

From Forest Residues to a Circular Bioeconomy

– Lessons from Sweden's Path to Decarbonizing
the Heating sector and Mobilizing Biomass at large Scale

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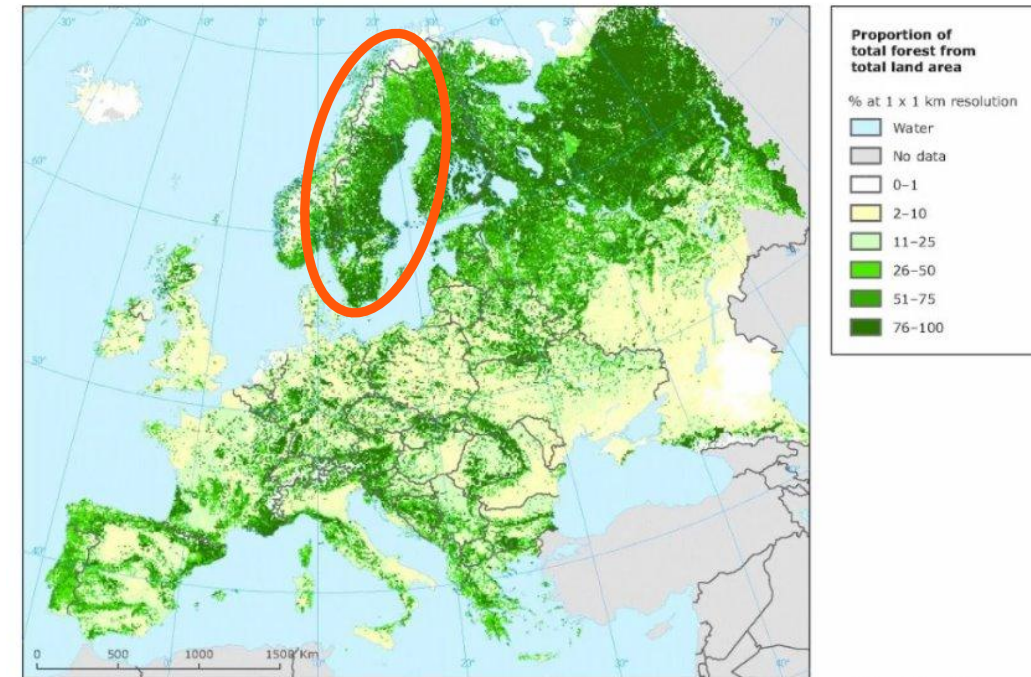
PROGRAM MANAGER, Maria Iwarsson Wide

Agenda

- 1) Decarbonizing the **heating sector** via forest residues
- 2) Efficient **forest fuel systems** and large-scale biomass mobilization
- 3) **Learnings** from the Swedish transition and a future outlook for a circular biobased economy

The importance of forest and forestry to growth, economy and welfare

- **70%** of Sweden's land is forested. **75%** of forests are actively managed.
- **300 000** small scale family forest owners
- Sweden is a **leading global exporter** of pulp, paper, and sawn wood.
- In **2024**, total forest product exports reached **~SEK 185 billion**
- Around **85%** of products are exported.
- Forestry industry accounts for **9–12%** of Swedish industry in employment, exports, turnover, and value added.



"Skogsmark" per 100-hektarsruta, inklusive "other wooded land". För Sverige i så fall totalt 28 miljoner hektar. Källa. EEA

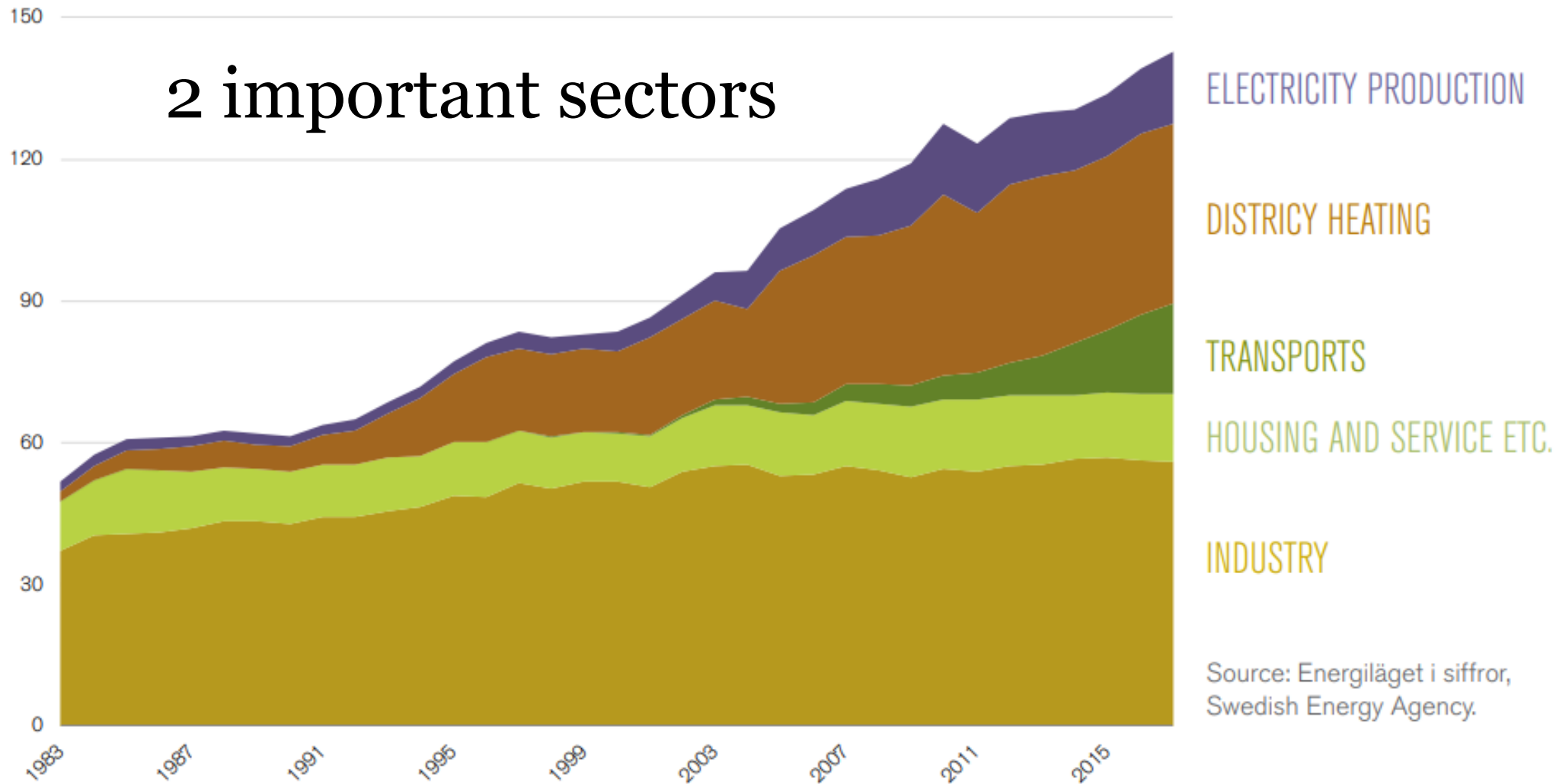
The importance of bioenergy in Sweden

- Bioenergy is Sweden's **largest source of energy**
- 38 % of Sweden's energy use today



» FIG. 5 BIOENERGY USE PER SECTOR 1983 - 2017 (TWh)

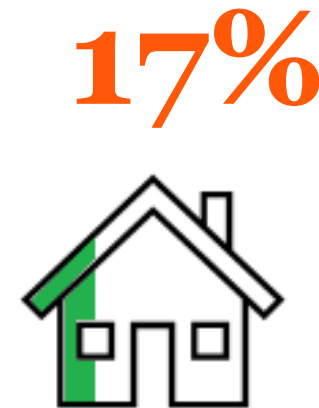
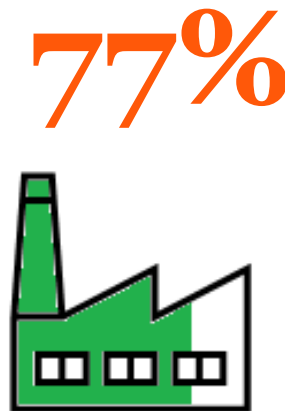
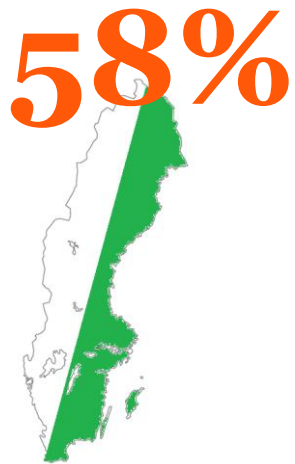
2 important sectors



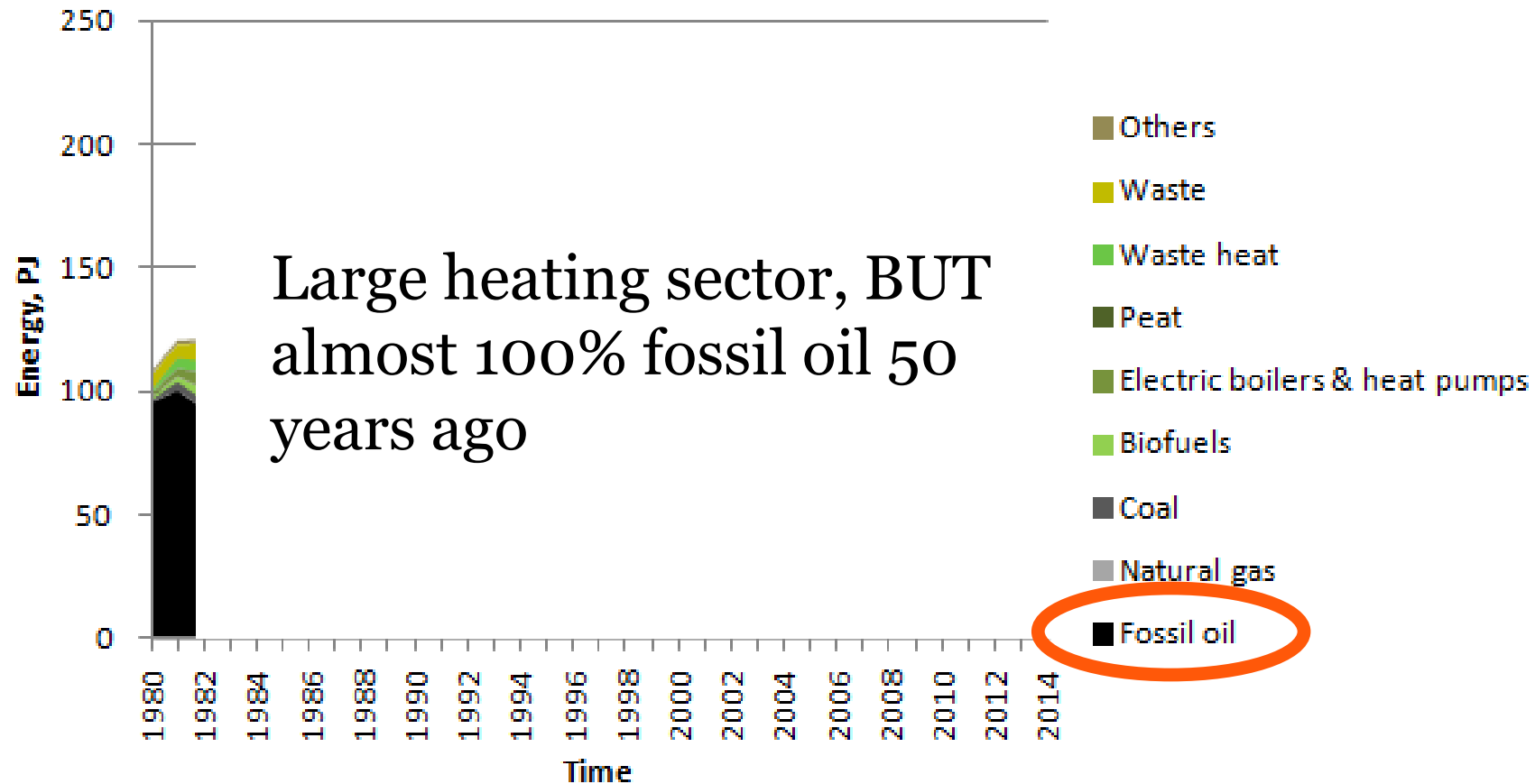
The use of bioenergy in Sweden has increased steadily over the past 35 years.
The use has more than doubled since 1990.

The importance of District Heating

- Sweden is cold in winter times
- We have a robust, resilient, efficient and flexible solution
- Power grid a limiting factor in many cities today




The story of the heating sector in Sweden



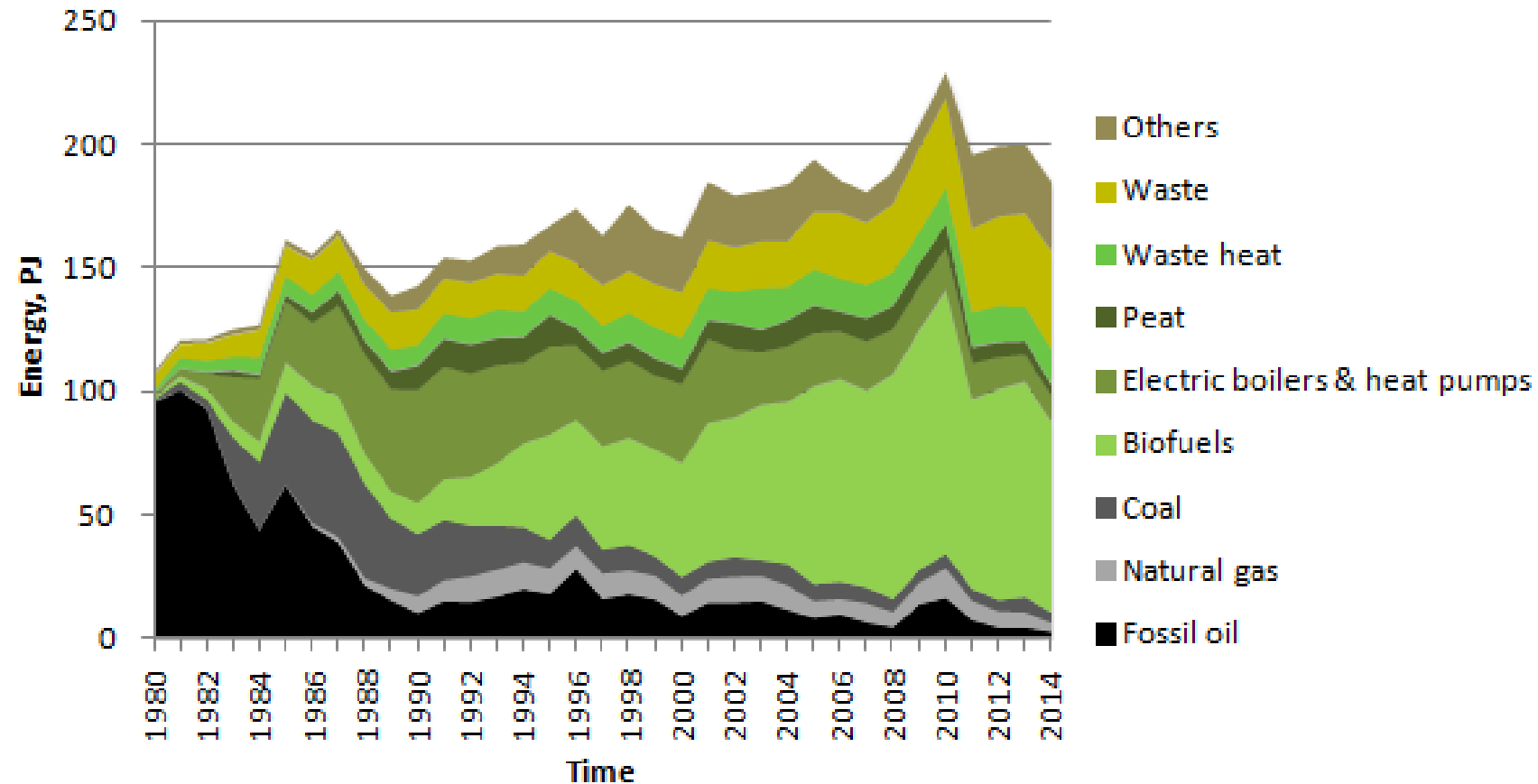
Key Drivers for Increasing Bioenergy in District Heating Over Time

- **1970s–1980s: Oil Crisis & Energy Security**
Shift from imported oil to domestic fuels for supply security.
- **1980s–1990s: Cost Efficiency & Waste Utilization**
Use of cheap forestry residues and industrial by-products.
- **1990s–2000s: Environmental & Climate Policy**
Carbon taxes and emission regulations favored bioenergy.
- **2000s–2010s: EU Directives & Renewable Targets**
Compliance with EU goals drove investment and expansion.
- **2010s–2020s: Climate Neutrality & Circular Economy**
Integration with waste streams and resource efficiency.
- **2020s–Present: Fossil Phase-Out & Energy Resilience**
Geopolitical risks and high energy prices boost local bioenergy.



Yesterday

Tomorrow

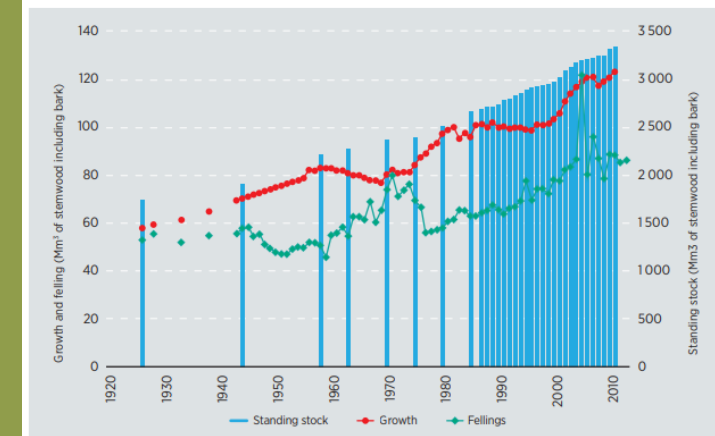
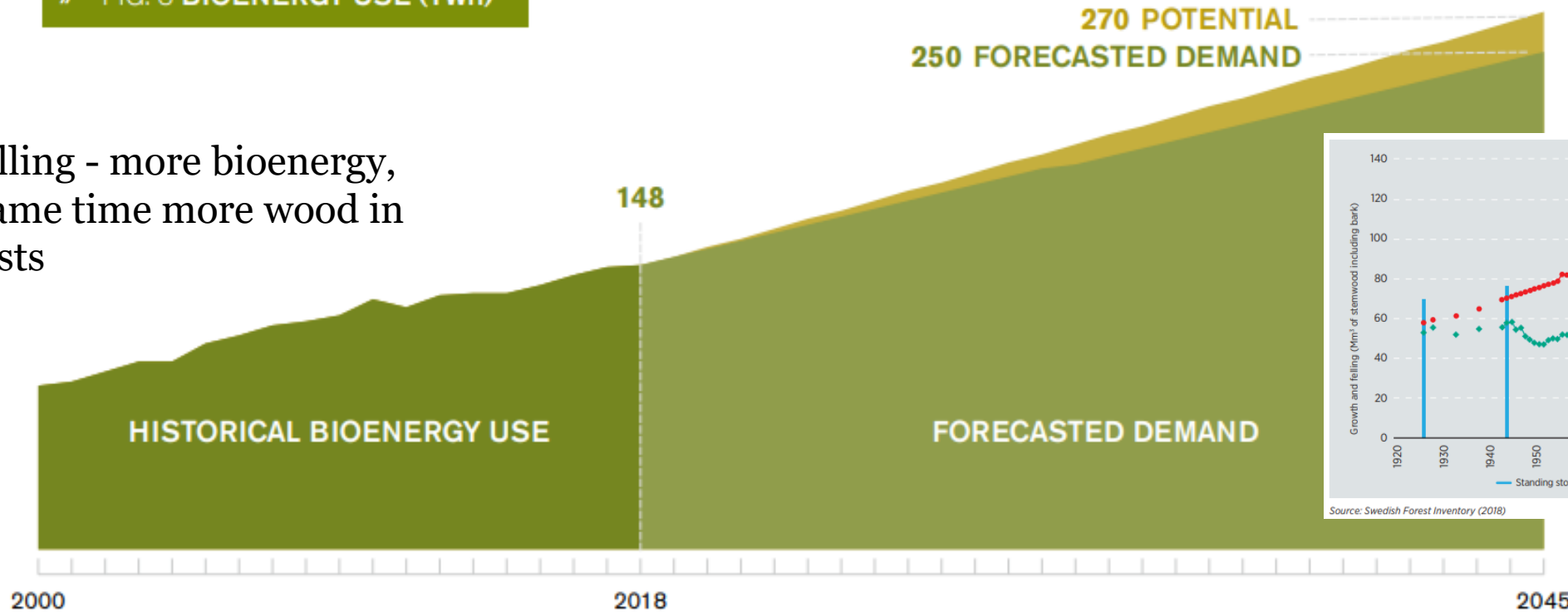




Today's use and future demand

» FIG. 3 BIOENERGY USE (TWh)

More felling - more bioenergy,
at the same time more wood in
the forests



Source: Swedish Forest Inventory (2018)

The chart shows total energy supply (delivered) of bioenergy in Sweden, development since 2000 and forecast for demand until 2045, and potential for increased supply.

(2) Efficient forest fuel systems and large-scale biomass mobilization



Today; 9 TWh/y
Potential; 21 TWh/y



Today; 0,2 TWh/y
Potential; 3+4 TWh/y





Small tree-harvesting



Volumes – Methods – Assortments?





Success factors

- Profitability; many small trees – multi-tree handling
 - Efficient, stable accumulation
 - Feeding rollers
 - Long, powerful crane
- > Machine size!
- Removal per hectare
 - Continuous felling/accumulation
 - Swath method

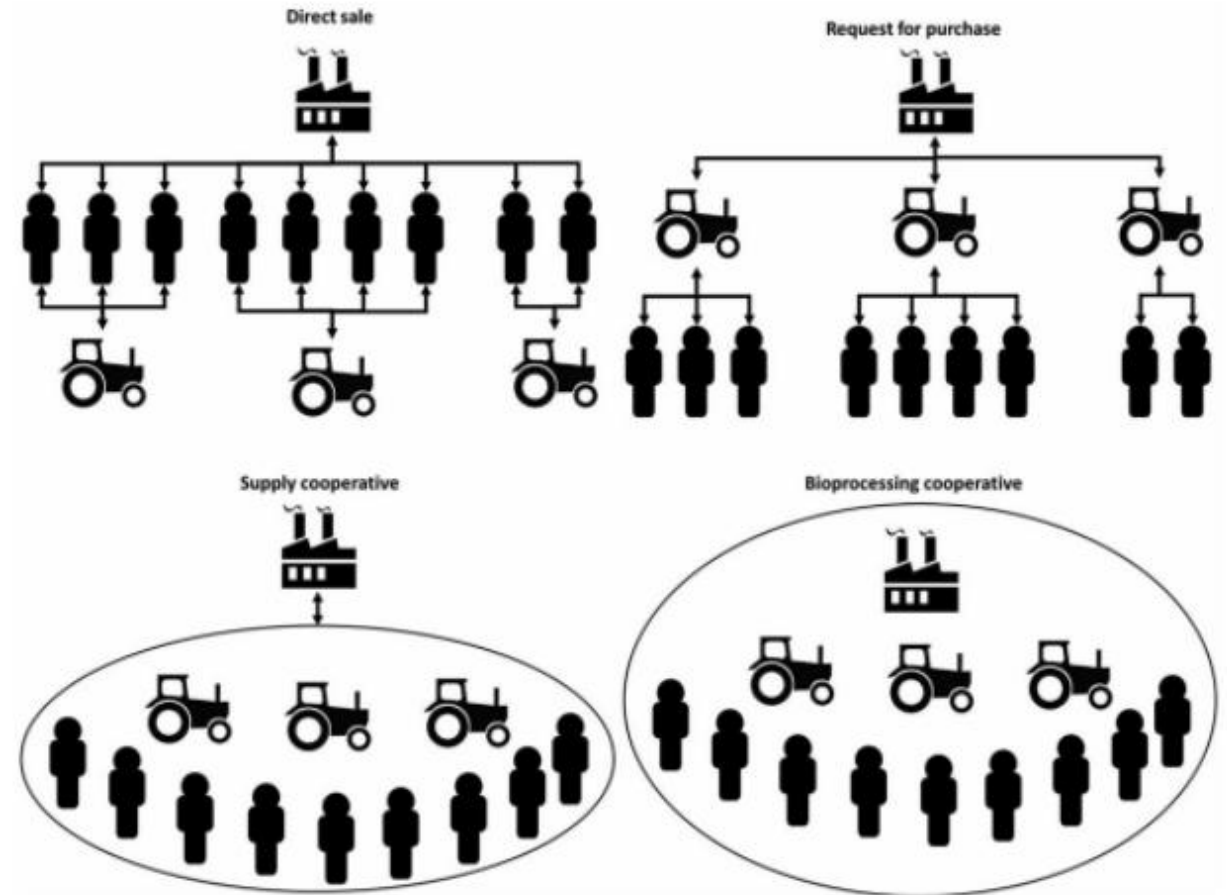
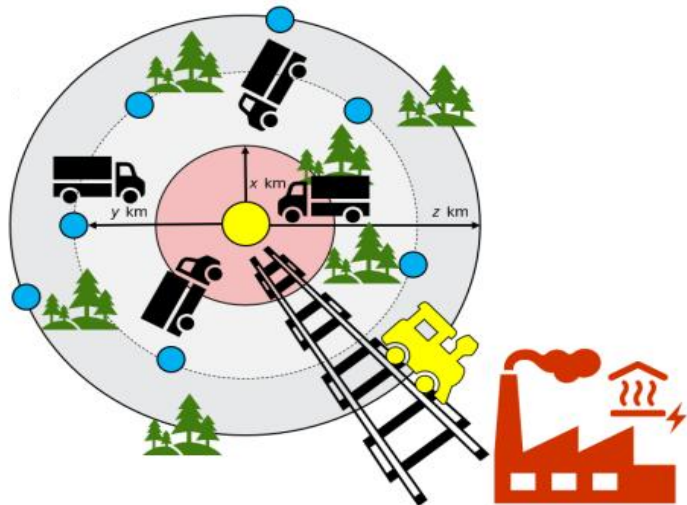






Small scale logistics

- Machine-rings coordination
- Co-operation
- Sharing equipment



Fuel quality management and storage



End-users in all scales

Large scale
3 TWh/y

Medium scale
300 GWh/y

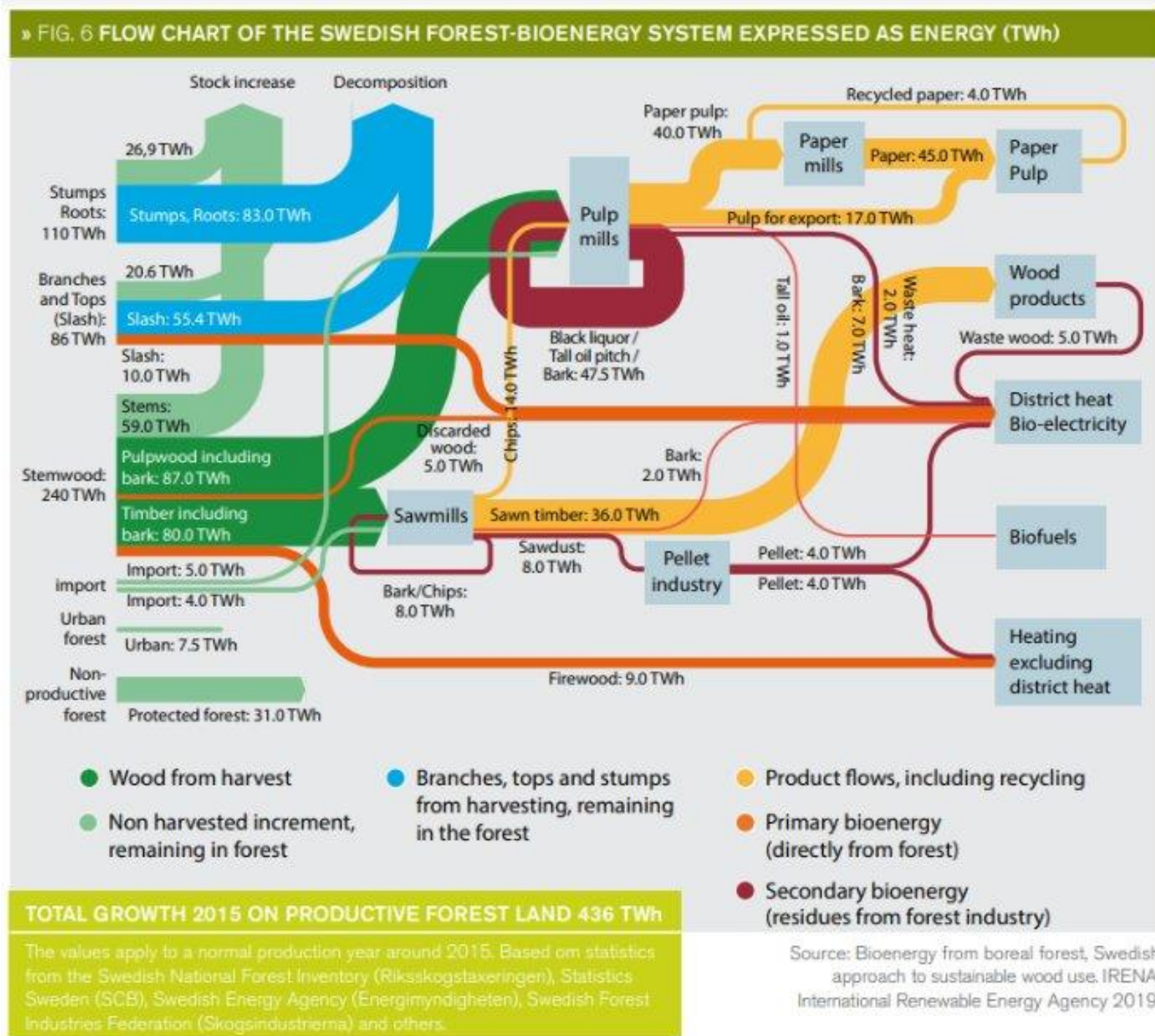
Small scale
1 GWh/y



(3) Learnings from the Swedish transition and a future outlook for a circular biobased economy

Energy in relation to forestry – a circular perspective

- Bioenergy is mostly by-products
- Value-oriented flows
- Industrial symbioses
- Circularity





Many solutions needed, but the forest offers many alternatives

A systems perspective of forest energy

- Domestic and local sourced renewable energy
- Piece by piece transition, can add value to existing and new infrastructure.
- Small-scale decentralized fuel production
- Create rural jobs, but capacity building take time
- Mobilizing biomass at scale requires relations, risk sharing and support at start. Access to finance
- Increase energy security and add robustness
- Circular long term value-adding perspective important
- At present an unutilized opportunity. Joint value-creation by combining silvicultural, land upgrading and energy to open up for high value production in the future. Multi-sector benefints