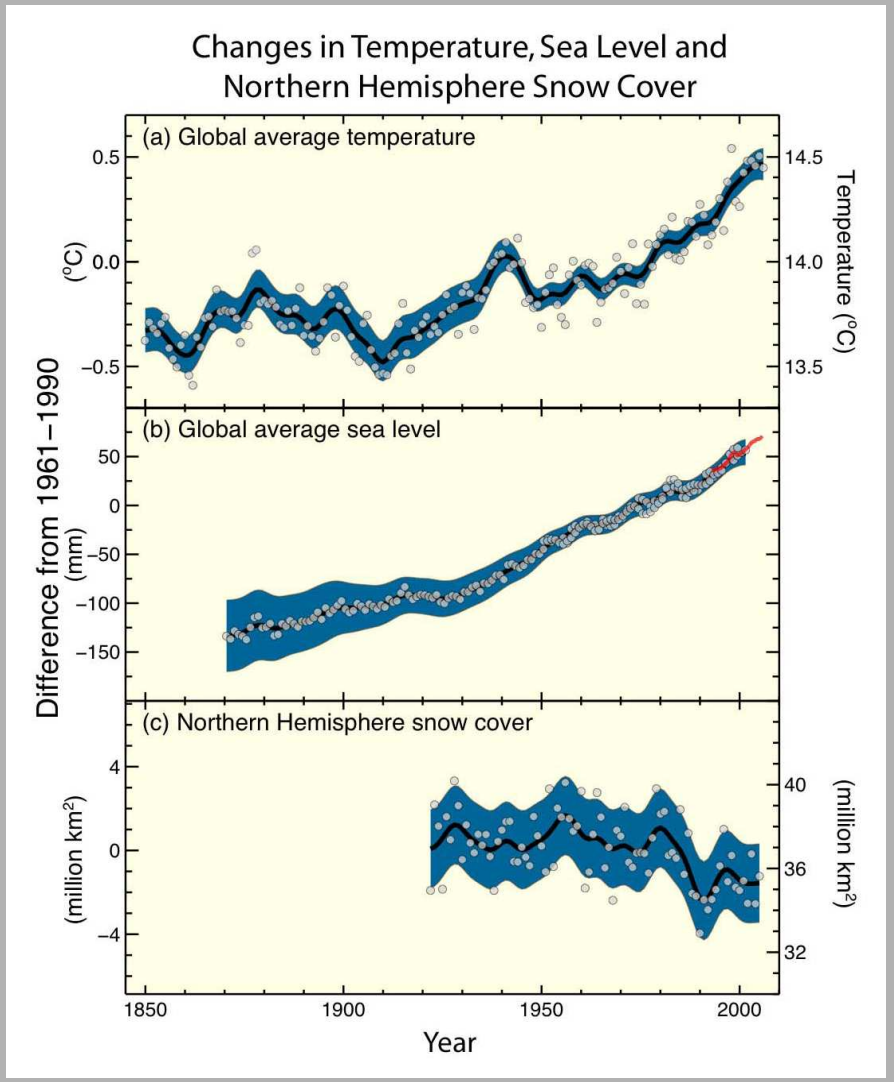
Outline

- Introductions
- Why consider developing sources of forest bioenergy?
- Describe global and regional patterns of bioenergy use
- Synthesize factors influencing bioenergy deployment
  - Drivers
  - Challenges
- Canadian biomass inventory and bioenergy potential
- Operational Research challenges
- Opportunities for future collaboration
  - IEA Bioenergy Task 43 – Biomass Feedstocks for Energy Markets
  - COST Action FP0902
  - FPInnovations NSERC 'Value Chain Optimization' network

Why Forest Bioenergy?
Global climate change





Source: www.ipcc.ch

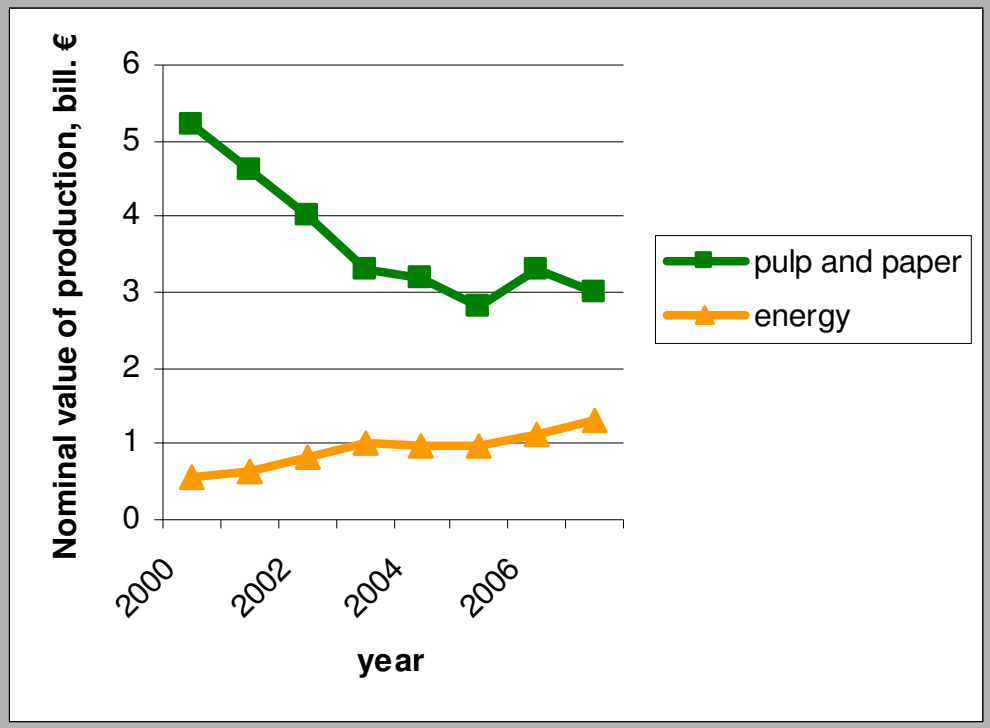
Why Forest Bioenergy?

« 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

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

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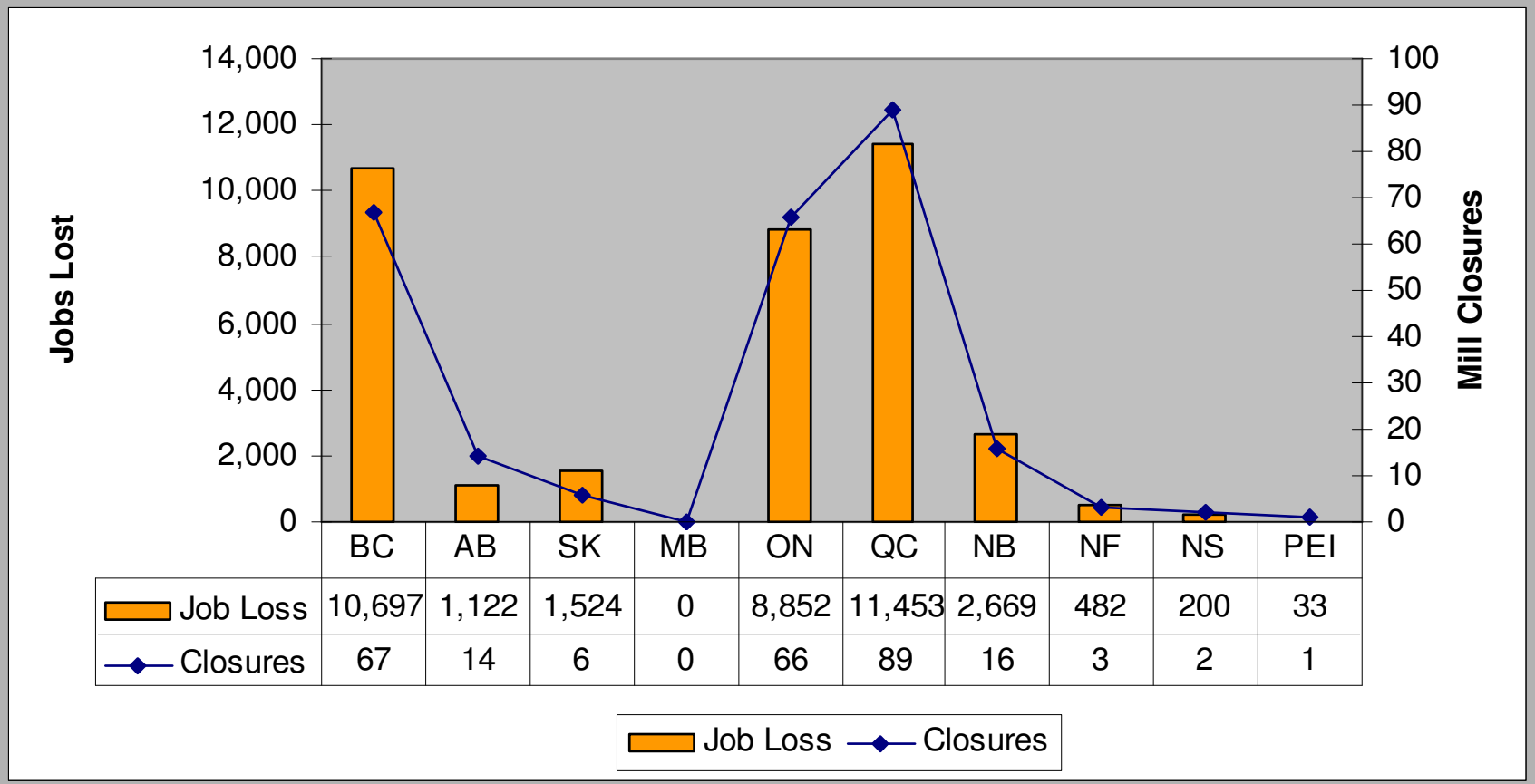
Why forest bioenergy?

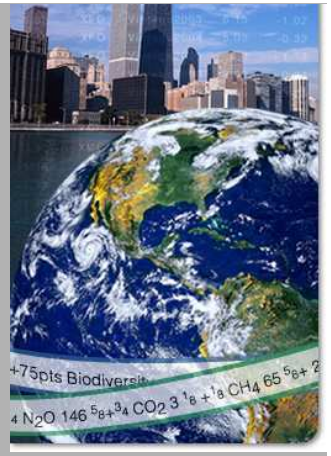
Sustaining rural economies in the forested areas becomes increasingly challenging due to mill closures and other factors.

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

Why forest bioenergy?



Opportunity for valuing environmental services…

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

US market, US$/Mg CO_2 Source: CCX **European Market, €/Mg CO_2**

CCX | CCFE | ECX

January 2, 2009 Updated end of day.

Total Daily Electronic Volume: 2,000 mt CO2

CCX CFI	CLOSE	CHANGE
CFI 2003	$1.65	$1.65
CFI 2008	$1.65	$1.65
CFI 2010	$1.70	$1.70

To view all listed contracts click here.

CCX CFI Vintage 2009 (Quoted in mt CO2)

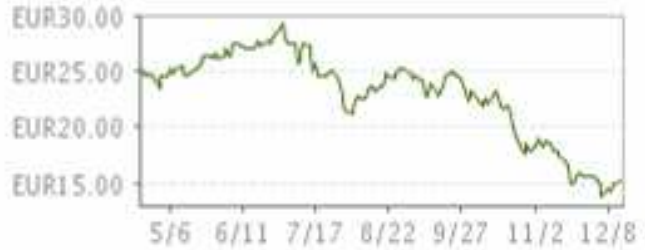
CCX | CCFE | ECX

December 31, 2008 Updated end of day.

ECX CFI	SETTLE	CHANGE
CFI Dec10	€16.46	€-0.12
CFI Dec12	€17.95	€-0.12

To view all listed contracts click here.

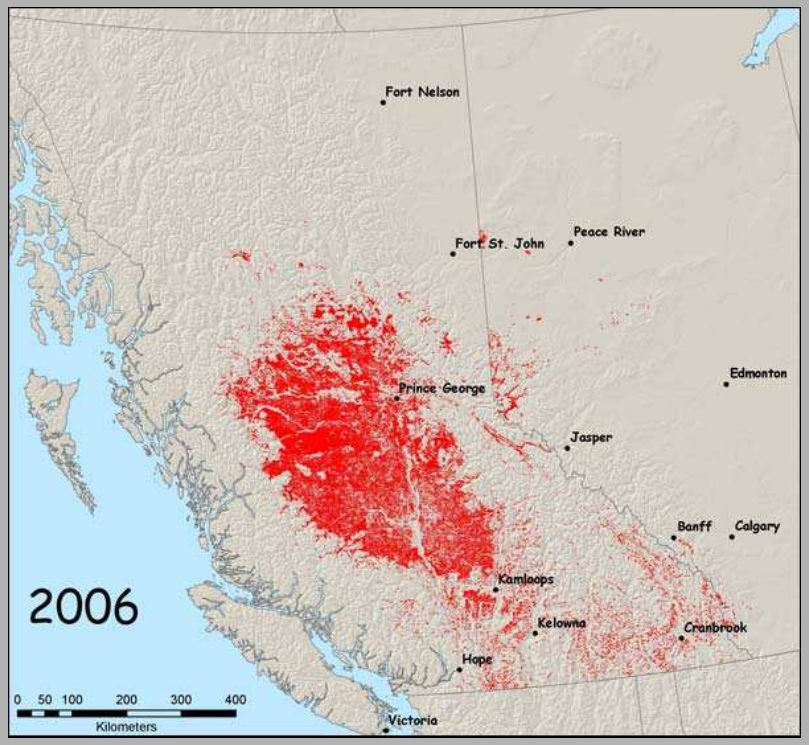
ECX CFI Dec08 (180 day price history)



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,

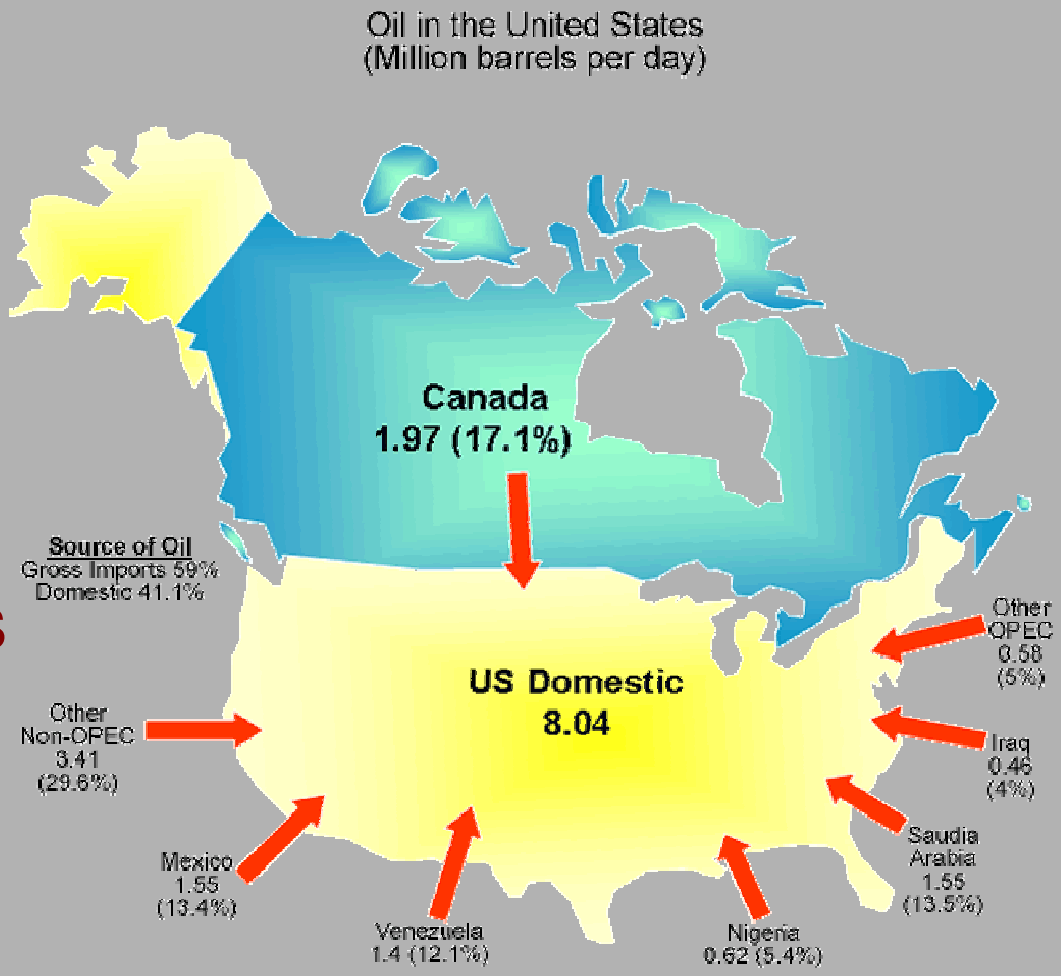
- 80% of mature pine dead

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

Why Forest Bioenergy?

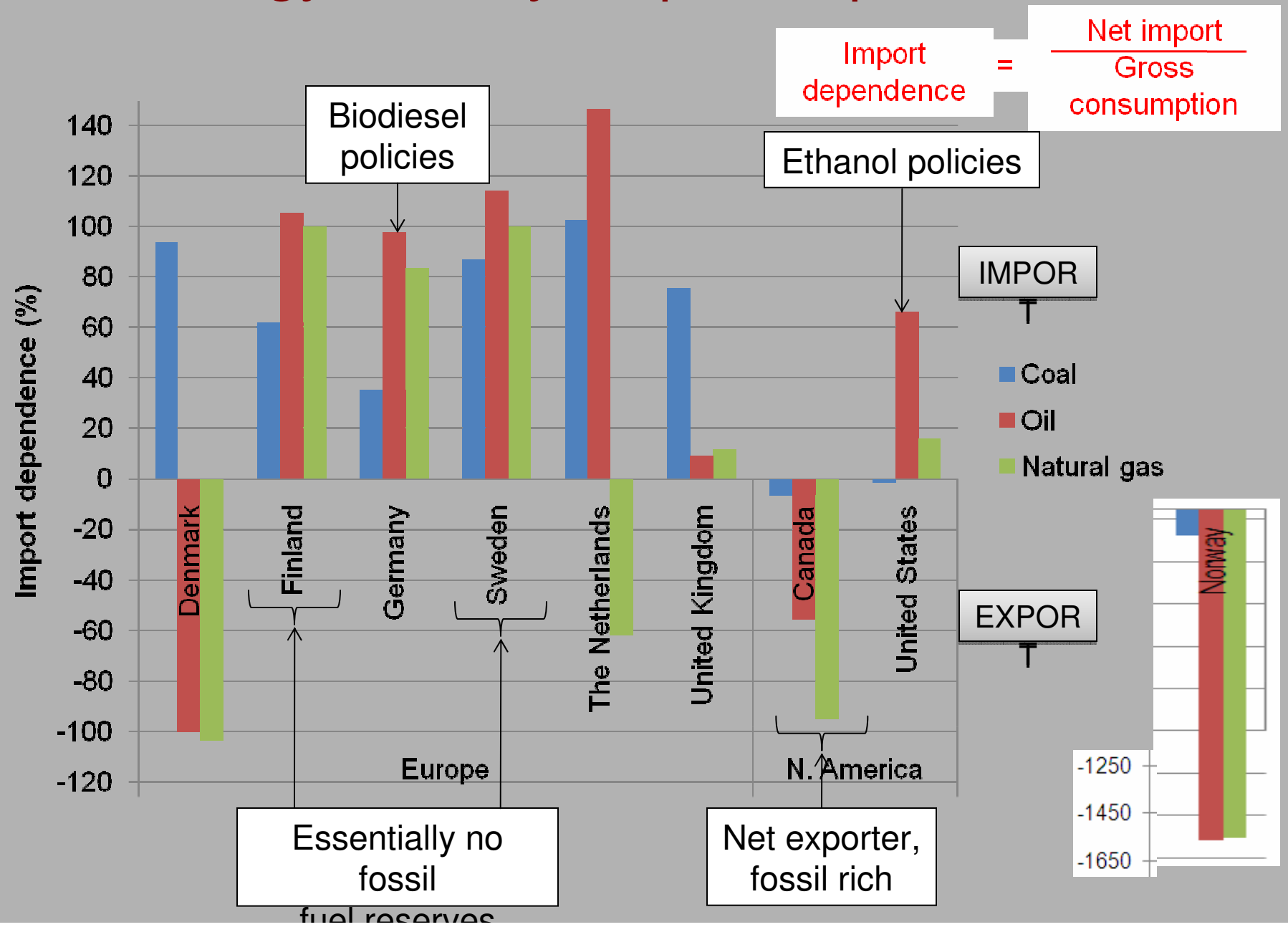
Energy Security.

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



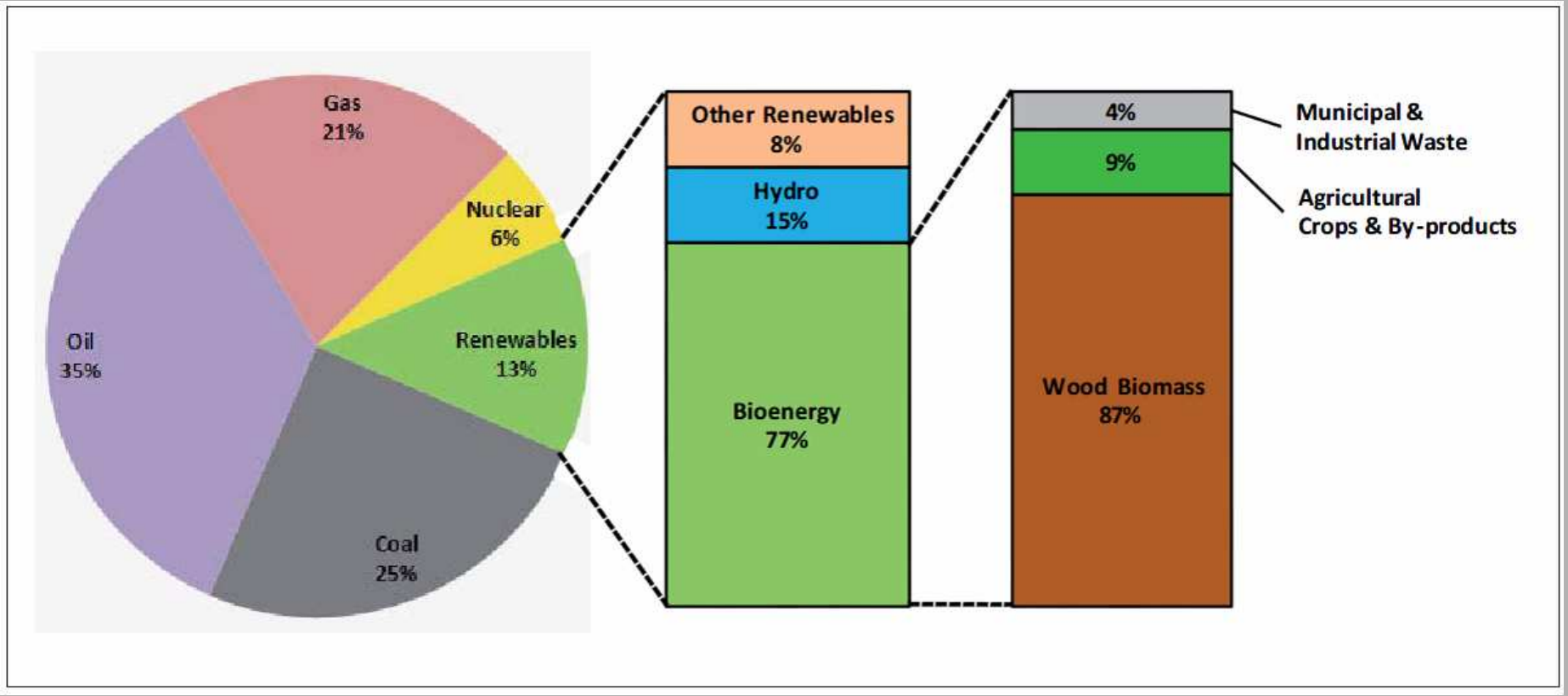
Energy security: Import dependence

Import dependence = Net import / Gross consumption



Global and regional patterns of bioenergy use

Share of bioenergy in world primary energy mix

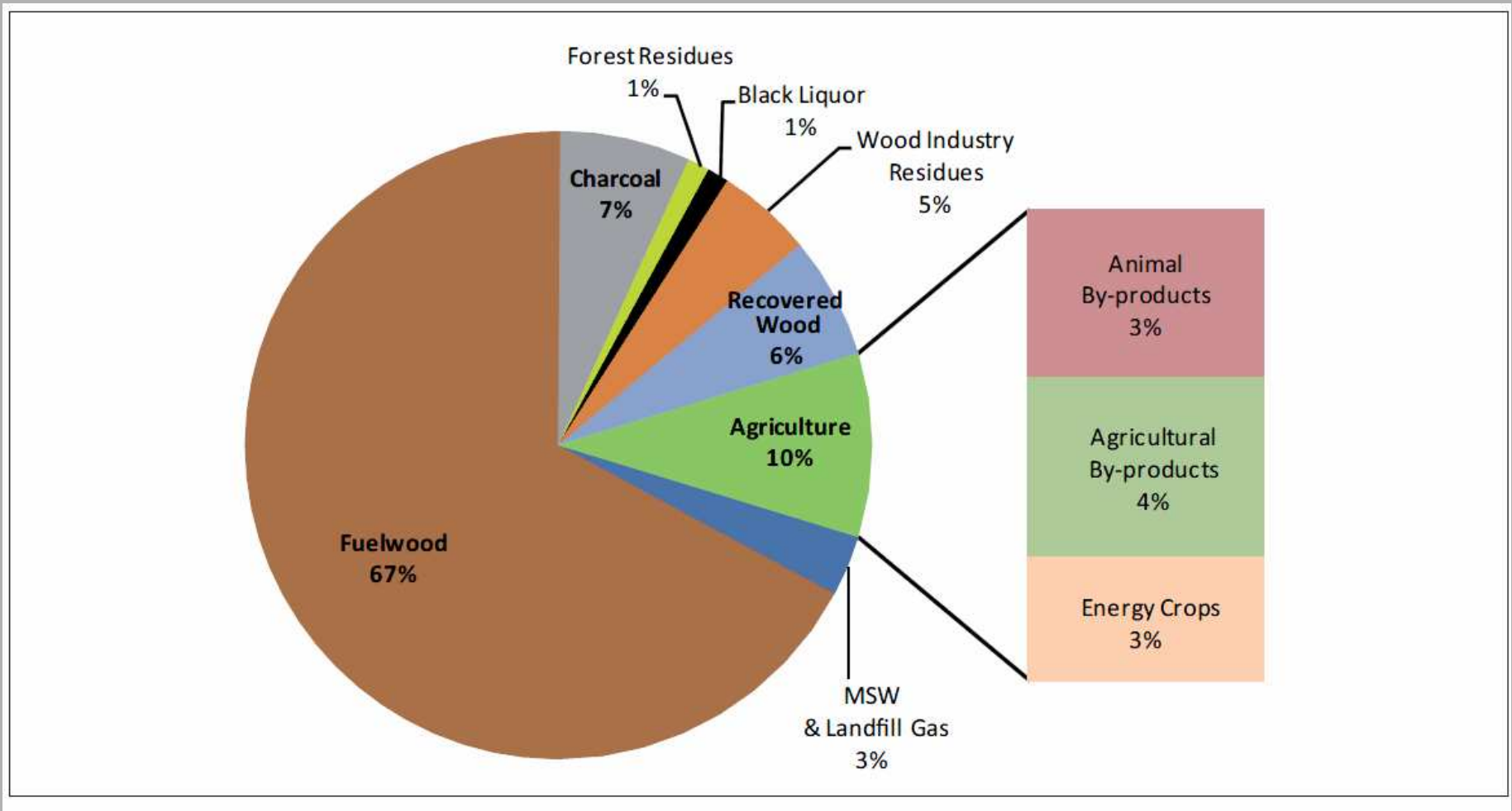


About 72% of woodfuel consumption is in developing countries

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

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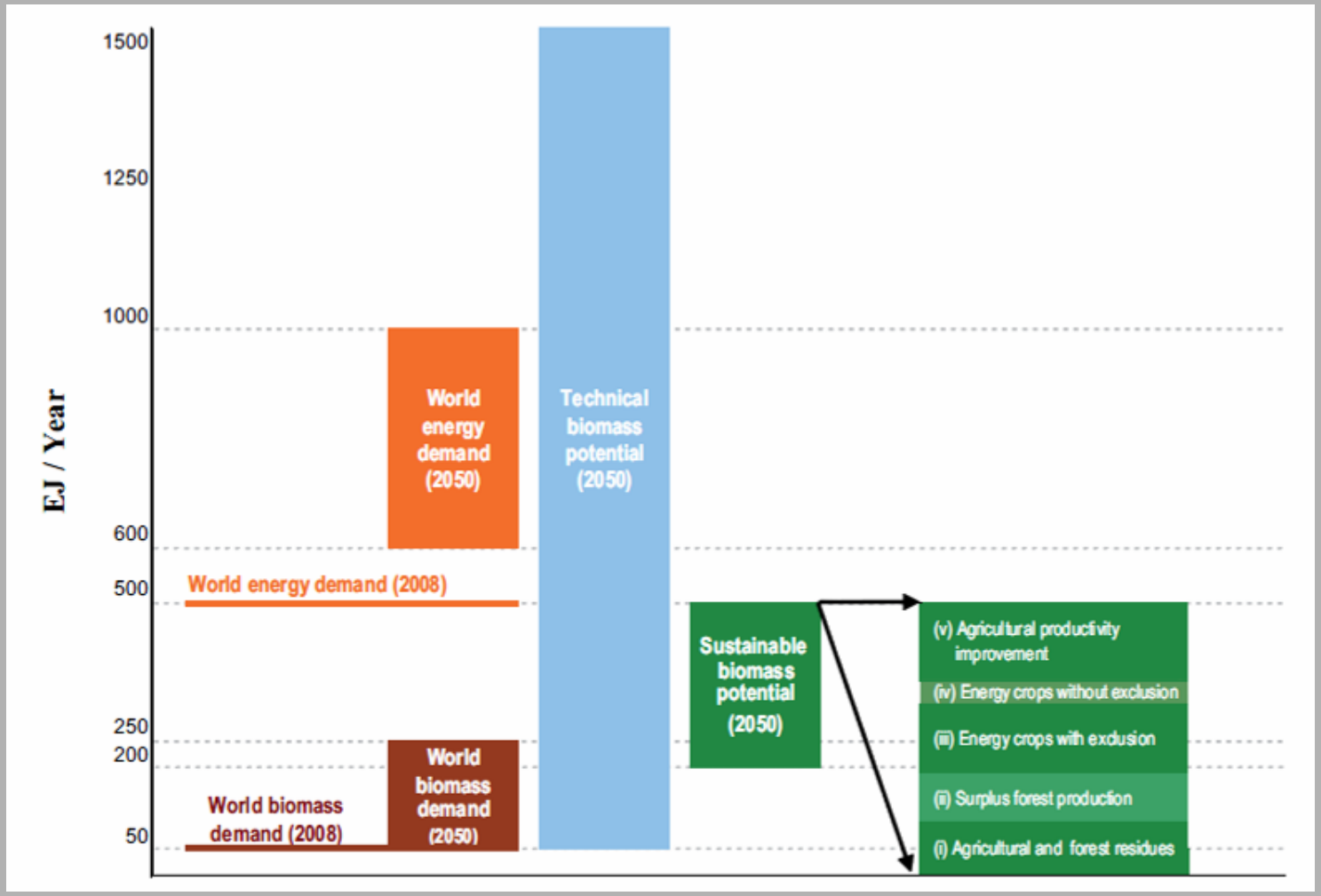
Global and regional patterns of bioenergy use



Huge difference between current and potential use of biomass

This difference and range in estimates is an opportunity and a challenge!

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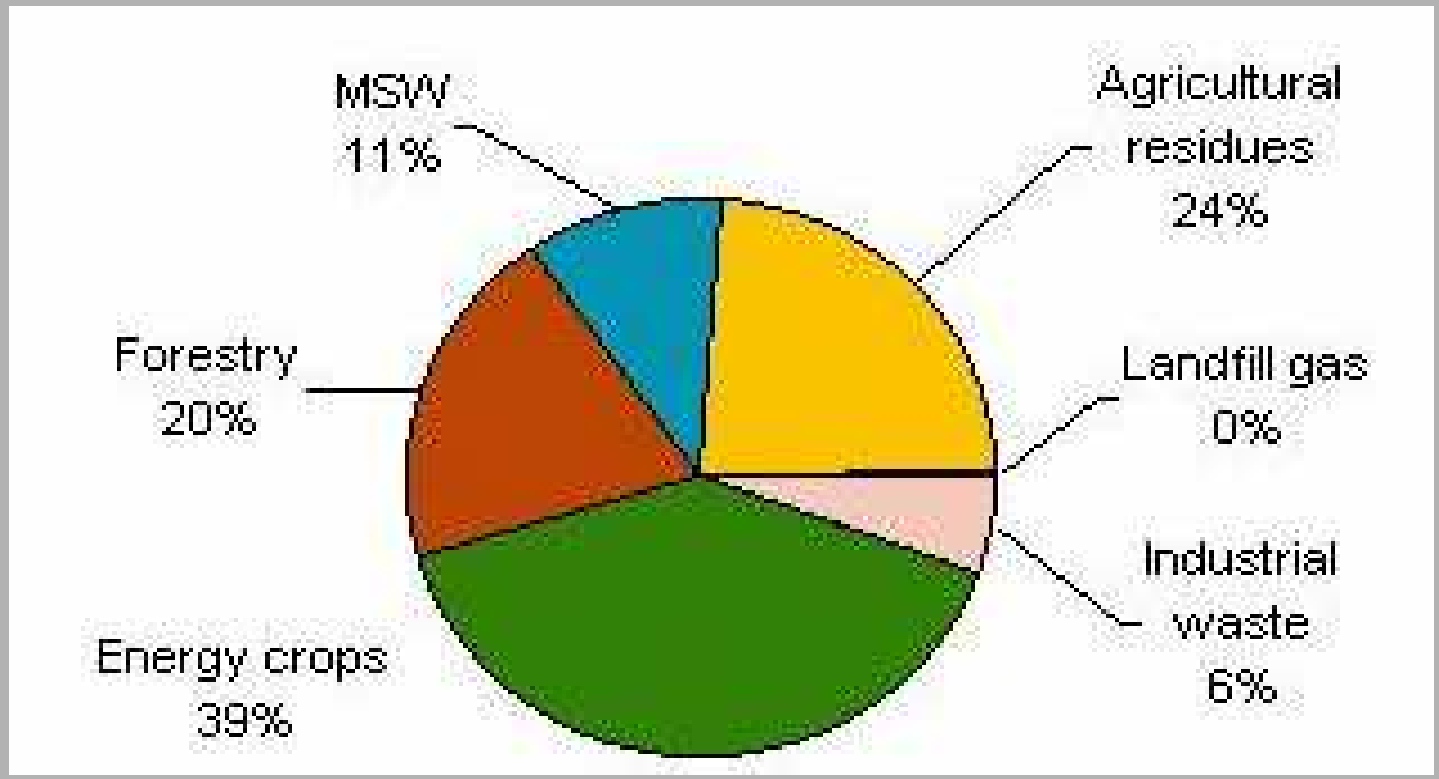
Projected biomass resources distribution in EU 15 in 2030

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

Forests will continue to be an important resource

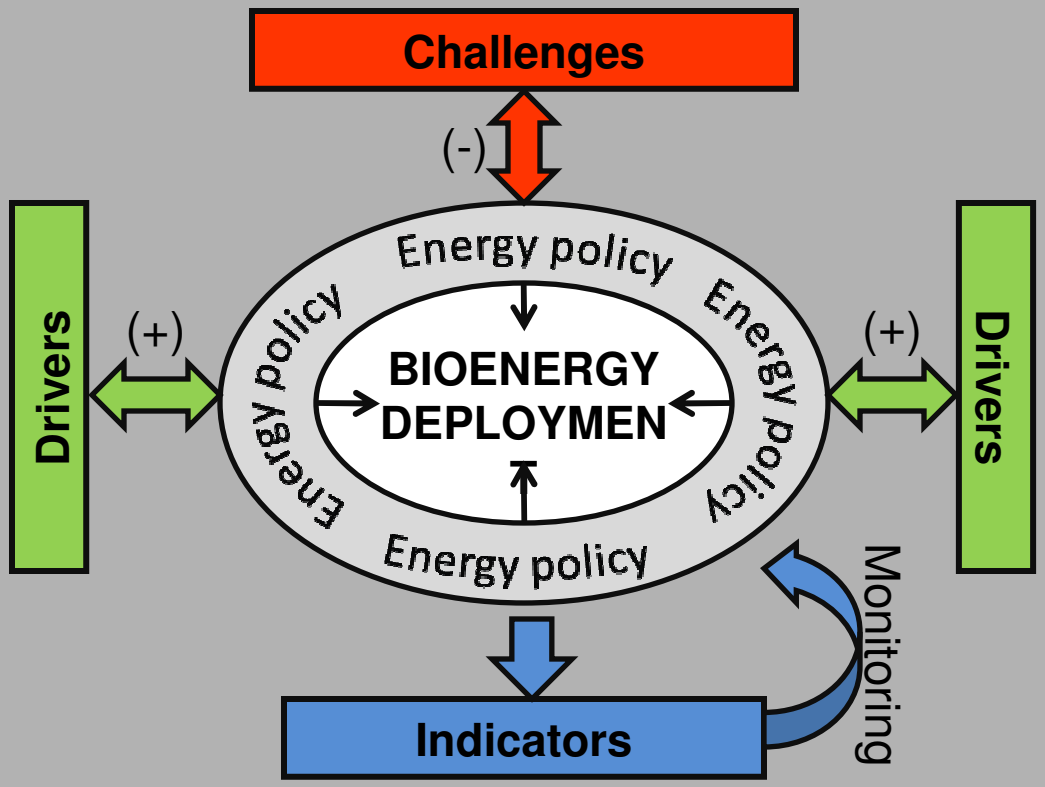


(Jorgensen and van Djik)

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?

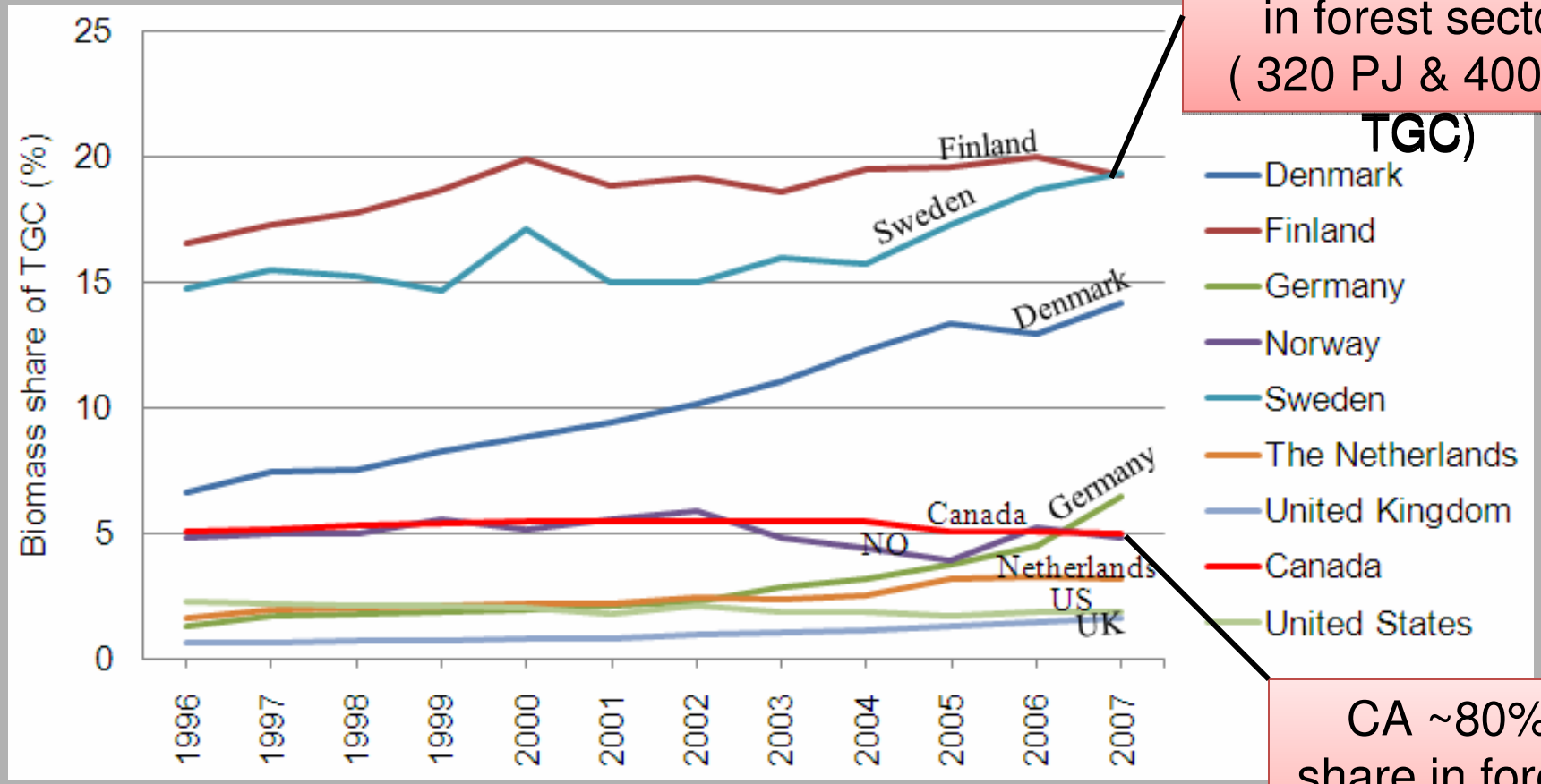


Adaptive framework context

- 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)

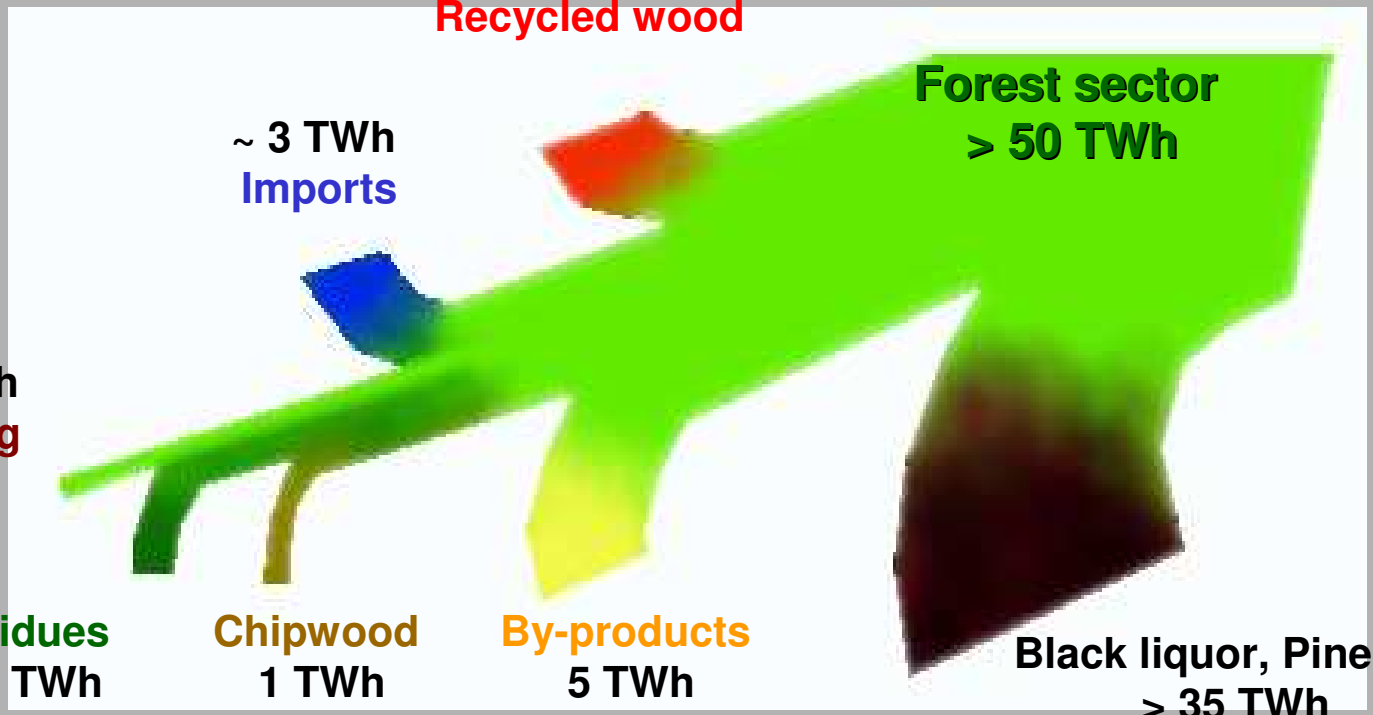
CA ~80% share in forest sector (~600 PJ TGC)

(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

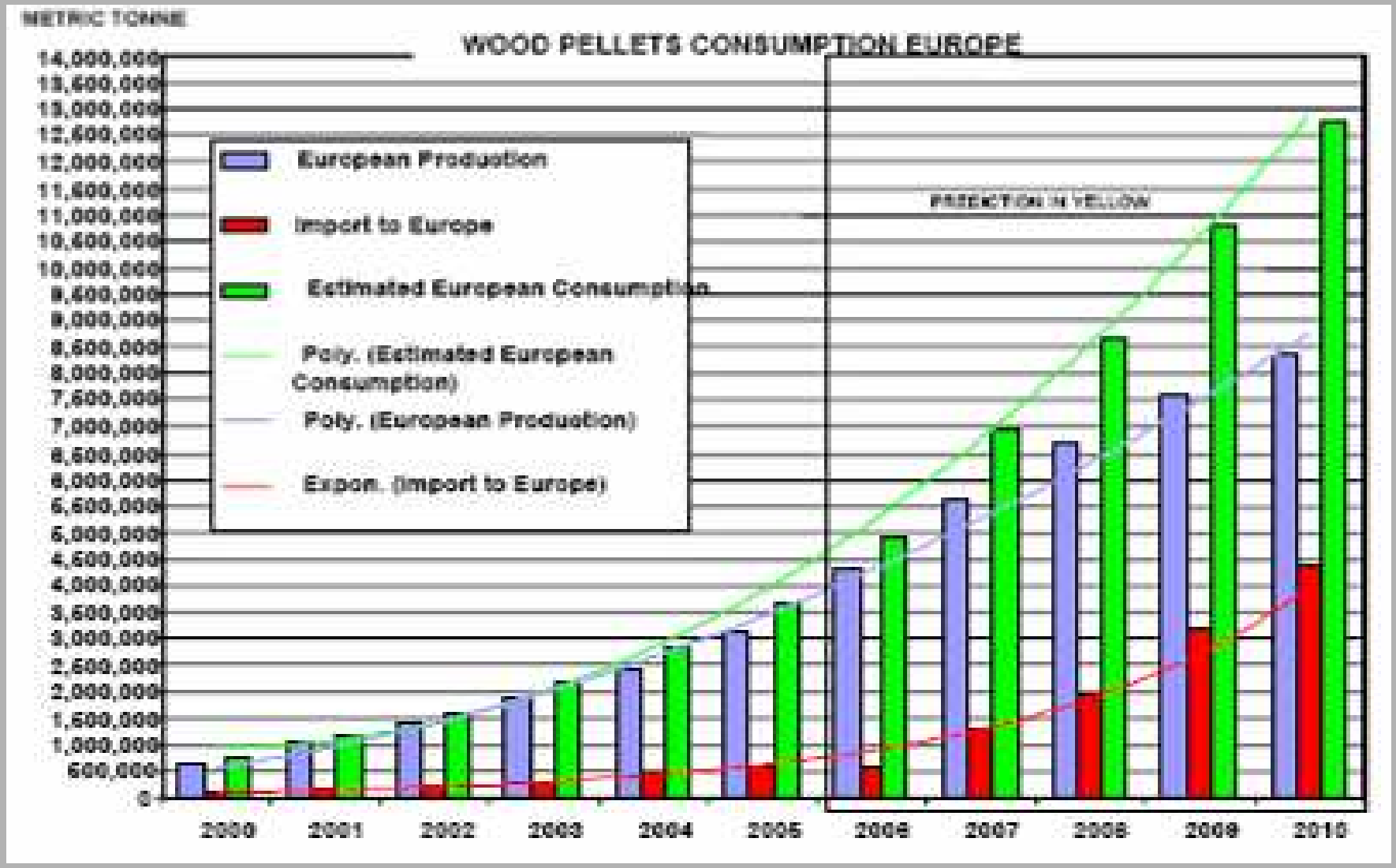


Source: Björheden, 2004

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 logging residues (FI, SE)
  - 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



Global trade in bioenergy feedstocks is developing rapidly

BC wood pellets shipped to Liége, Belgium

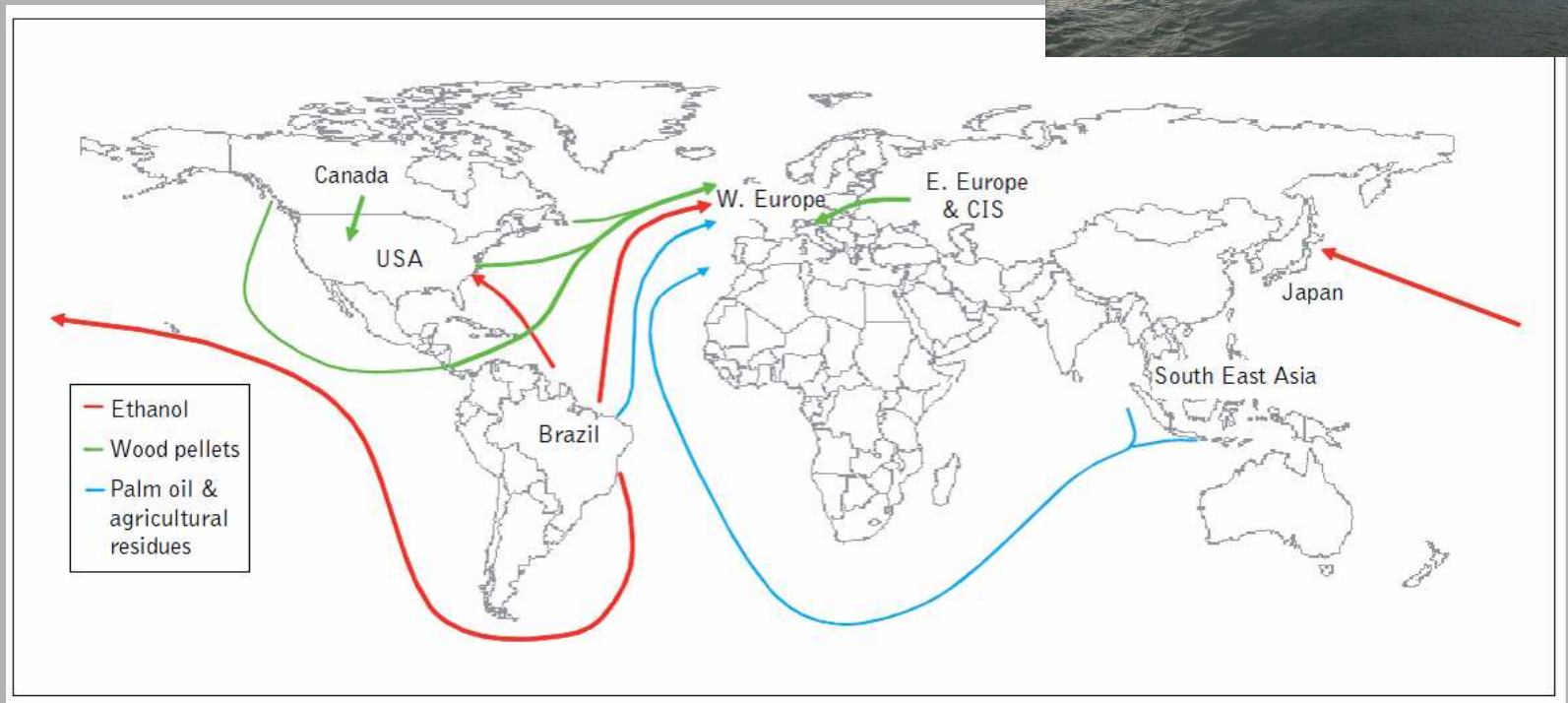


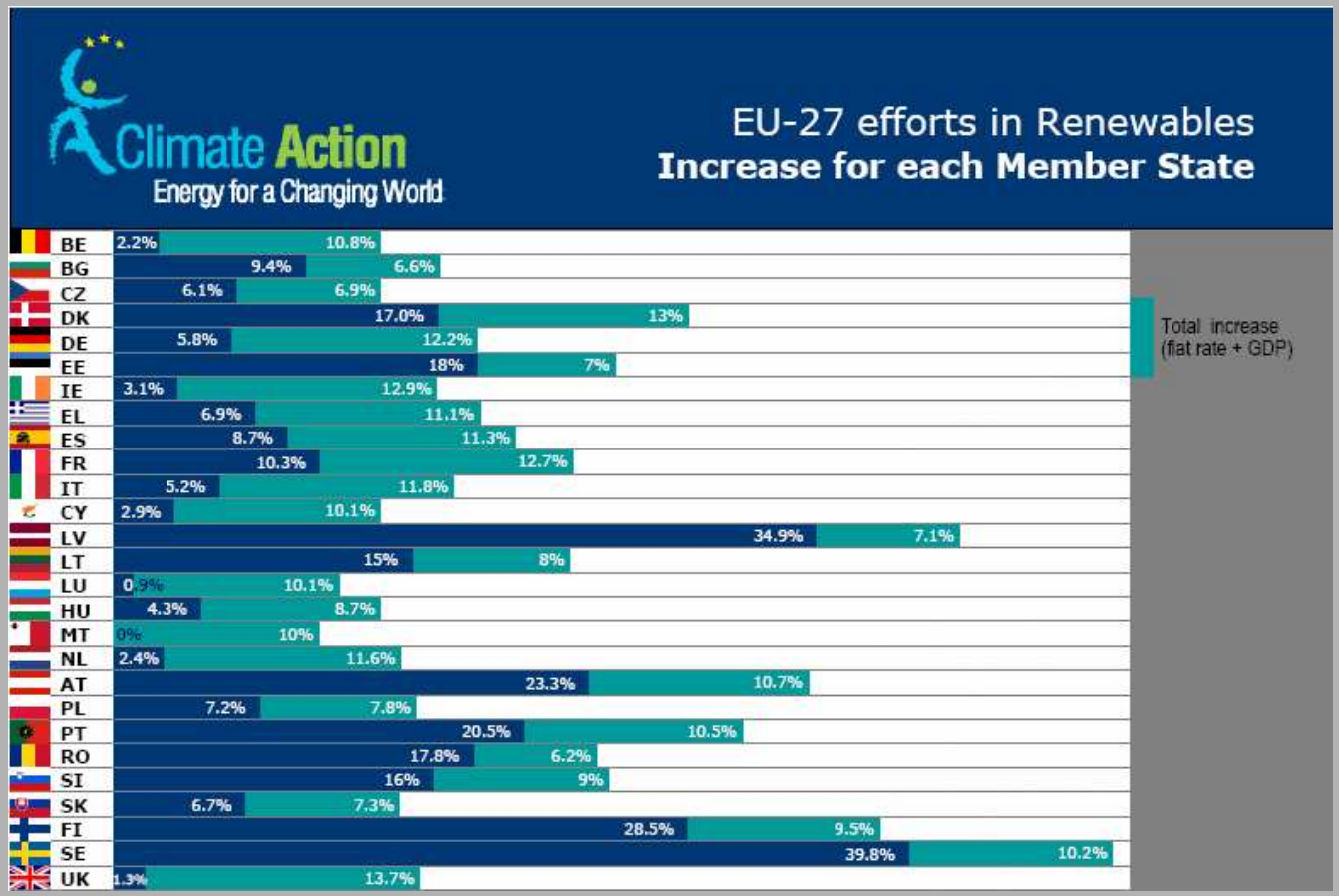
Figure 7: Main international biomass for energy trade routes. Intra-European trade is not displayed for clarity. Source: Junginger and Faaij, 2008.

IEA Bioenergy: ExCo: 2009:05

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

EU Climate policy

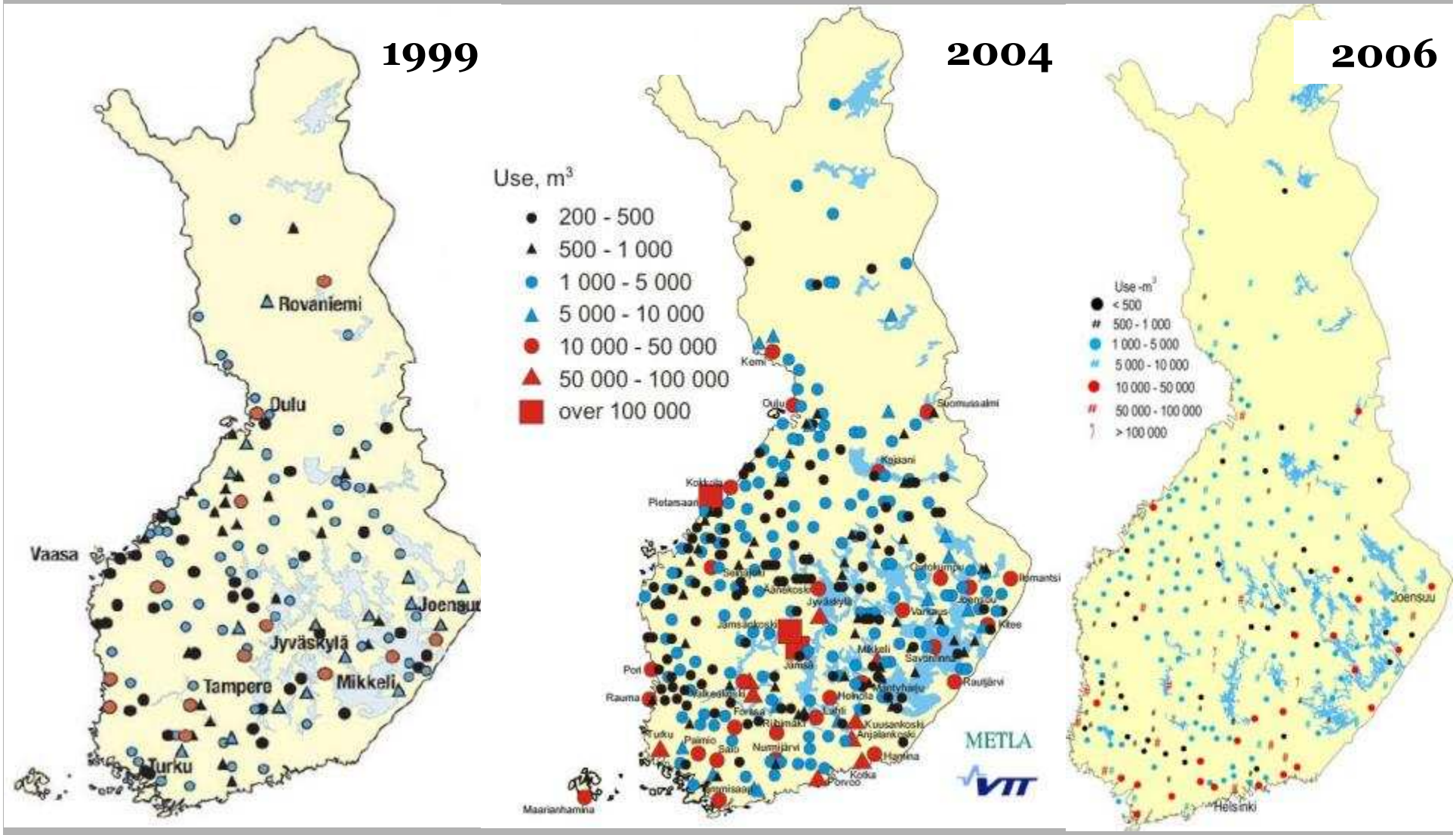


- EU's 20/20/20 targets
- Demand for forest biomass has been growing faster than supply in some areas across Europe
- Availability and proper use of harvesting technology to meet the growing demand

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

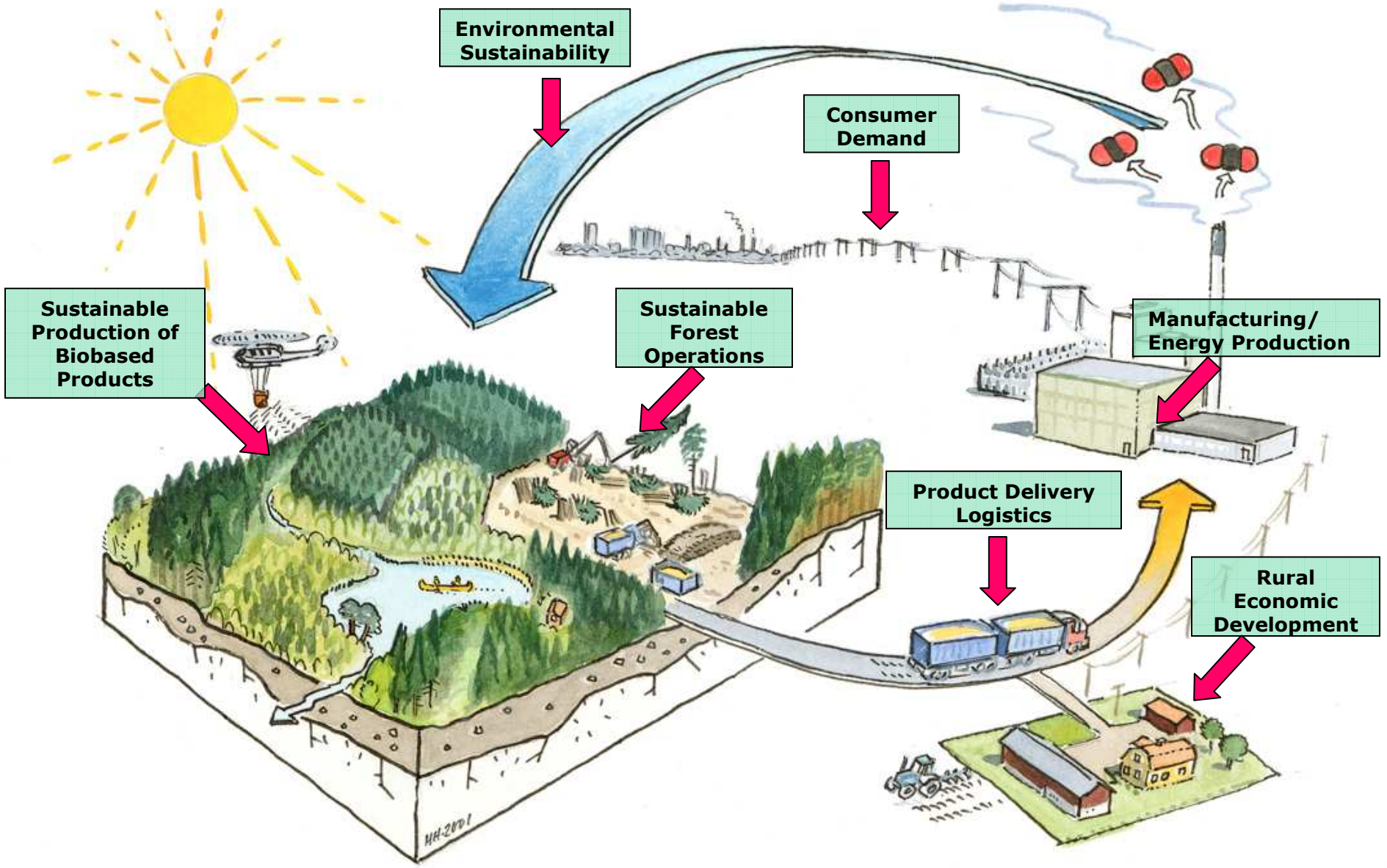
Users of forest energy in Finland



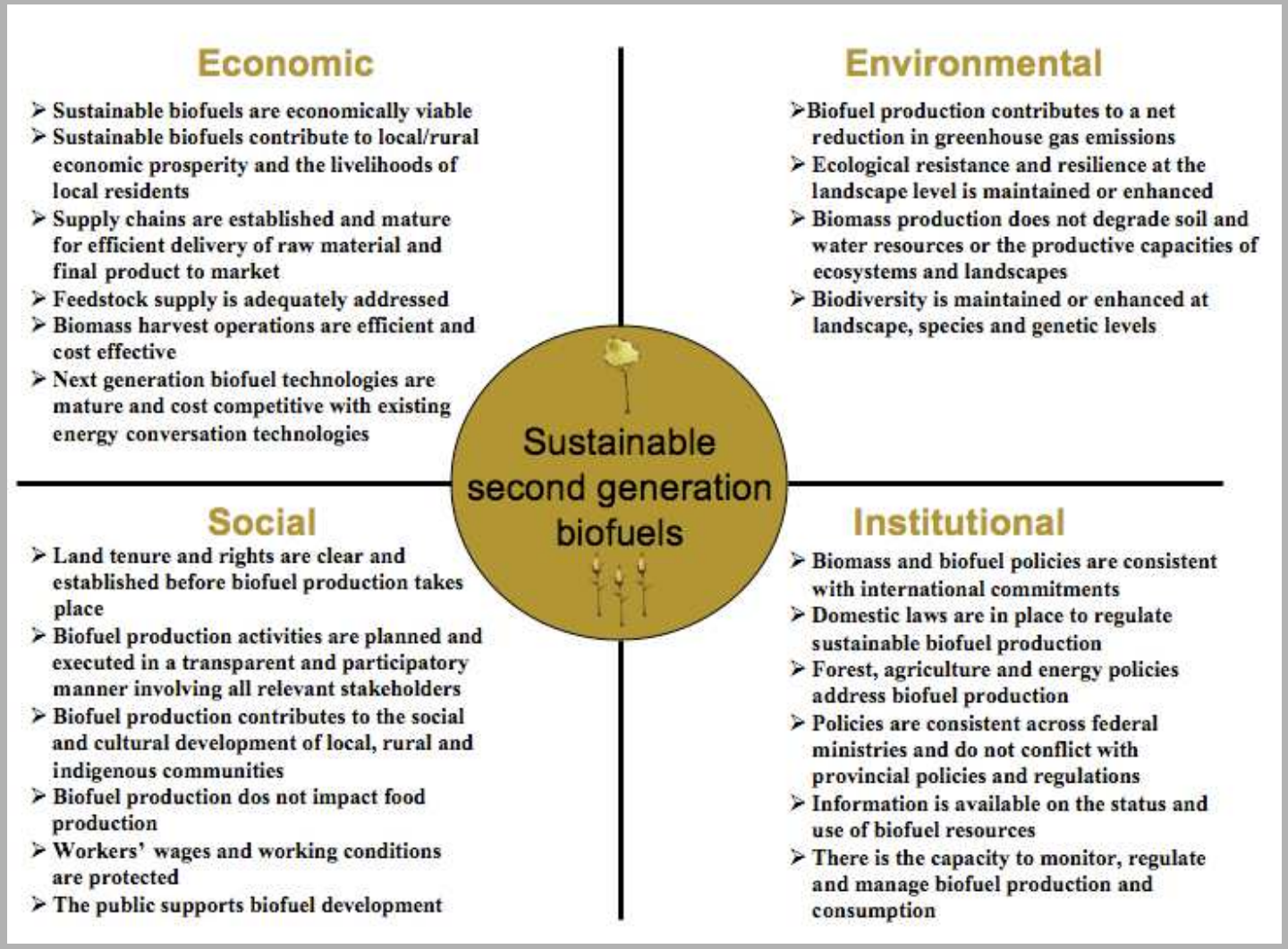
Assumptions

- **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

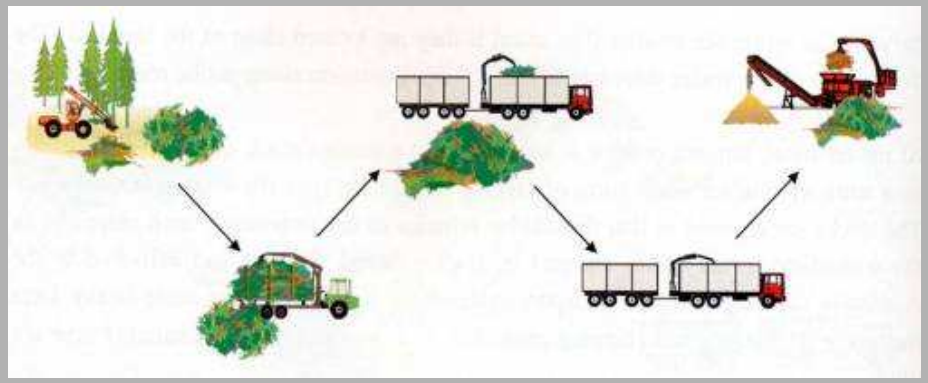


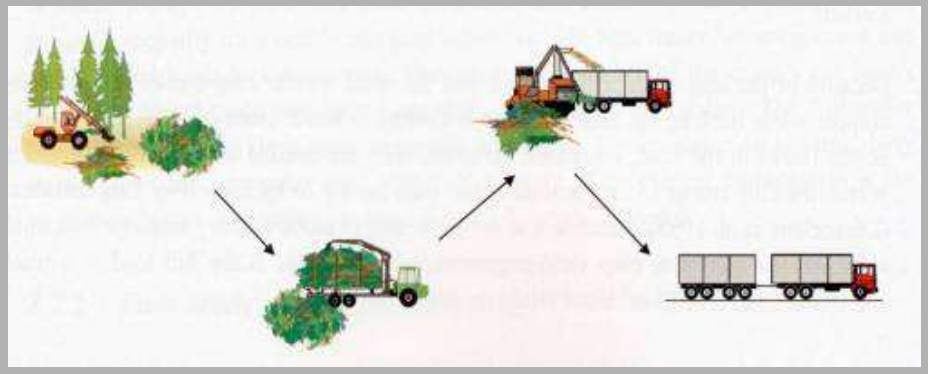
Principles and criteria of sustainable forest bioenergy production



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

Northern Maine – early 1980s





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

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

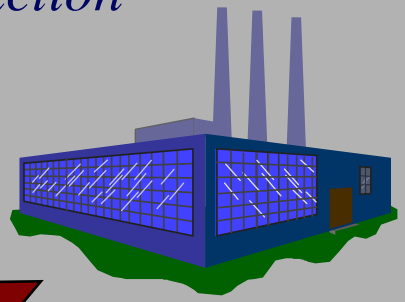
Hybrid poplar

Logistical character of forestry

Forest industry

Tertiary production

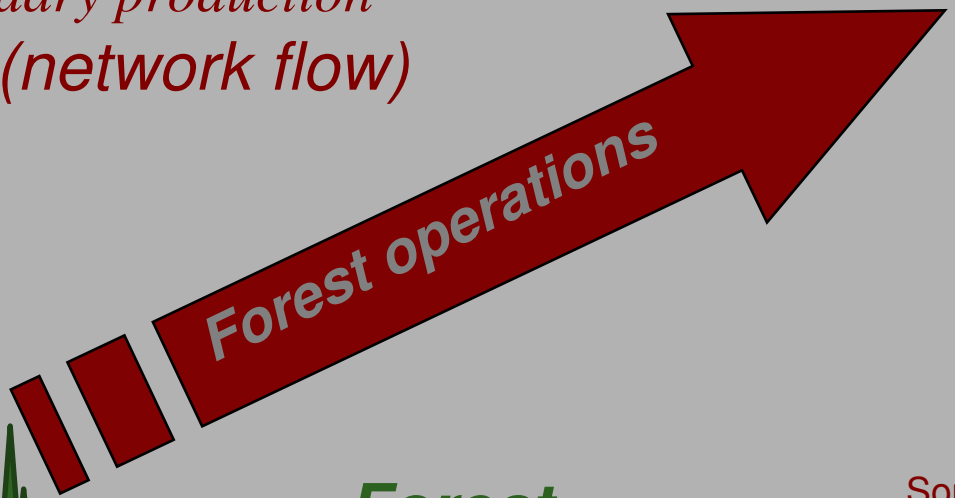
Points

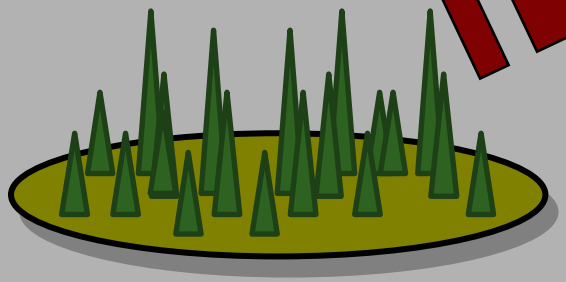


Forest operations & transports

Secondary production

Lines (network flow)





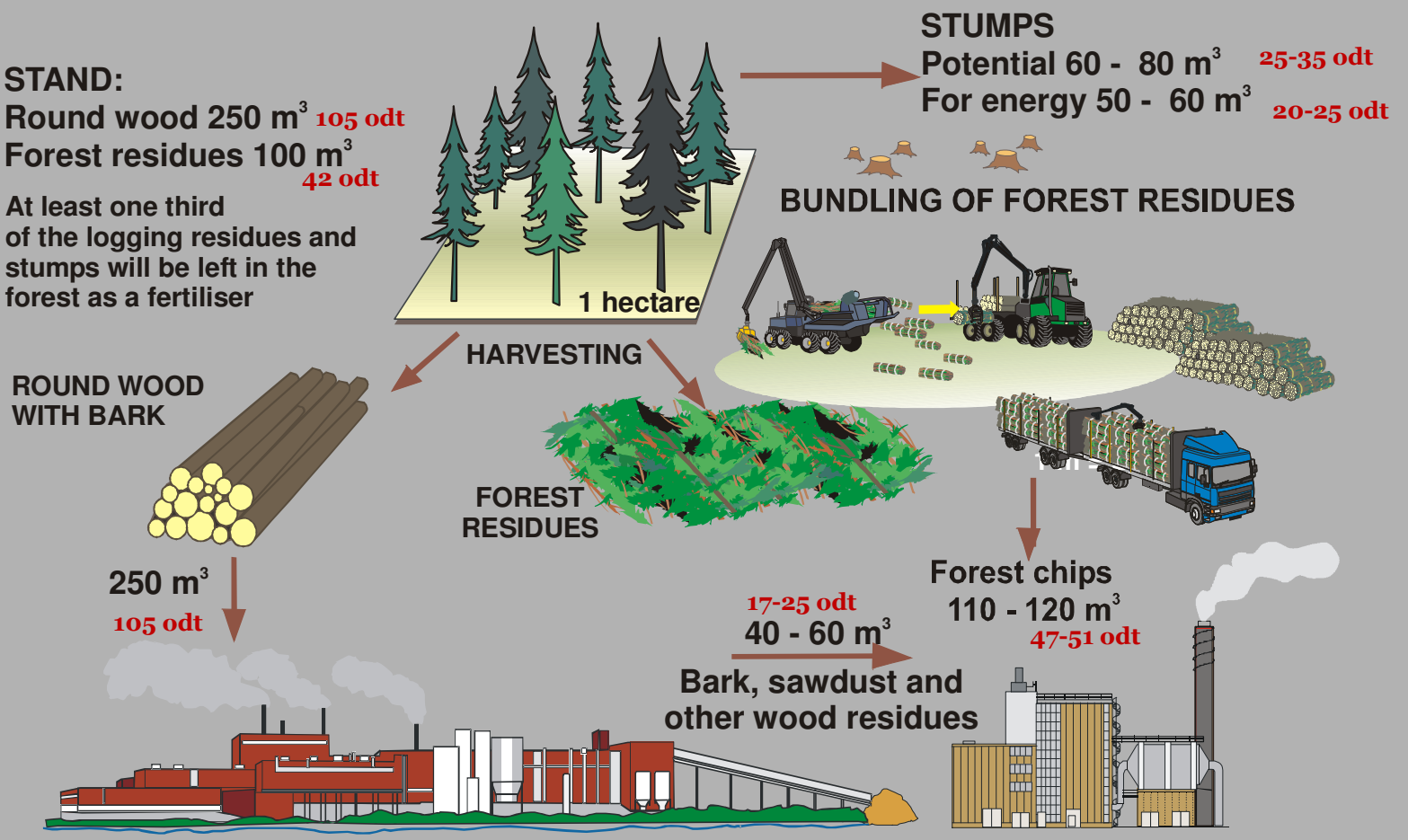
Forest

Primary production

Areas

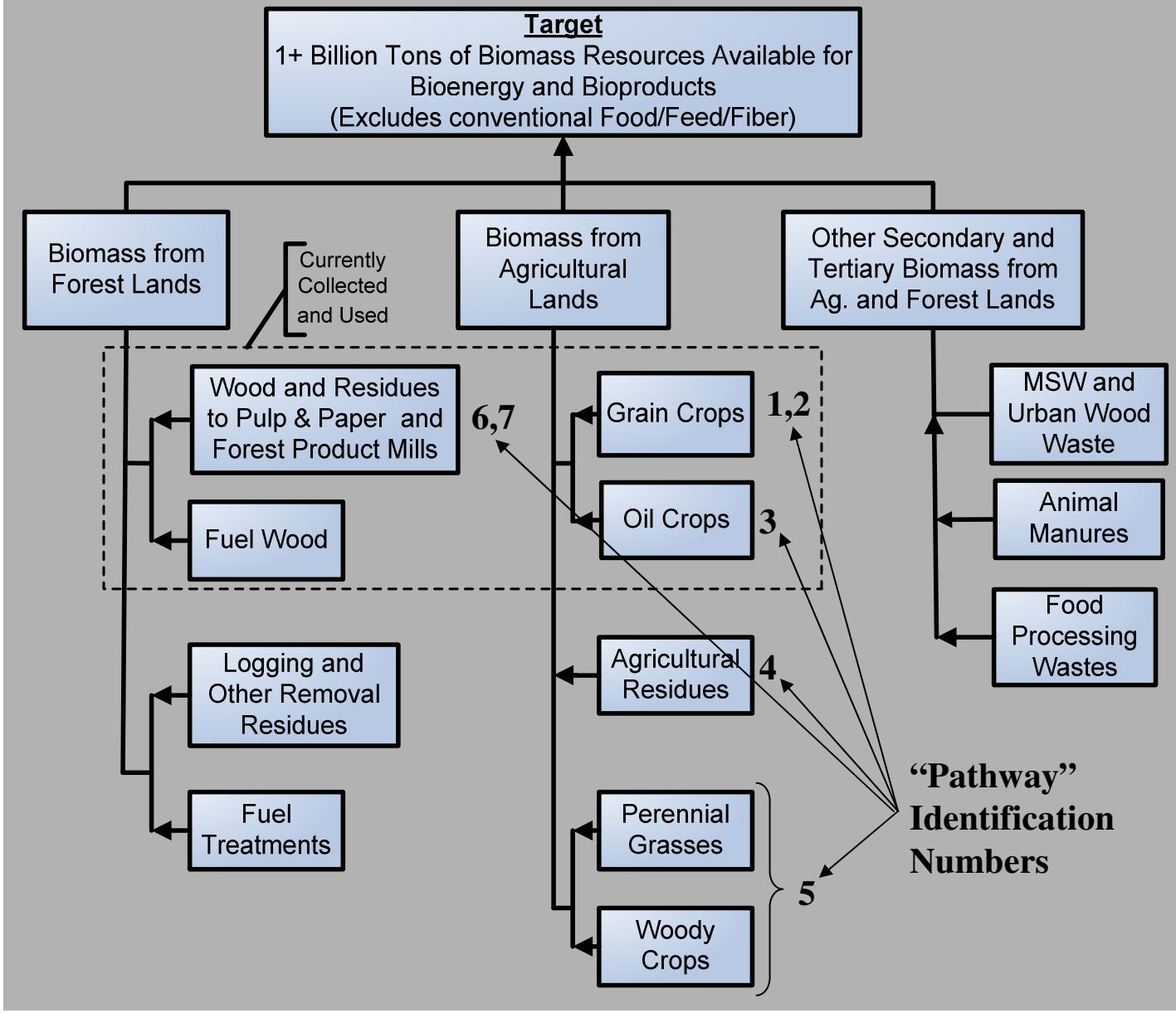
Source: Björheden

Requires efficient integration

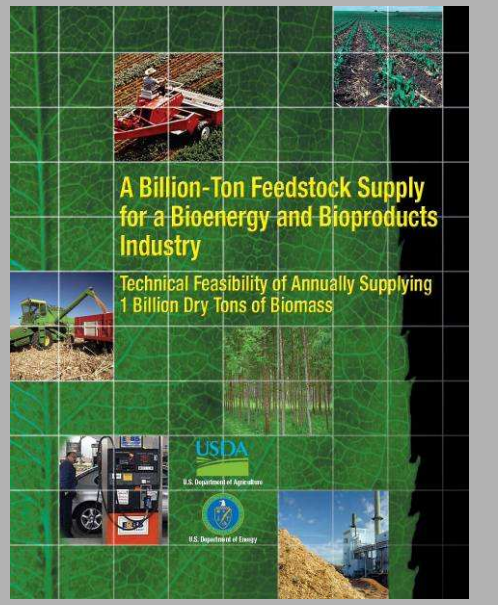


E.Alakangas

Pathway Link to Resource Base

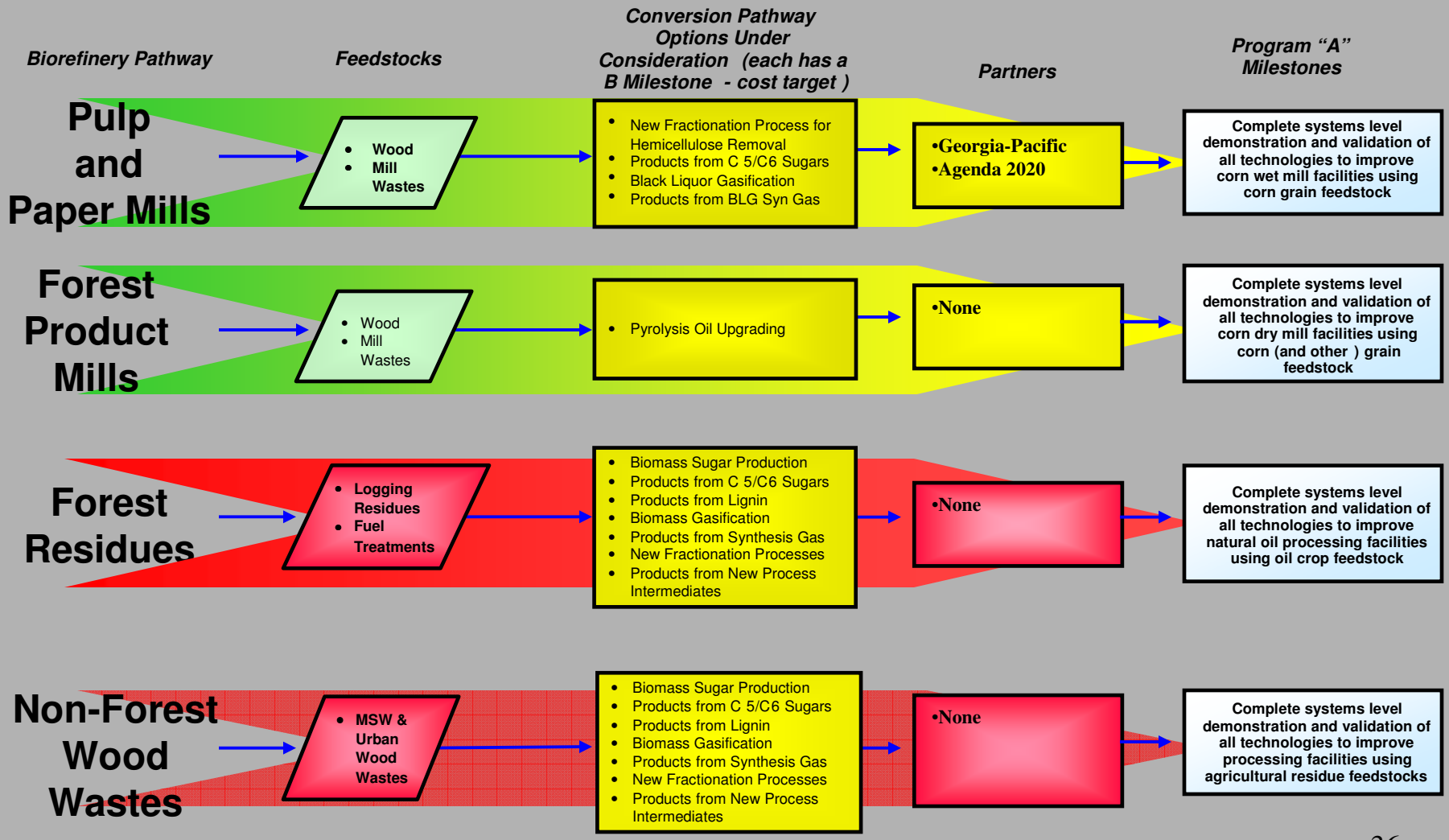


DOE/USDA Billion Ton Vision Paper



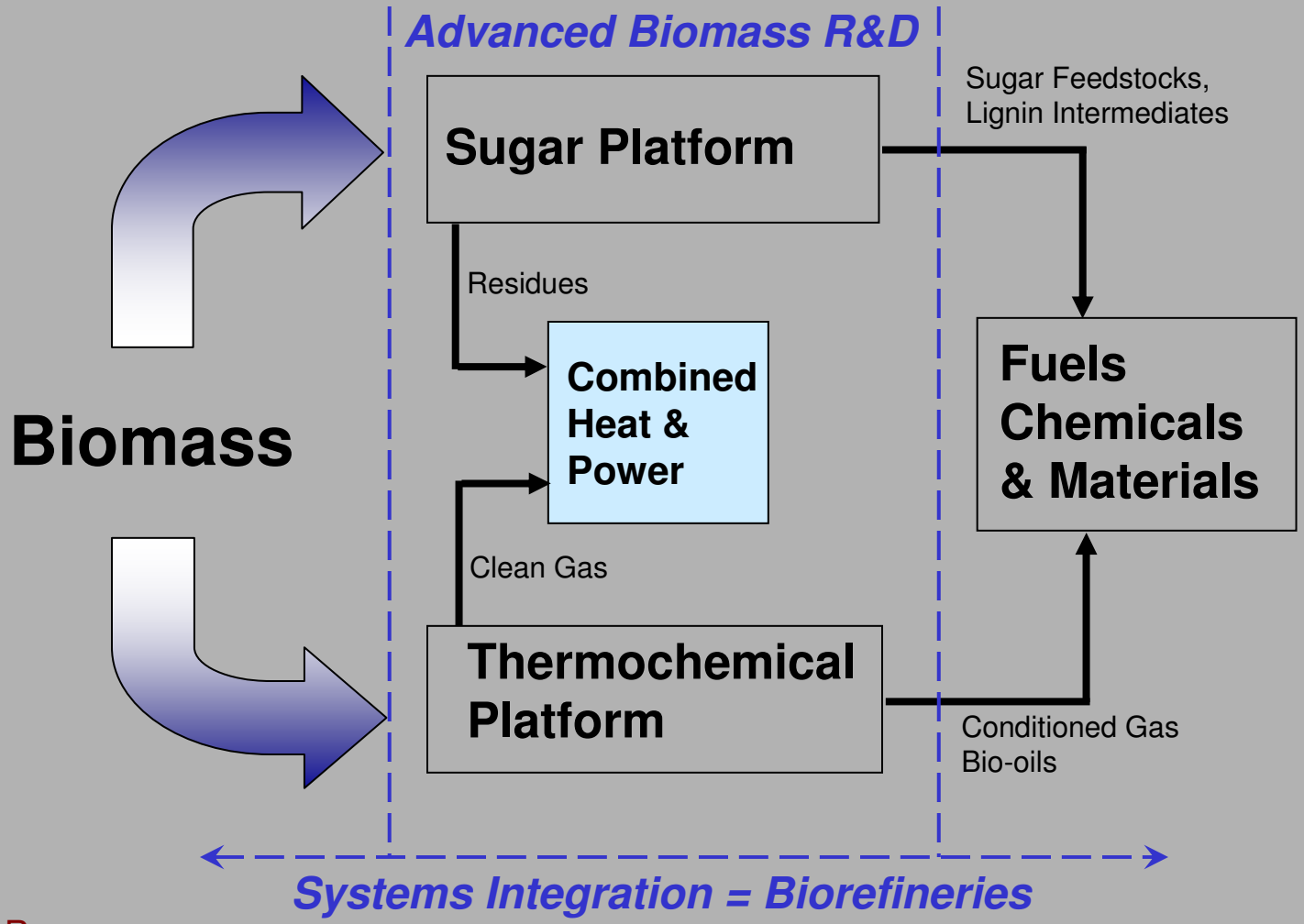
Source: Russo

Forest Sector Biorefinery Pathways



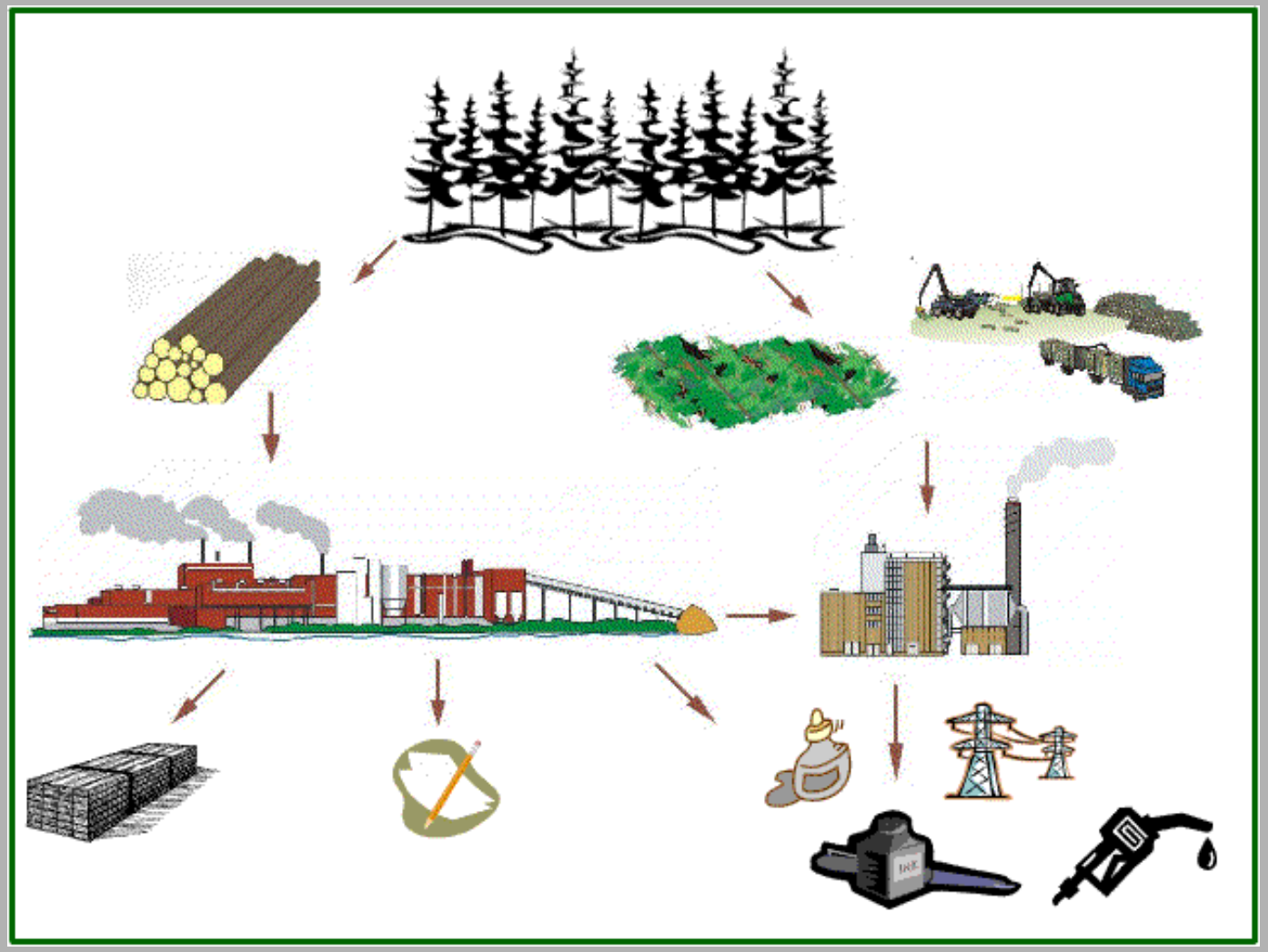
Source: Russo

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



Source: Russo

Biomass sources from forest industry



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

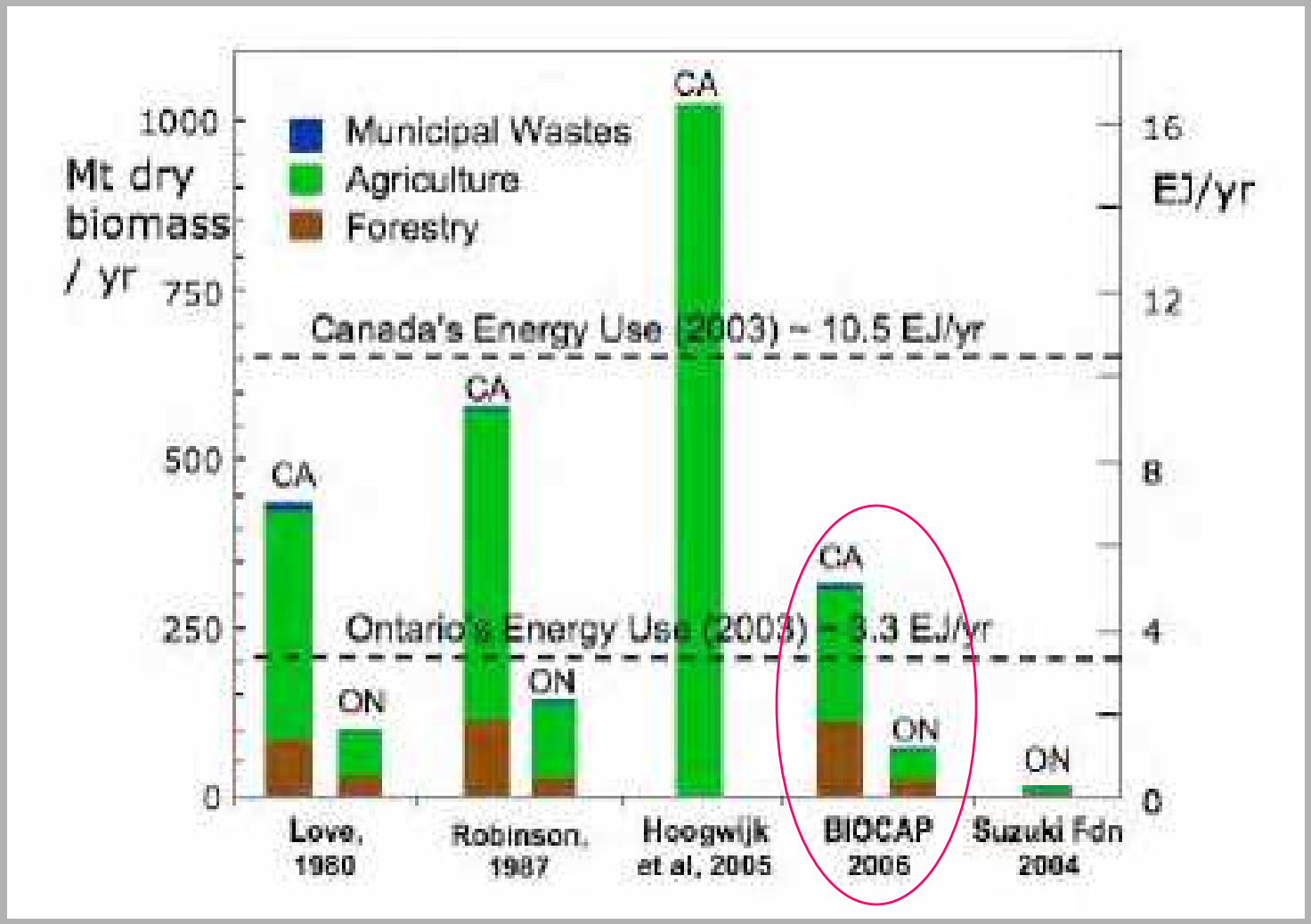
Hybrid poplar energy plantations

Estimates of sustainable bioenergy potential in Canada

Considering potential from agriculture, forests and municipal sources

Map of Canadian forest cover

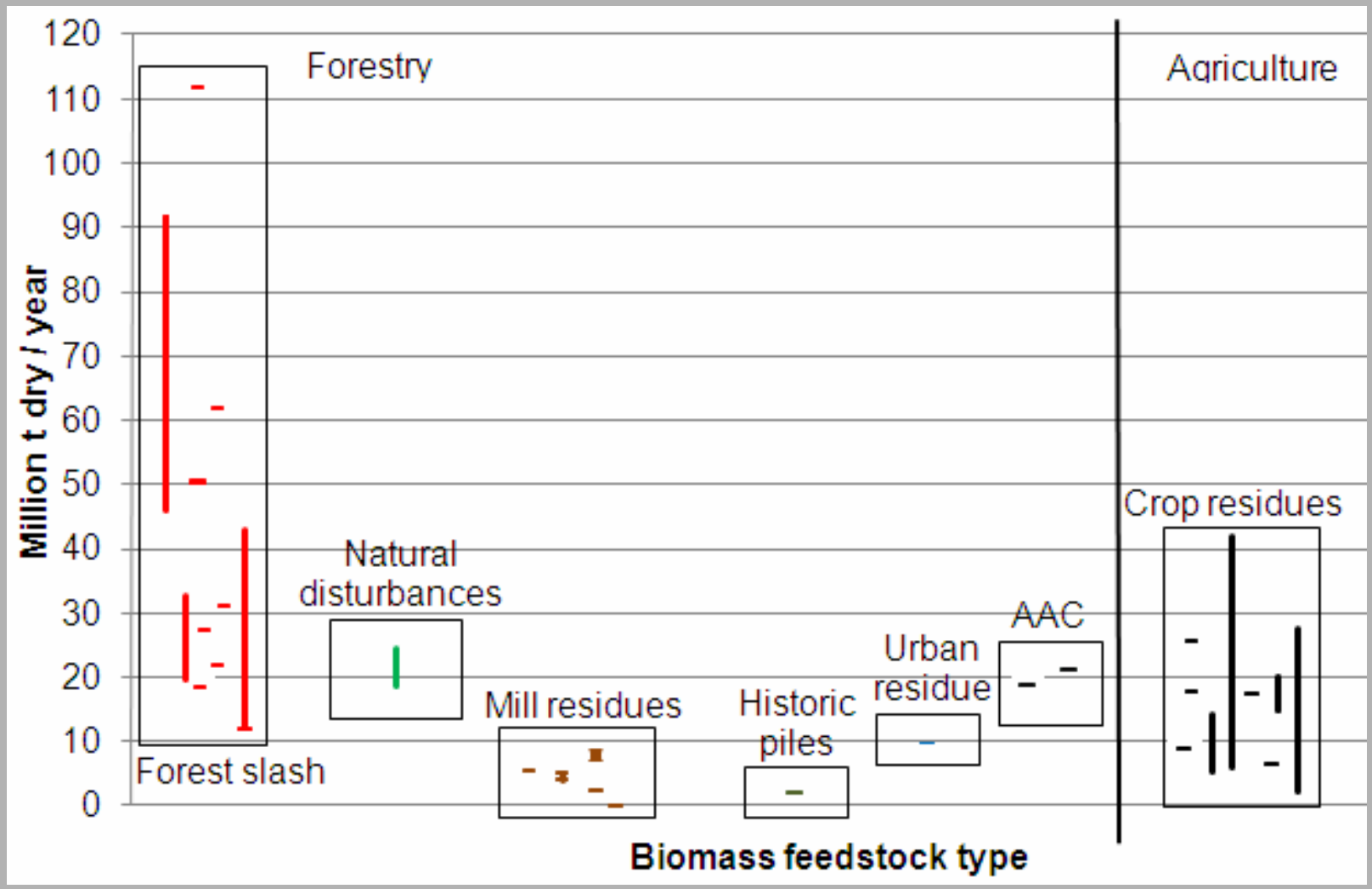
Estimates of sustainable bioenergy potential in Canada and Ontario compared with total energy demand



Source: Layzell et al., 2006

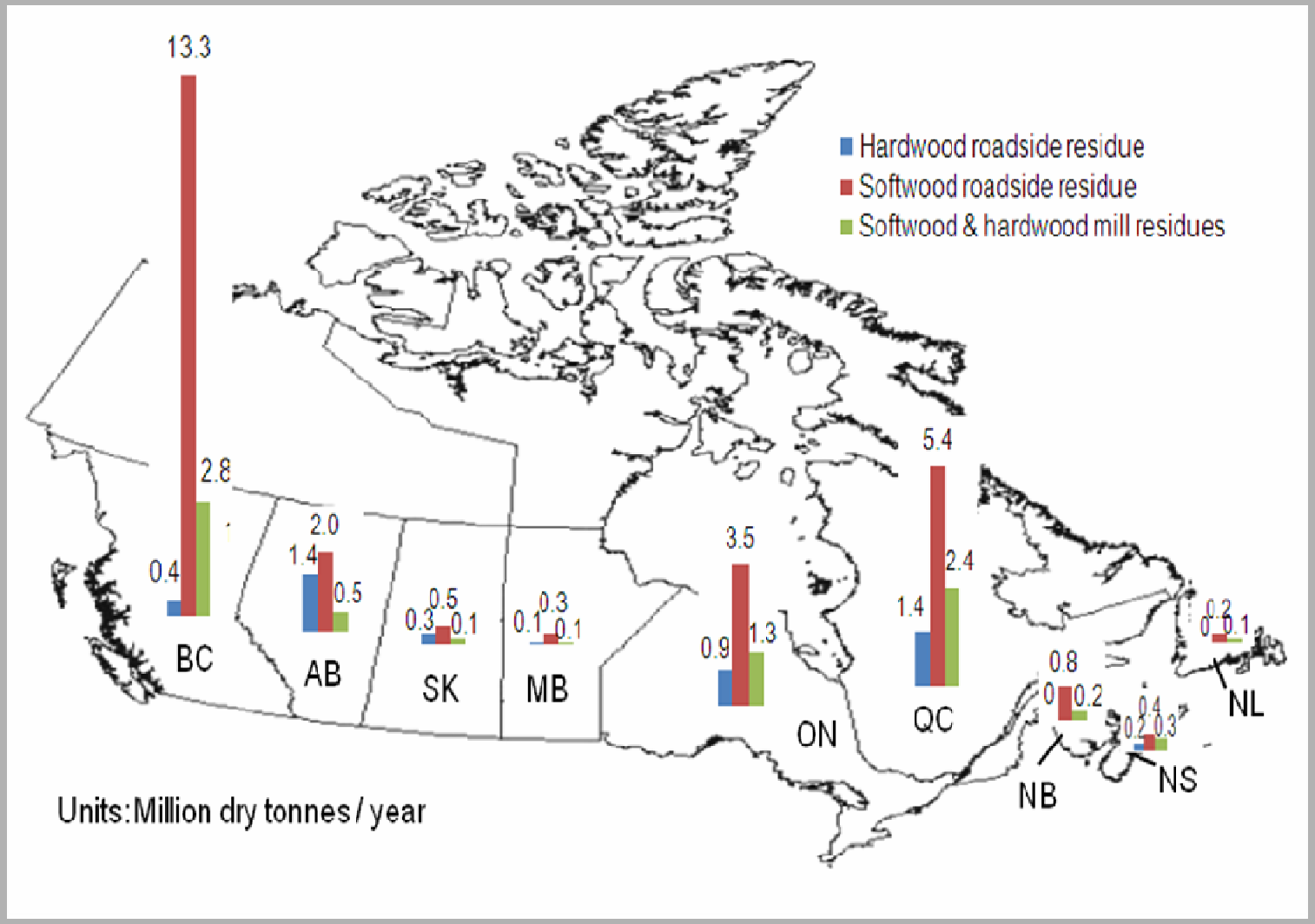
E = exa = 10^{18}

Canadian biomass inventories (n=12) of forest and agricultural biomass sources



Source: Smith, Ralevic & Lattimore, 2009

Provincial forest harvesting roadside residues



Source: Smith, Ralevic & Lattimore, 2009

What might enable deployment of bioenergy production systems using forest fuels in North America?

- Sustainable high rates of biomass productivity
- Competitive biomass procurement and transportation systems
- Competitive cost of capitalization

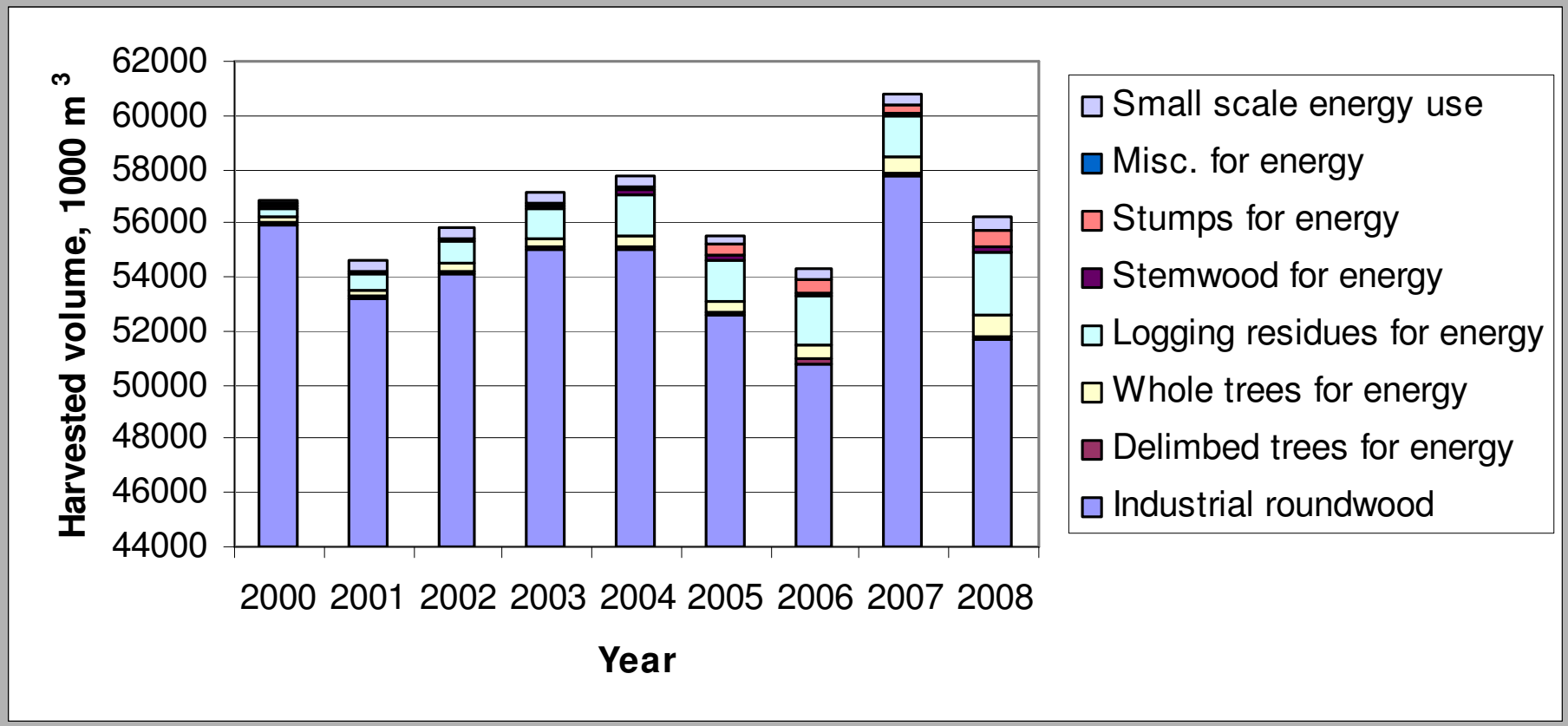
Local factors may differ…

e.g. forest growth rates, production costs, skilled labor, affordable capital, efficient equipment

Operational Research challenges

- **Local analysis of fuel assortments and their distribution** to customers with varying demands
- Development of **new supply structures** (e.g. the use of terminals and their location)
- Optimizing the **use of machinery** depending on different productivities and varying environmental demands and conditions
- Optimizing supply depending on **environmental restrictions** – possibility to find consensus for biomass utilization
- Optimizing fuel supply to **limit competition** for fuel resources
- Optimization of forest resources and how they can be grown to **optimize the use of forest biomass**
- **Land use planning** (optimal use of scarce space to grow e.g. forests, SRC, SRF and agricultural crops)

OR challenges:
Fluctuating annual harvest



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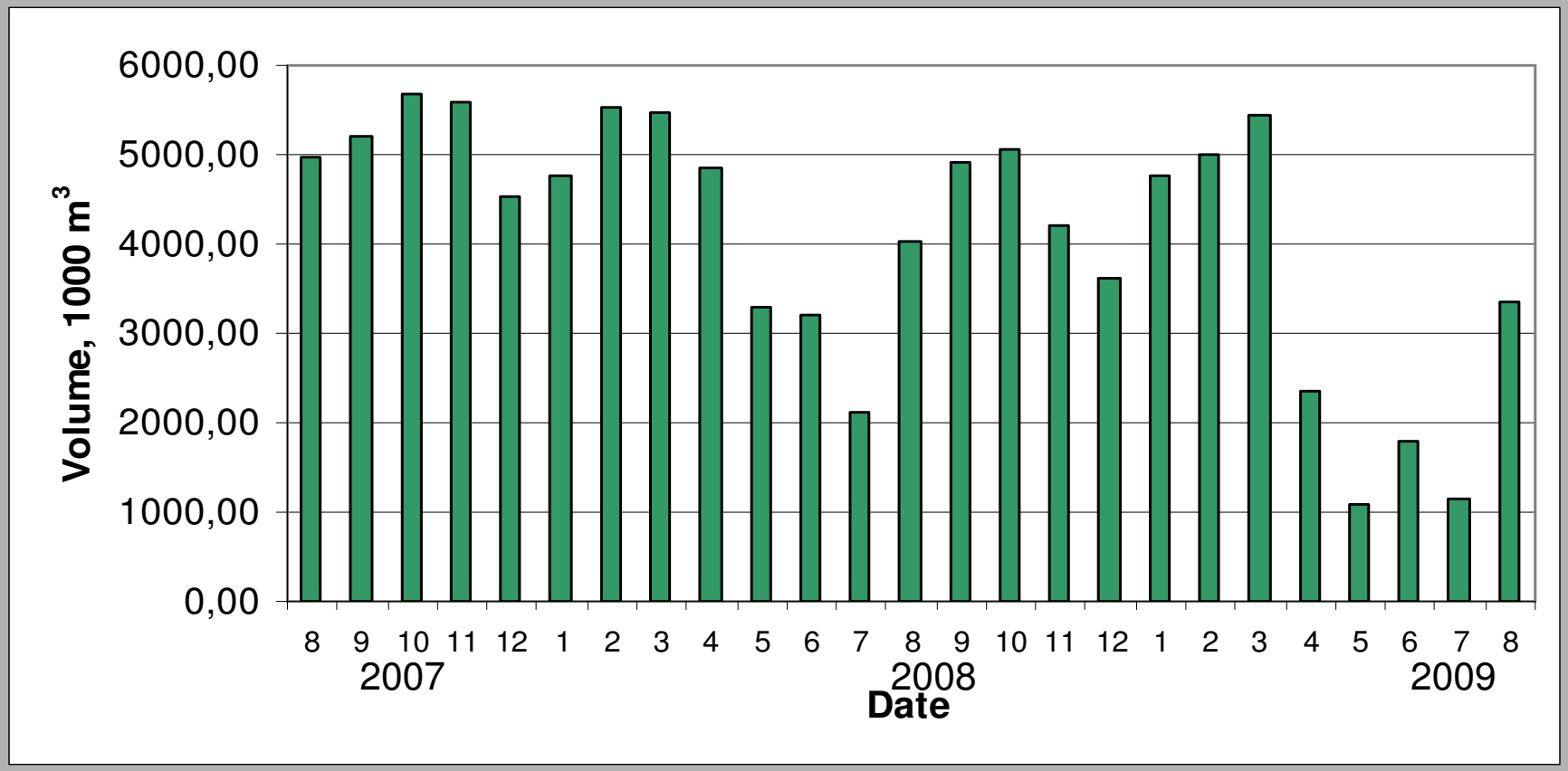
OR challenges:

Even larger monthly variation



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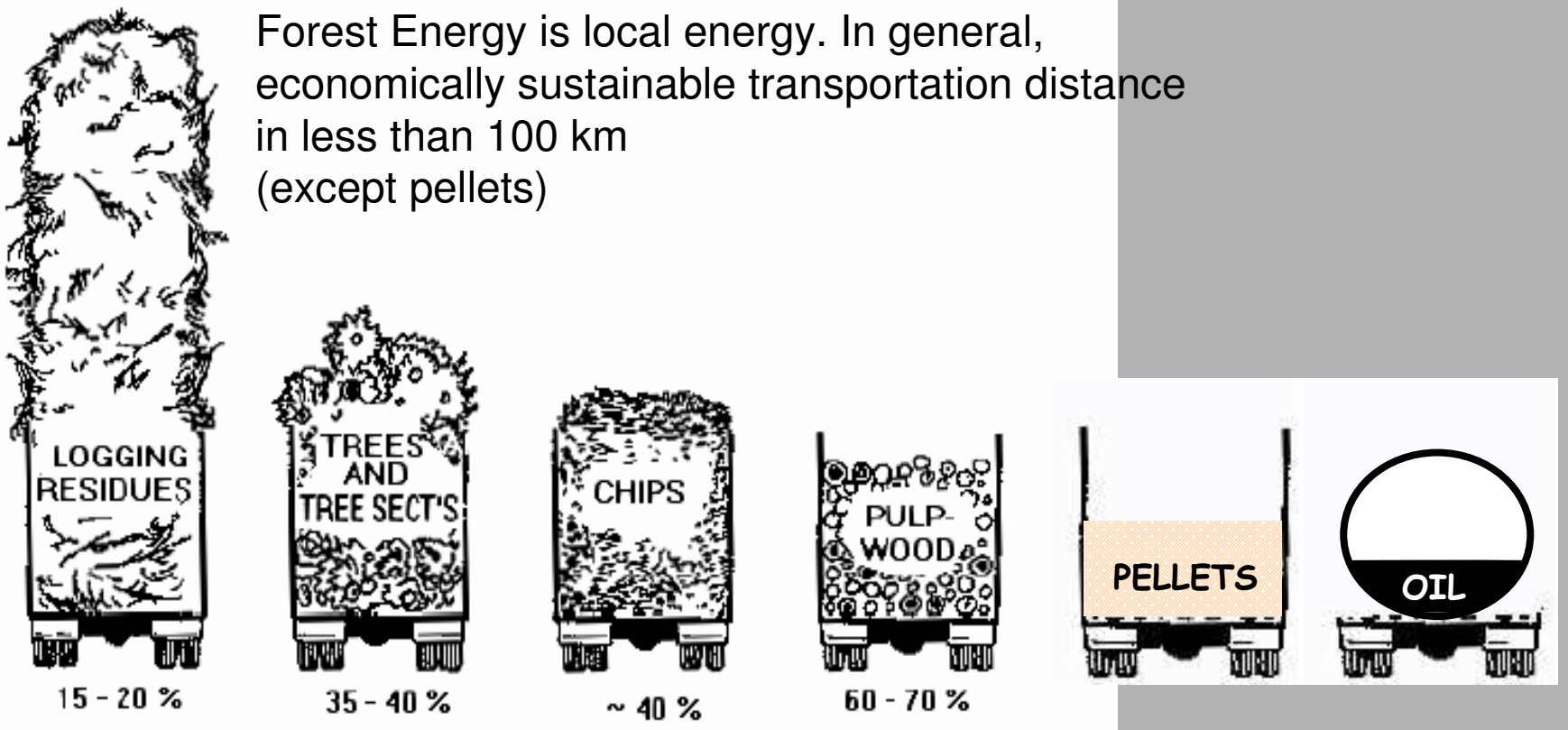
Transportation of woodfuel fractions

Forest Energy is local energy. In general, economically sustainable transportation distance in less than 100 km
(except pellets)

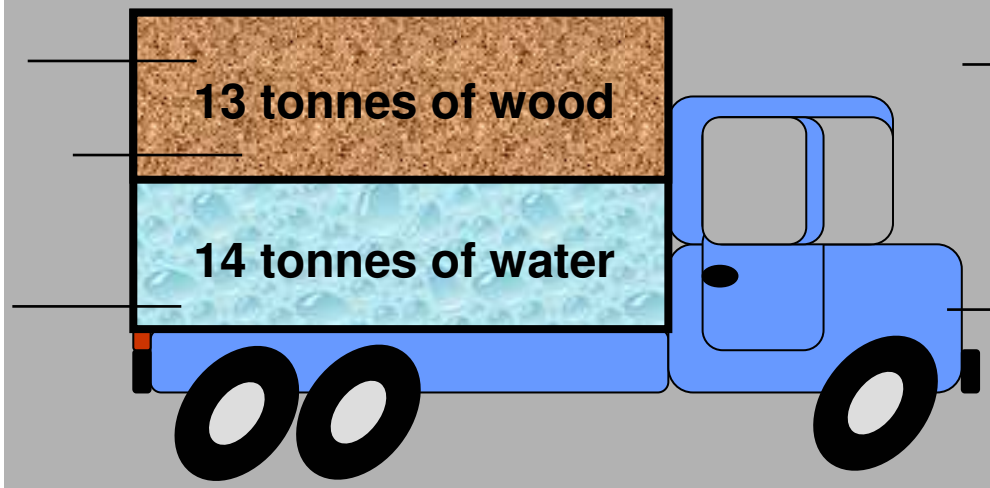


Proportion of solids in forest fuels. All loads have the same solid content. (Modified after Nilsson 1983).

Moisture content in long distance transportation

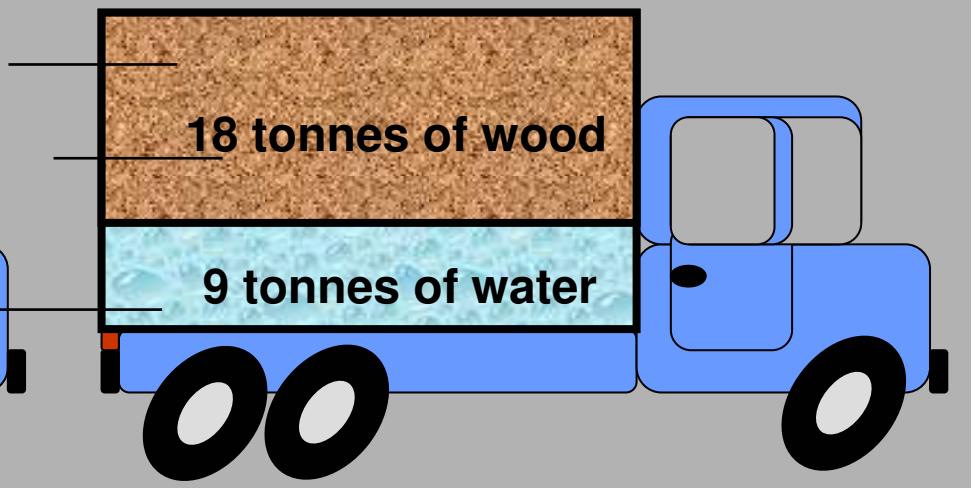
27 tonnes Brittish chip lorry
70 £ per hour, 2 hours per roundtrip

Moisture content > 50%



32 m^3
850 kg/m^3
71 MWh
CAN$ 4.2 / MWh

Moisture content ~30%



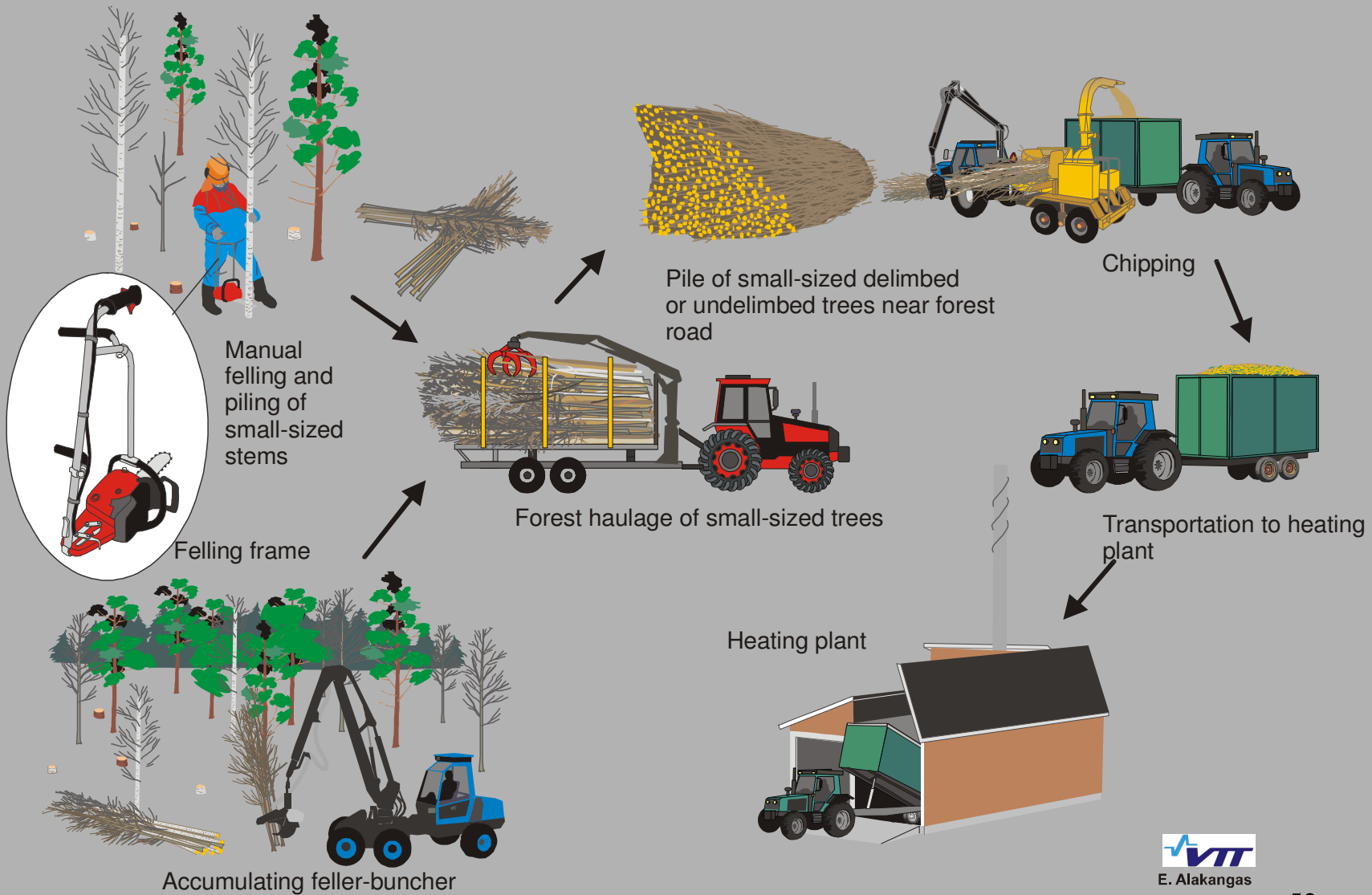
45 m^3
600 kg/m^3
108 MWh
CAN$ 2.25 / MWh

Fuel quality improvements through

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

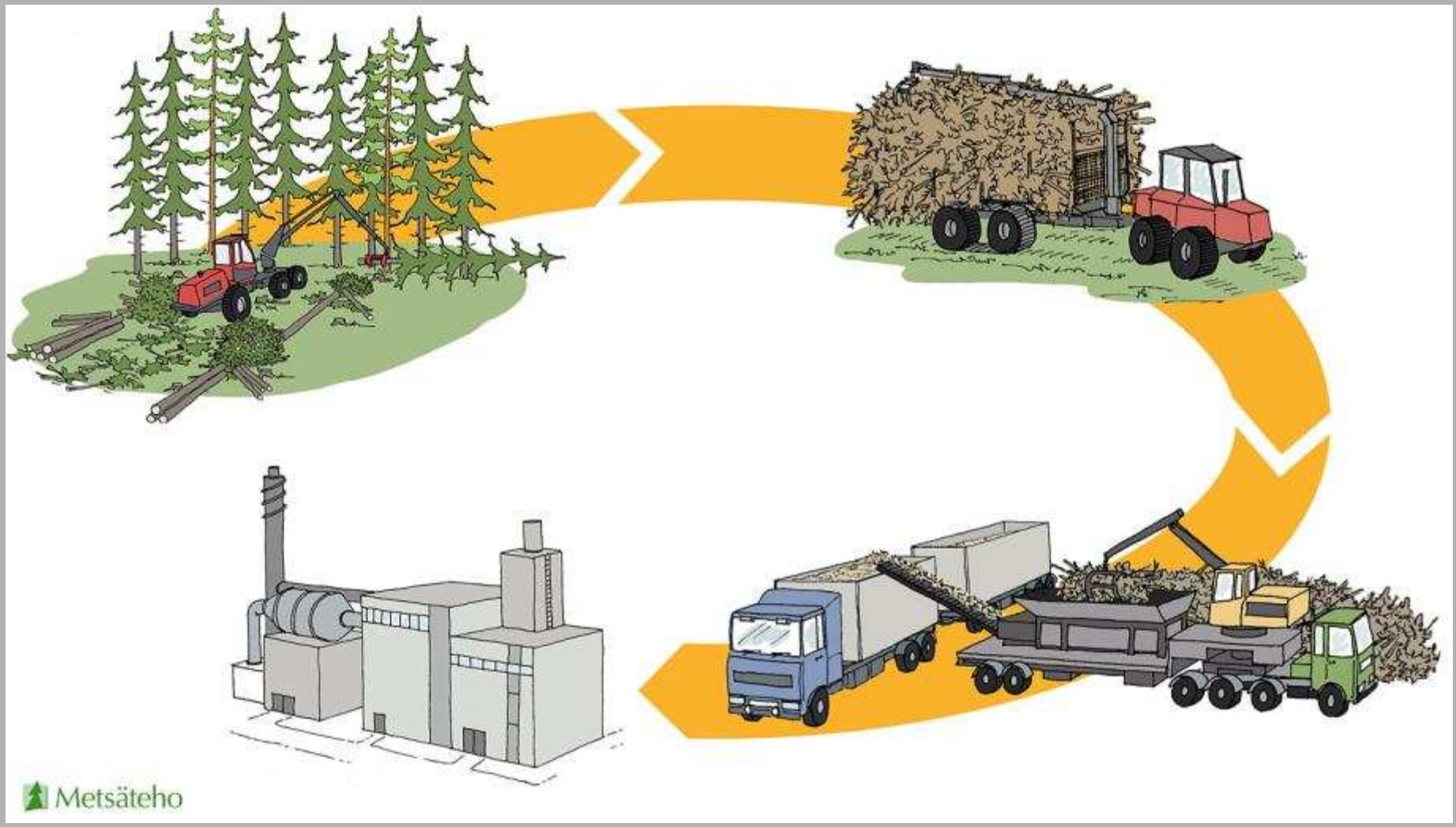
Optimized supply chains:
Small scale systems in Central Europe

Biomass from Thinnings

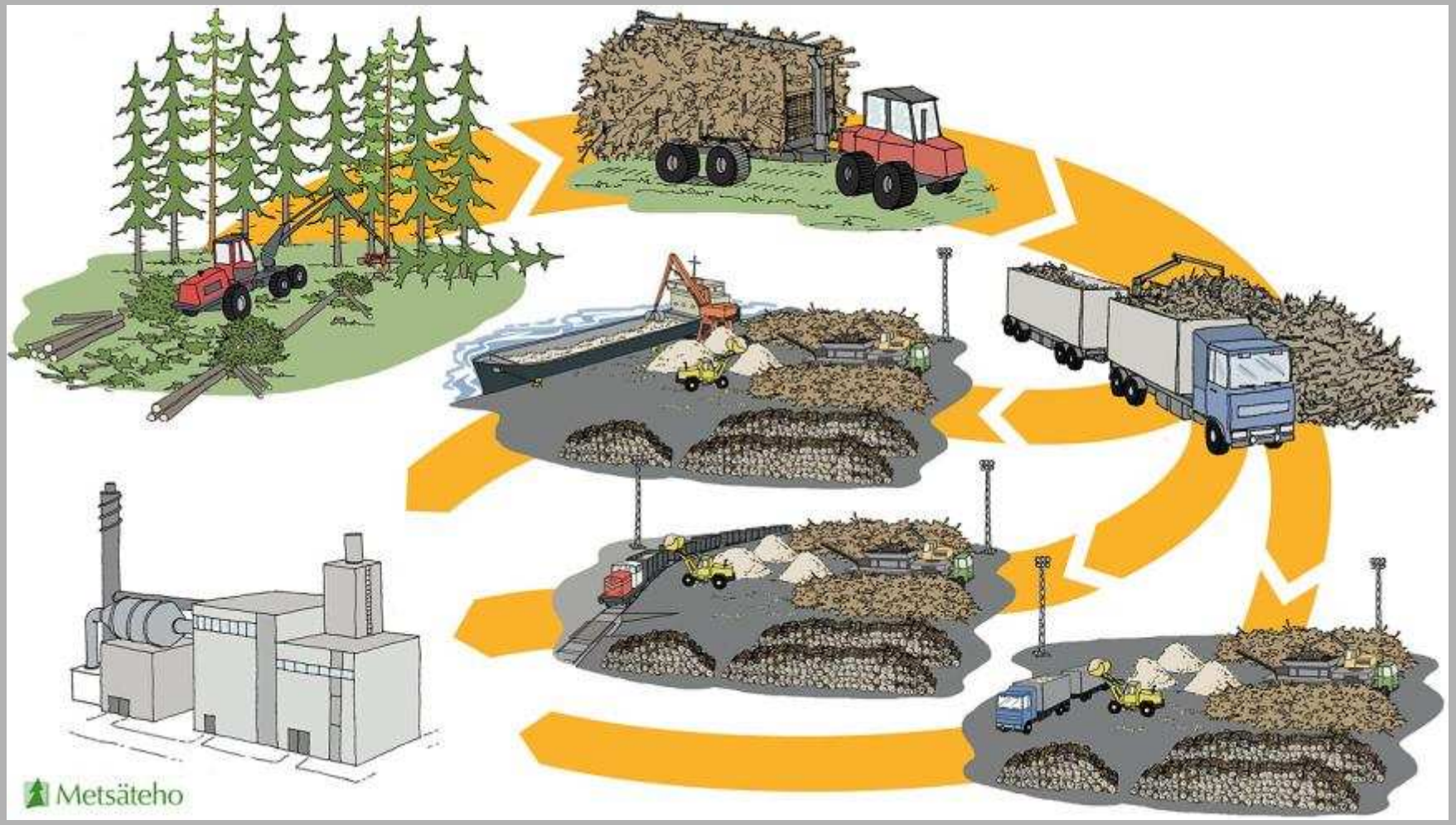


E. Alakangas

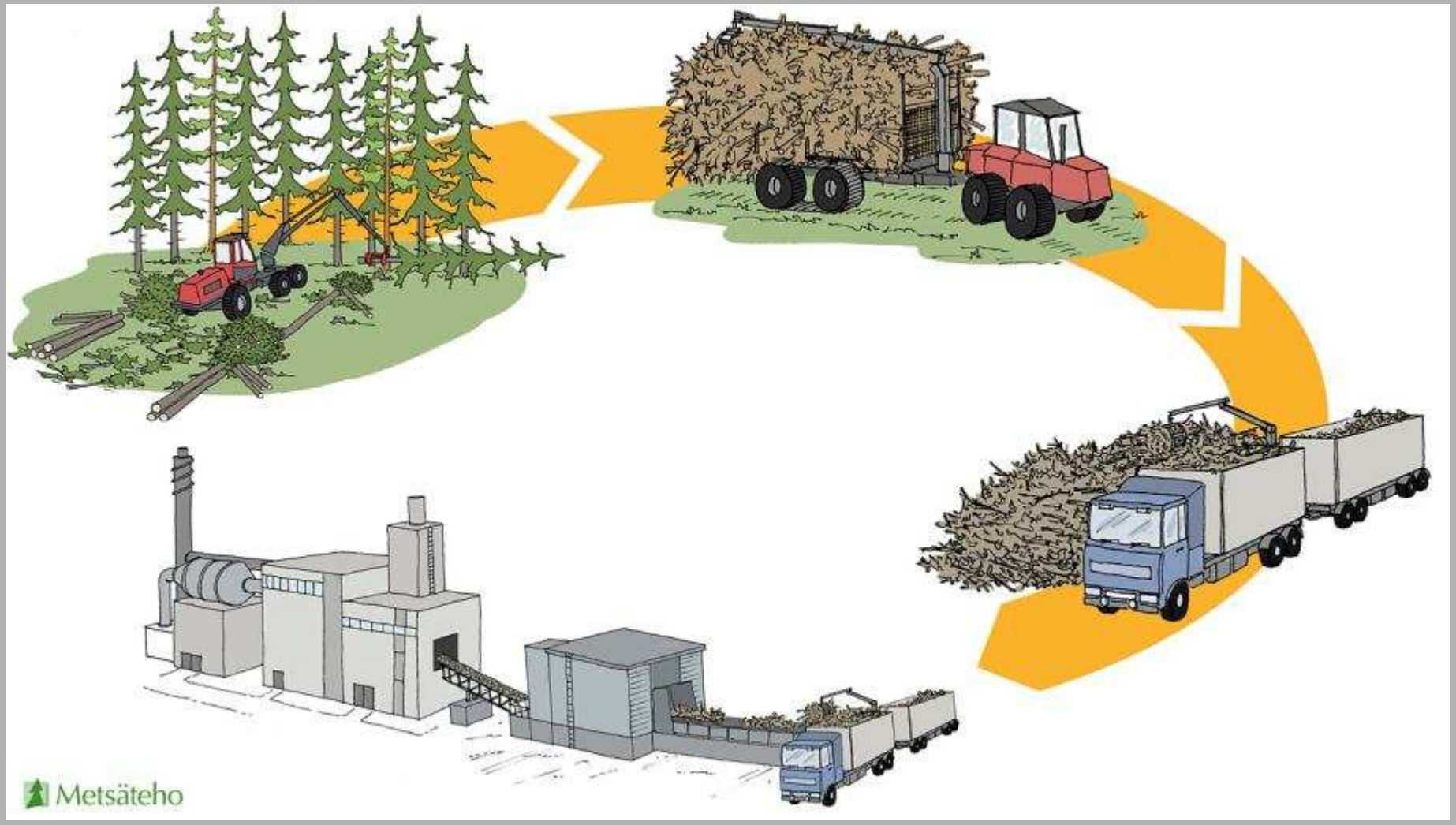
Logging residue (roadside chipping)



Logging residue (terminal chipping)

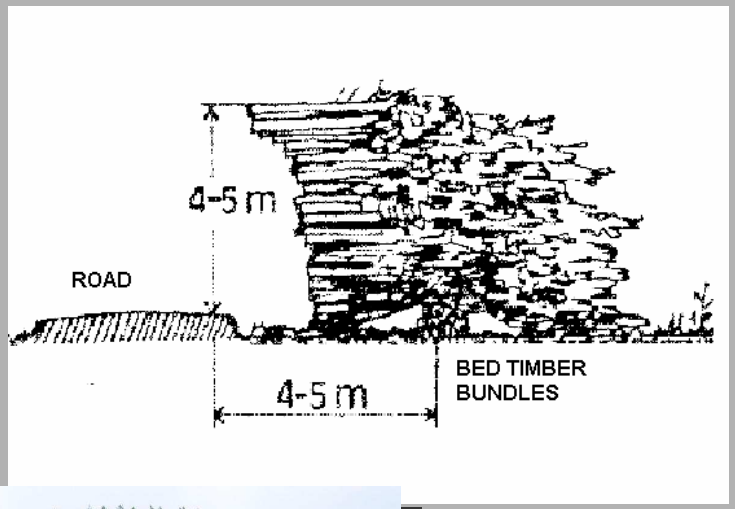


Logging residue (chipping at plant)



Fuel quality improvements through

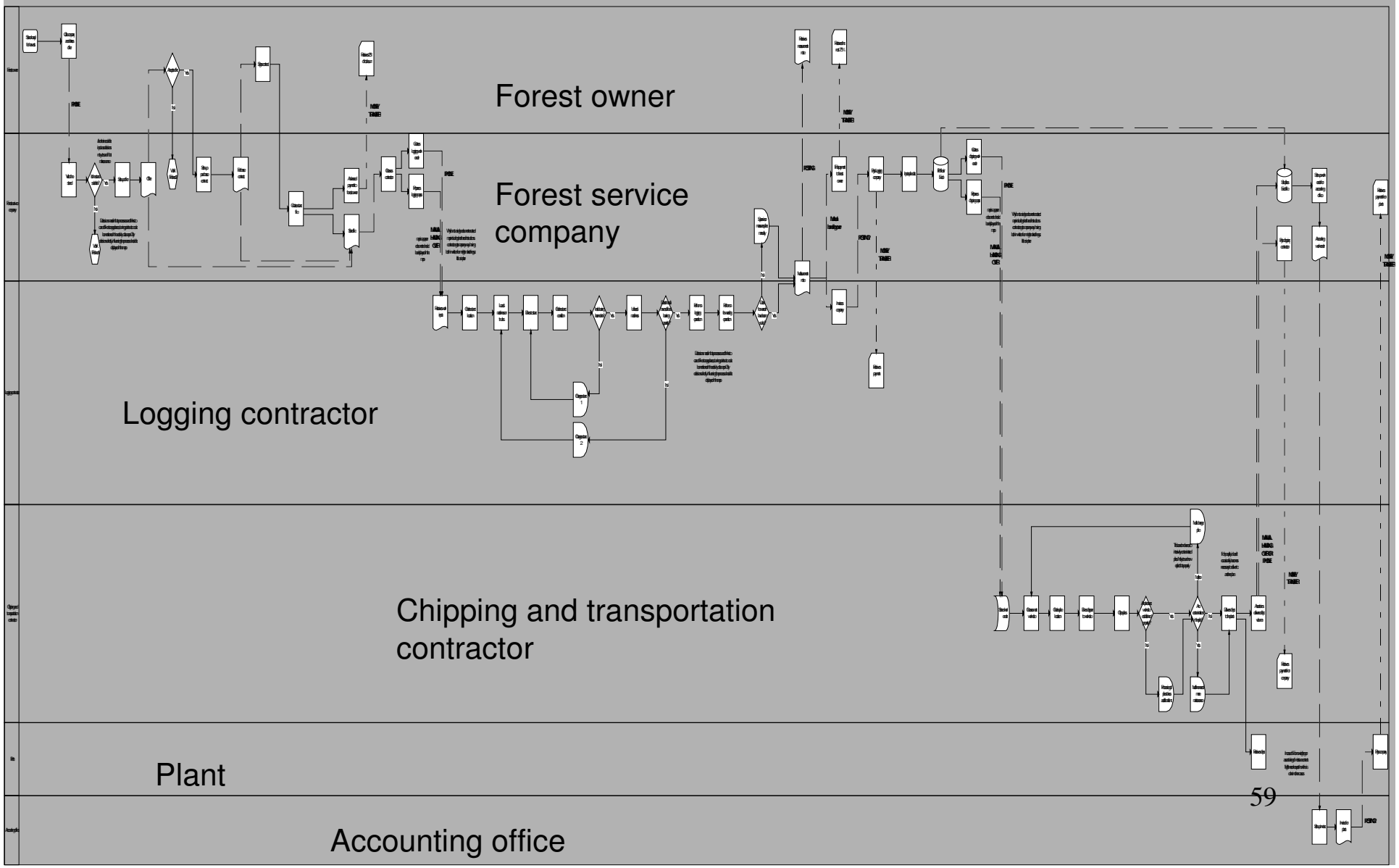
- Optimized supply chain
- Optimized storage methods/management
- Right material to the right customer



Fuel quality improvements through

- Optimized supply chain
- Optimized storage management/methods
- Right material to the right customer

Optimized storage mgmt: Process mapping



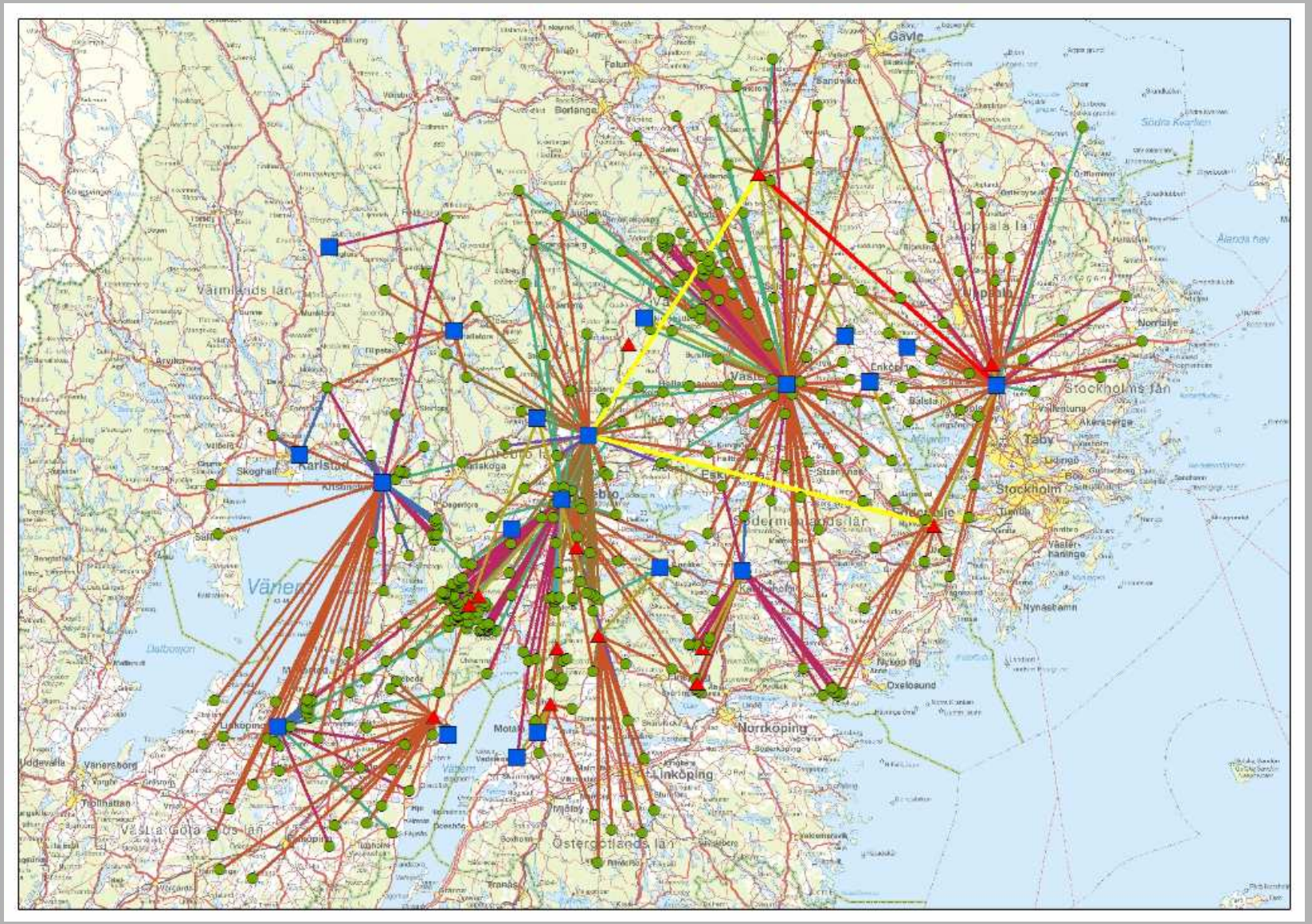
Supply chain analysis

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**

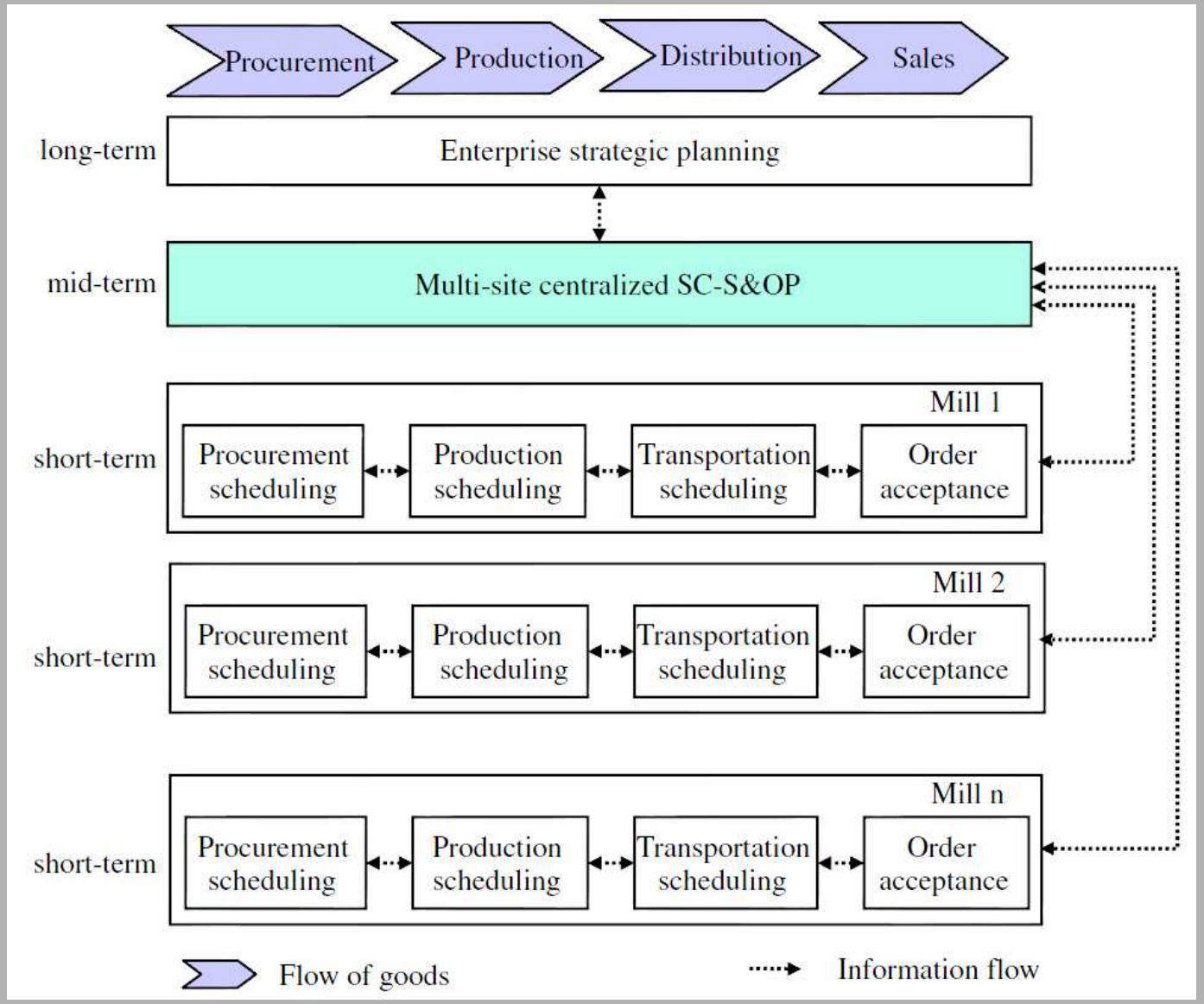
- Total cost of the supply system

All flows of assortments – Swedish case



Source: Filsberg et al. 2010

Supply chain planning matrix



Source: Feng et al. 2008

Opportunities for collaboration

International networks

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

- **IEA Bioenergy Task 31 and new Task 43 --**
  Biomass Feedstocks for Energy markets
  www.ieabioenergytask31.org
- **COST Action FP0902 --** Development and harmonisation of new operational research and assessment procedures for sustainable forest biomass supply

Canadian research network (proposed)

- **FPInnovations/NSERC forest initiative**

  Value Chain Optimization Network

Opportunities for collaboration

TASK 43
Biomass Feedstocks for Energy Markets
New Task for
the New Triennium 2010-2012

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

bee
Biomass Energy Europe

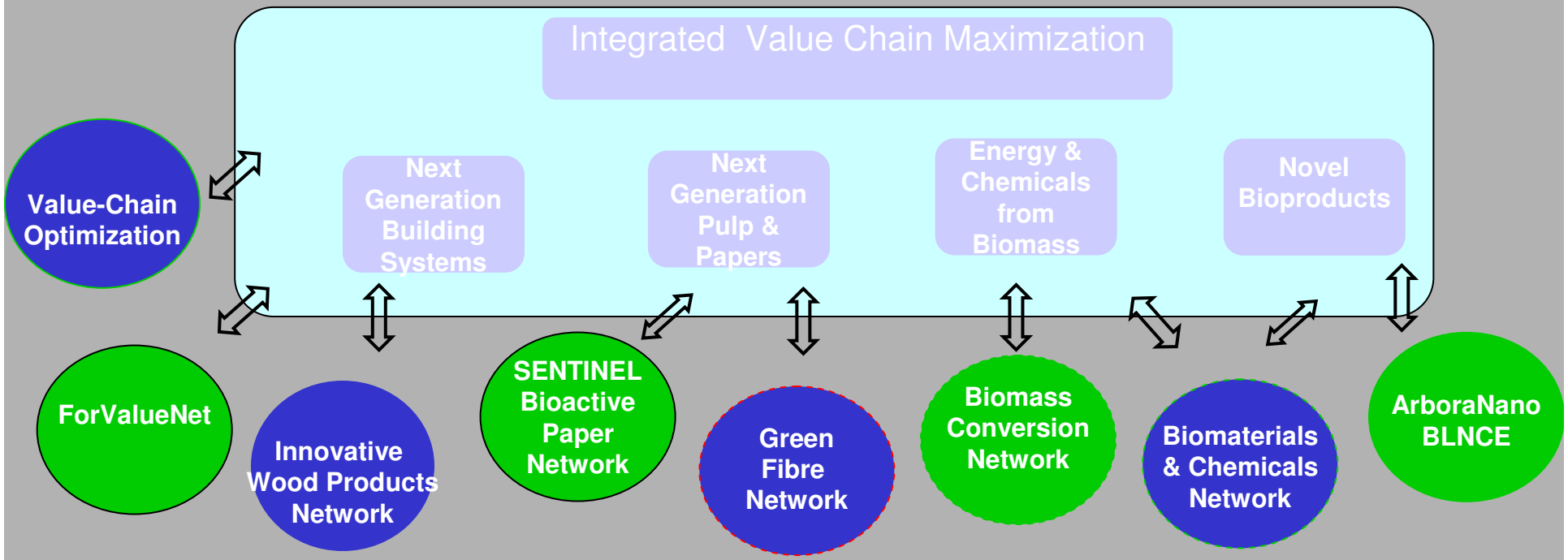
FPInnovations

EUROPEAN FOREST INSTITUTE
ATLANTIC EUROPEAN REGIONAL OFFICE - EFIATLANTIC

IUFRO
The Global Network for
Forest Science Cooperation

New networks proposed under the FPInnovations/NSERC Initiative

FPInnovations' Flagship Innovation Program



Value Chain Optimization Network

(proposed)

- Integrated Strategies for the New Forest Bioeconomy
- Integrated Value Chains
- Optimizing the Value Chains

- **Scientific Director**

  Sophie D'Amours – Université Laval

THANK YOU!

Questions?

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