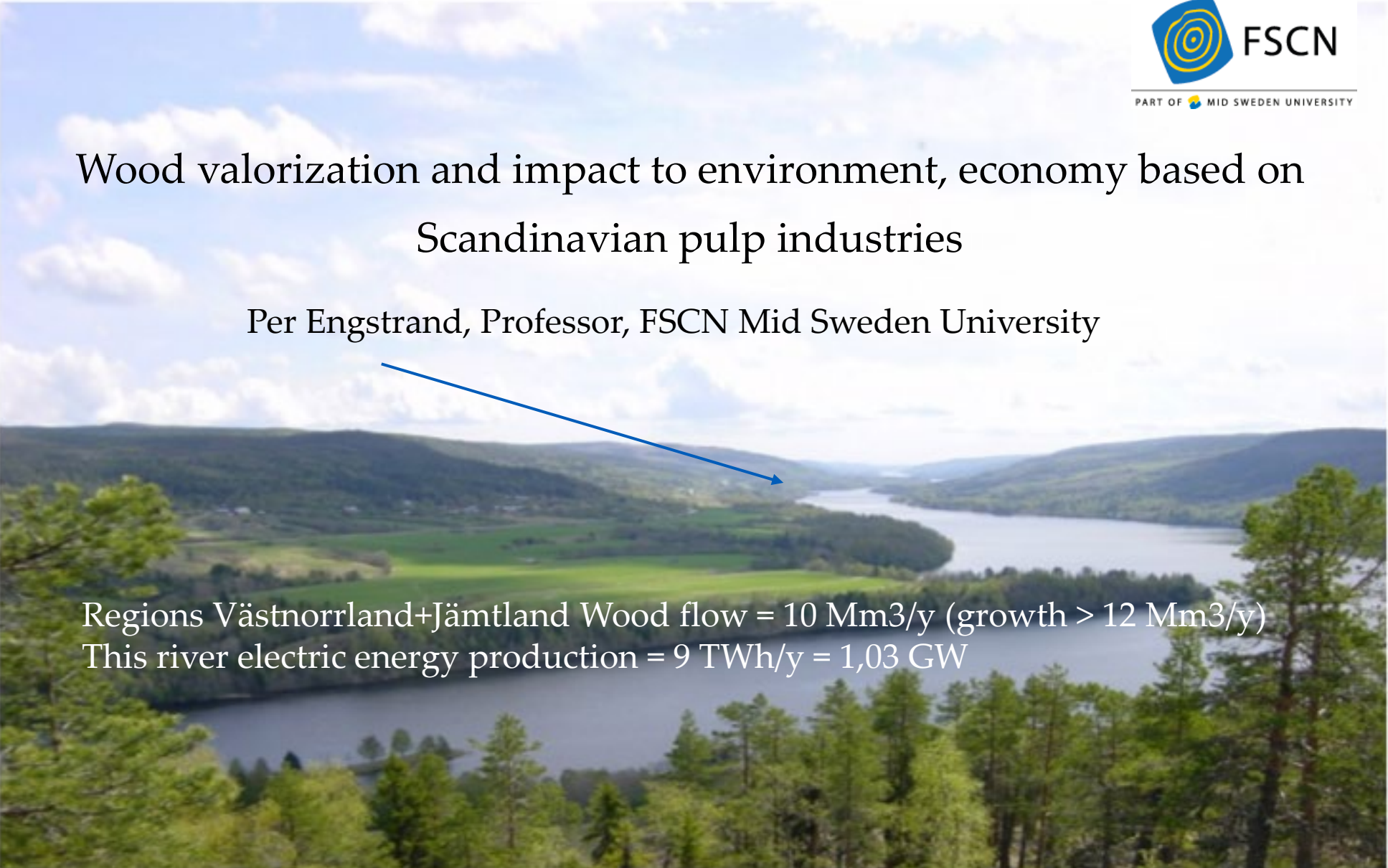


# Wood valorization and impact to environment, economy based on Scandinavian pulp industries

Per Engstrand, Professor, FSCN Mid Sweden University



Regions Västnorrland+Jämtland Wood flow = 10 Mm<sup>3</sup>/y (growth > 12 Mm<sup>3</sup>/y)  
This river electric energy production = 9 TWh/y = 1,03 GW

# My background

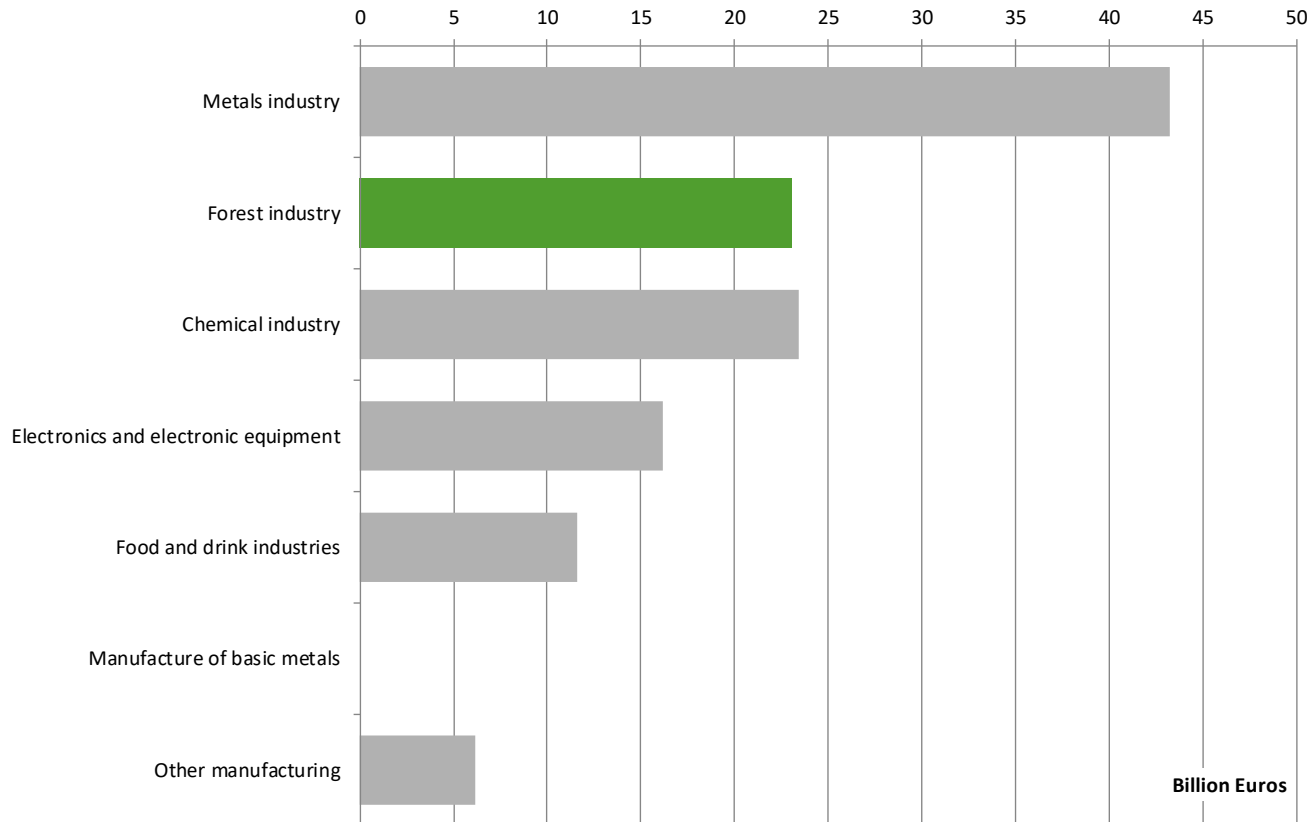
- KTH Chemical Engineering – 1975-80 Business Economy - 1978-79
- STFI/Innventia/RISE Bioeconomy (1980-90), MoDo (1990-95), Beloit (1995-98), Holmen (1998-2007) and Mid Sweden University (2007--
- 15 patents, >150 scientific publications and conference contributions
- 18 PhD and Licentiate students to exams 2008 - 2022
- Performing R&D programs and projects to create improved and new energy efficient processes related to eco-friendly solutions for improved and new wood/cellulose, fibre and nanocellulose based materials

# Outline

- Nordic (Finnish and Swedish) forest industry impact on national economies
- Nordic chemical pulp mills and recent biorefinery/pulping investments
- Chemical pulping processes
- Sustainability, wood growth/use, recycling, effluent and environmental aspects
- Future possibilities replacing fossil-based with wood-based
- World-wide forest use and forest industry productions

# Forest industry is one of the largest industries in Finland

## Forest industry products value 23 billion €



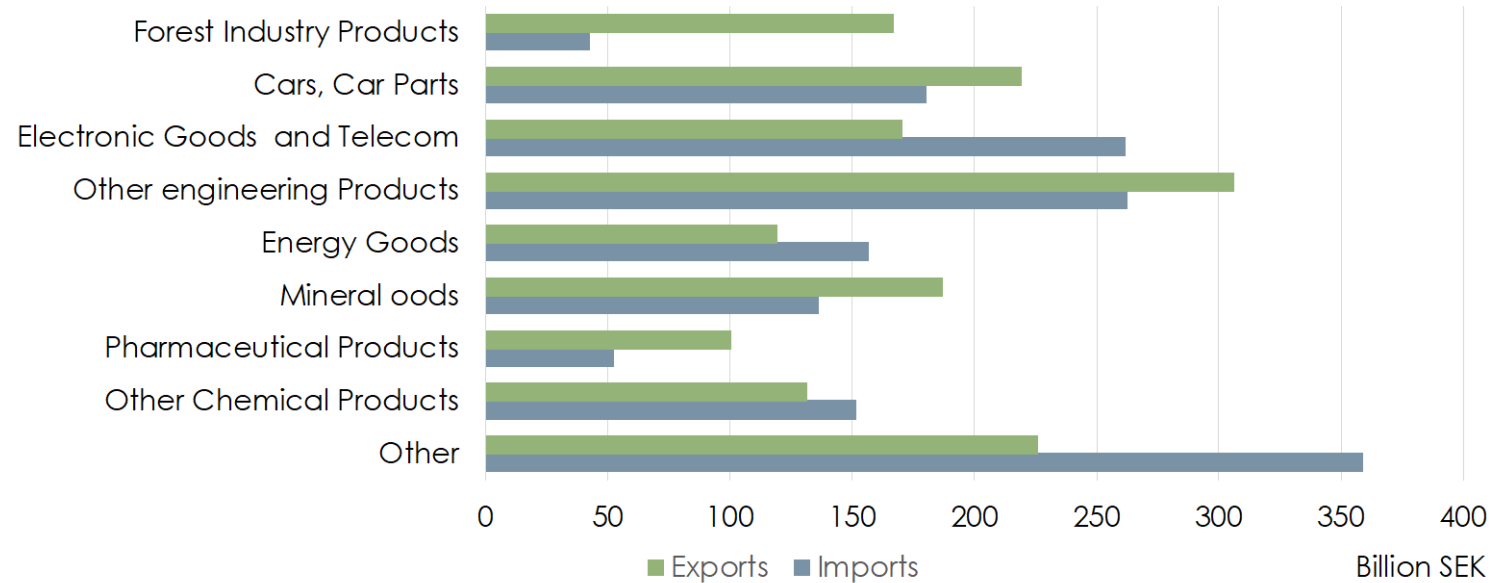
2019	
Gross value of manufacturing, Bn €	
Total manufacturing	123,7
Change from prev. year	1,7 %
Forest industry*	23,1
Change from prev. year	-6,3 %

\* Including furniture

## Comparisons between some industry sectors in Sweden

### Forest industry products value 17 Billion €

## Exports and Imports of Some Product Groups 2021



Source: Statistics Sweden

Total Exports: 1 628 Billion SEK (2020: 1 427 Billion SEK)  
Total imports: 1 604 Billion SEK (2020: 1 376 Billion SEK)



## Forest industry exports – Finland - 2021

### Value of exports, Million EUR 2021

Pulp, paper, board and converted	9 300 M€
Wood products	3 650 M€
Furniture industry	250 M€
<b>Forest industry total</b>	<b>13 200 M€</b>

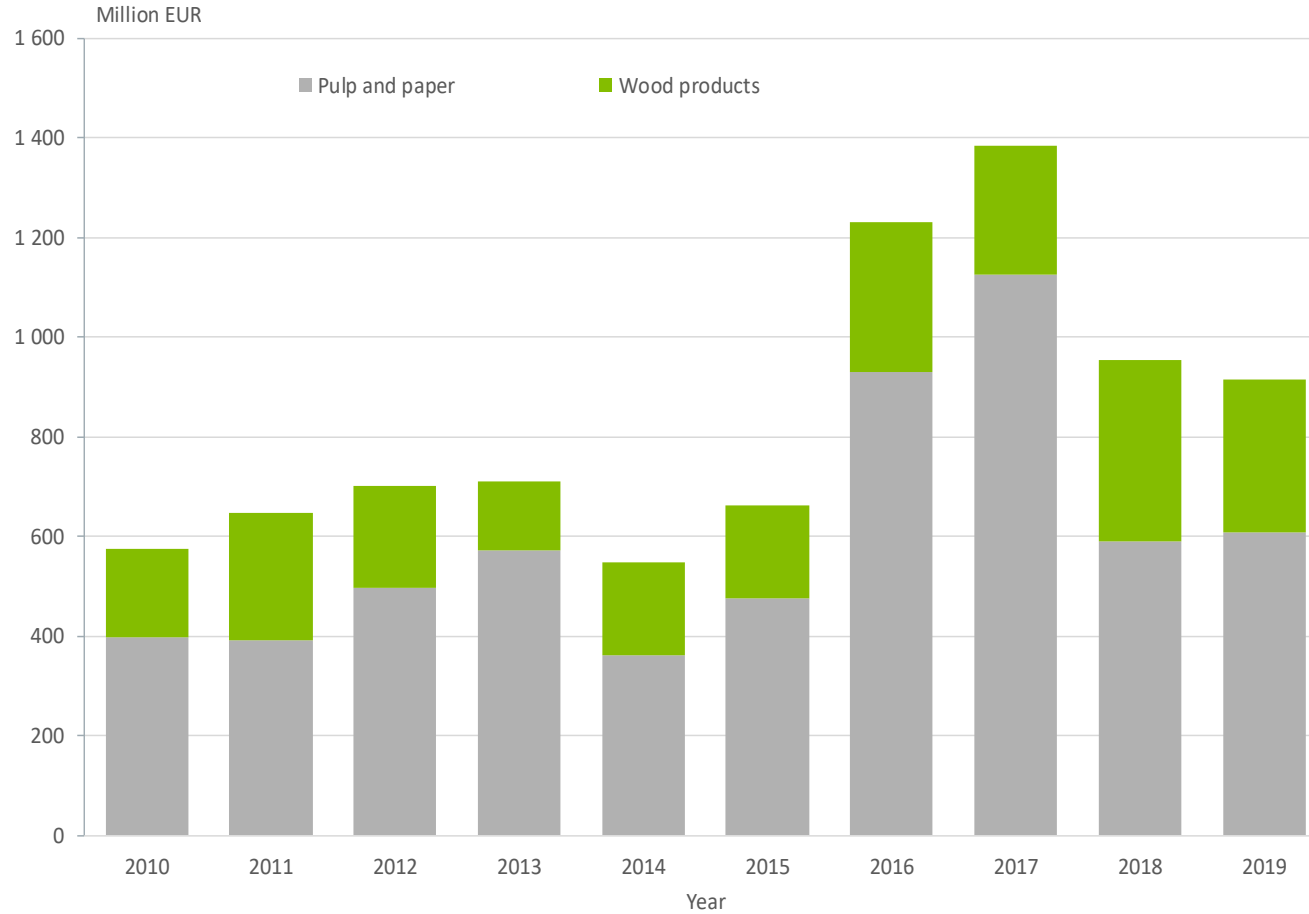
## Forest industry exports – Sweden - 2021

### Value of exports, Million EUR 2021

Paper and board 70 BSEK / 10SEK/€	7 000 M€
Sawn Wood 48 BSEK	4 800 M€
Pulp and recovered paper 28 BSEK	2 800 M€
Paper products 11 BSEK	1 100 M€
Plywood, Veneer Wood products 2 BSEK*	200 M€
Roundwood, chips, sawdust 2 BSEK*	200 M€
<b>Forest industry total</b>	<b>16 100 M€</b>

\*More import than export

# Investments in Finland

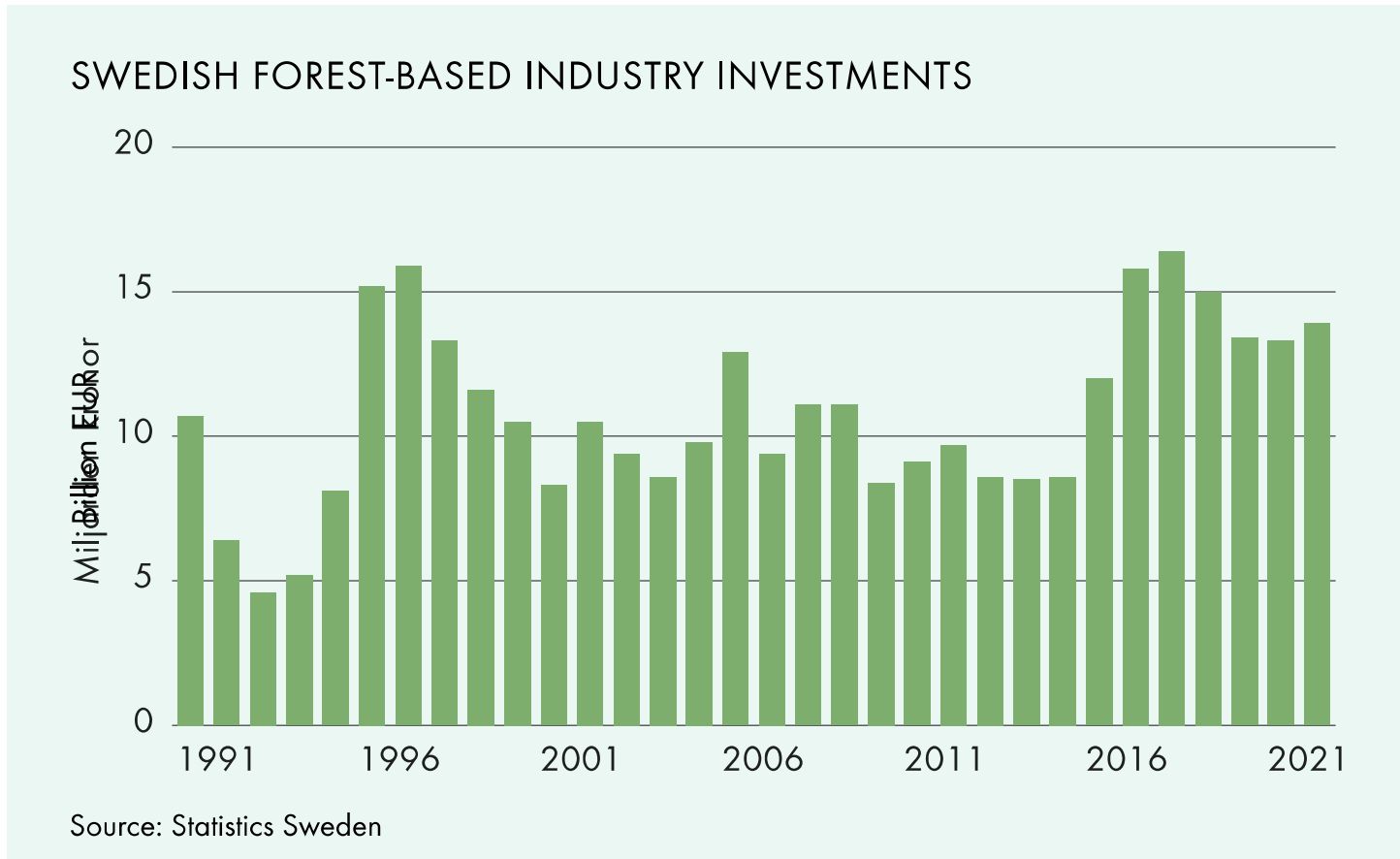


Forest industry investments			
Million €	2018	2019	change
Wood products industry	364	308	-15 %
Pulp and paper industry	589	608	3 %
Forest industry total	953	916	-4 %

\* incl. Furniture

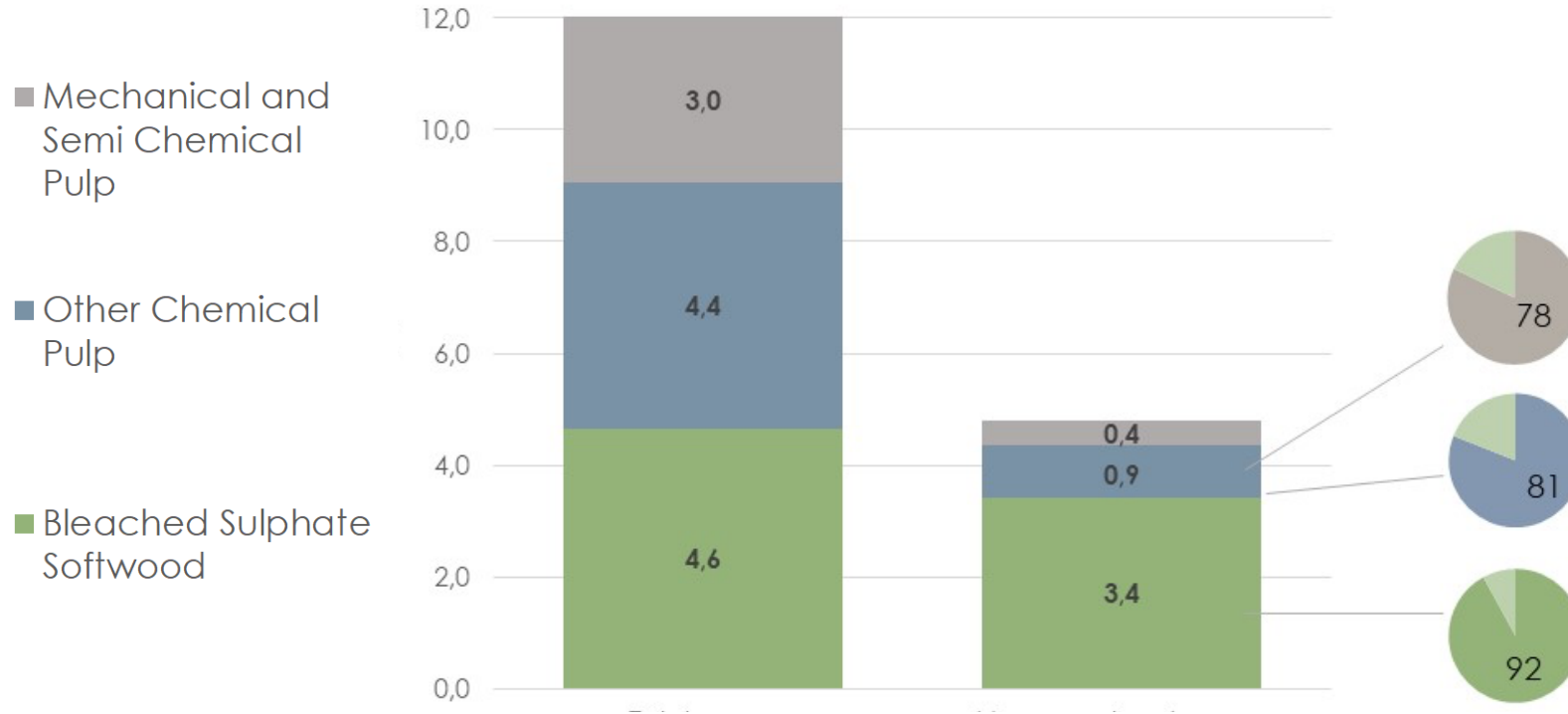


# Investments in Sweden



# Swedish Pulp Production and Exports 2021

(4,8 Mt/y market pulp)

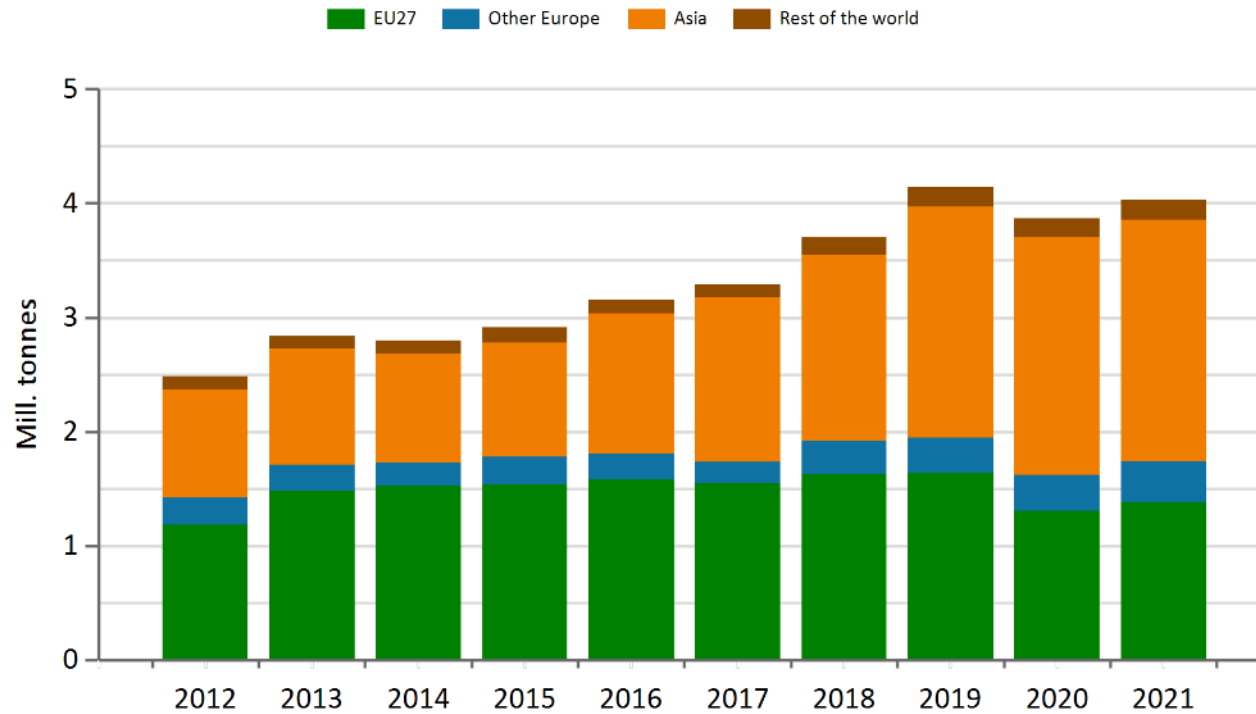


Total Production: 11.7 Million Tonnes (2020: 12.0 Million Tonnes)  
 Production Market Pulp: 4.8 Million Tonnes (2020: 4.8 Million Tonnes)  
 Total Exports: 4.2 Million Tonnes (2020: 4.3 Million Tonnes)

Source: Swedish Forest Industries

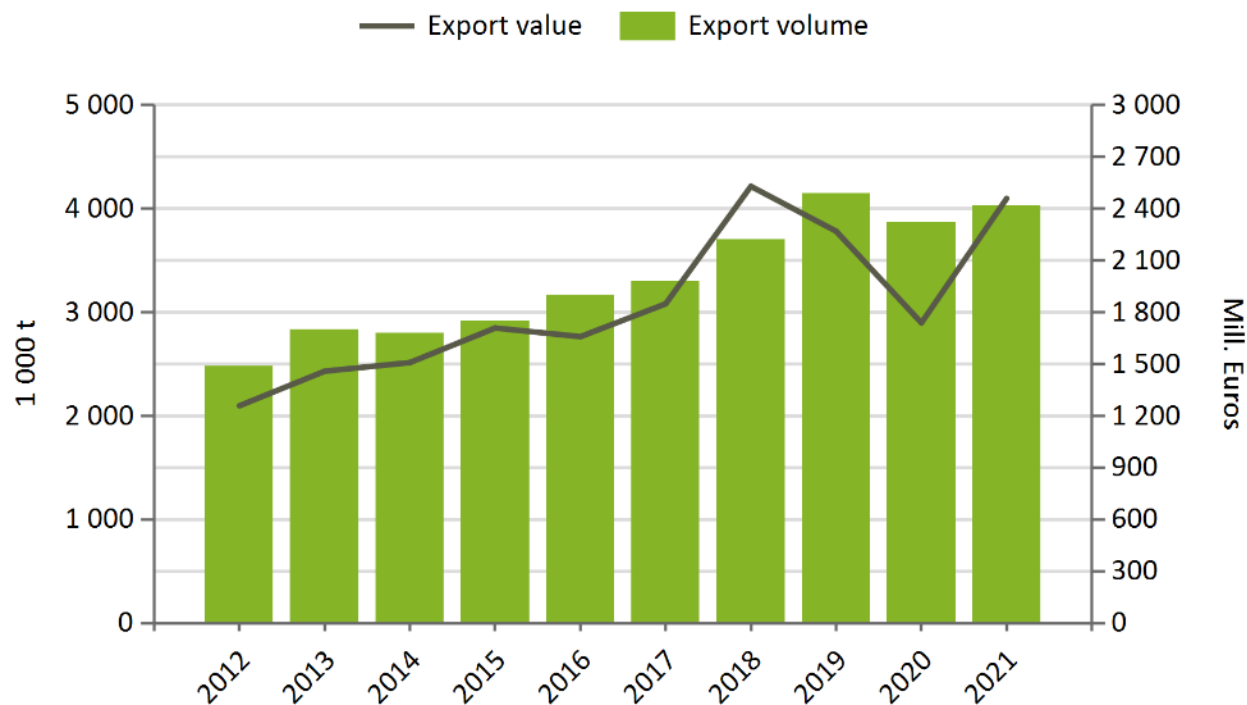


## Finnish chemical pulp – major markets development



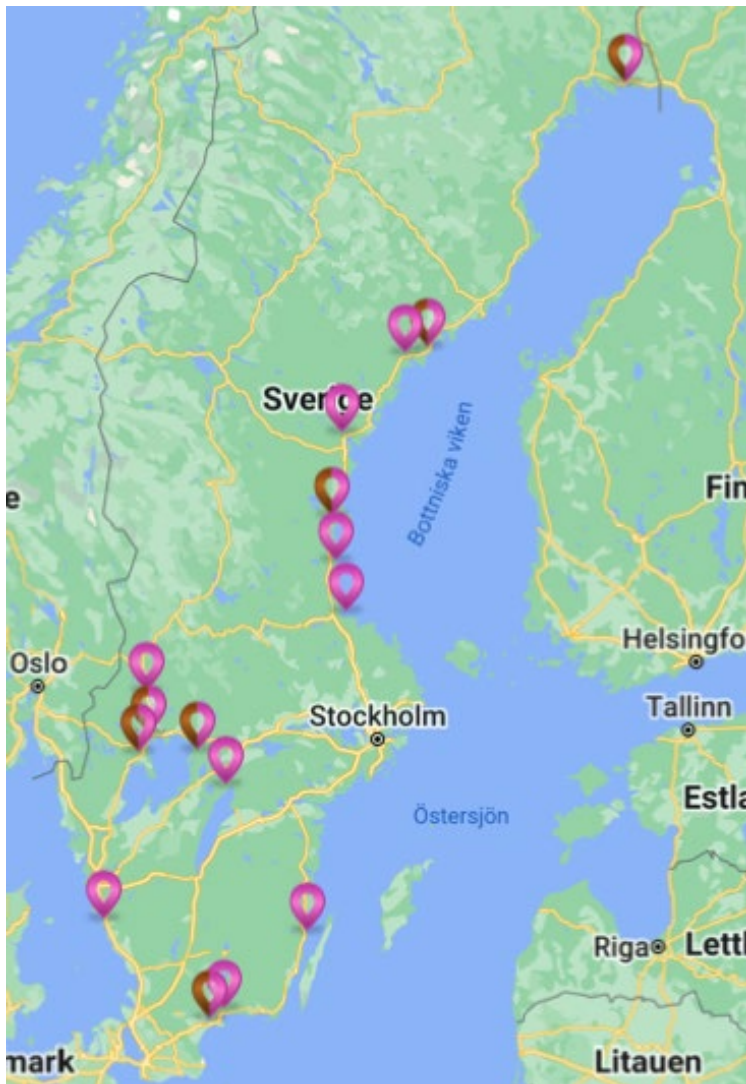
Exports, 1000 tonnes	2021
EU27	1 400
Other Europe	350
Asia	2 100
Rest of the world	200
<b>Total</b>	<b>4 050</b>

# DEVELOPMENT OF VOLUME AND VALUE OF CHEMICAL PULP EXPORTS



<b>Pulp exports</b>	<b>1 000 tonnes</b>
2021	4 030
2020	3 870
Change, %	4,1 %
<b>Export value of pulp</b>	<b>Mill. EUR</b>
2021	2 460
2020	1 740
Change, %	41,3 %

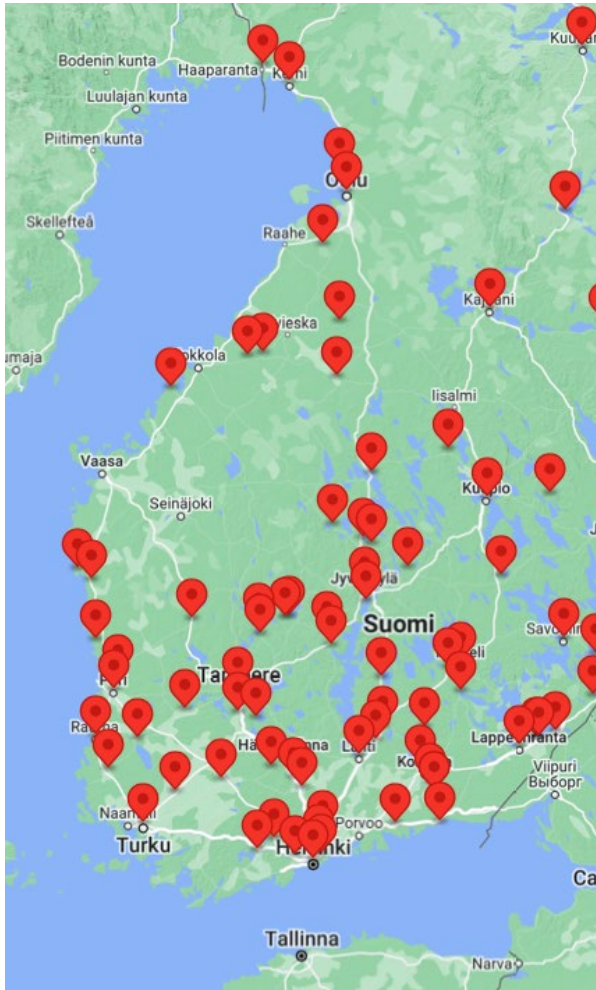
# Swedish chemical pulpmills with market pulps



Aditya Birla Domsjö – Softwood Sulfite Viscose 250000 tpy  
 Ahlström-Munksjö Aspa NBSK and UBSK 250000 tpy  
 Billerud – Karlsborg partly market NBSK – Total 350000 tpy  
 Billerud – Gruvön partly market NBSK – Total 760000 tpy  
 Billerud – Skärblacka partly market NBSK – Total 460000 tpy  
 Holmen Iggesund partly market HBK/NBSK Total 450000 tpy  
 Metsä Husum – partly market NBSK Total 700000 tpy  
 Nordic Paper Säffle partly market Sulfite – Total >100000 tpy  
 Nordic Paper Bäckhammar partly market NBSK – Total 200000 tpy  
 Rottneros Vallvik NBSK 250000 tpy  
 SCA Östrand – NBSK 900000 tpy  
 Stora Enso Skutskär absorbent pulps NBSK 600000 tpy  
 Stora Enso Nymölla Hardwood Sulfite partly market Tot 400000 tpy  
 Södra Värö NBSK 700000 tpy  
 Södra Mönsterås NBSK 700000 tpy  
 Södra Mörrum NBSK/BHK/Viscose 600000 tpy

**Total chemical pulp production 9,0 Mtpy whereof 4,8 Mtpy is market pulp. Remaining is integrated partly or totally with paper, liner and board production.**

# Finnish chemical pulpmills with market pulps



Metsä Kemi NBSK/BHK 620000 tpy

Metsä Rauma NBSK 650000 tpy

Metsä Äänekoski NBSK/BHK and more 1300000 tpy

Stora Enso Enocell NBSK/BHK 630 000 tpy

Stora Enso Imatra, partly market NBSK/BHK 1300000 tpy

Stora Enso Sunila NBSK 375000 tpy, lignin 50000 tpy, tall oil and turpentine

Stora Enso Oulo, partly market UBSK 550000 (market 100000tpy)

UPM Kaukas NBSK/BHK 700000 tpy

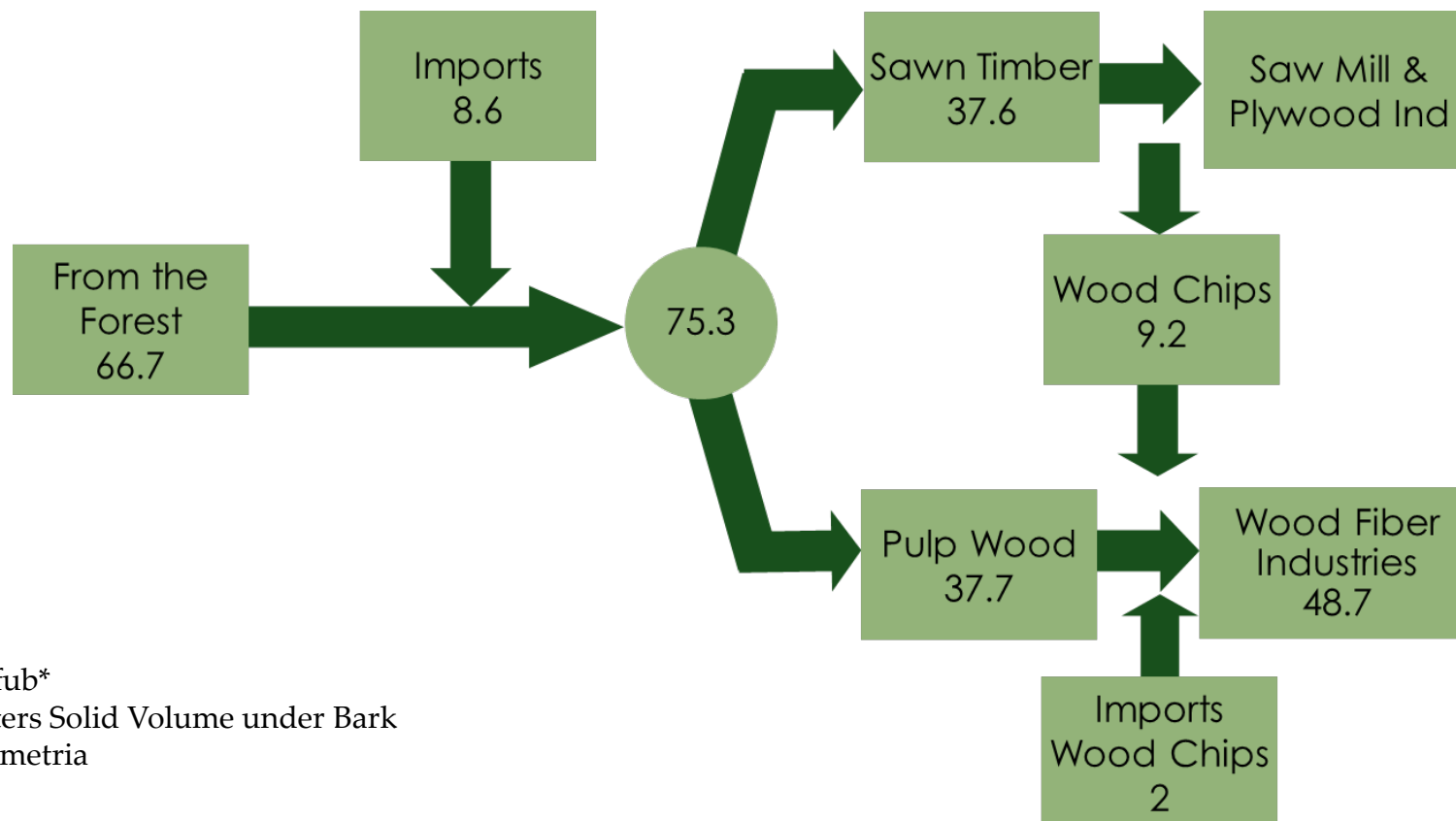
UPM Kymi partly market NBSK/BHK 870000 tpy

UPM Pietarsaari mill NBSK/BHK 800000 tpy

**Total pulp production 8,3 Mtpy whereof 4,05 Mtpy is market pulp.**

**Remaining is integrated partly or totally with paper, liner and board production.**

## Wood flow from forest to mill in Sweden 2019 (mill. M<sup>3</sup>)

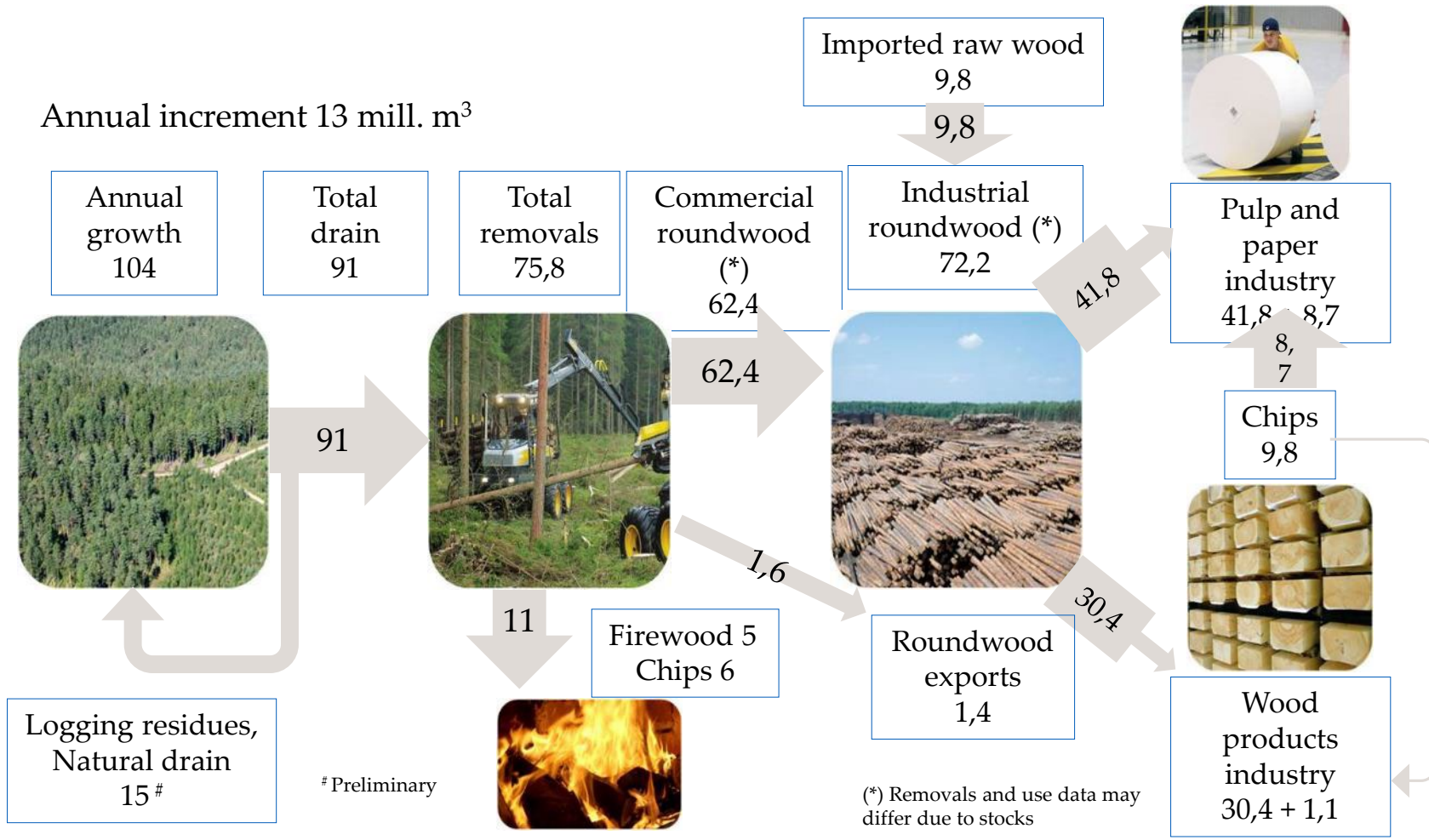


Million m<sup>3</sup>fub\*

\*Cubic Meters Solid Volume under Bark

Source: Biometria

# Wood flow from forest to mill in Finland 2021 (mill. M<sup>3</sup>)



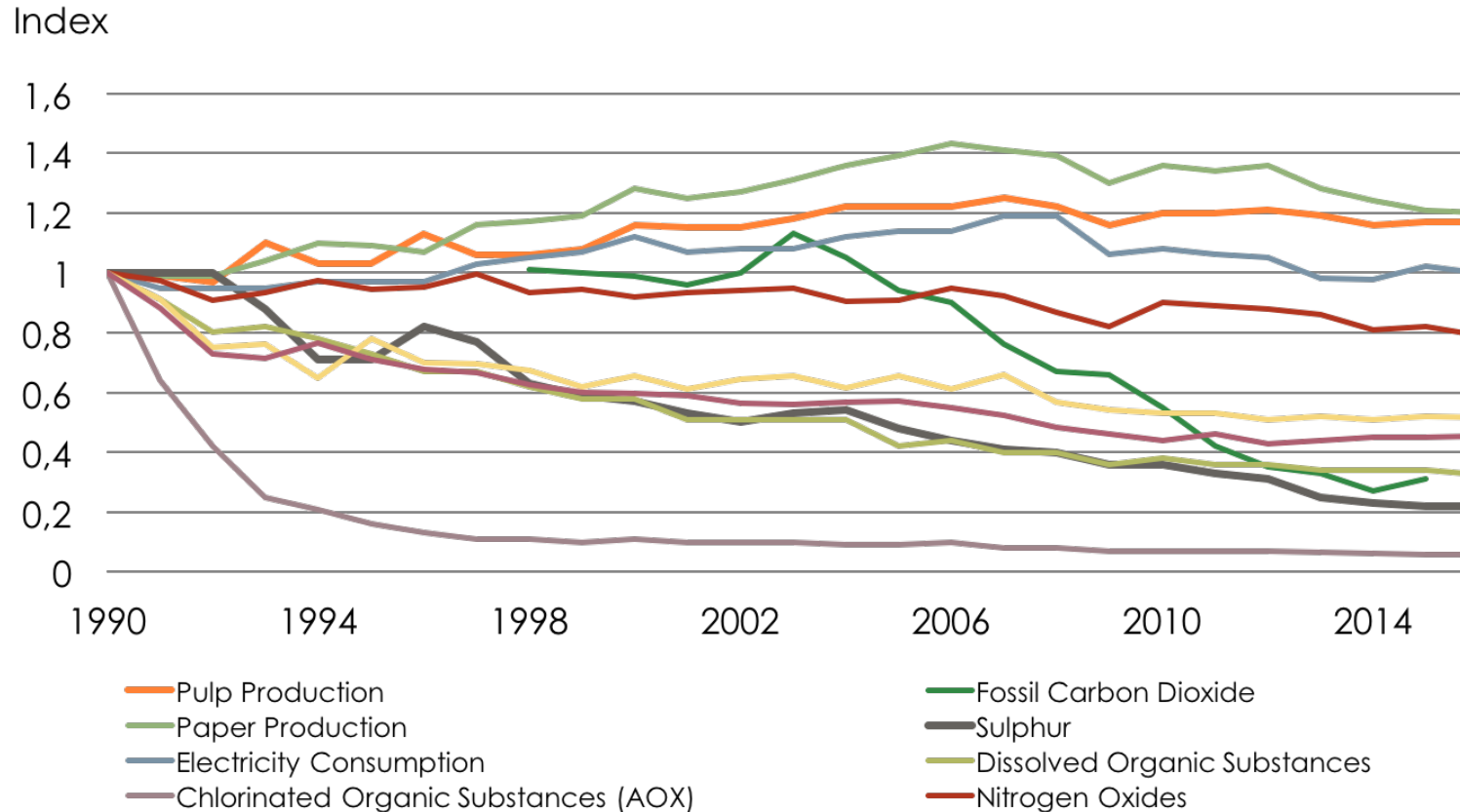
SOURCE: Luke

SOURCE: Finnish Forest Industries Federation



# Higher Production and Lower Emissions

## 1990-2016 in Swedish pulp & paper industry

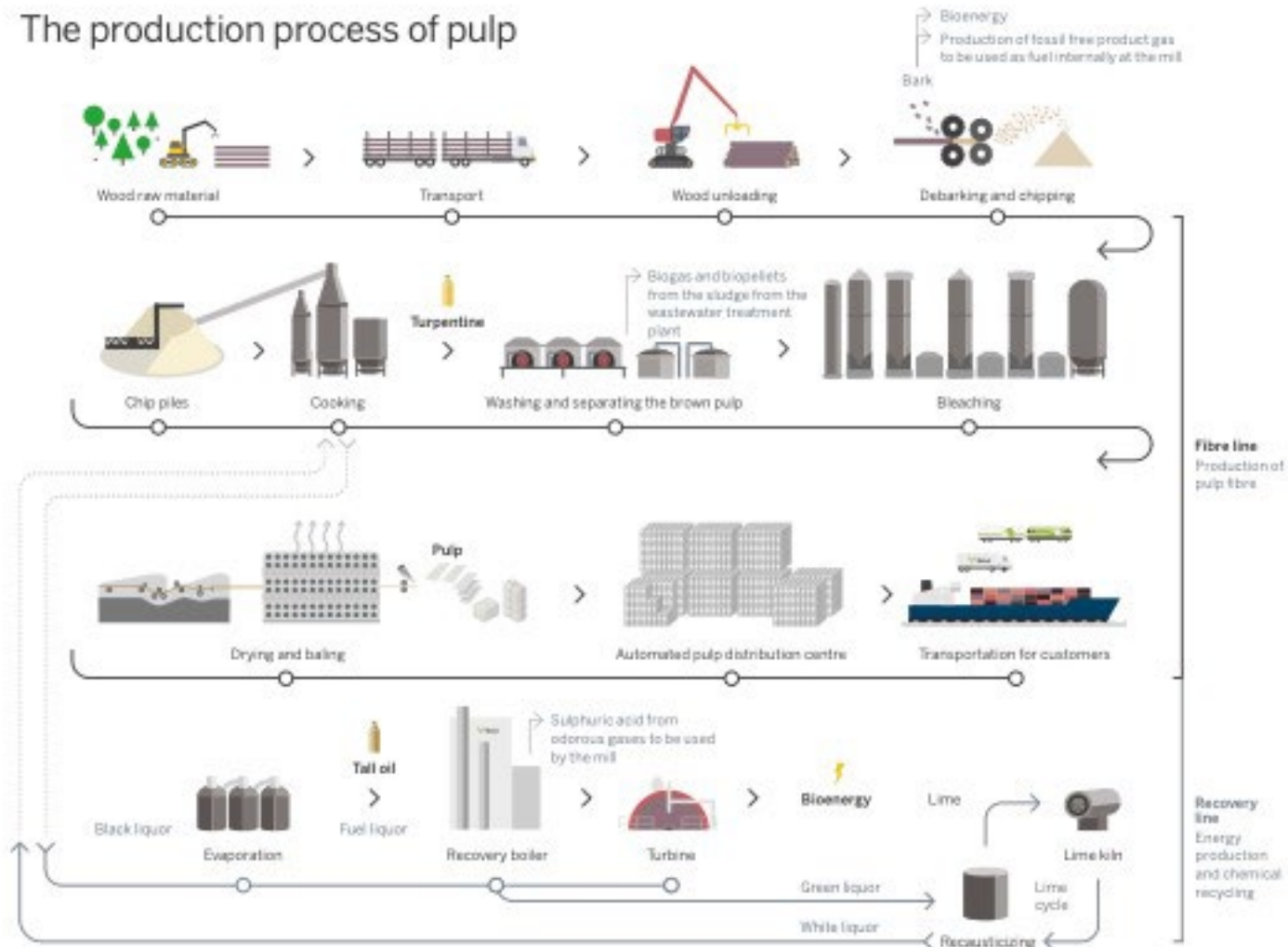


## Wood based biorefineries – what is included?

- Pulps (virgin fibres) are made from residues of timber harvesting and wood industry
- Packaging, printing and tissue papers from virgin pulps and recycled paper pulps
- Microfibrillar- & Nano-cellulose are made from chemical pulp or from side streams
- Chemical pulp mills produce bleached pulp fibres with about 50% yield from wood
- Remaining 50% is dissolved lignin, hemicellulose and extractives
- Lignin partly used to produce biofuels, materials and high value chemicals
- Hemicellulose partly used for production chemicals and materials as barriers
- Extractives for pine oil, turpentine and high value chemicals
- Rest is incinerated to recover cooking chemicals and to produce heat and electricity
- Excess heat and electricity is supplied to surrounding society and industries

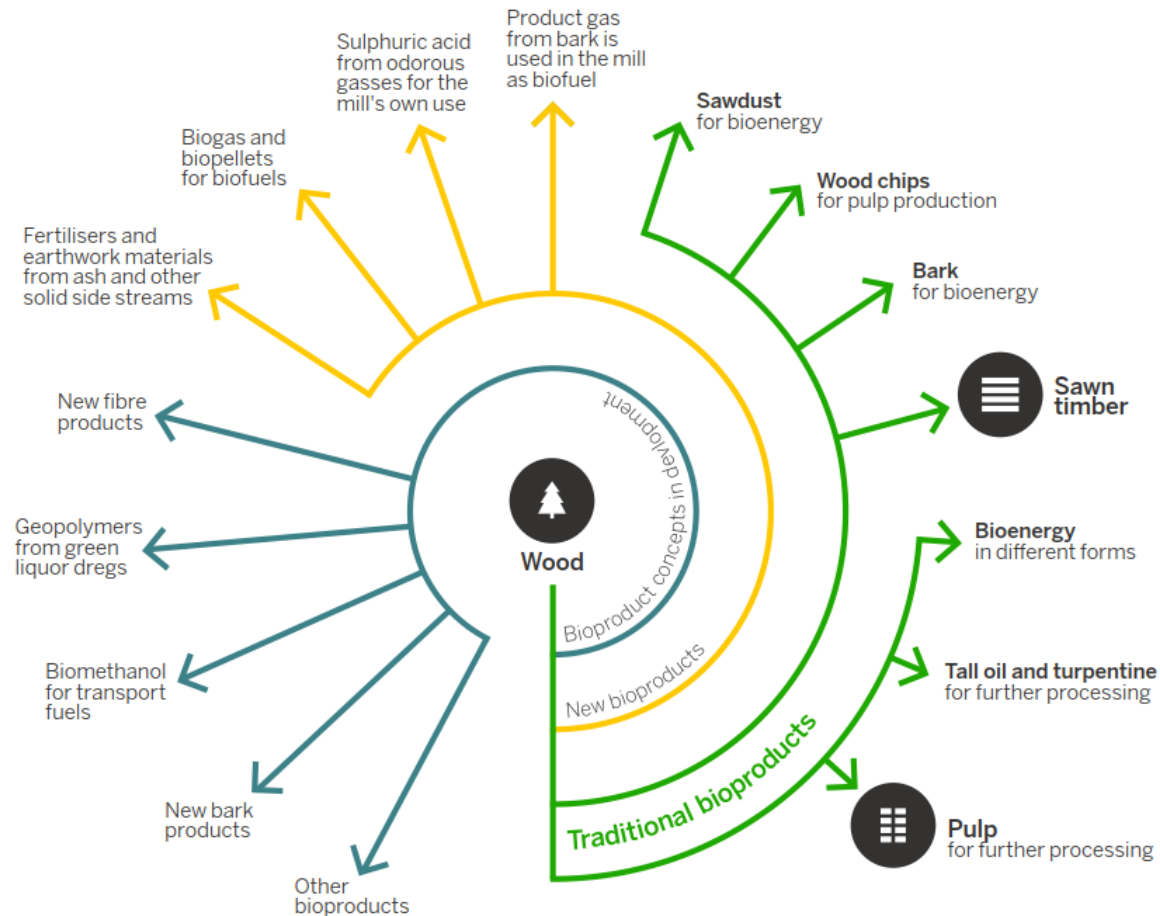
# Metsä - Äänekoski bioproduct mill

The production process of pulp



# Metsä Bioproduct mill concept

## UTILISATION OF MAIN AND SIDE STREAMS IN OUR BIOPRODUCT MILL CONCEPT



# Metsä - Äänekoski bioproduct mill – nice picture



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Softwood and hardwood pulp



Crude Tall Oil



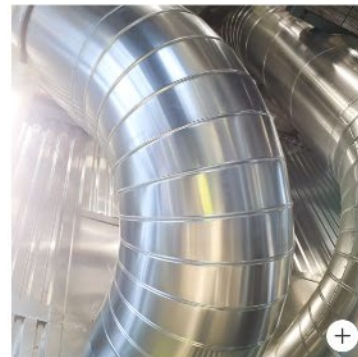
Crude Sulphate Turpentine



Bioenergy



Product gas



Sulphuric acid



Biopellets and biogas

## SCA Östrand 2018 doubling bleached kraft pulp to 900 ktpy and 2022 tripling the BCTMP to 300 ktpy

- One of the largest industrial investments 800 M€, 430000 to 900000 tpy, largest bleached softwood kraft pulp line in the world
- Quality-certified ISO 9001, environmentally certified ISO 14001, energy certified EN 16001. Chain-of-custody FSC® and PEFC™
- TCF- (Total Chlorine Free) and ECF- (Elementary Chlorine Free)
- State of the art technology minimizing emissions to air and water
- World leading in resource management, surplus green energy both as electricity 1,2 TWh/y and as district heating
- Products NBSK, 900 000 tpy (2020), CTMP, 300 000 tpy (2022/23), talloil and turpentine

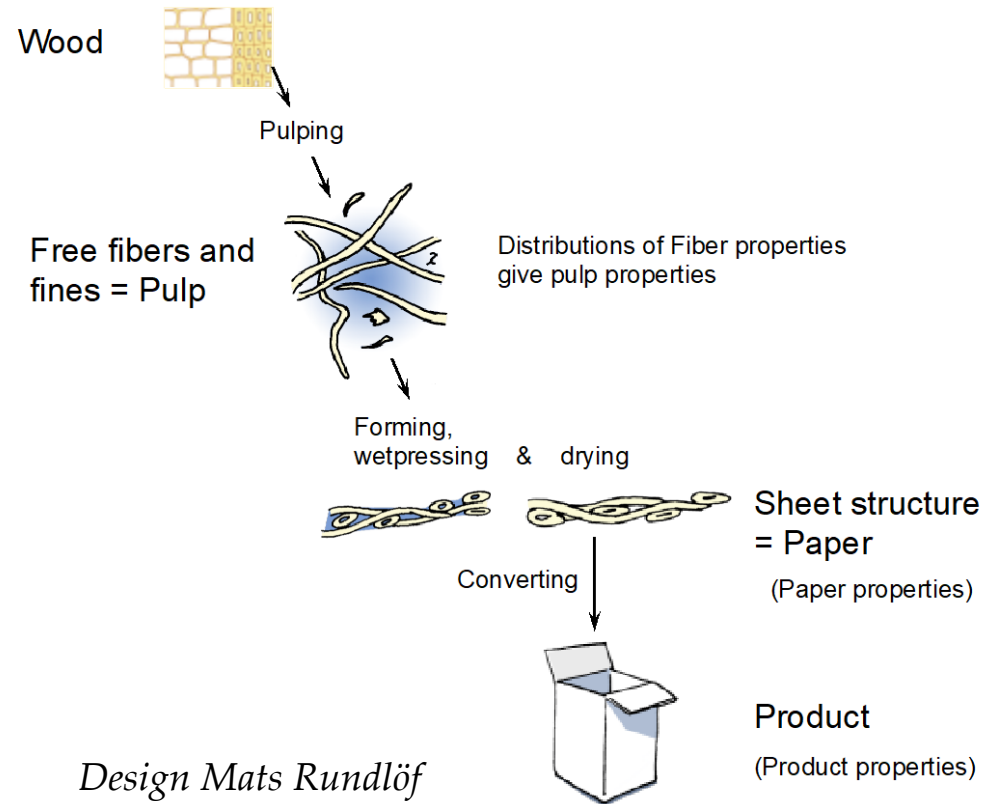
# Pulping – fibre separation for production of packaging, printing, hygiene and other products

Wood fibres are separated mechanically or chemically to pulp

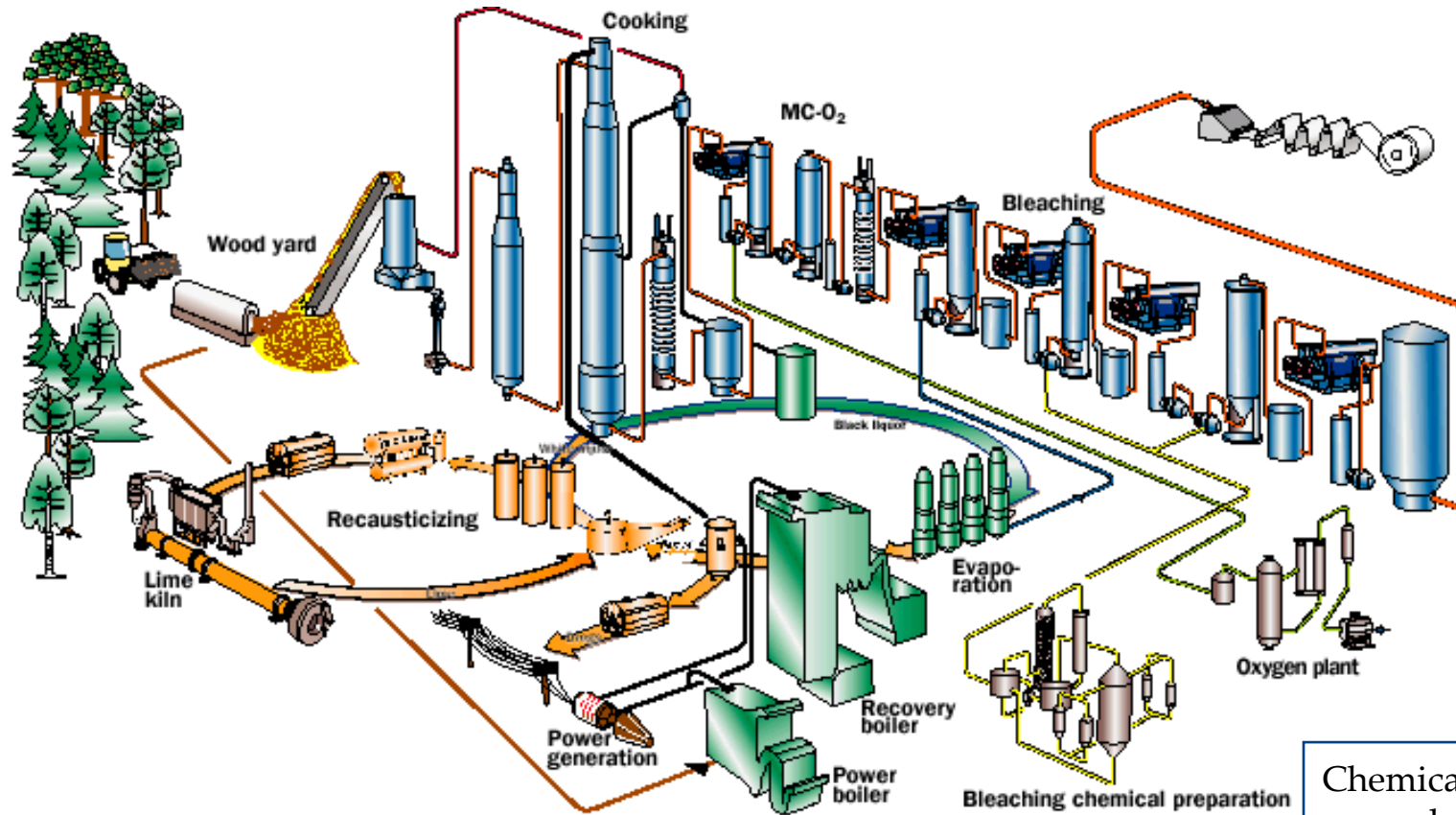
Pulp is in many cases further treated by bleaching and refining/beating

Pulp fibre based materials are formed, pressed, dried and surface treated

Examples of materials are; packaging products, printing papers, hygiene products etc.



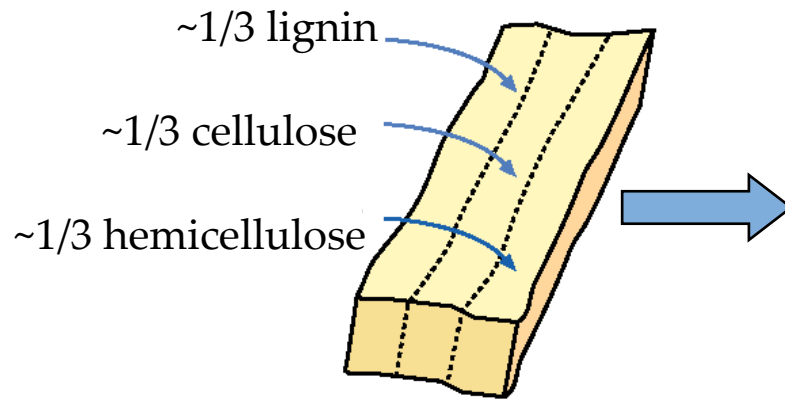
# Chemical pulping system with internal/external use of bioenergy and internal generation of process chemicals



Chemical pulping process example from Prof Mikael Lindström, KTH



# Chemical liberation of fibers



Bleached Softwood Kraft Pulp

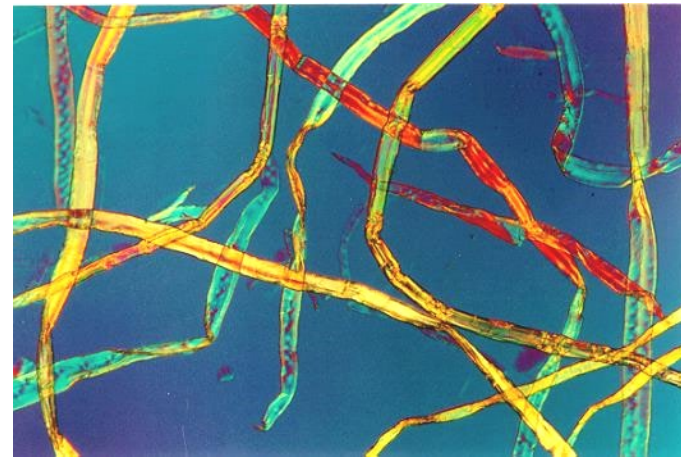
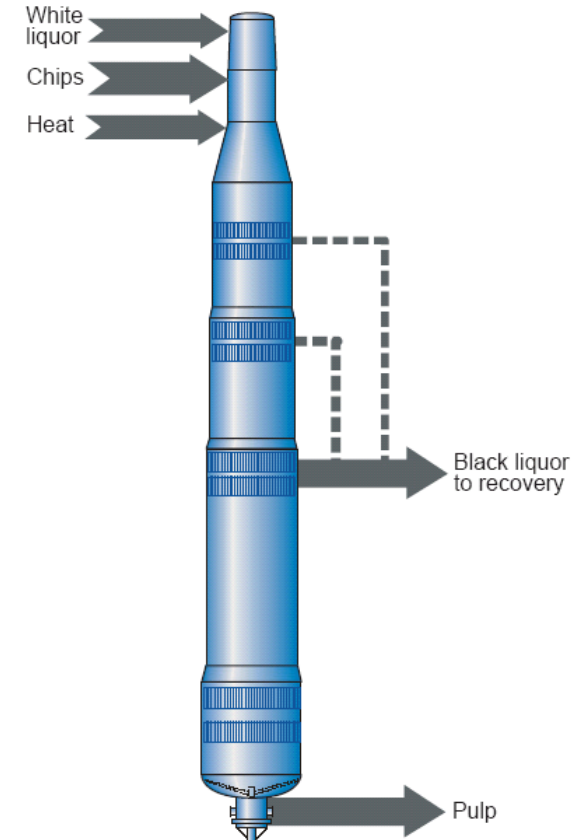


Foto:STFi

# Principles of chemical pulp technology:

- Liberate fibers from wood
- Make the fiber flexible
- Remove lignin
- Eliminate colored groups (in some cases)
- Recover cooking (and bleaching) chemicals
- Convert dissolved organic materials into energy – and/or to biorefinery products

## Kraft Cooking



KI 51 1258J

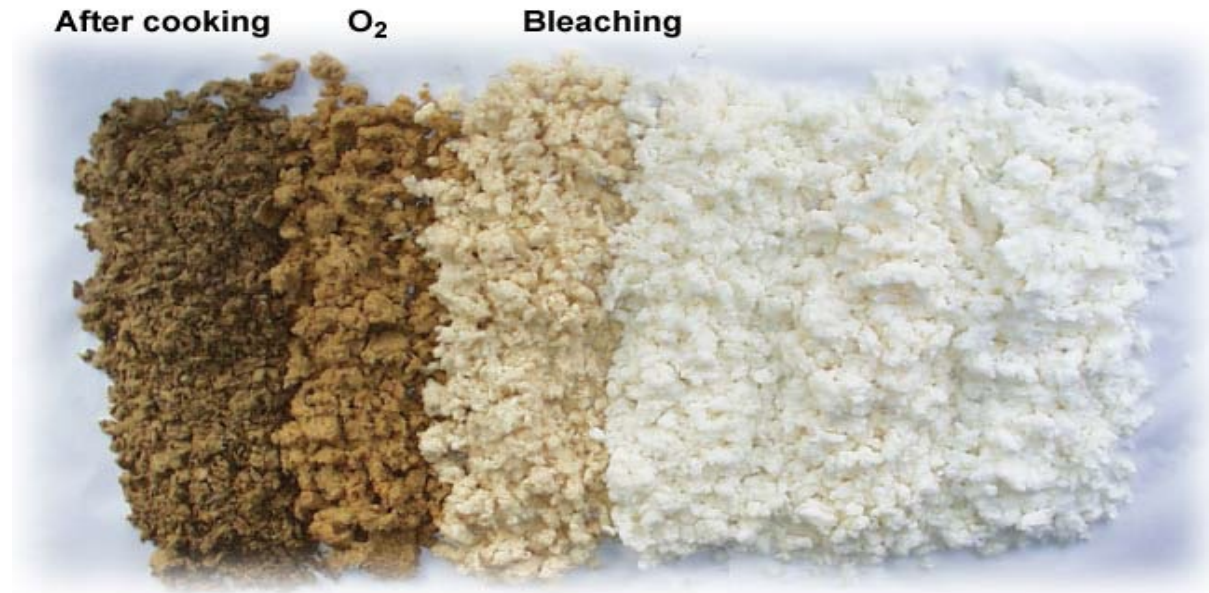
GBN/VMS 2005-01-04

## Bleaching of chemical pulps

- Chemical pulps - especially kraft pulps are dark brown due to modified lignin structures
- Bright pulps are needed in hygiene products printing & writing, high quality board
- Homogenous pulps needs complete defibration
- Brightness stability
- Hygienic reasons
- Pure cellulose / viscose pulps

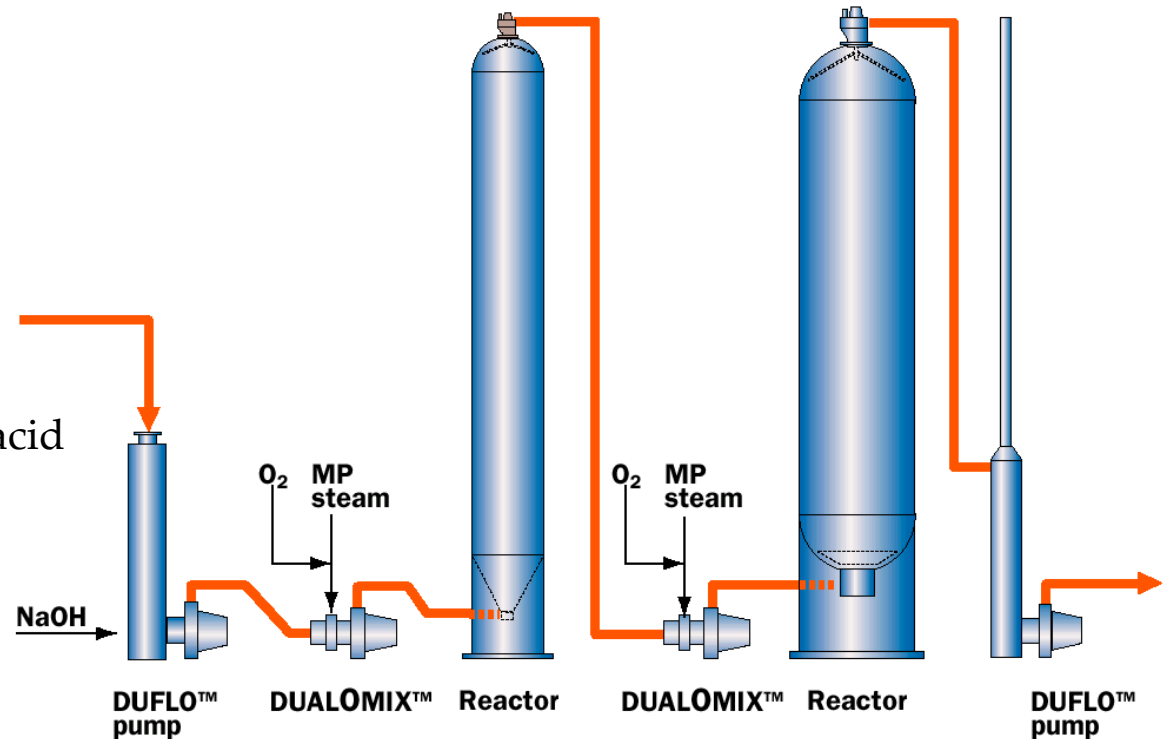
### Pulp bleaching

The dark colour of the pulp is mainly due to residual lignin.  
This is removed gradually during bleaching.



## Oxygen based bleaching chemicals

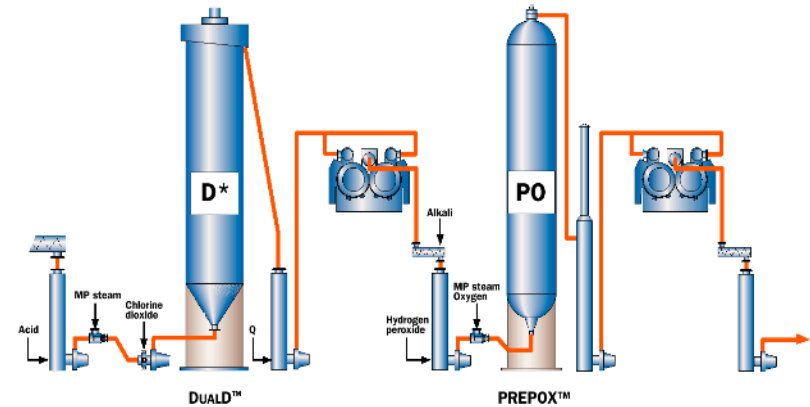
- O - Oxygene, P - Peroxide, Z - Ozone and T – PAA, Peracetic acid
- Often cheap (O)
- Environmental friendly
- Relatively poor selectivity (OPZ)
- All can not degrade hexenuronic acid
- Sometimes expensive (Z, T)



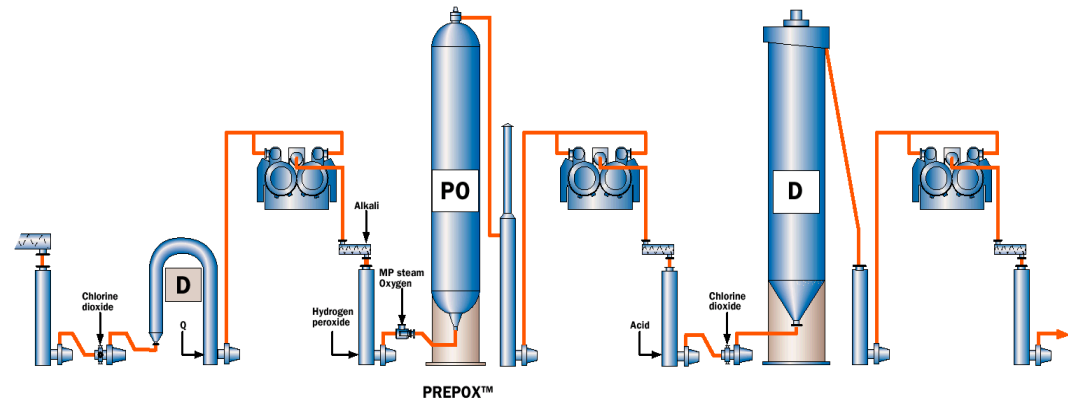
## Chlorine based bleaching chemicals

- D – chlorine dioxide, C - Chlorine gas, H - Hypochlorite
- High selectivity towards lignin
- Able to attack non-phenolic lignin and hexenuronic acid
- Relatively high prize
- **Environmental problems, Chlorine**
- In Sweden only D is used
- The chemistry of the different bleaching me  
"hooks" into each other even more than for  
based bleaching

Modern bleaching sequence for hardwood kraft - (DQ)<sup>\*</sup>(PO)



Modern bleaching sequence for softwood kraft - (DQ)(PO)D



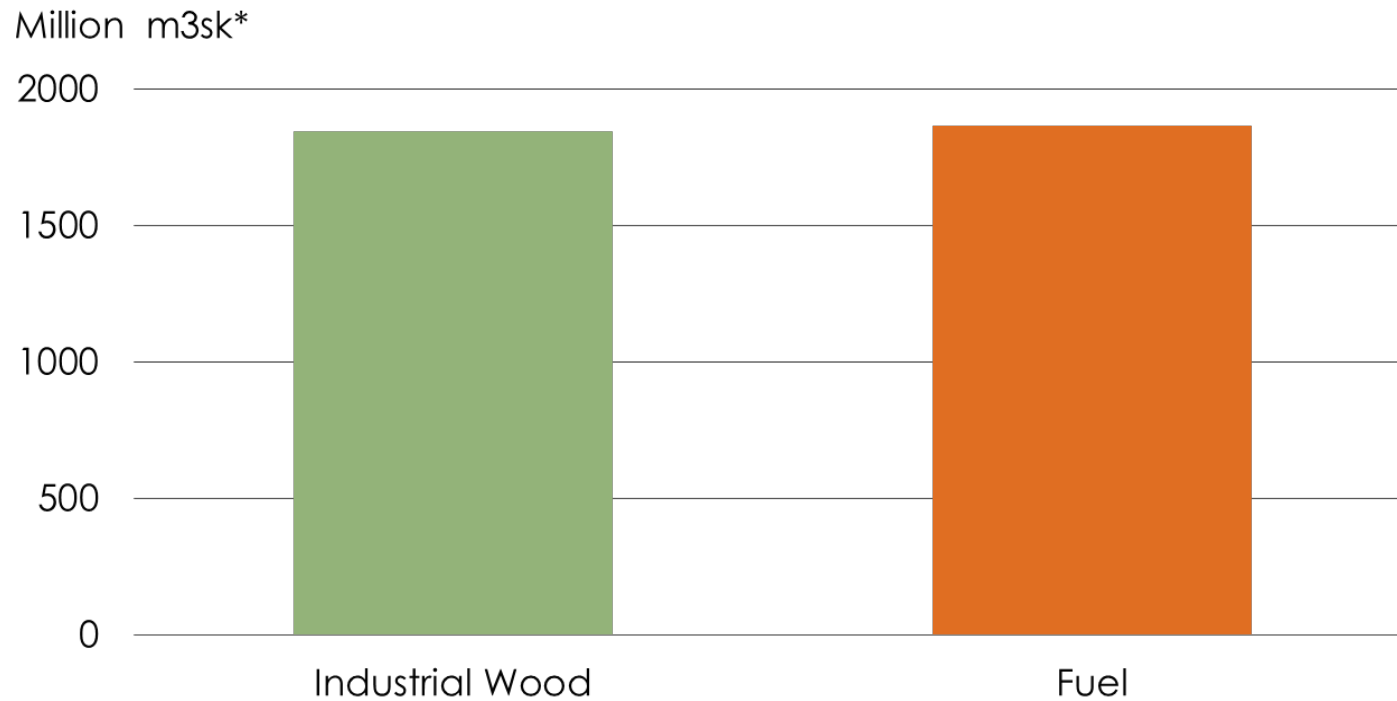
## Future possibilities - new materials from cellulose and replacing fossil based

- Higher energy efficiency – less internal use of energy
- More additional products as nano-cellulose, lignin based products including transport fuels, hemicellulose and extractive based products
- Specially designed fibres for a wider product range
- Focus on replacing fossil based materials – helping society to avoid use of harmful plastics – new pulp & paper technology developments

# World-wide use of pulps for packaging, printing, hygiene and other materials / products

- FAO statistics – the world
- CEPI statistics - Europe
- Swedish Forest industry statistics
- Environmental statistics

# Global Use of Wood 2015



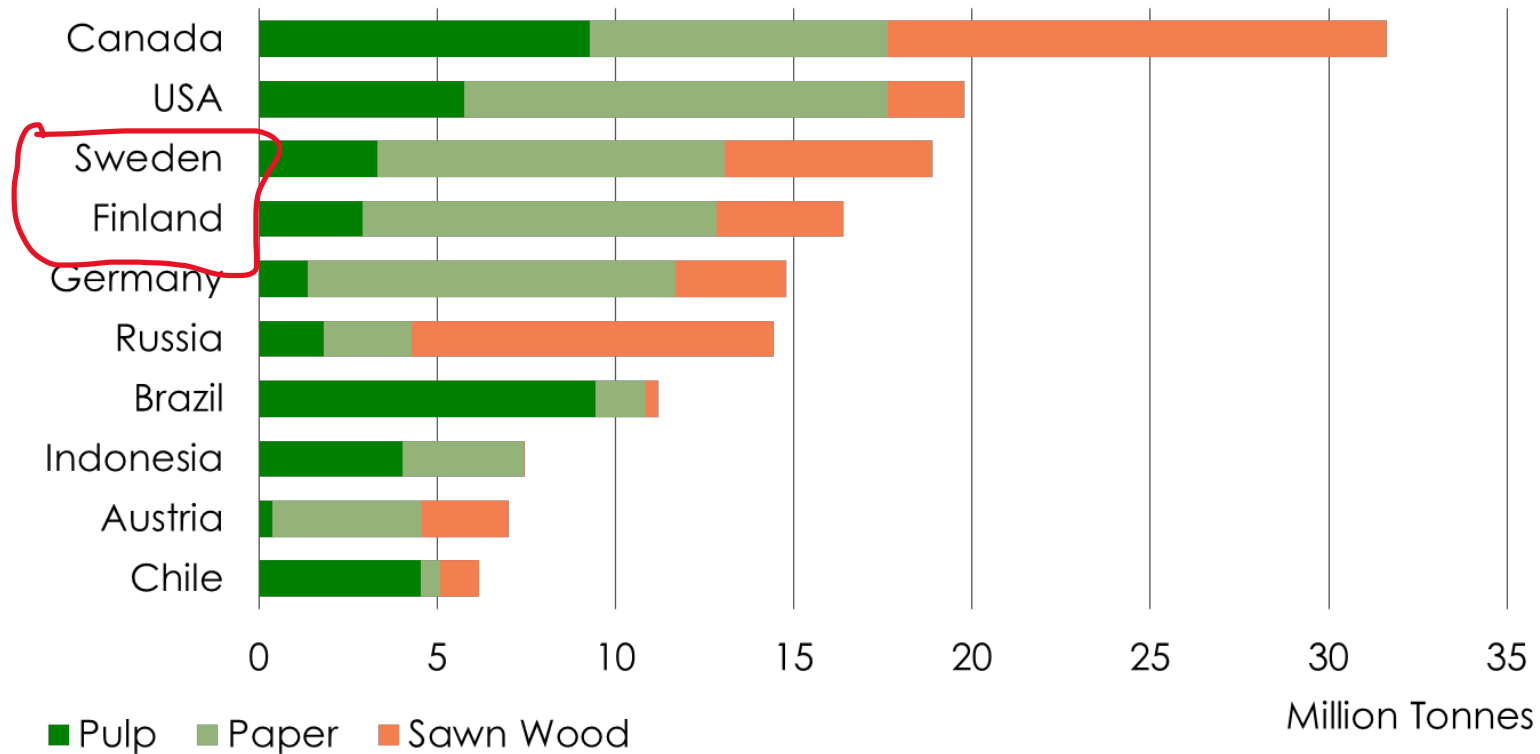
\* m<sup>3</sup>sk = Forest Cubic Meters

Source: FAO



# World Leading Exporters 2015

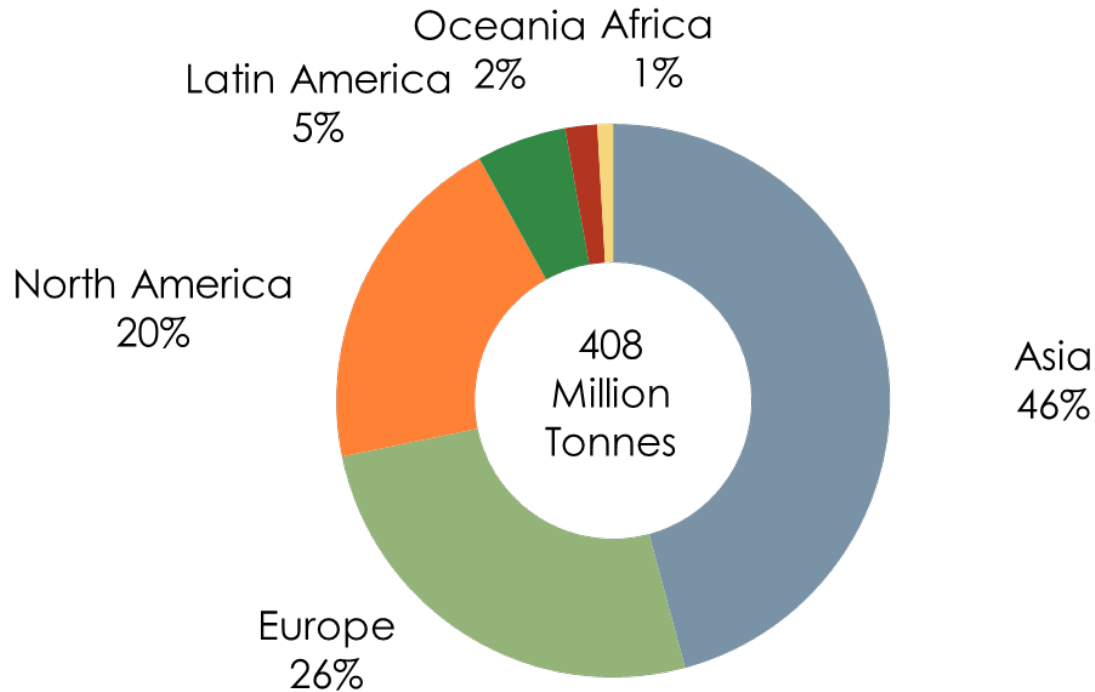
## Pulp, Paper and Sawn Timber



Source: Swedish Forest Industries Federation, CEPI, RISI, FAO, National Associations

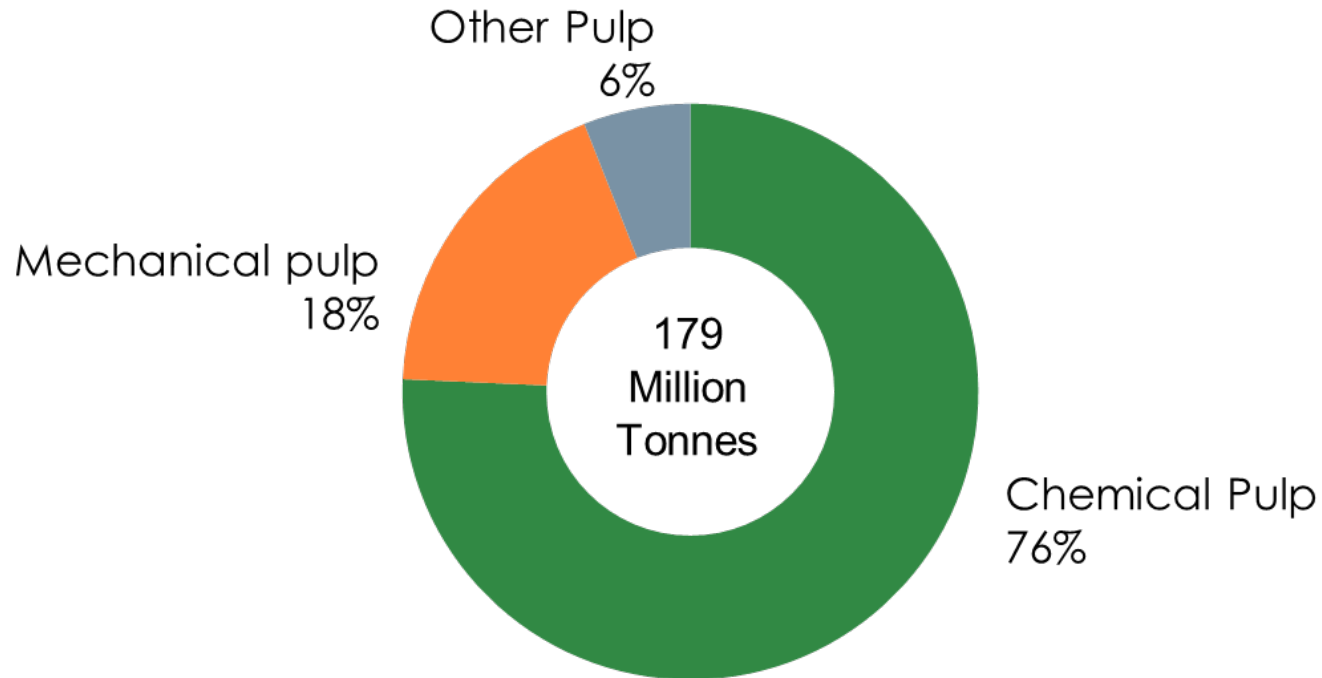
# Global Paper Production 2015

## by Region



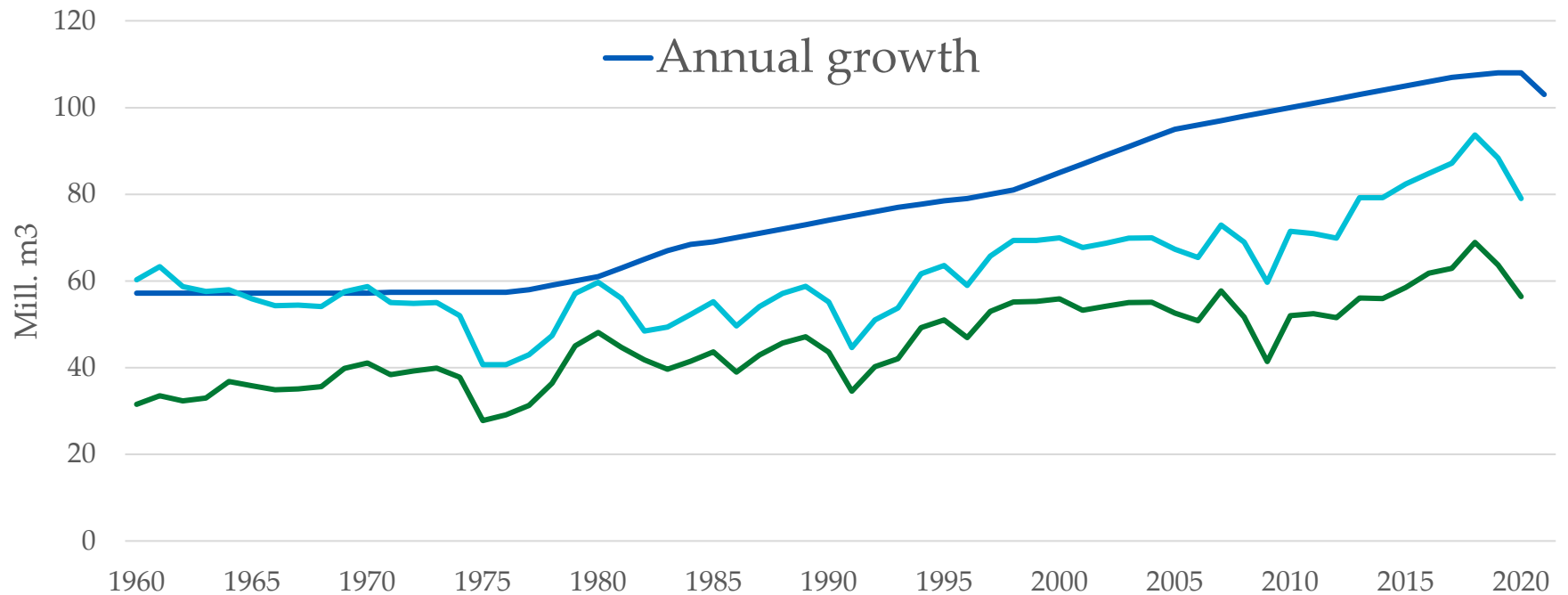
Source: RISI

# Global Pulp Production 2015 by Quality

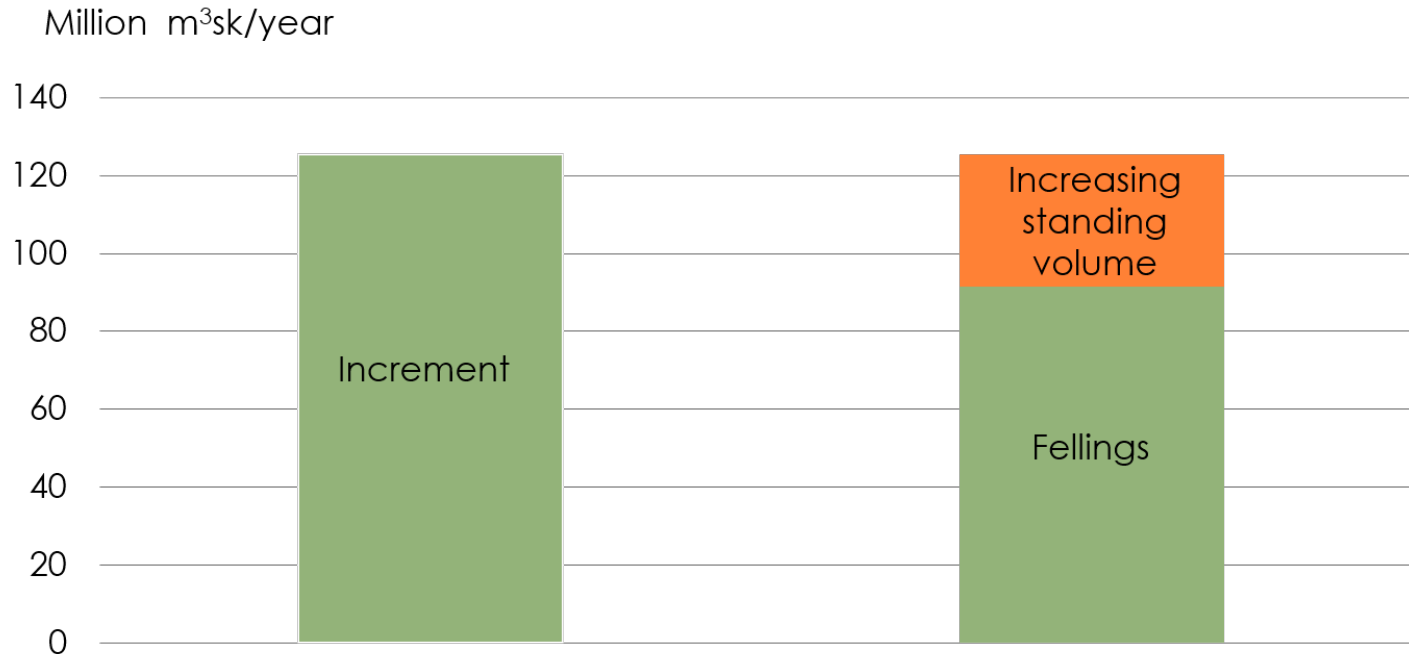


Source: RISI

# The growth of Finnish forests is over 100 mill. m<sup>3</sup> per year



# Growth is Larger than Felling Sweden 2014



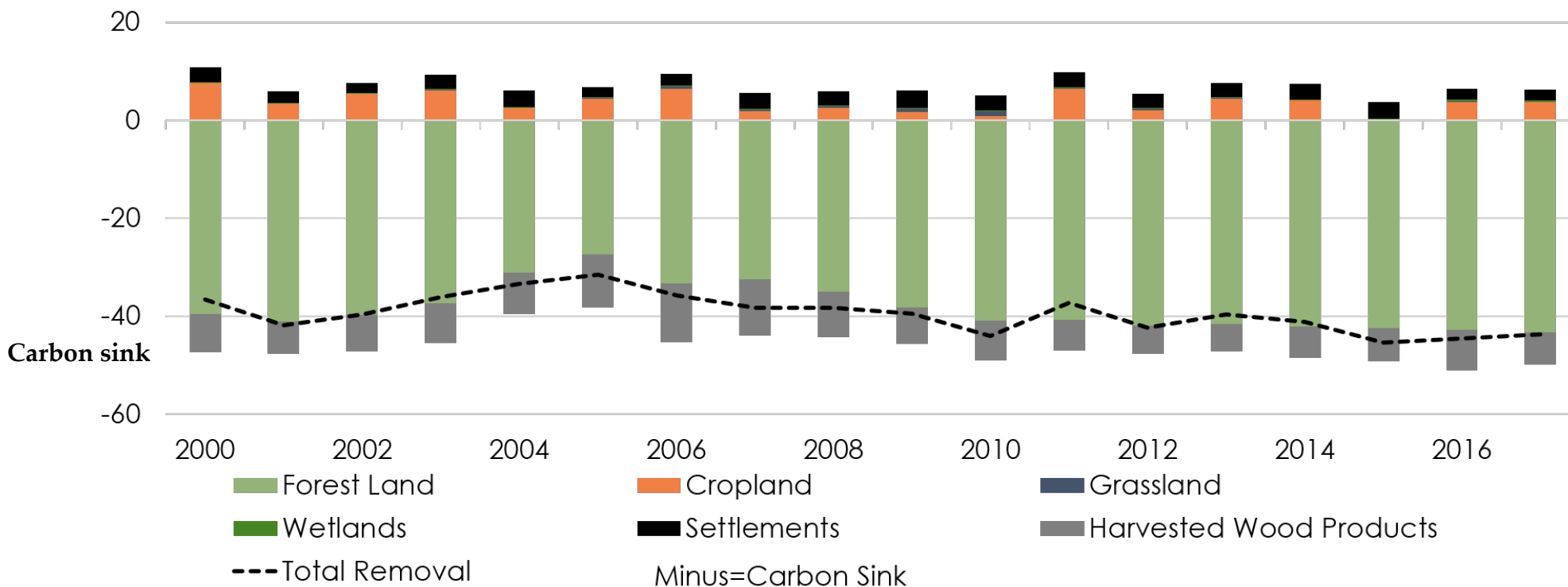
\* m<sup>3</sup>sk = Forest Cubic Meters

Source: Swedish National Forest Inventory

# Emissions of Greenhouse Gases 2000-2017


## From Land Use in Sweden


CO<sub>2</sub> equivalents, Million Tonnes/year



Source: Swedish Forest Industries, Swedish Environmental Protection Agency

## Carbon Absorbed and Released by the Forest Over the Lifecycle

 Carbon Release

 Carbon Uptake

 Felling

 Annual Growth  
(Forest Cubic Metres)

The principle of how a forestry ecosystem takes up and releases carbon. The area shaded in green indicates that the forest is taking up more carbon than it releases. The area shaded in orange indicates where the opposite is the case.



Source: SLU (The Swedish University of Agricultural Sciences)