What Science Can Tell Us
Challenges of Bioenergy

Based on:

Forest Bioenergy for Europe

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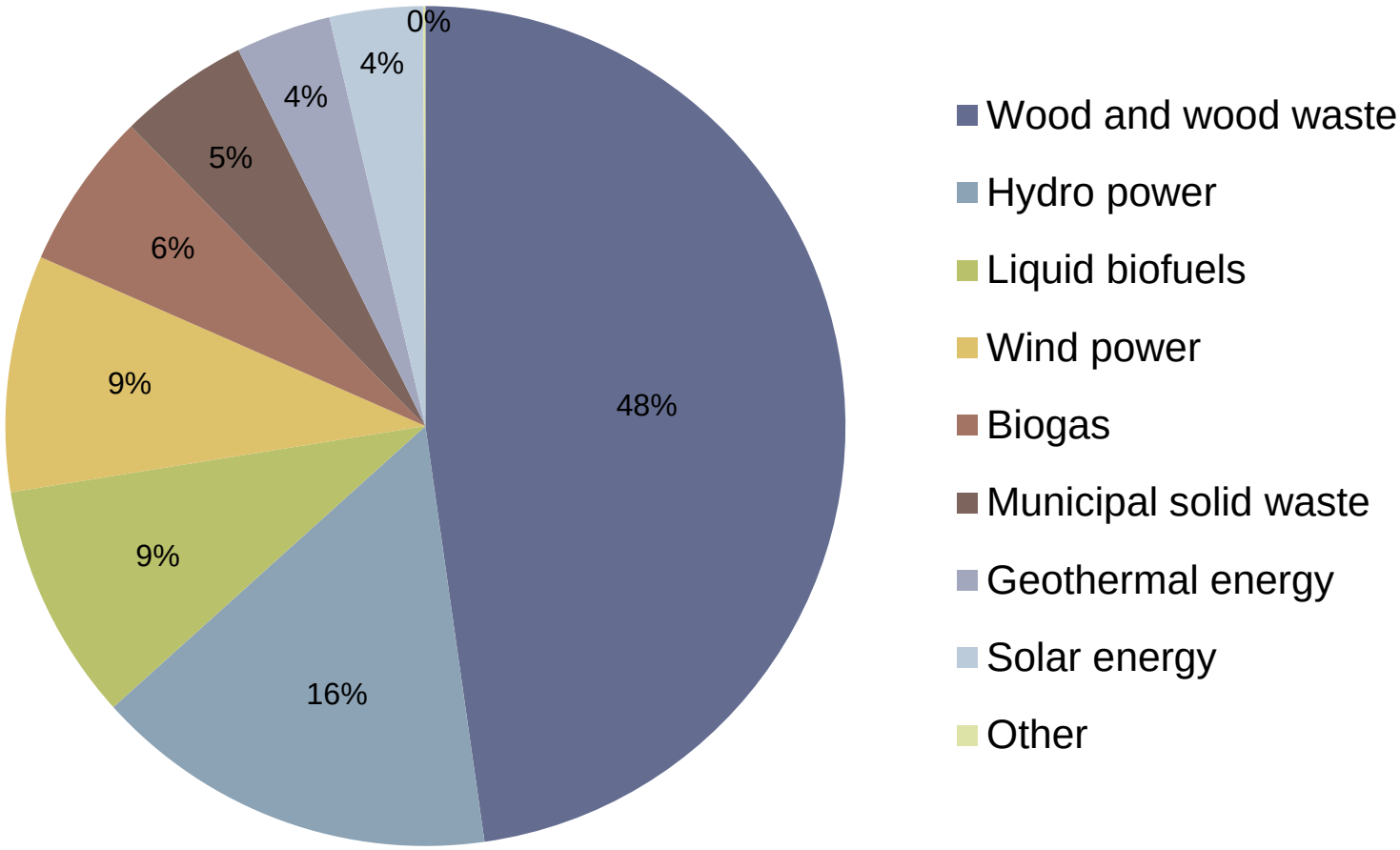
Consumption, markets and policies related to forest biomass based energy

Wood and wood wastes 48%

Share of renewable energy sources in gross inland consumption of renewable energy in the European Union, 2011. (Data source: Eurostat)



Since 2000, the consumption of wood fuels has increased over 50%

Wood from forests 49%

Wood fuels used for primary energy production by sub-category in the EU (2011)

- Wood (fuelwood from forests) 49%
- Wood waste (solid by-prod. from industry) 17%
- Black liquor (pulping industries) 15%
- Other wood and wood waste (e.g. recycled wood) 20%

* NB: The data on wood used for energy production are inconsistent in several European countries.

Bioenergy markets and policies

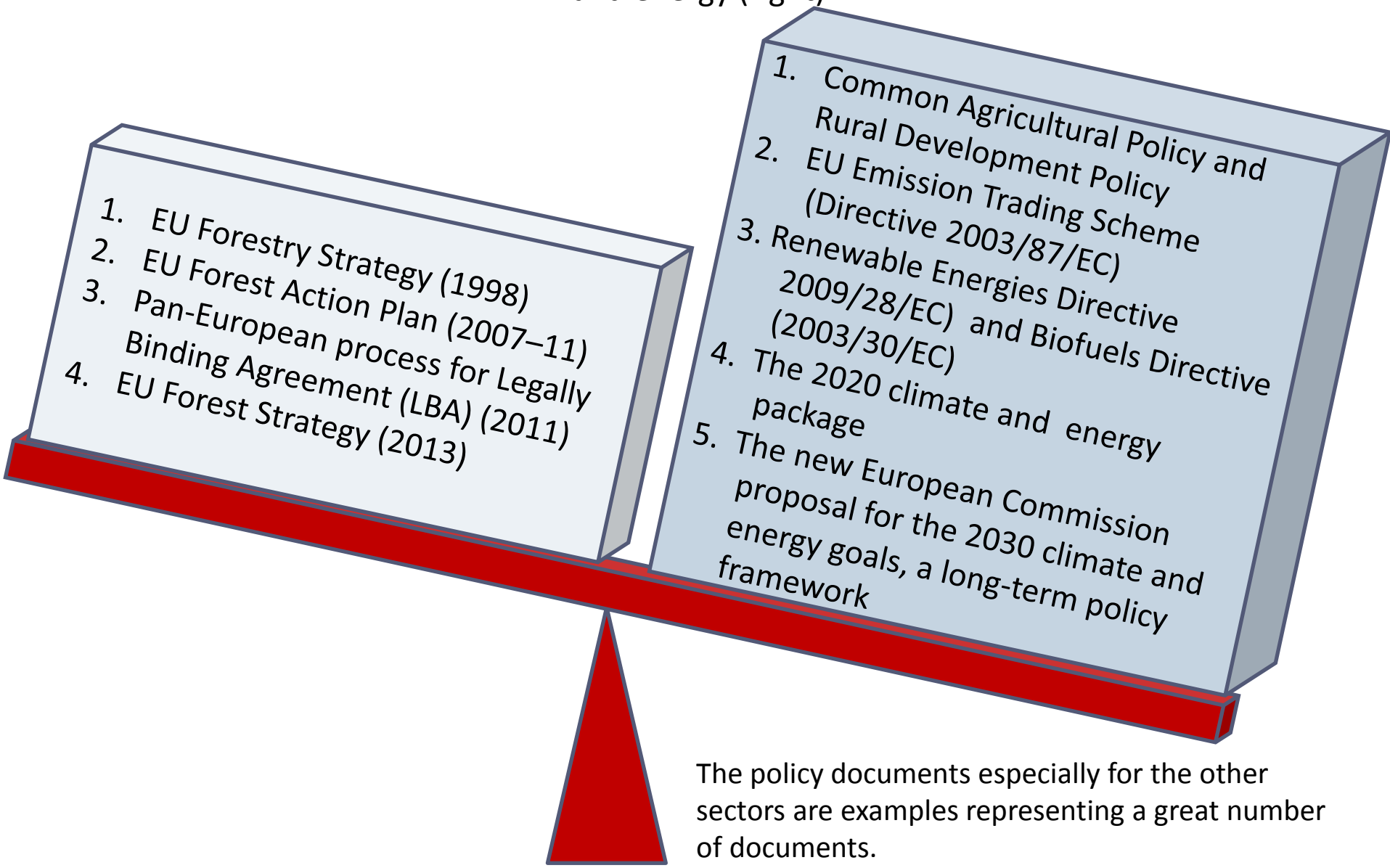
- Biomass for energy is “sleeping giant” (IEA)
  - globally the major renewable energy source
  - still great potential role in the global energy budget

- Wood represents the first renewable within the EU
  - the Renewable Energy Directive of 2009 → a basis for the growing demand of biomass
  - the new European Commission proposal for 2030 climate and energy goals (January 22, 2014)
    - promotes market driven solutions → a challenge for biomass, as well

Markets and policies form an inter-connected driving force

European policy documents

directly related to forests (left) and to other policy sectors such as agriculture, environment and energy (right)



The policy documents especially for the other sectors are examples representing a great number of documents.

The main political objectives of EU's renewable strategy

- Decreasing use of fossil energy
- Reduced CO_2 emissions
- Increased energy self sufficiency
- Attractive and environmentally friendly energies for consumers
- From a forced consumption to increasingly free will of consumers to use renewables

See: Climate and Energy Package (2009) and The New European Commission Proposal for 2030 Climate and Energy Goals (2014).

A concluding remark related to strategies and plans

The EU forest policy sensu stricto has only limited impact on the development of bioenergy from the forest, as a consequence of the EU legislative framework that is providing only quite a marginal role to the European Commission in policy design, financing and implementation.

Forest bioenergy related decision making is more defined by such policy sectors as agriculture, environment, energy and climate.

Future challenges

The review (Solberg et al. 2013) of recent studies indicates:

Increased use of energy wood is not a threat to the EU's forest industry

- Wood energy's role likely modest in achieving the EU target (20% renewables by 2020)

- An important role of the forest industry as a producer and user of wood-based energy, even regardless of
  - the possible decline in consumption and production of some end products
  - decreasing production of pulp (an important generator of bioenergy)

- A major share of the woody energy biomass will consists of
  - bark, sawdust and black liquor
  - logging residues and stumps

EUwood study's (2010) medium scenario suggests a gap of 316 million cubic meters in 2030

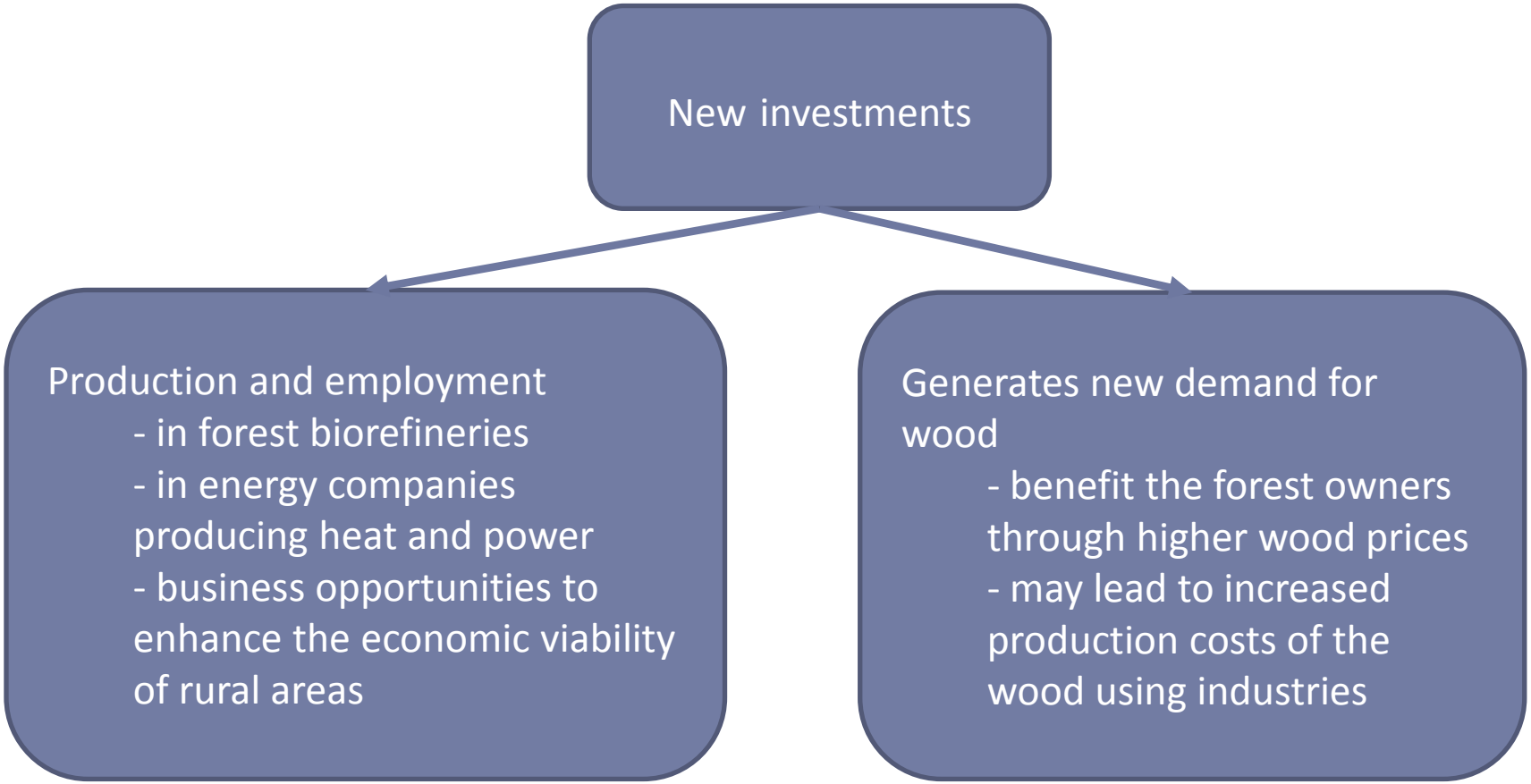
- The study is based on the past decades' trend
- Scarcity of wood could lead to
  - fierce competition between buyers
  - significant loss of forest biodiversity

Counterargument: Studies based on economic theory and market models project the demand for wood biomass to be significantly lower in the EU, due to

1. the structural changes in global and EU forest products markets
2. the impacts of international trade in forest biomass (which trend extrapolation does not take into consideration)
3. forest biomass markets and production of bioenergy and forest industry products react to prices of raw materials and end products

The growing stock in the EU of about 150 m^3/ha is increasing, since annual removals 420 million m^3 (without bark) are far less than the total annual wood increment of 700 million m^3 (without bark)

Consequences of forest bioenergy production



If these consequences are caused by policies rather than markets, they may cause unwanted indirect effects like inefficiencies and distorted markets.

Many opportunities of conversion technologies

Conversion of forest biomass

- Biomass is delivered in various physical forms and moisture content (heterogeneity)
- Converted into many energy commodities such as heat, power or transport fuels
- A great number of diverse technologies
  - varying costs, conversion efficiencies, capacities or emissions, for example
- The technology depends greatly on the local conditions such as infrastructure, feedstock accessibility, use of other energies and prices or policies

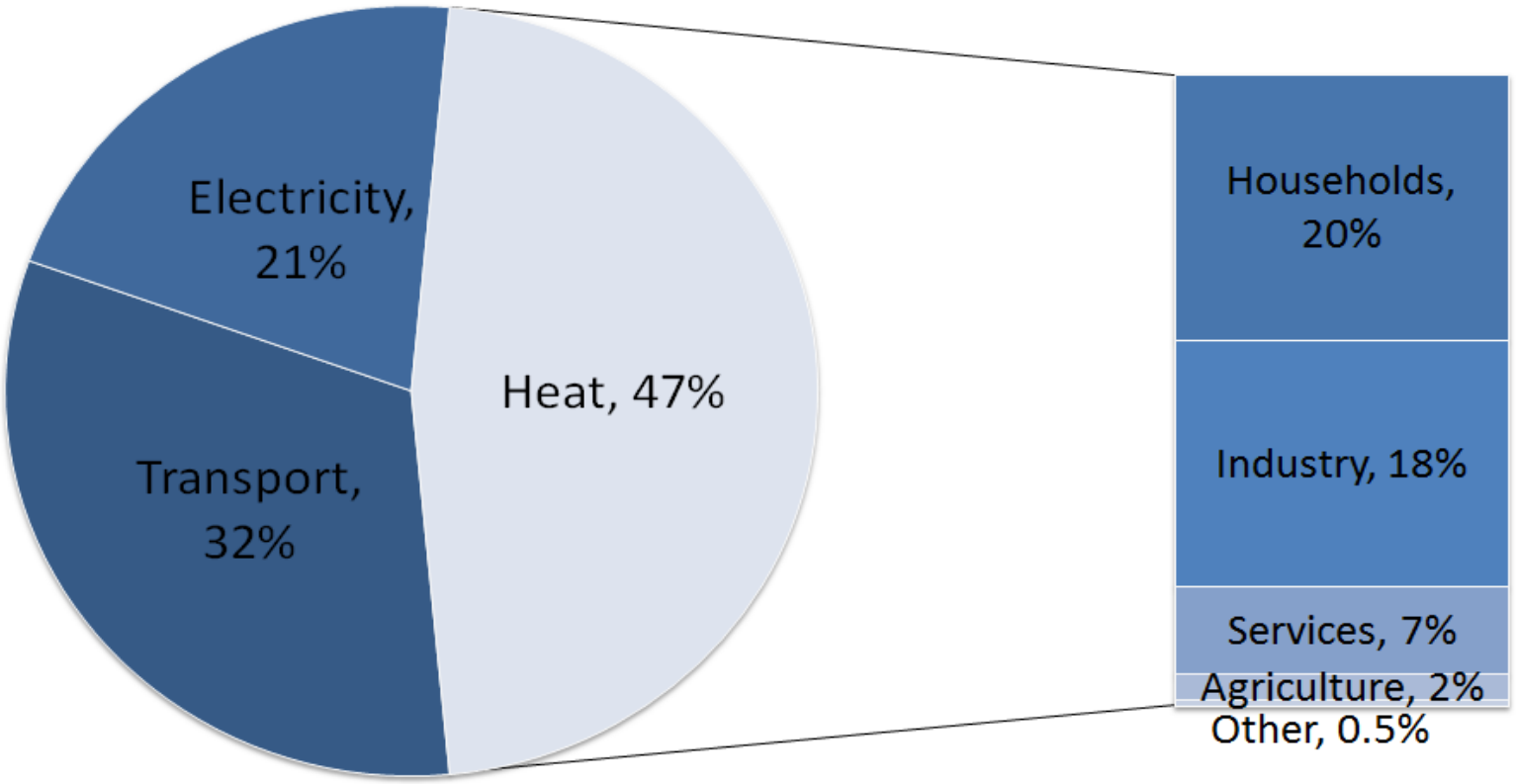
Energy efficiency according to the North American sources (EROEI, Energy Return on Energy Invested)

Energy Return/Energy Invested

– Liquid fuels	
• Conventional oil	15–25
• Ethanol from sugarcane	9
• Biodiesel from soybean	6
• Tar sands	5
– Electricity	
• Hydro power	> 40
• Natural gas	7
– Solid fuels for heat	
• Coal	40–80
• Fire wood, chips	30

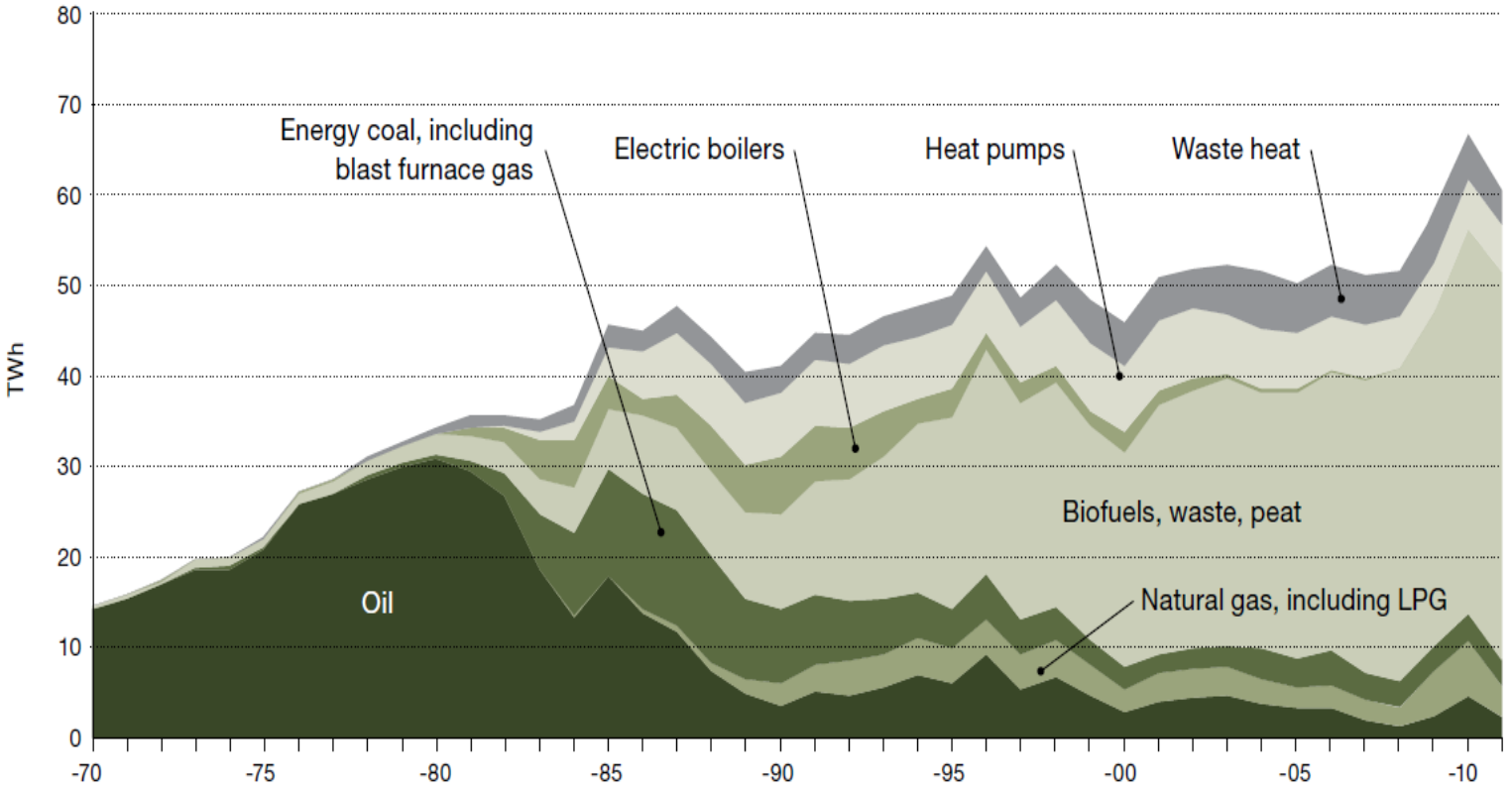
Sources: Inman, M. 2013. The True Cost of Fossil Fuels. Scientific American 308, 58 – 61. Hall, C.A.S. and Day J.W. 2009. Revisiting the Limits to Growth After Peak Oil. American Scientist, Vol. 97, No 3.

Final energy use in EU-27 in 2010 by type of energy and final energy use for heat by individual sector



Source: European Technology Platform on Renewable Heating and Cooling

An example of the development: the use of the energy sources for district heating in Sweden between the years 1970 and 2011

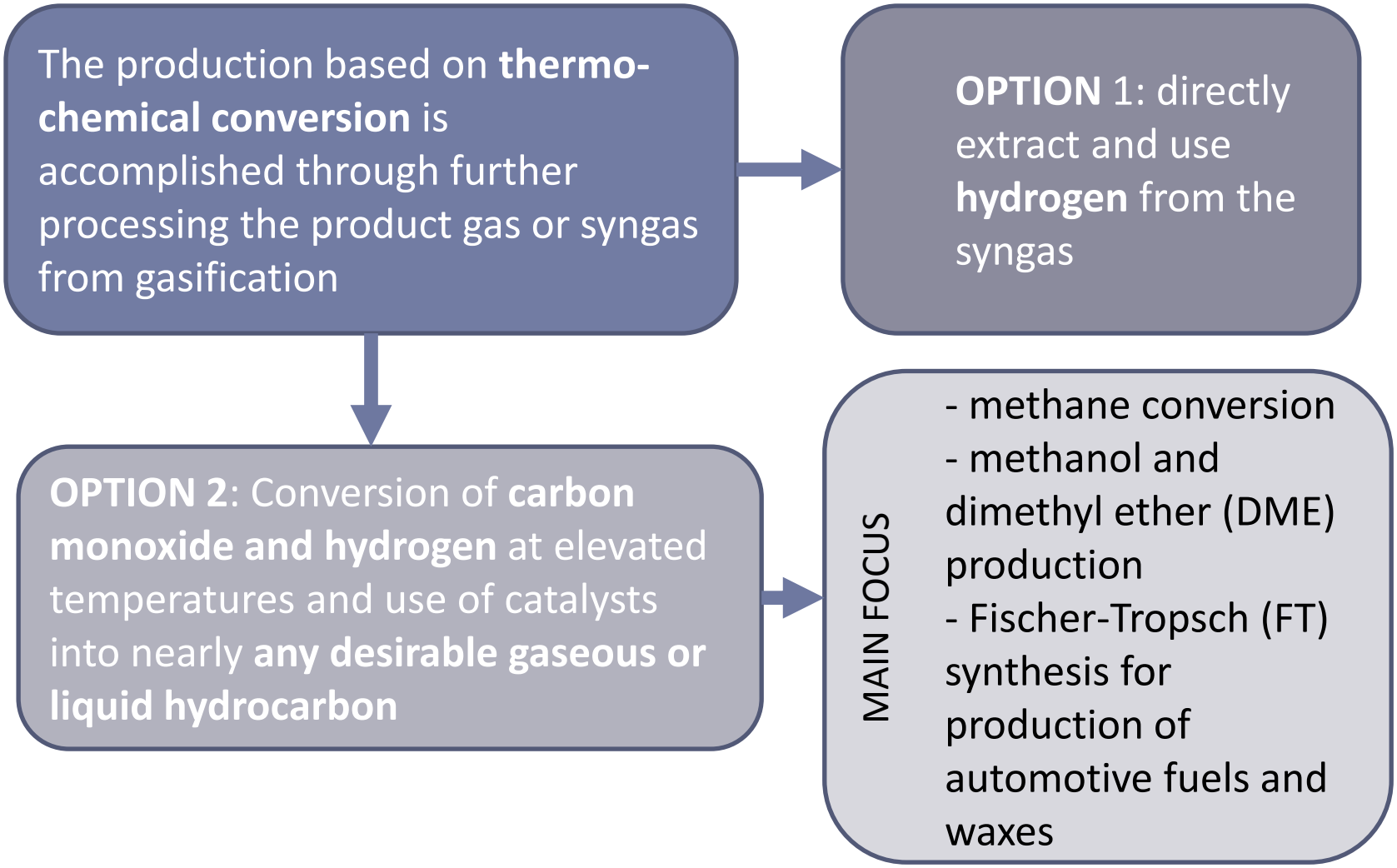


Source: Statistics Sweden and the Swedish Energy Agency, EN 20 SM.
Note: With effect from and including 2009, more fuels are included in the indicator. Figures for 2011 are preliminary, and also from not entirely comparable sources.

An example of opportunities: The production of electricity based on biomass in the European Union

- Increased by almost four-fold between the years 2000 and 2012
- The highest rate of growth after wind power
- There is a diverse number of conversion routes for electricity and each with its own character

An example of technologies: production of transportation fuels through gasification



Harvesting and logistics

From biomass to feedstock

- Organisation and operations needed to *collect*, *transport* and *process* forest biomass, and
- *Convert* the biomass from raw material into feedstock for bioenergy
- Biomass includes a range of woody materials which are uneconomic to process for alternative markets
  - harvesting residues and small diameter wood from thinnings
  - Small diameter roundwood depending on market situation
  - stumps and root systems
  - processed and waste wood products
- Combined use with agricultural wastes and municipality solid wastes.

Supply chains for roundwood, logging residues and stumps from final fellings

Social innovations for efficiency

- EU would need over 40 000 man years labour input to mobilize the energy wood potential
  - an eight fold larger labour force than works in the forest energy supply today
  - training demands new solutions
    - internet has proven a useful tool to increase knowledge and level of training in some countries
    - enterprises emerge to offer formalized training via courses and summer schools

- Need for the emergence of agents, enterprises and businesses
  - willing to take over the whole responsibility of sourcing materials, transporting and converting them ready for use

- Producer and marketing groupings encouraged to overcome the fragmentation issue and to develop economies of scale

Harvesting of stumps and coarse roots

- Integrated to clearcut
- Excavators fitted with specially designed heads lift and sometimes split the stumps
- Splitting diminishes the required lifting force
- Stumps are stacked in heaps at the site for drying
- A combination of crushing+vibration promising
- Concerns
  - detrimental soil disturbance
  - possible negative effects on water quality
  - fast release of carbon dioxide increases carbon debt
  - soil contamination

How to decrease the transportation costs?

- Transport costs are significant for the viability of the wood energy sector (up to 50%)
- Biomass has a high moisture content and low bulk density
- Use of rail and waterway transport over long distances
- Optimization models provide the optimum solution
  - decisions related to the network design
  - technology choice and plant size and location
  - mix of products and raw materials, storage location
  - logistic options, supply areas, and material flows
- GIS and modelling approaches to this challenge are becoming commonplace

Potential in forest biomass production for energy

Potential of forest energy varies in the European countries

Countries with large forest resources

- a developed management of long rotation forest, and strong forest industries
- emerging bioenergy markets are initially fed with industrial residues
- biomass available in branches, tops and stumps, small diameter trees
- means to increase growth (fertilization or improved stand establishment)
  - takes many decades to make real changes in long rotation forestry (LRF)

In the European Union
annual removals 420 million m³ (without bark) are far less than the total annual wood increment of 700 million m³

Countries with small forest resources → the demand is higher than the sustainable supply from LRF

- short rotation forestry (SRF)
  - fast growing tree species are planted on suitable land
  - offers an option to provide forest biomass to the market
  - to make a difference on the market large areas are needed

Biomass for energy - a low priced commodity problem

- Usually incentives are used both to procure existing biomass in LRF and to make SRF profitable over large areas → Constrains reducing the potential available for market
  - techno-economical realities
    - development of technologies for emerging but small market
    - continuous financial support and subsidies (also for competing value chains) will lead to market disturbances
  - environmental constraints
    - environmentally sound processes and performances along the whole value chain
  - lack of societal acceptance related perceptions, beliefs and attitudes
    - all the market players (producers, consumers etc.) shall be convinced with the concept

Are subsidies a sustainable long-term solution?

Short Rotation Forestry (SRF) for biomass

- Refers to plantations with fast-growing tree species and rotations not longer than 20 years.
- Traditionally used for fiber/pulp production in tropical and temperate
- A growing number of plantations have been established to produce wood biomass for energy (Sweden, Poland, UK)
  - commonly direct combustion to produce heat and/or electricity
- SRF for energy is mainly practiced on agricultural land or set-a-side farmland
- Management (e.g. density, fertilization, harvesting cycles, etc.) is less intensive than for conventional agricultural crops but more intensive than for conventional forestry

Forest energy biomass and sustainability

Energy biomass production and sustainability

- The National Renewable Energy Action Plans of EU countries by 2020
  - intensive biomass production in the existing forests
  - tens of millions of hectares land area available for forestry with a higher intensity than on average European forest production of today
- Land intensive production
- Impacts can also take place outside Europe
  - the EU Renewable Energy target for 2020 is too high to be met by domestic wood resources
  - would require roughly three times higher imports in 2020 than today
  - the most challenging consequences mentioned by research are deforestation and forest degradation, land grabbing, and endangered food security

Large economic opportunities but severe challenges of sustainability

Forests provide multiple ecosystem services (ES)

Provisioning services
- sawlogs and fibers
- woody biomass for energy
- non-timber forest products

Supporting services
- nutrient cycling
- oxygen production
- soil formation

Regulating services
- climate regulation
- water purification and flood protection

Cultural and social services
- education
- recreation
- aesthetic value

Woody biomass production necessarily interacts with other forest-related ecosystem services, sometimes negatively, sometimes positively

Preconditions of balanced environmental, social and economic pillars of sustainability

- maintaining a certain standing stock (sustained yield)
- long-term site productivity and biodiversity
- carbon sequestration/release and energy use
- risks for direct and indirect land use change
- socio-economic dimensions, especially competition with other industries
- sectorial governance for sustainable solutions
- implications for forest owners

Forest biomass use for energy can be carried out as a successful and sustainable business along with traditional timber production based industries

Carbon neutrality

Monitoring based on current UNFCCC accounting systems

- carbon (C) released while burning will be recaptured by tree regrowth
- any release over regrowth → losses of C stock → accounted for in the land use sector
- assumptions are based on an incomplete accounting mechanism for the land use sector
  - only few countries currently account for a limited number of C stock changes

Temporal and spatial issues in focus

- from forestry point of view controversial carbon is fixed either in the atmospheric CO_2 or in the ecosystem hydrocarbons
- according to various literature sources carbon neutrality is not valid under policy relevant time horizons (10 to 40 years) ⇔ carbon debt and payback time (slow regrowth)
- however, energy biomass mainly from youngest parts of trees such as surface wood, tops, branches, small diameter trees
- analysis based on tree, stand, landscape or region levels yields gives fully different results of carbon sustainability
- the real fossil fuel **substitution effect** depends on several factors that should be thoroughly accounted for

Cross-continental influence

Globally sustainable and renewable resources based development across generations

- continuous, and increasing, access to physical and biological natural capital, besides human, technological and financial capital

- forests and other productive lands, remains renewable only if it is not depleted below a critical threshold

Risks of high profits in a rich market for products grown in countries of other continents with poor governance

- renewable resources depletion below the sustainability threshold
- large scale biomass poorly sustainable production for export to EU in many countries of other continents
- land grab due to tolerance of inequity
- competition with food crops for both land and water inducing stress in rural societies in poor countries
- clearing lands of existing vegetation and harm to biodiversity for raising commercial plantations
- pressure on domestic supplies resulting in unbearable rise in wood energy prices

Concluding remarks

- **Forest bioenergy: a thousand different things**
  - A biomass source, management, end products, conversion, logistics, environmental impacts, markets and opportunities to use it in many ways across the EU

- **Need to reassess EU forest biomass demand**
  - Need to take into account that forest biomass, forest products and bioenergy production react to market incentives

- **Address the hidden impacts of policies and trade-offs**
  - Policies (such as subsidies) may cause new problems

- **Tailor sustainability policies**
  - Woody biomass imports and EU's sustainability standards
  - Improved analysis for temporal and spatial variation of carbon neutrality

- **Focus on energy efficiency, minimizing emissions and promoting new businesses**
  - The potential annual harvest of biomass from forests for energy in the EU is about 200 million m^3
  - Need to strengthen wood utilization