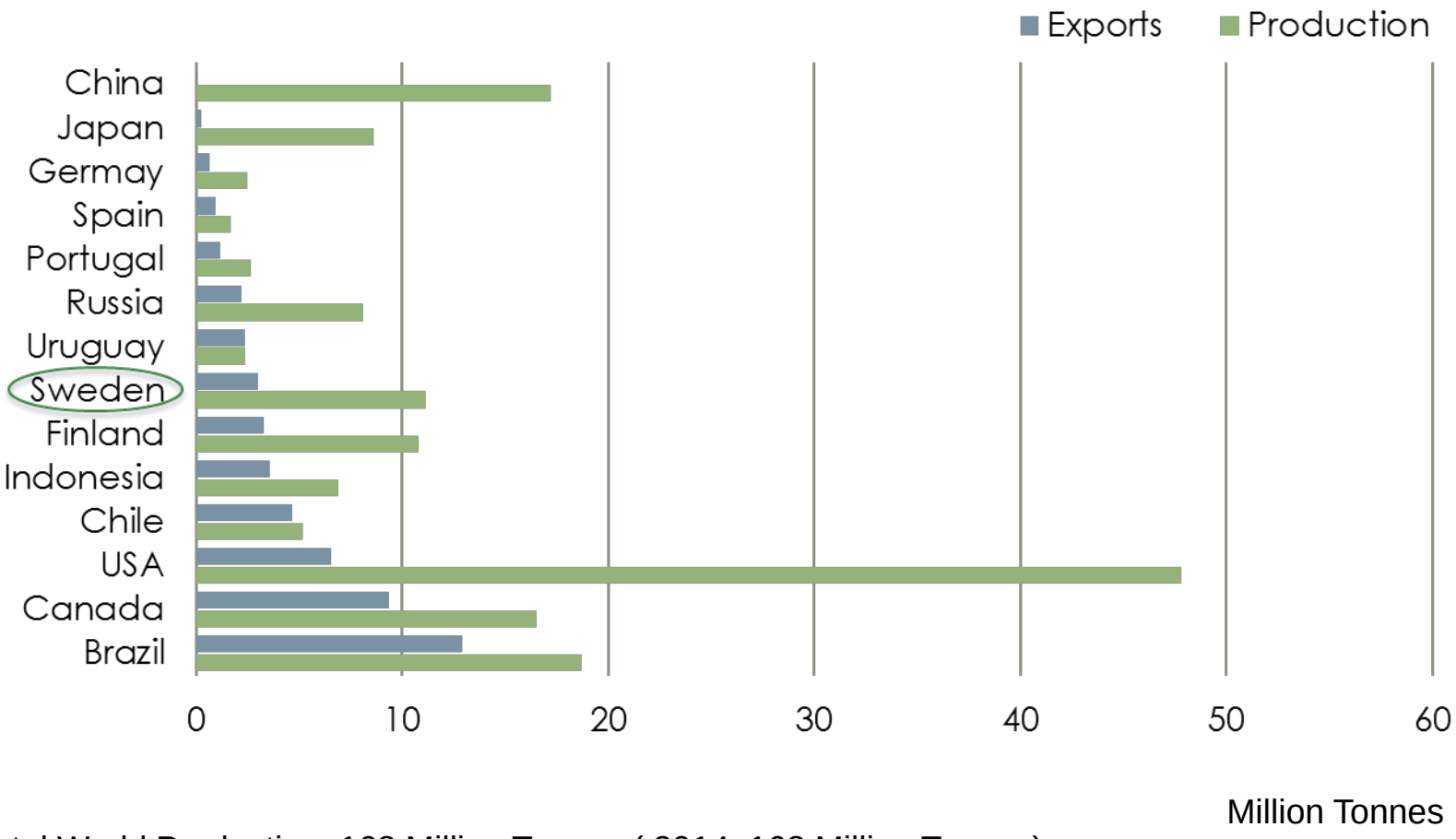
Pulp and Paper Industry

Anders Törngren Swedish EPA

Pulp and Paper

- Production and capacity
  - Global, Europe, Sweden
- Process
  - Kraft pulp mill
  - BAT (Best available techniques)
  - Emission to air and water
  - Paper
- Energy
- Water management and Effluent treatment
- Summary

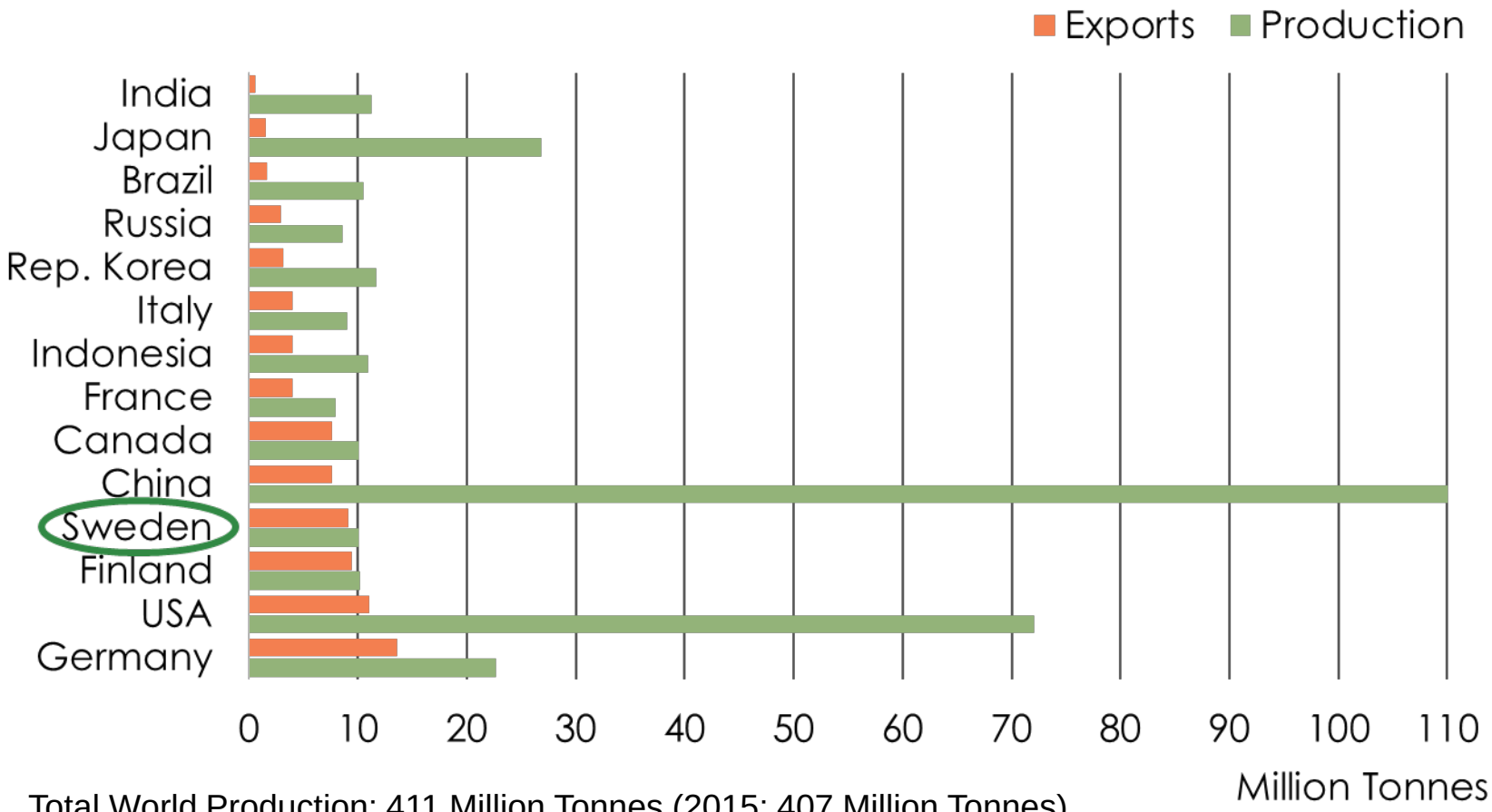
Production and Exports of Pulp 2016



Total World Production: 168 Million Tonnes (2014: 168 Million Tonnes)
Total World Exports: 51 Million Tonnes (2014: 50 Million Tonnes)

Source: RISI, CEPI

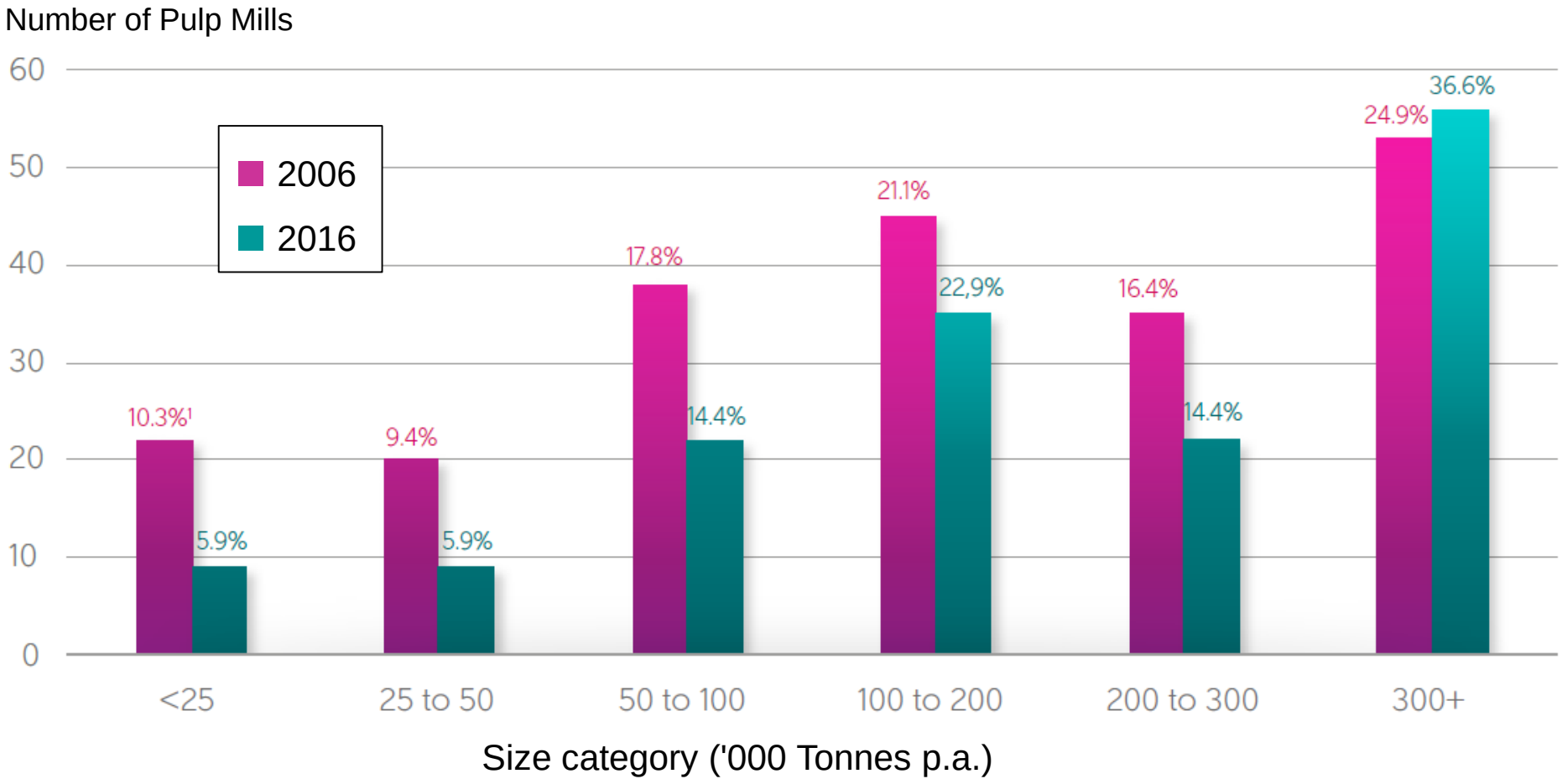
Production and Exports of Paper 2016



Total World Production: 411 Million Tonnes (2015: 407 Million Tonnes)
Total World Exports: 112 Million Tonnes (2015: 111 Million Tonnes)

Source: RISI, CEPI

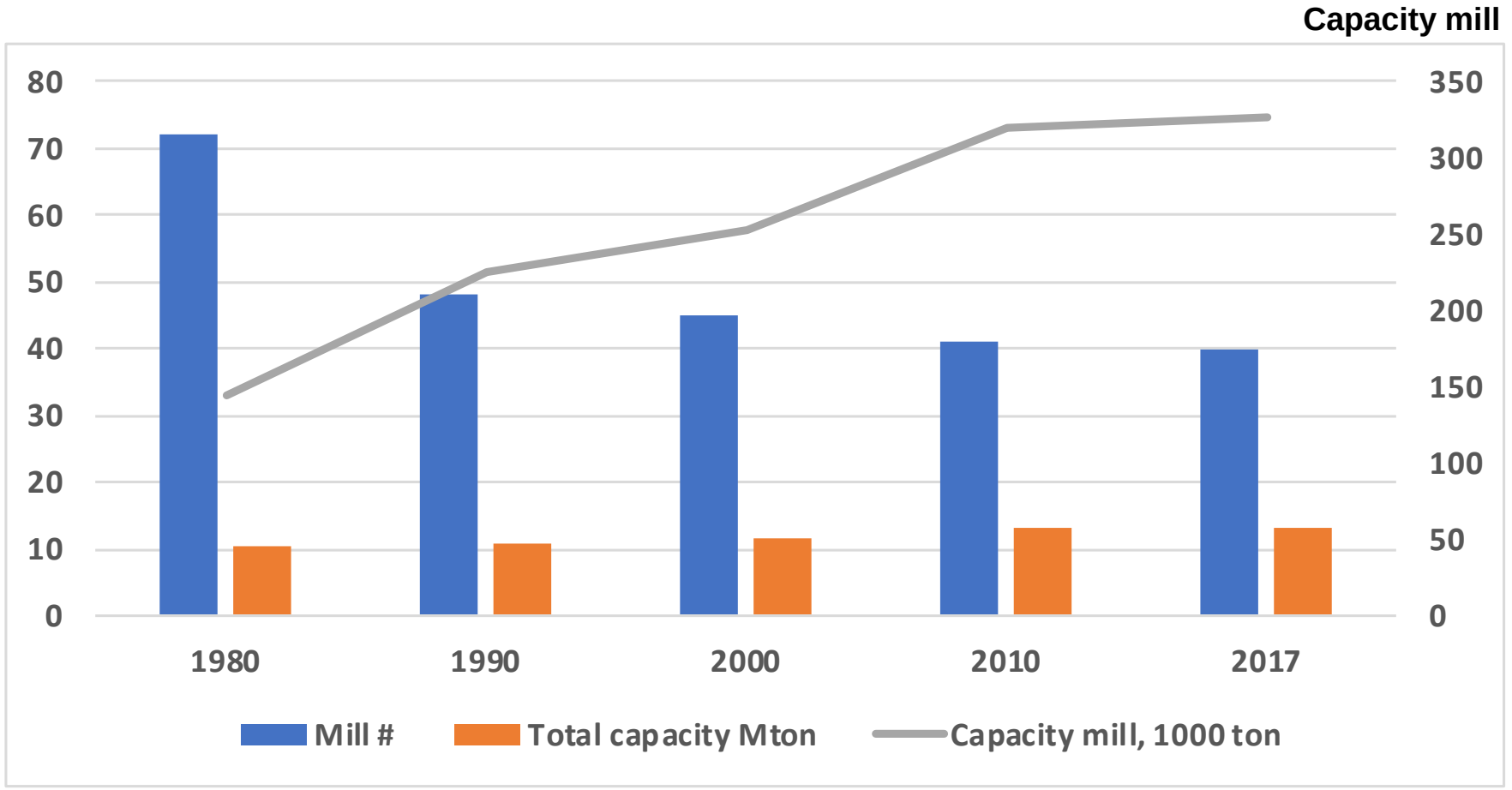
Number of European* Pulp Mills by Volume in 2006 and 2016



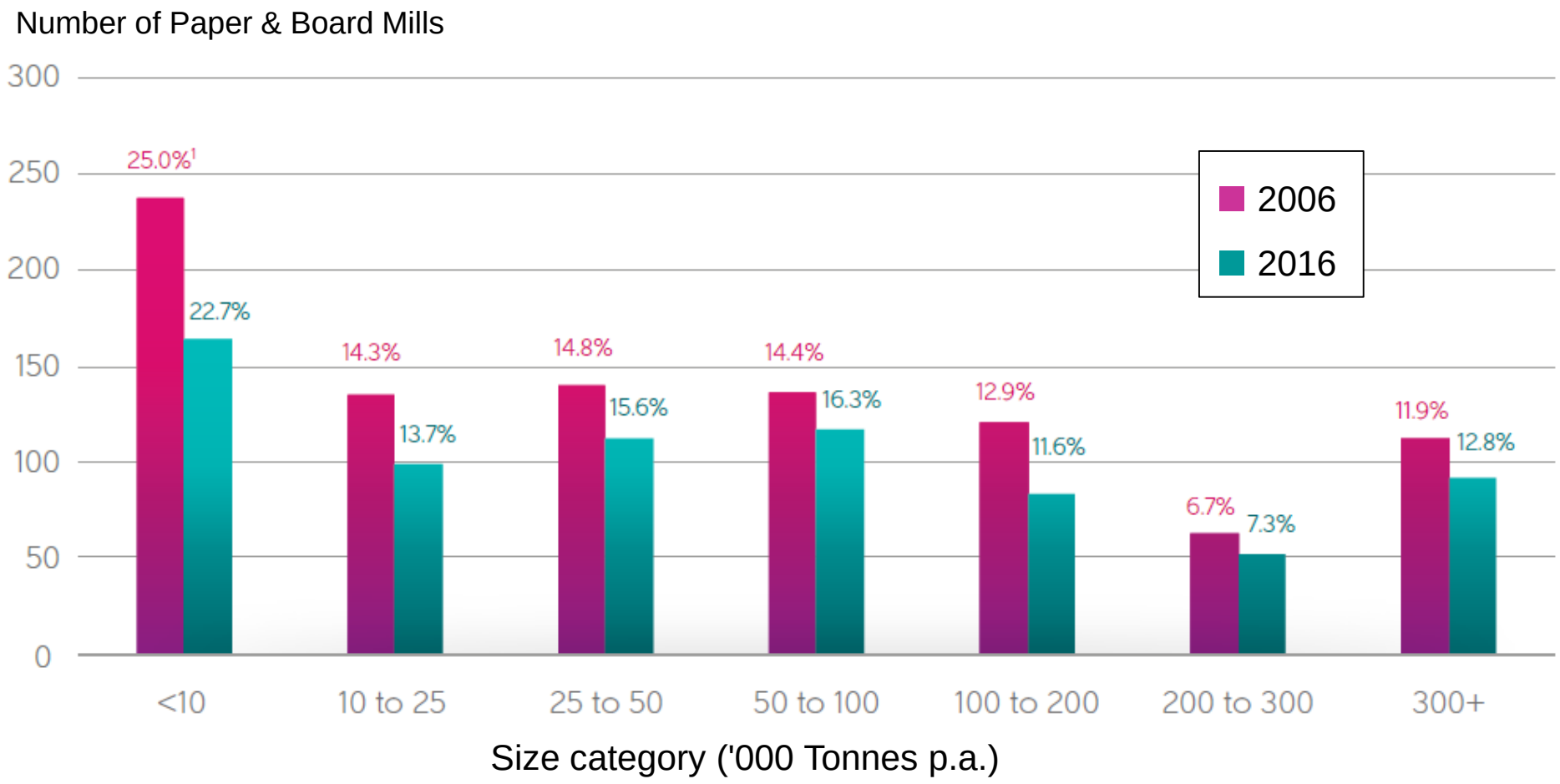
[1]Share of Total Number of Mills
* Europe countries within Cepi

CEPI Statistics

Structure in the Swedish pulp industry 1980-2017



Number of European* Paper & Board Mills by Volume in 2006 and 2016



[1]Share of Total Number of Mills
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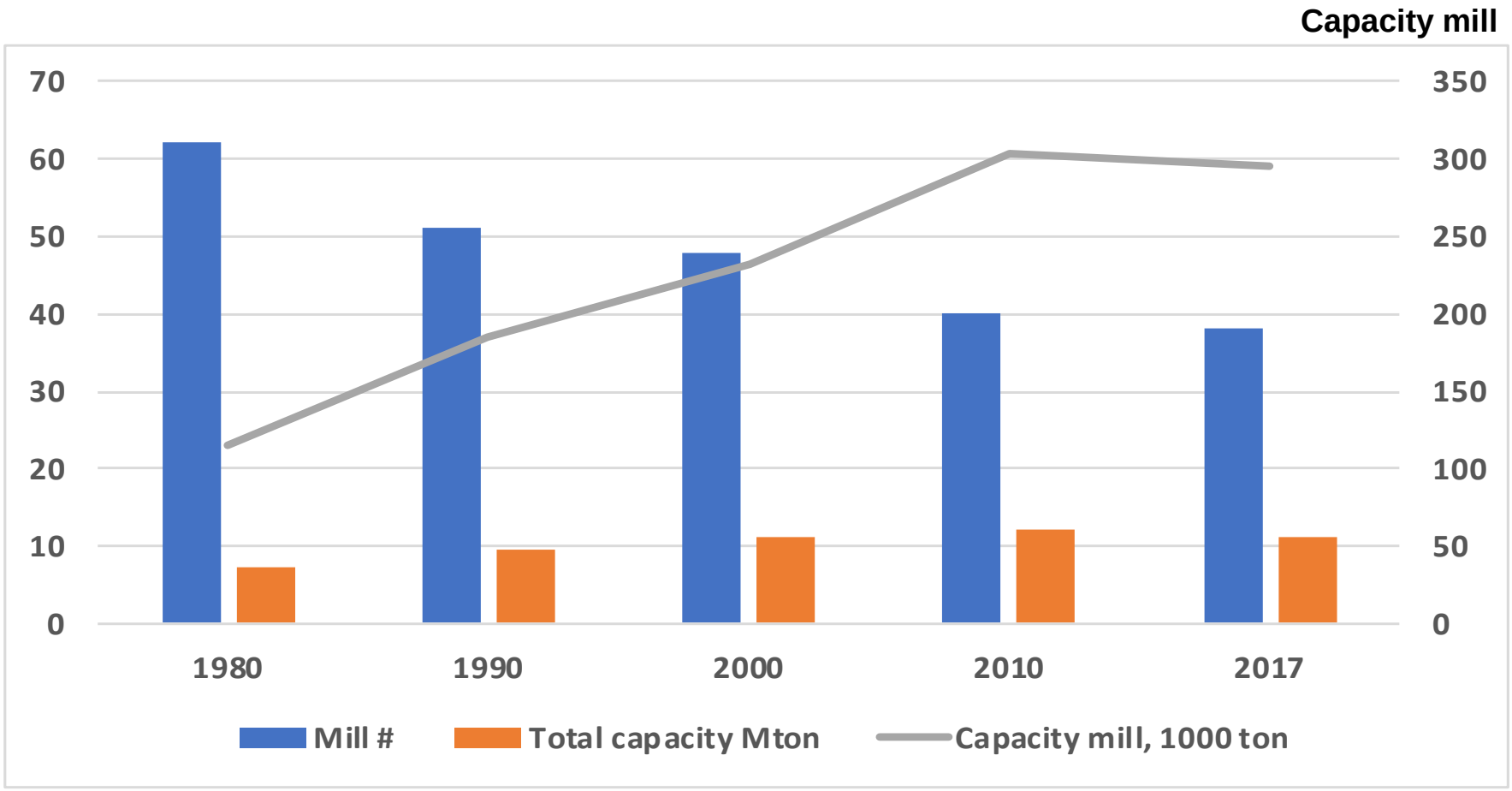
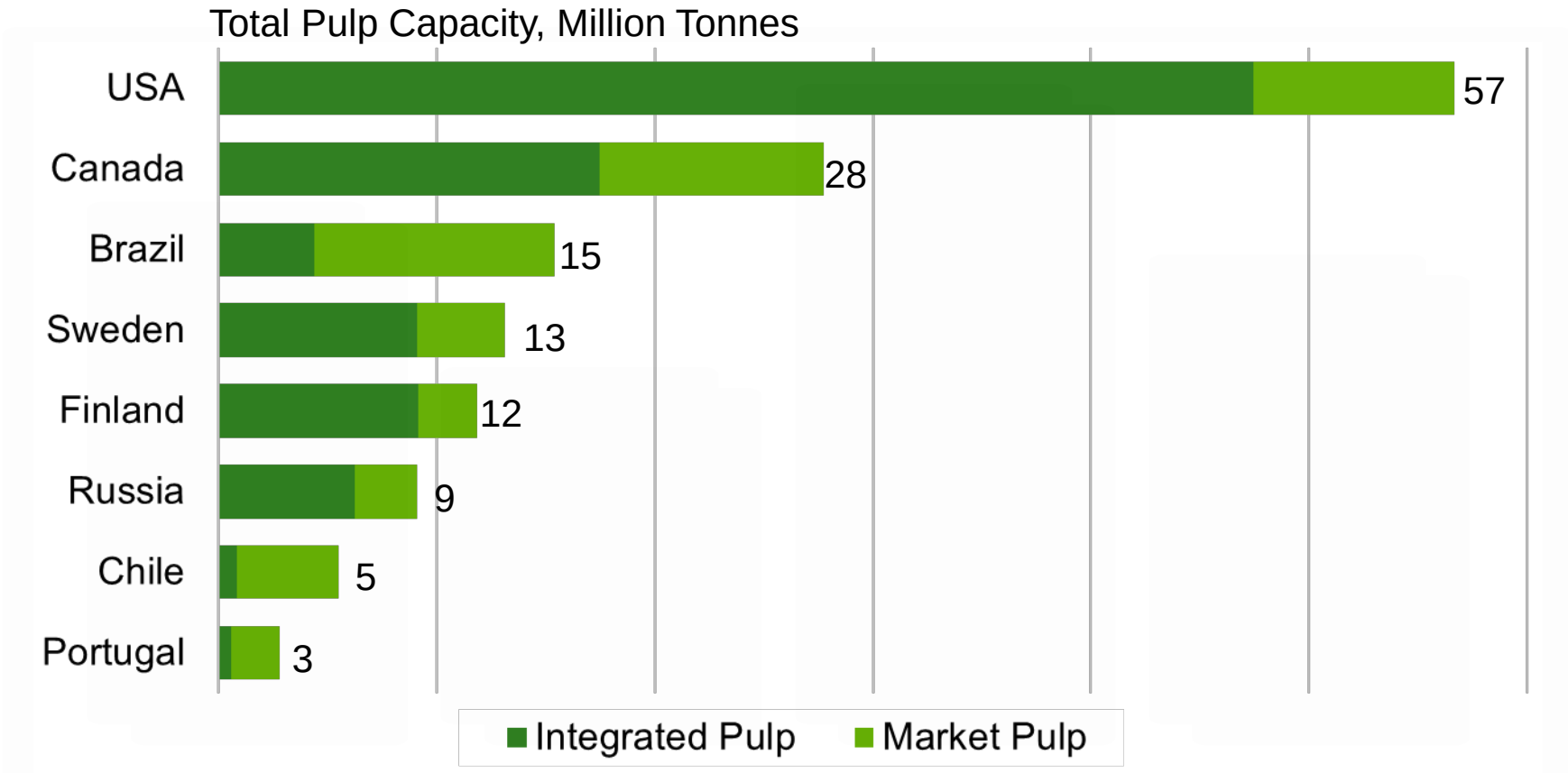
CEPI Statistics

Structure in the Swedish paper industry 1980-2017

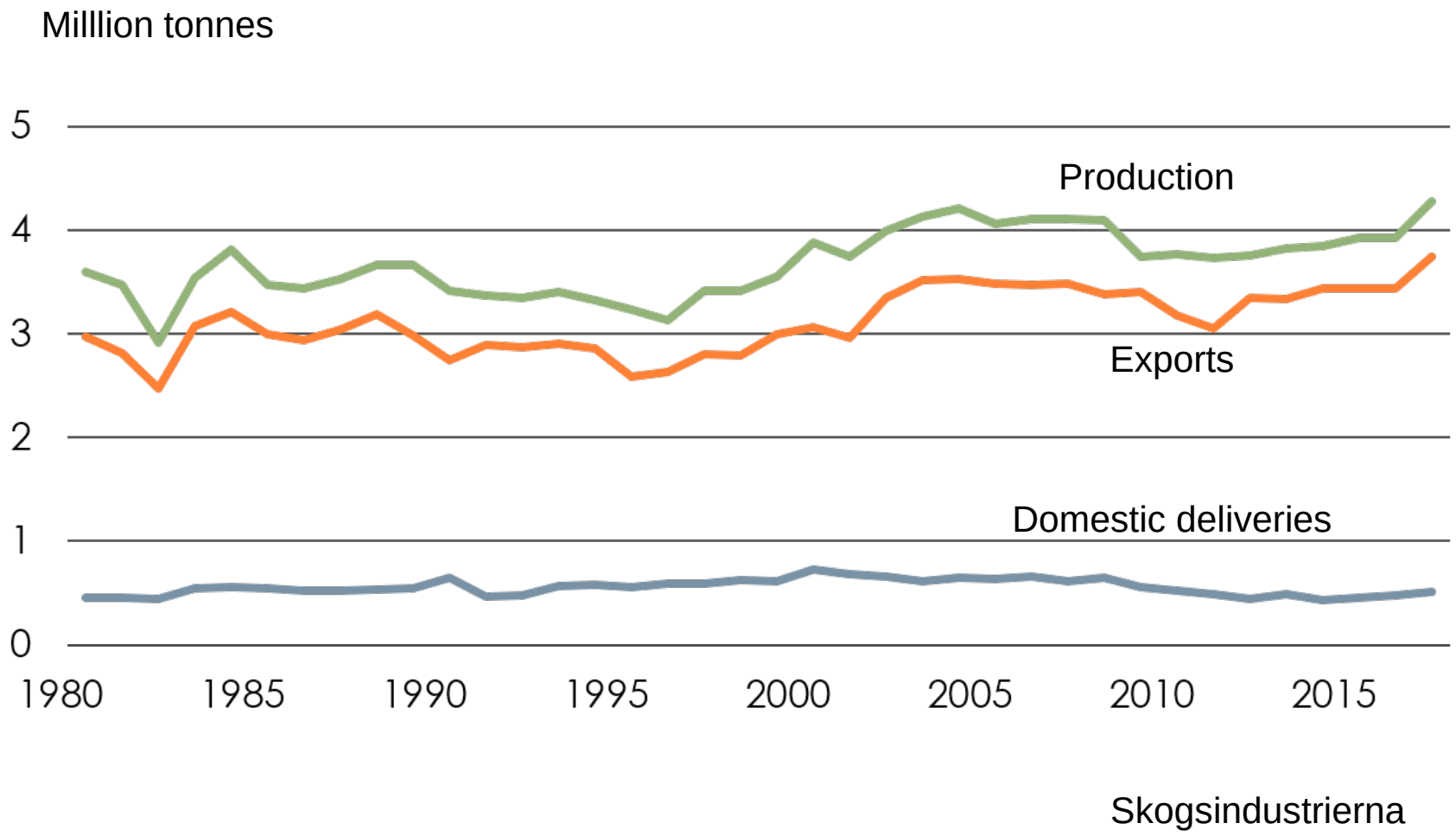


Share of Integrated Pulp in the Pulp and Paper Industry 2011

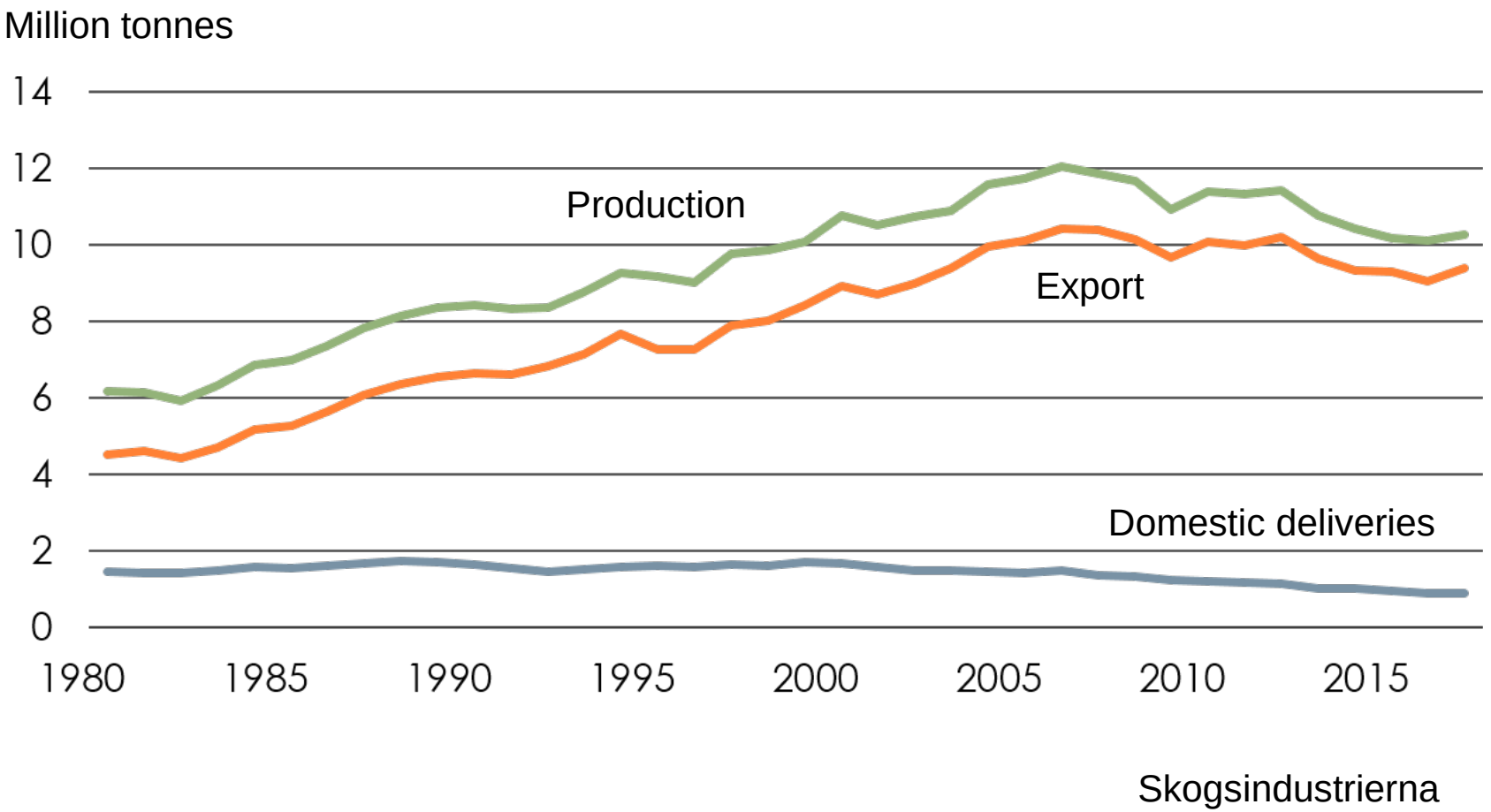


Source: FAO

Market pulp production and deliveries Sweden 1980-2017



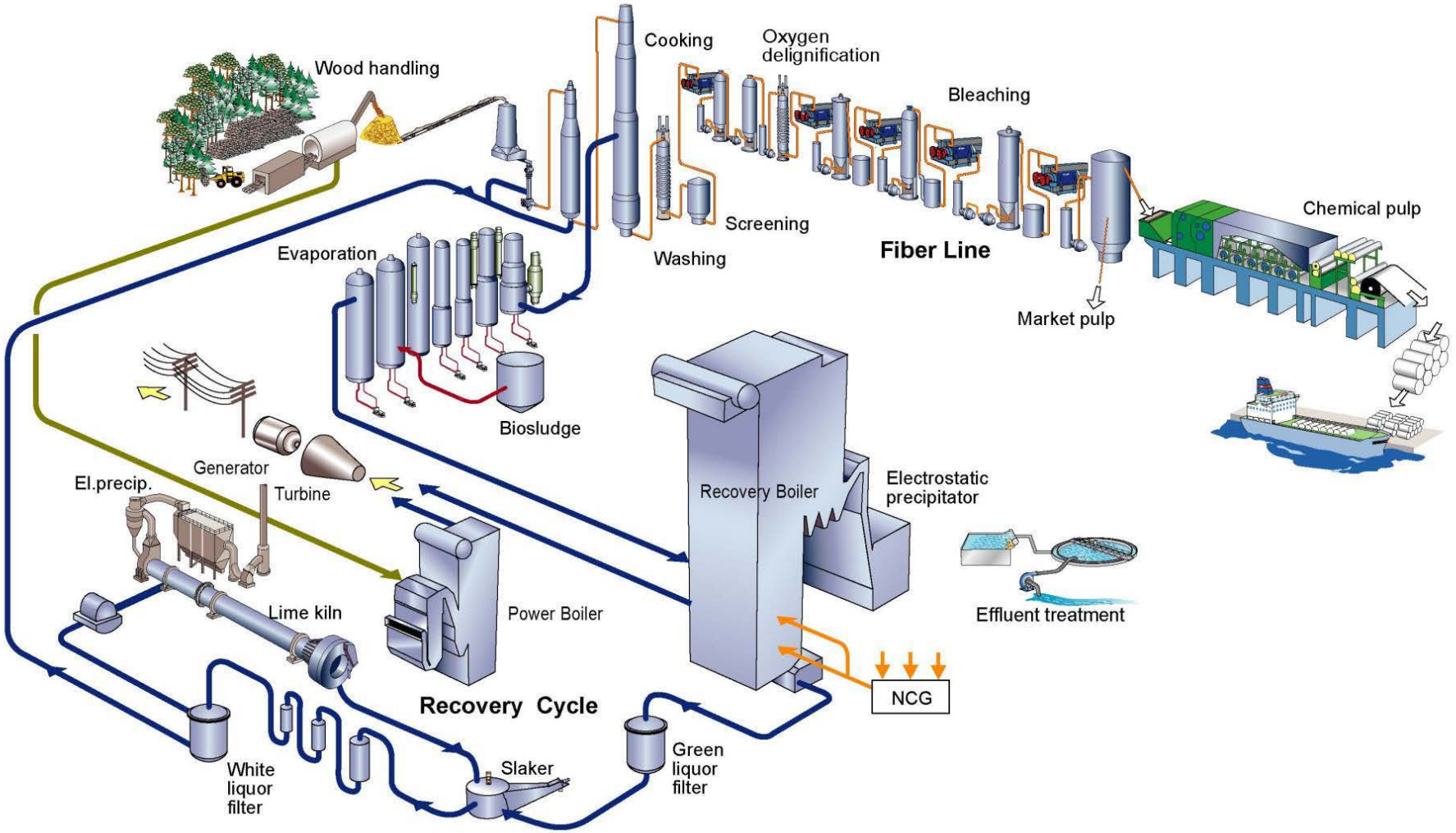
Paper production and deliveries Sweden 1980-2017



Kraft mill process

- Debarking (water emission)
- Chipping and screening (no major environmental impact)
- Cooking (water emission, energy)
- Condensation (water emission, energy)
- Spillage (water emission)
- Washing loss (water emission)
- Bleaching (water emission)
- Recovery boiler (air emission, energy)
- Lime kiln (air emission)
- Boilers (air emission, energy)
- Paper machine (water emission, Energy)

Typical Kraft Pulp Mill



Typical Kraft Pulp Mill

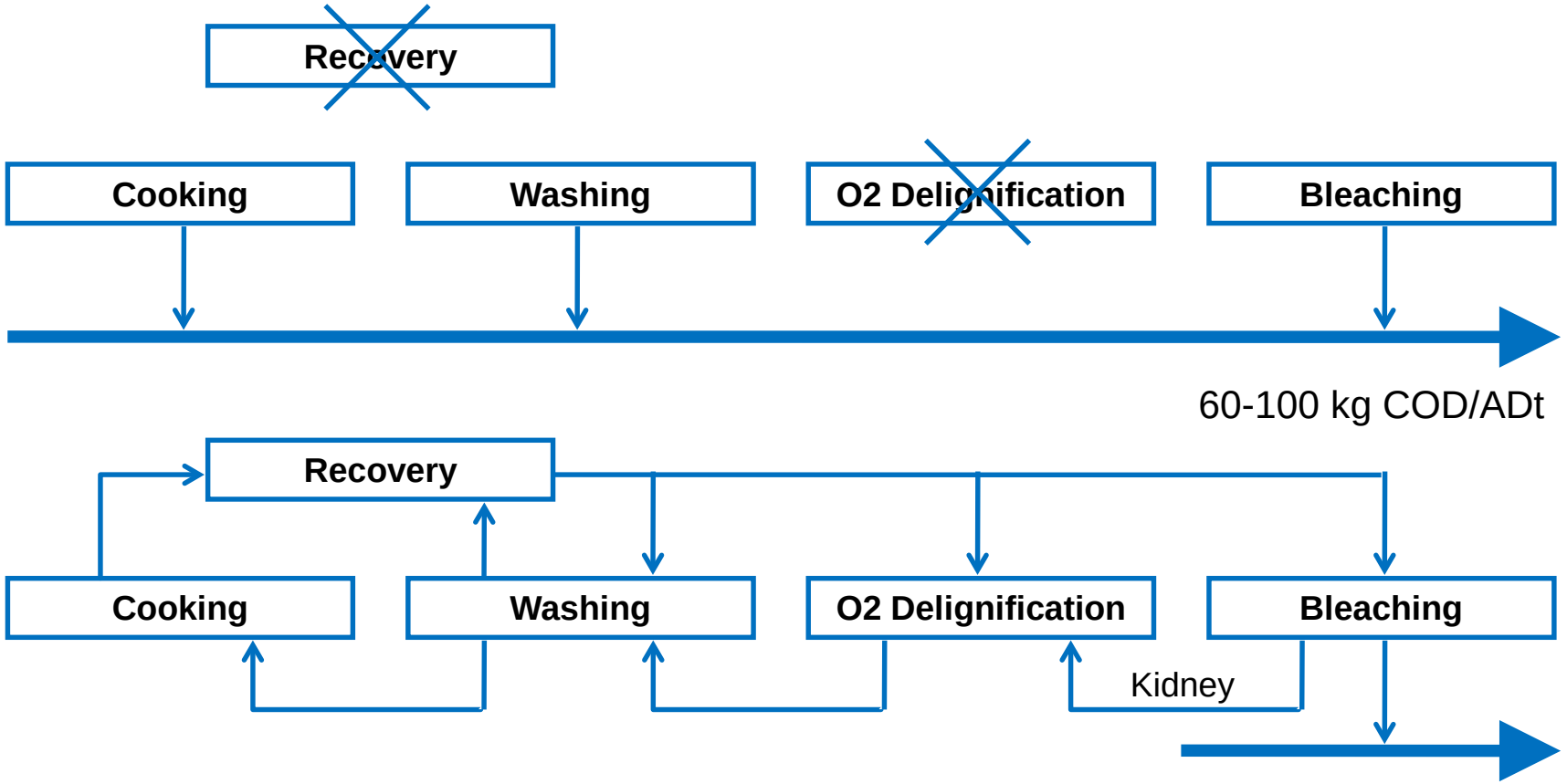
Kraft Pulp Mill- Debarking (drum debarking)

	Effluent volume m^3/tonne pulp	COD kg/tonne of pulp COD kg/t
Wet Debarking+ bark press	3-10	20-30
Dry Debarking+ bark press	0,5-2,5	1-10

Kraft Pulp Mill (Cooking)

- Continuous or Batch cooking
- Residual Lignin – Kappa number
- Conventional cooking – extended cooking
- Oxygen delignification – single/double

Closure of the water streams



BAT-associated waste water flow
Bleached pulp 25-50 m^3/ADt
Unbleached pulp 15-40 m^3/ADt

Kraft Pulp Mill (delignification)

	Kappa Hardwood	Kappa Softwood	COD, kg/t Hardwood	COD, kg/t Softwood
Conv. Cooking	**14-22**	**30-35**	**28-44**	**60-70**
Conv. Cooking+O_2	**13-15**	**18-20**	**26-30**	**36-40**
Extended Cooking	**14-16**	**18-22**	**28-32**	**36-44**
Extended Cooking+O_2	**8-10**	**8-12**	**16-20**	**16-24**

COD *before* external treatment

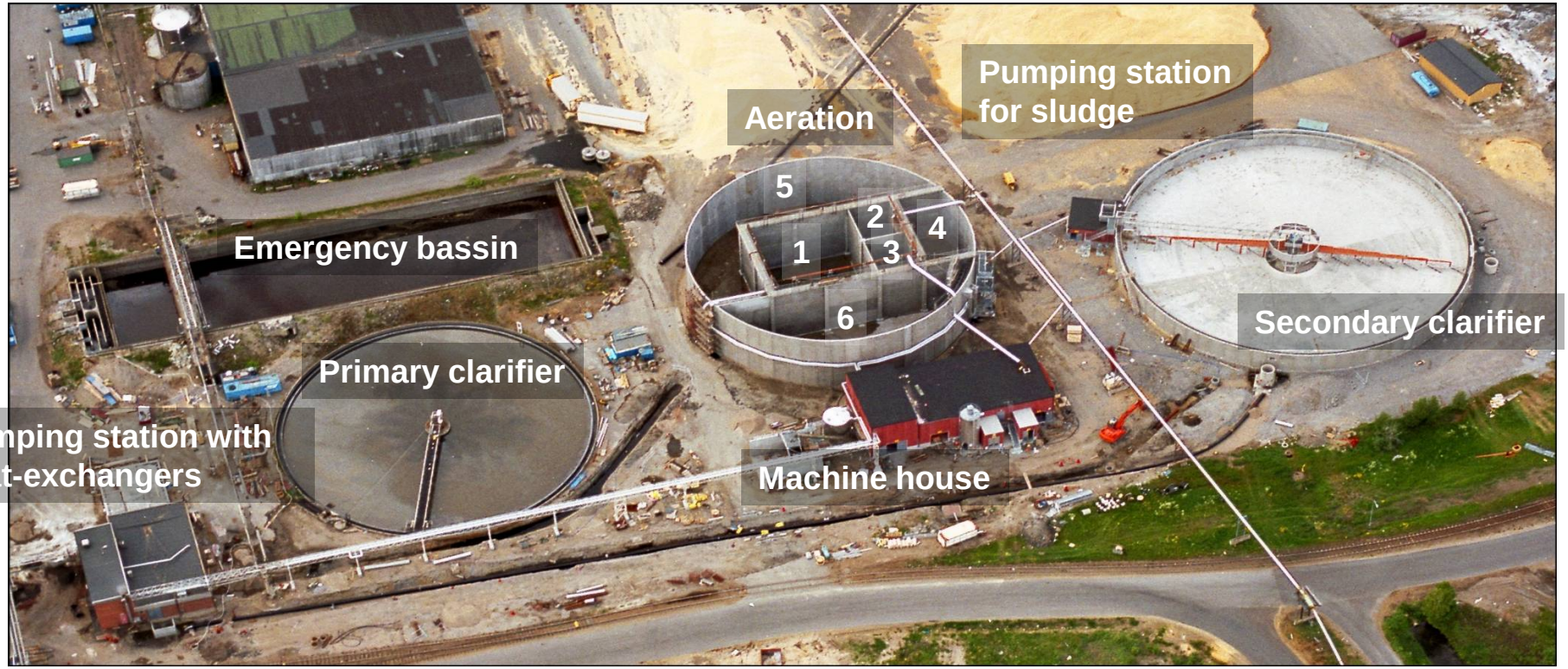
Process stage	COD kg/Adt
Wood handling	**1**-10
Condensates	**2**-8
Spillage	**2**-10
Washing loss	**6**-12
Bleaching	**15**-65
Total from mill	**31**-105

Figures are a 10 years old, today levels might be even lower.

External Treatment- Biological Treatment

Reduction rate	COD (%)	AOX (%)	P (%)	N (%)
Aerated lagoon	30-60	20-45	0-15	0
Activated sludge	50-**70** (90)	40-65	40-85	20-50

Activated sludge plant



Design and technical data 35 000 m³ effluents 35 ton COD/d

Aeration 12 m water depth, 47.5 m diameter 22 000 m³

Secondary clarifier 4 m water depth, 60 m diameter, 11 000 m³

Primary clarifier 1.8 m water depth , 52 m diameter, 3 200 m³

COD-reduction ~90%

Sludge production 0,16 kg/ton COD removed (guarantee)

Electricity ~1 MW

Chemicals ~700 ton (mainly urea and phosphoric acid)

General BAT

- Training & motivation of staff
- Process control & optimisation
- Maintenance
- Environmental management system

Measures to reach BAT – Water- KRAFT Pulp

- Dry debarking
- Increased delignification by extended cooking and add. oxygen stages

  ECF or TCF bleaching (recycling)

  Process water recycle
- Efficient and closed brown stock washing

Measures to reach BAT – Water (cont)

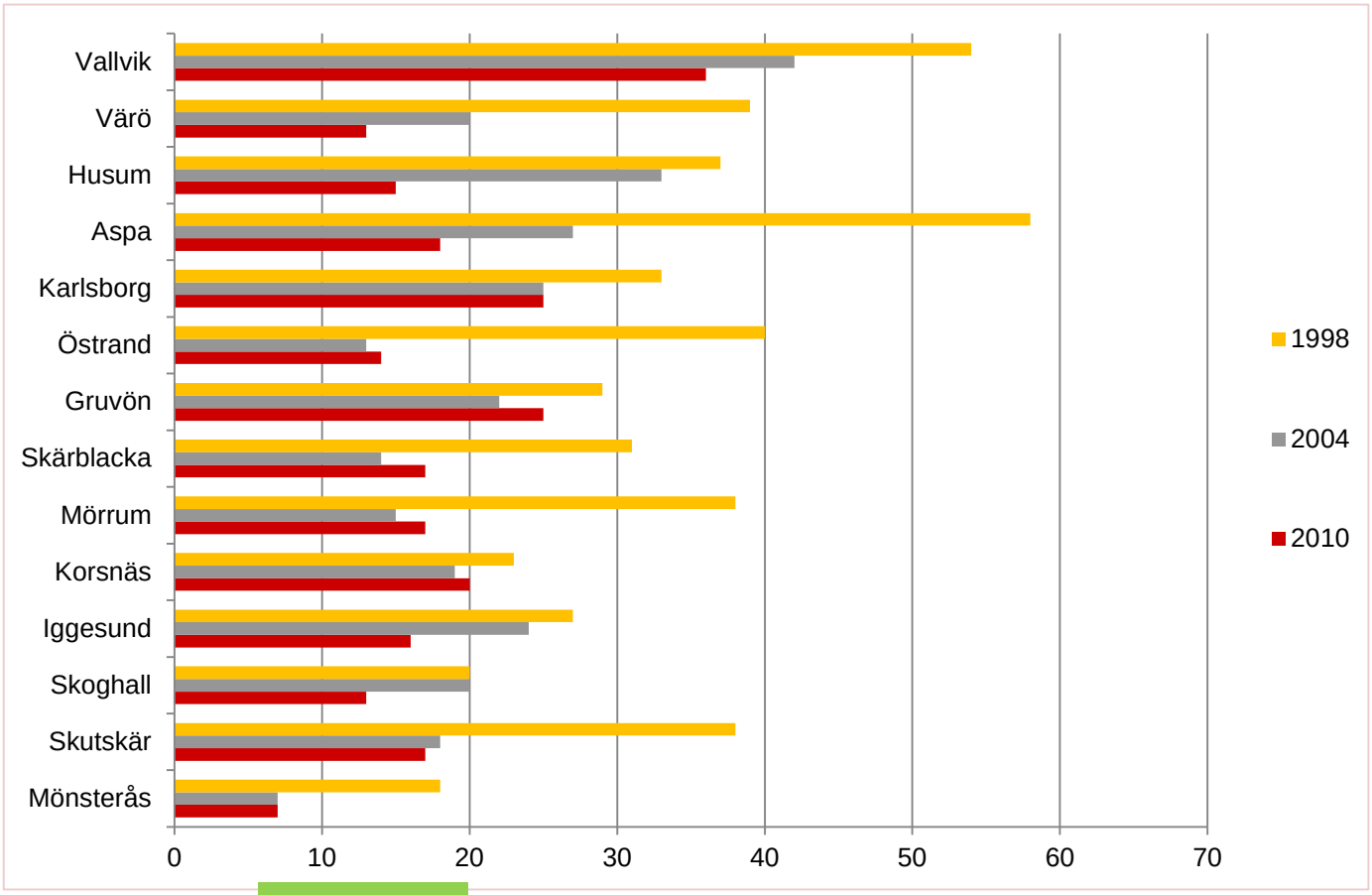
- Effective spill recovery system
- In addition to process-integrated measures, primary and biological treatment of waste water

BREF Levels Water- Kraft

***revised BREF 2014**

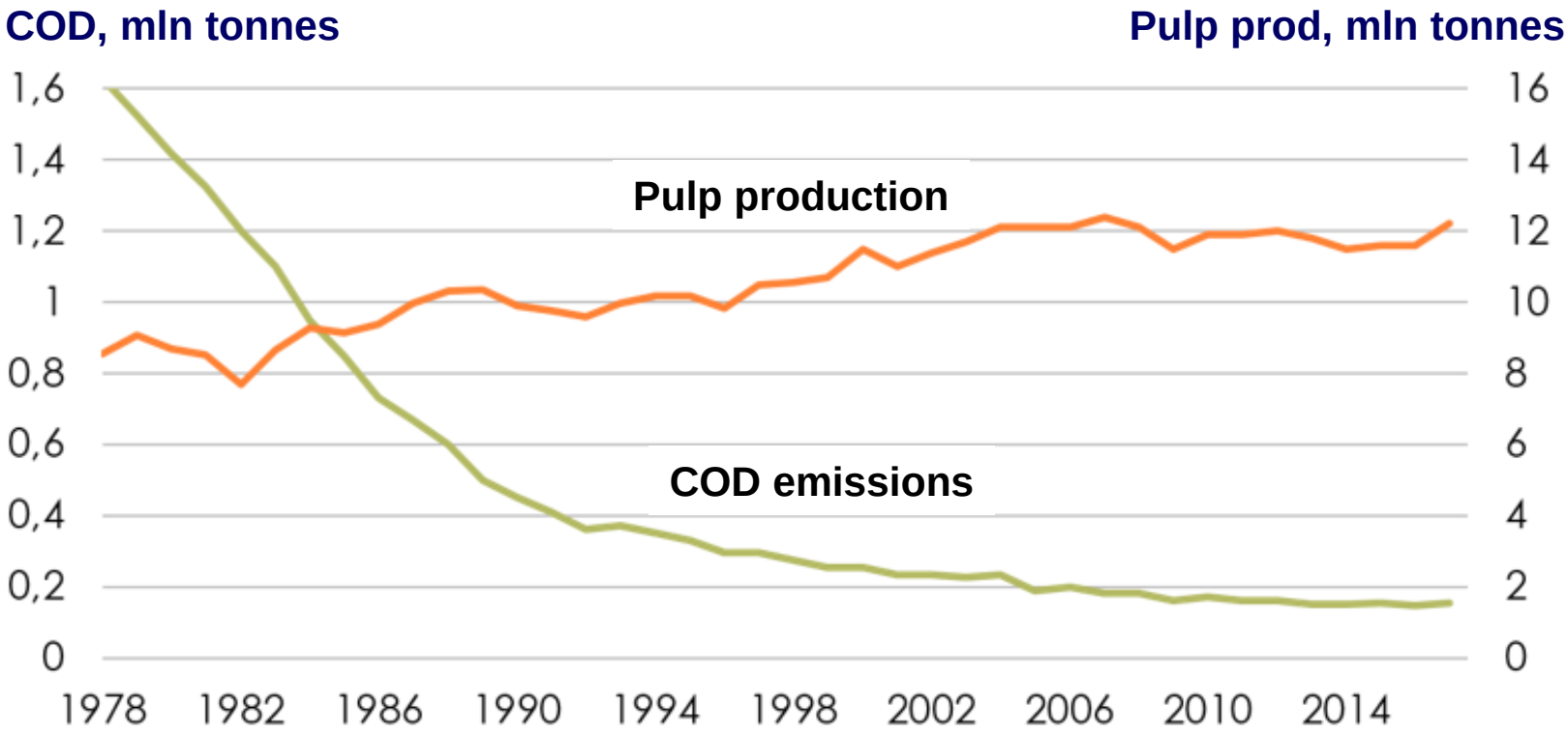
		BLEACHED	UNBLBLEACHED
FLOW	m^3/Adt	30-50	15-25
COD	Kg/Adt	8-23 (7-20)*	5-10 (2,5-8)*
BOD	Kg/Adt	0,3-1,5	0,2-0,7
TSS	Kg/Adt	0,6-1,5 (0,3-1,5)	0,3-1,0 (0,3-1,0)
AOX	Kg/Adt	<0,25 (0-0,2)*	-
Total-N	Kg/Adt	0,1-0,25 (0,05-0,25)*	0,1-0,25 (0,1-0,2)*
Total-P	Kg/adt	0,01-0,03 (0,01-0,03)	0,01-0,03 (0,01-0,02)

Kg COD/ton kraft pulp
Mills producing mainly bleached pulp



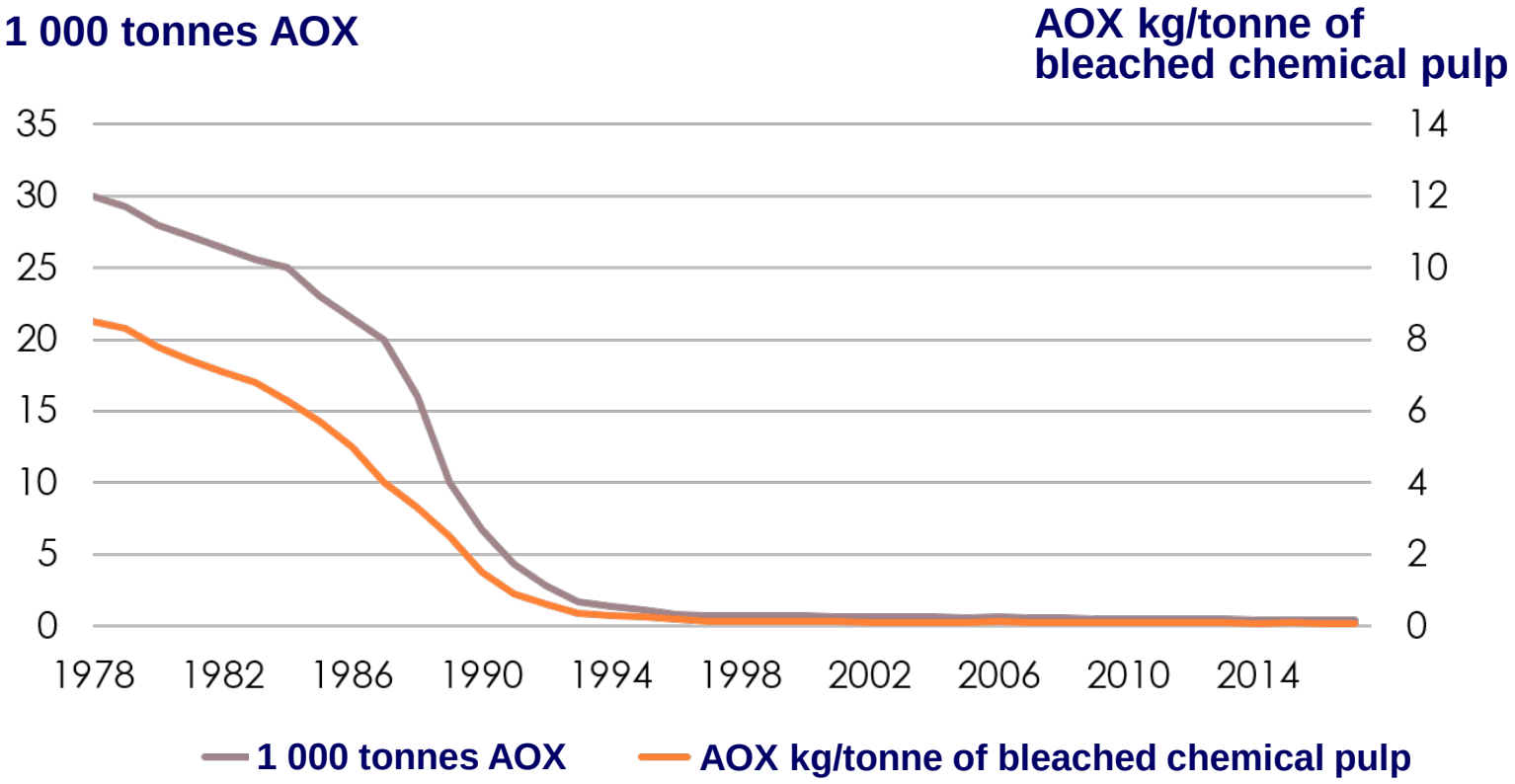
BAT-AEL

Dissolved organic substances (COD) from Swedish pulp and paper mills 1978-2017



Skogsindustrierna

Chlorinated organic substances (AOX) from Swedish pulp and paper mills 1978-2017



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Emissions to water of Dioxins from Pulp & Paper Sector

- 1973 **~25 g/year** Maximum use of Chlorine gas, 275000 ton/year
- 1988 **10 g/year** Oxygen delignification introduced, ClO_2
- 1993 **4 g/year** Chlorine gas totally phased out
- 1999 **1 g/year** Improve washing and WWTU
- 2006 **0,1 g/year** Latest emission monitoring project

Measures to reach BAT – Air

- Collection & incineration of malodorous gases with SO_2 control TRS emissions mitigated (combustion control) Residual Weak gases: 0,05-0,2 kg S/ADt

- SO_2 emissions from recovery & auxiliary boilers reduced (dry black liquid)

- Use of bark or other low S fuel or scrubber

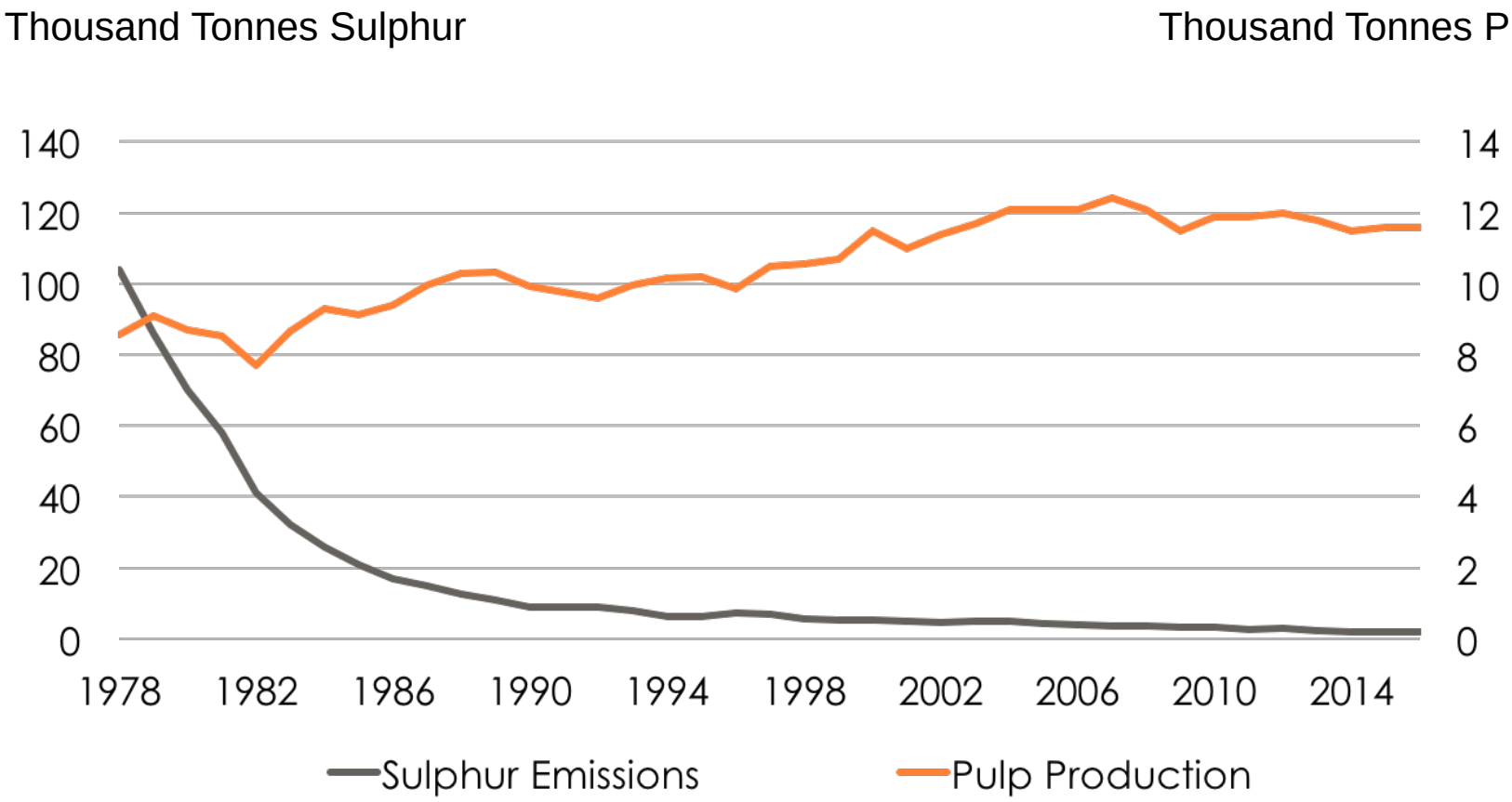
Measures to reach BAT – Air (cont)

- NOx emissions from recovery boiler reduced (controlling fire conditions, altered to proper design)
- Dust emissions from boilers reduced (electrostatic precipitators)

BREF Levels Air – Kraft- Processes
Recovery Boiler

- Dust, 0,02-0,3 kg/Adt (10-40 mg/Nm^3)
- Gasous S, 0,03-0,15 kg/Adt
- NOx, 1-1,5 kg/Adt (0,8-1,6)
- TRS (as S), 0,1-0,2 kg/Adt

Sulphur Emissions 1978 - 2016
From Swedish Pulp and Paper Mills



Measures to reach BAT
Non-integrated paper mill

- Minimise water use
  - recycle process water
  - reuse clean cooling and sealing water
- Primary and secondary biological treatment of waste water (secondary could in some cases be precipitation)

Measures to reach BAT
Non-integrated paper mill (cont)

- High Energy Efficiency
- Substitution of potentially harmful substance by less harmful alternative

- Waste minimisation by waste management (separate collection and reuse)

BREF levels
Non-integrated paper mills

Water emission

- COD, 0,5-2 kg/Adt
- BOD, 0,15-0,25 kg/Adt
- TSS, 0,2-0,4 kg/Adt

Energy demand

- Process heat 5,5-8 GJ/t
- Power 0,6-1 MWh/t

Energy

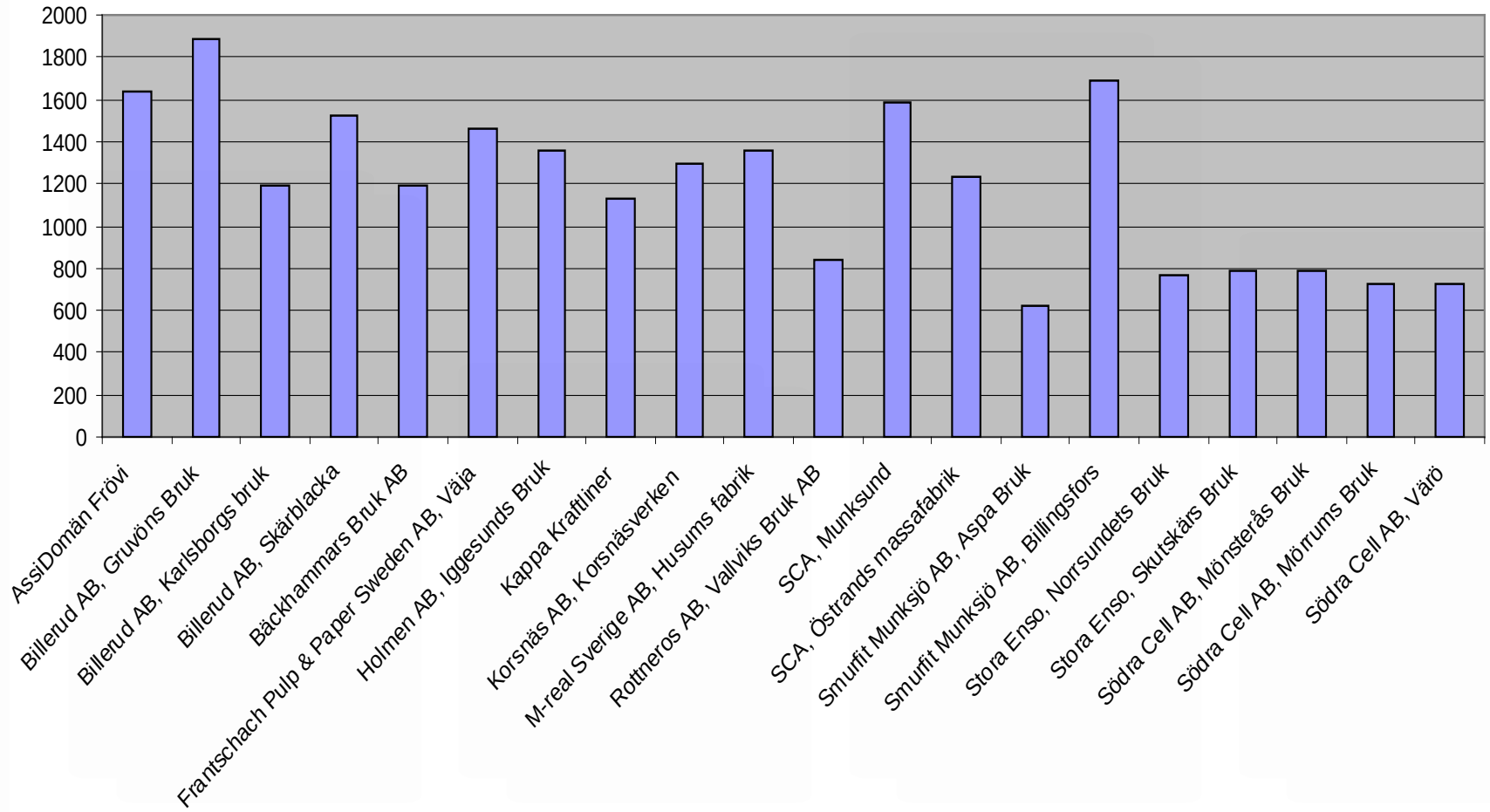
Examples of energy numbers from energy efficient mills

- Kraft pulp (4 types) 10-20 GJ/t
- Mechanical pulp (4 types) 0-12 GJ/t
- Recovered paper mills (3 types) 4-12 GJ/t
- Paper mill (3 types) 5,5-8 GJ/t

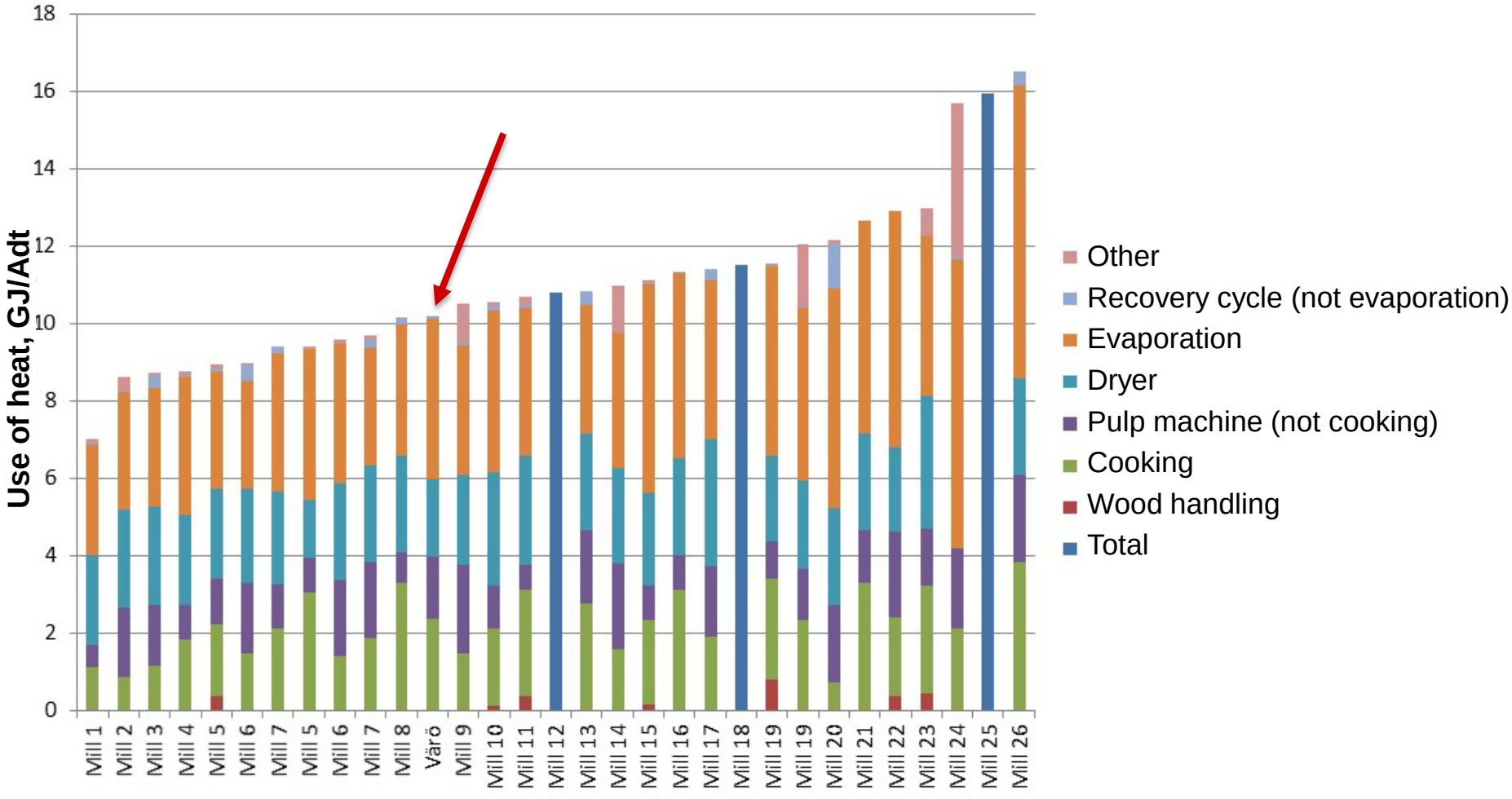
Energy consumption – Integrated bleached Kraft Mill

	Process Heat , MJ/t	El. Power , kWh/t
Cooking	2 000	150
O_2 Delignification	400	40
Bleaching	570	110
Evaporation	3 600	30
Recovery Boiler	600	50
Lime Kiln	1 300	10
Miscellanous	1 900	140
Total PULP	**10 400**	**530**

Used electricity at Swedish Kraft Pulp Mills, kWh/t
Benchmarking



International Benchmarking –
Use of heat at kraft pulp mills

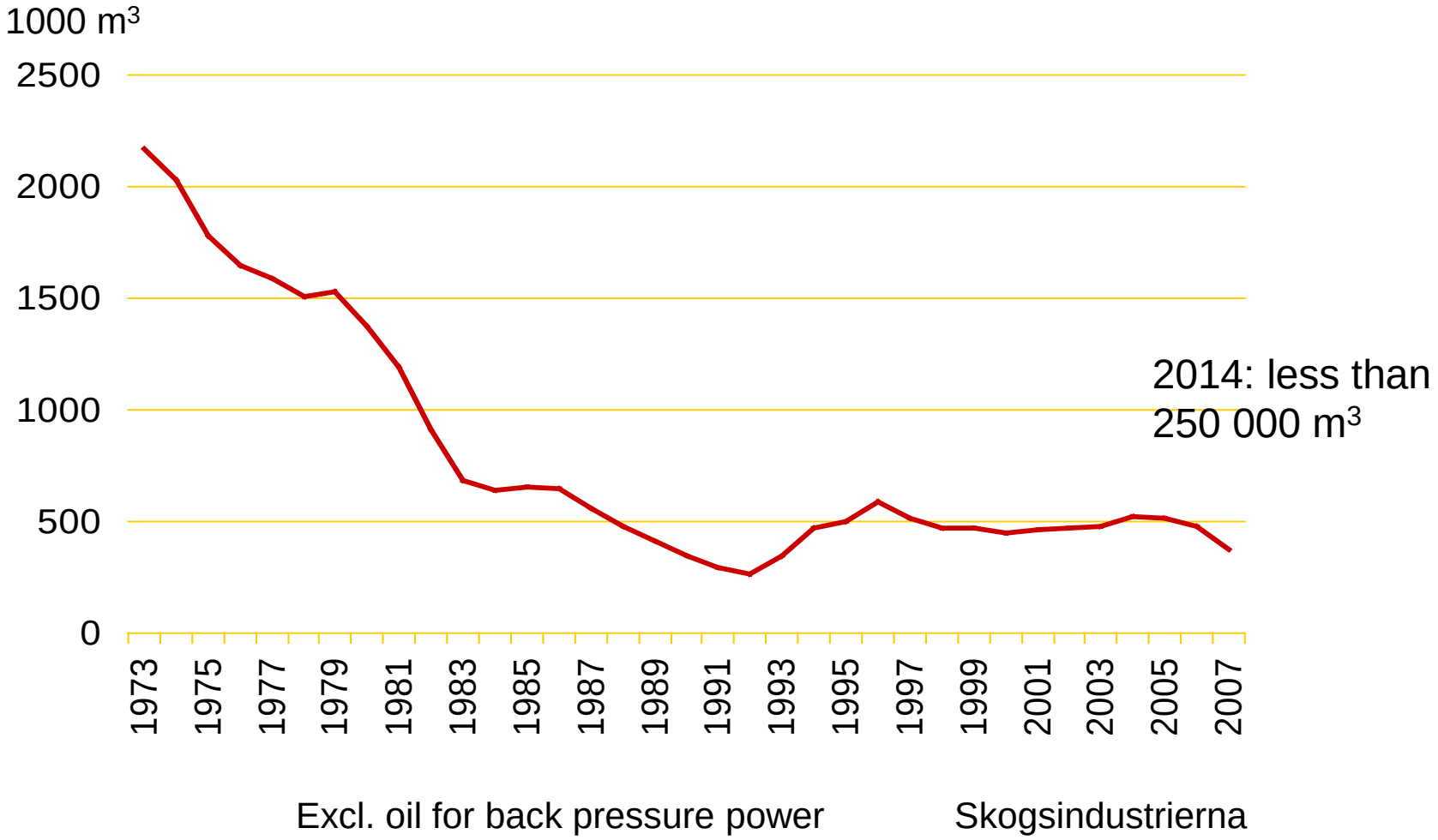


Aspects regarding energy

- Phasing out fossil fuels
- Drying of bark in order to increase energy efficiency
- Increasing of internal electricity production
- Delivery of waste heat to District heating system
- **Reduction of waste water will reduce energy demand**

Oil consumption 1973 - 2007

Swedish pulp and paper industry



Excl. oil for back pressure power

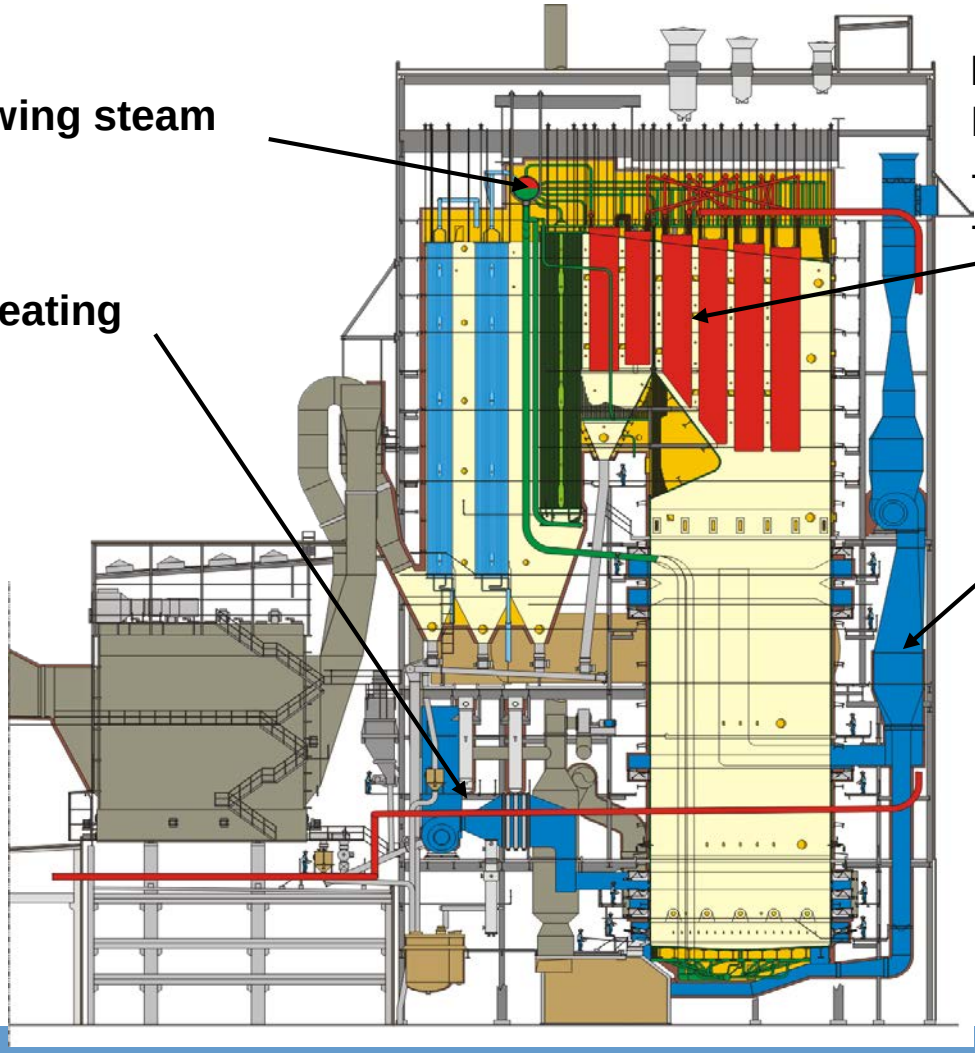
Skogsindustrierna

Energy
System for maximizing power production

External soot blowing steam

Feed water preheating

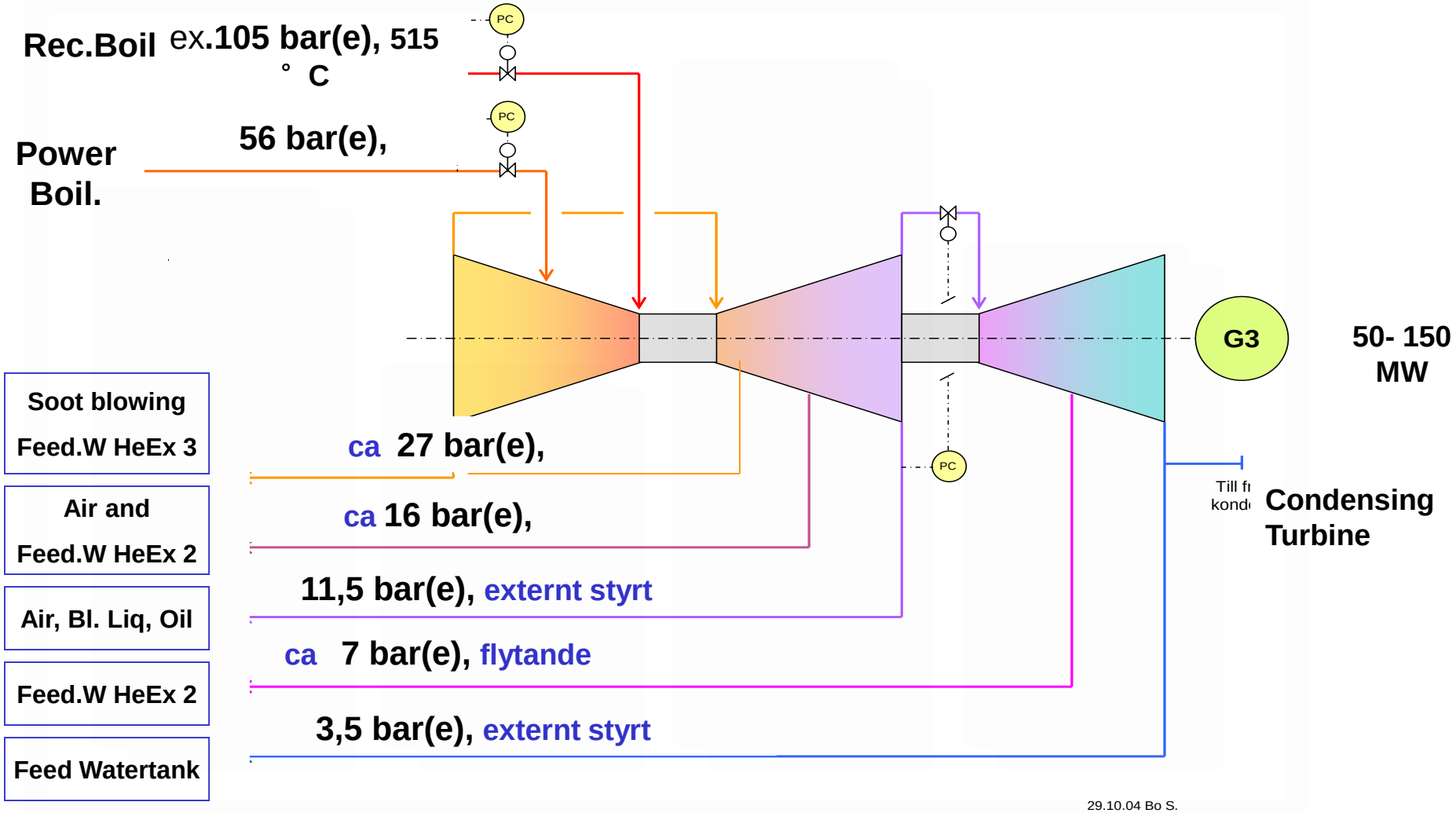
Heat Recovery from stack gases
- temperature ~125 ° C



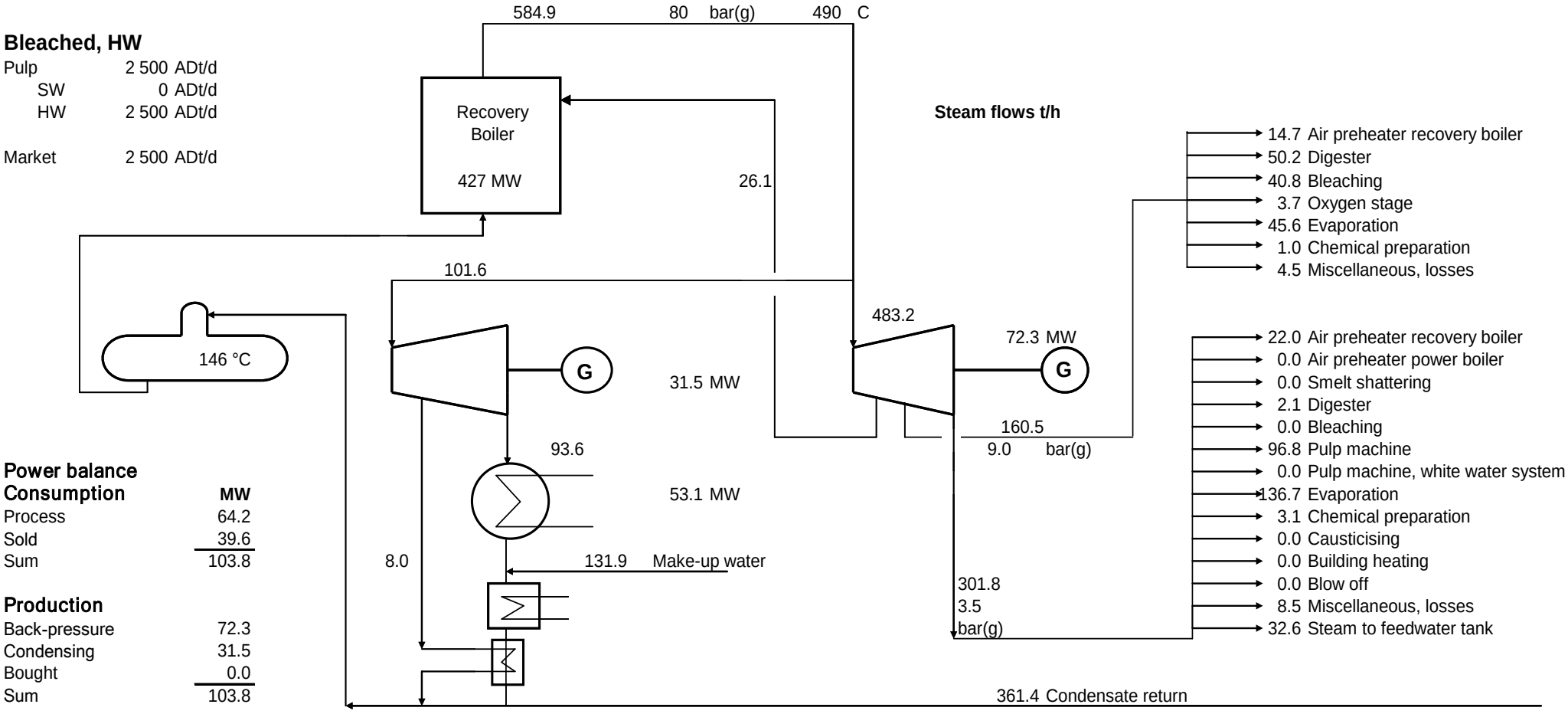
High Steam data
Example
- 515 °C
- 10.5 MPa

Air preheating
-Many stages

Energy Turbine and steam system
example for maximizing power production



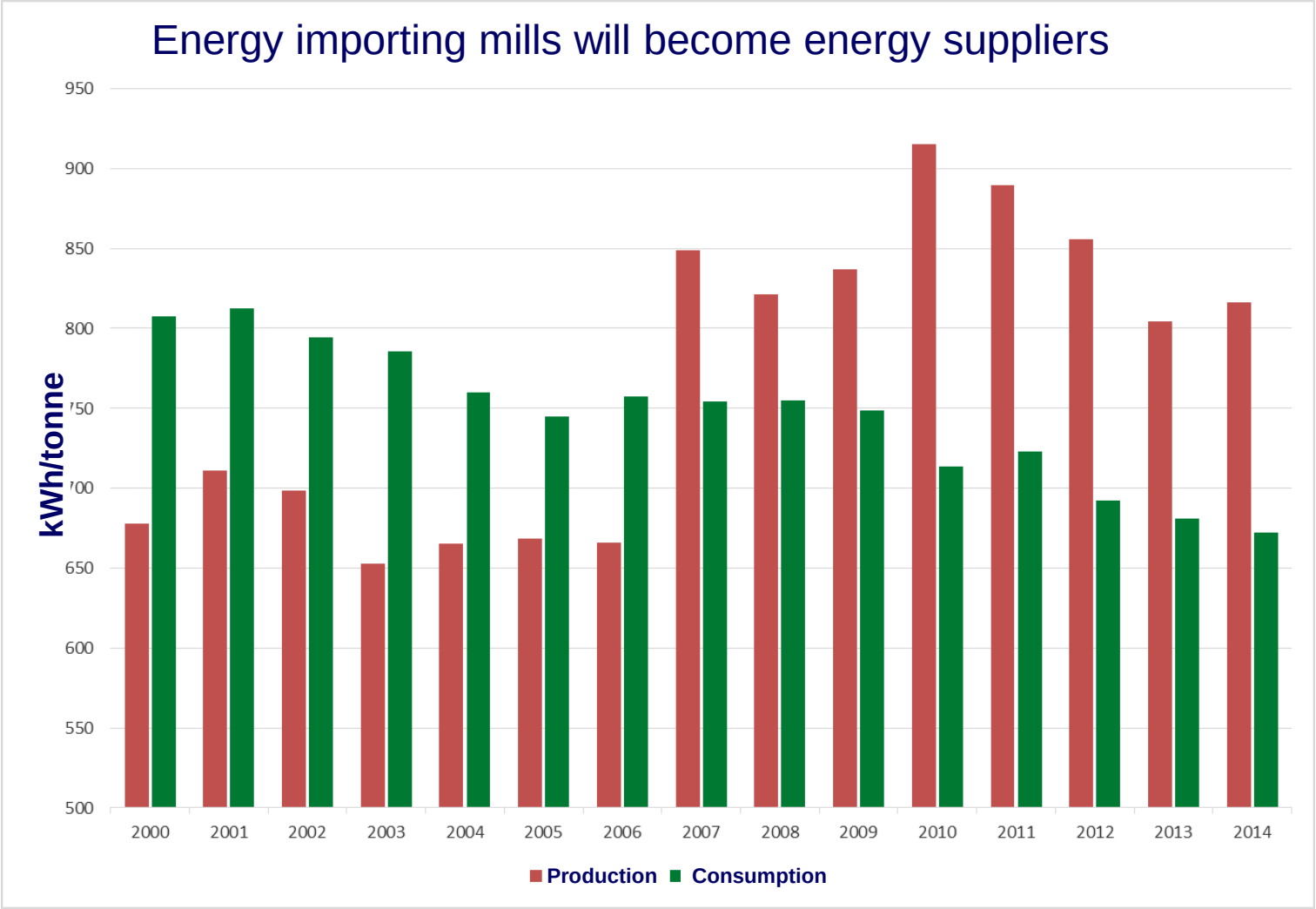
Energy
Energy Balance ex. Hardwood



Energy
Power Balance kWh/Adt

	Softwood		Hardwood	
Power consumption	Reference	Type mill	Reference	Type mill
Wood yard	45	45	40	40
Digester	44	44	39	39
Washing and screening	60	90	54	80
Oxygen stage	60	80	54	72
Bleaching	80	100	72	89
Final screening	45	45	40	40
Pulp machine	120	130	107	116
Evaporation	30	30	25	25
Causticising, lime kiln incl. fuel gasifier	57	30	46	24
Boiler house	80	100	64	80
Cooling tower etc	20	0	12	0
Raw water treatment and distribution	17	22	15	20
Effluent treatment	17	30	15	27
Chem preparation	10	10	9	9
Miscellaneous, losses	30	35	24	28
Sum	716	791	616	689
Sold power	579	0	381	0
Total	1 295	791	997	689
Power production				
Back-pressure power	774	593	694	438
Condensing power	521	0	303	0
Bought power	0	198	0	251
Sum	1 295	791	997	689

Production and use of electricity – example Värö Mill



Energy generation at a mill

- **Heat (steam) and Electricity**
- Recovery boiler

- Auxiliary boilers

Some factors for energy efficiency at the recovery boiler

- High TS in black liquor (80 %)
- High boiler pressure

	Typical today	Ref. Mill	Max. today	Future
Steam Pressure	60 bar 70-80	79 bar	90 bar 110 (115)	110 bar 120-130
Steam temperature	450-510	485	515	530
El production kWh/ton	695-740 500-800	790-805	835 800-900	895

Energy efficiency
Water emissions reduction

- Reduction of volume of waste water
  - less need for energy
  - less water to heat
- Reduced volume of waste water
  - less need for energy in the waste water treatment unit
- More concentrated waste water
  - possibility to use anaerobic waste water treatment
  - production of biogas

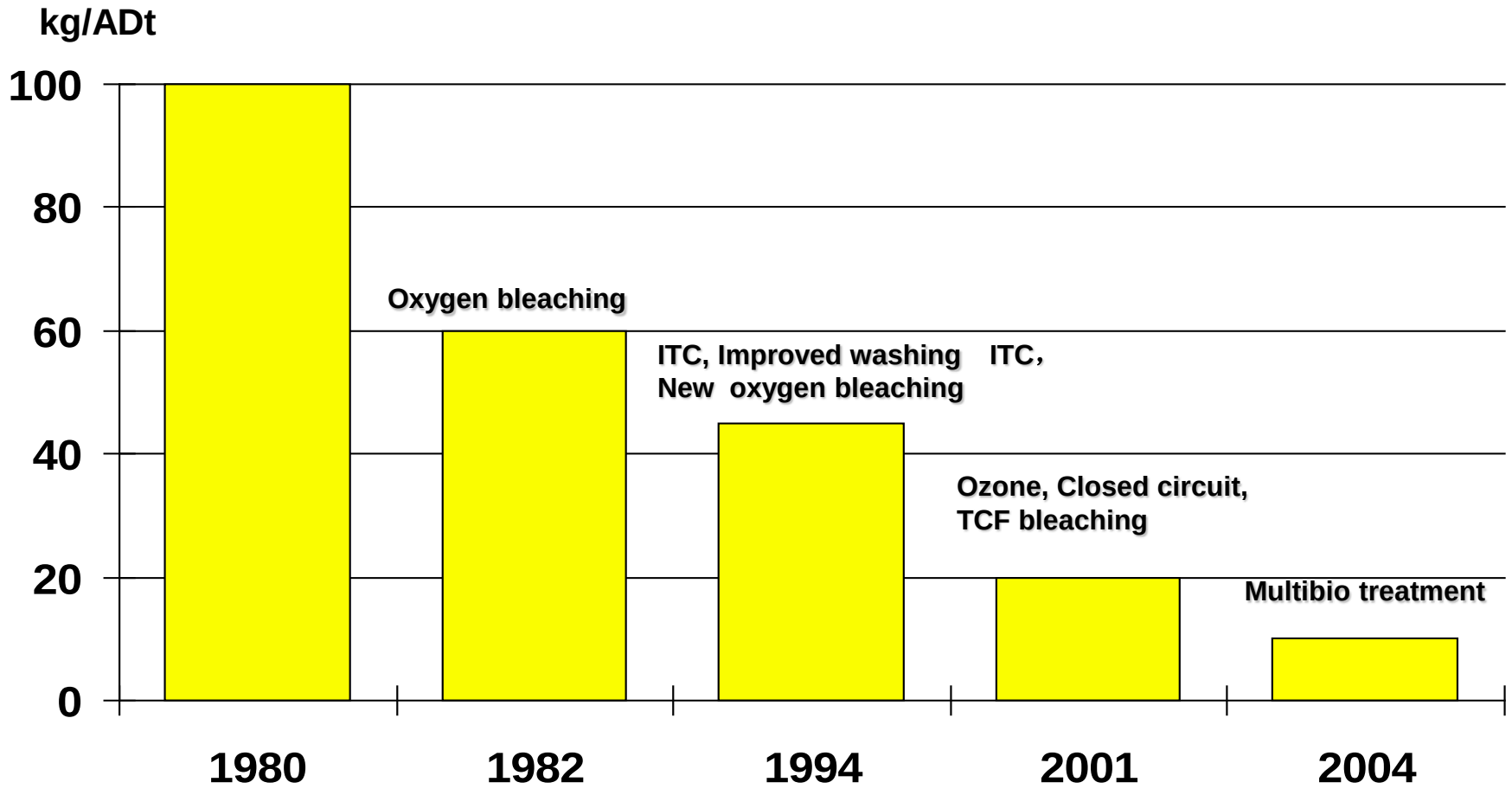
Energy efficient mills will be energy plants

Energy efficient mills will produce more energy than is needed at the mill

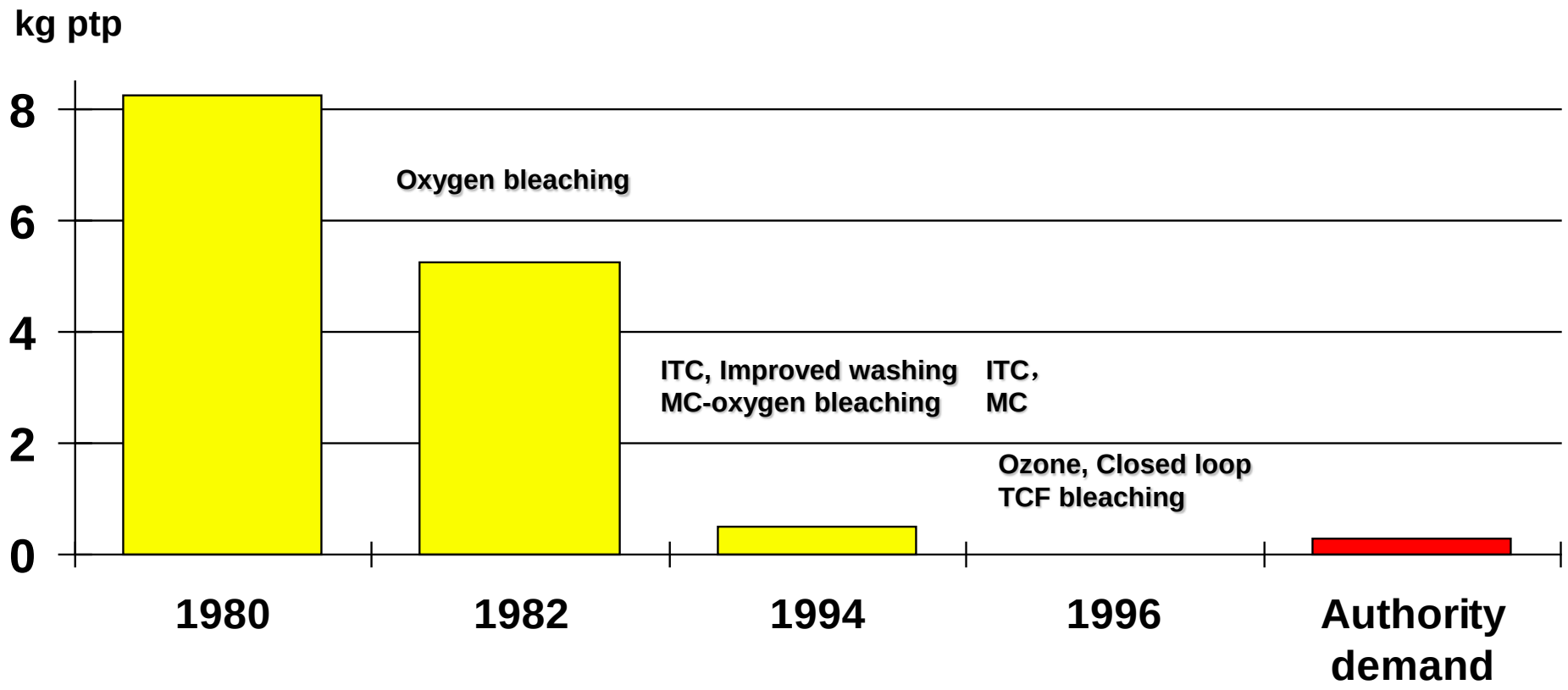
One of the big Pulp and Paper companies in Sweden are making the almost the same earning from energy as from Pulp

Water management and Effluent Treatment

COD levels after technical improvements
Östrand mill



AOX levels after technical improvements
Östrand Mill

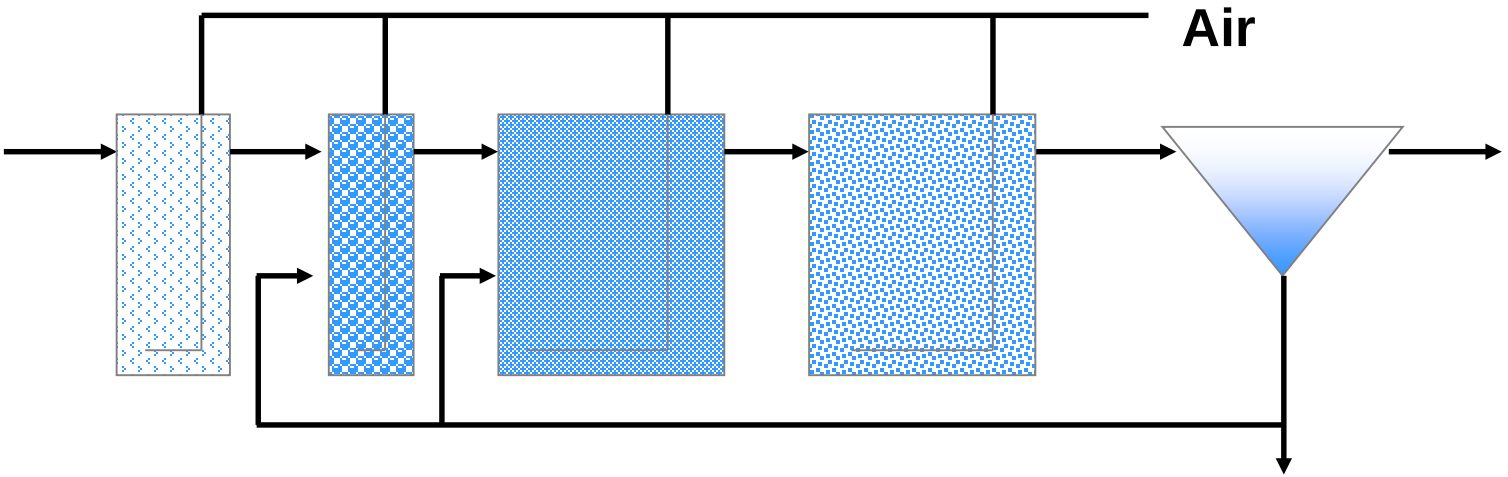


Why biological effluent treatment in forest industry?

- Reduction of BOD/COD
- Reduction of nutrients (N and P)
- Reduction of toxic (organic) substances
- Reduction of chlorate
- Reduction of chelating agent (EDTA/(DTPA)
- Reduction of excess sludge

LAS at Mönsterås

Combination Process



Relatively short retention time, 10 - 24 h

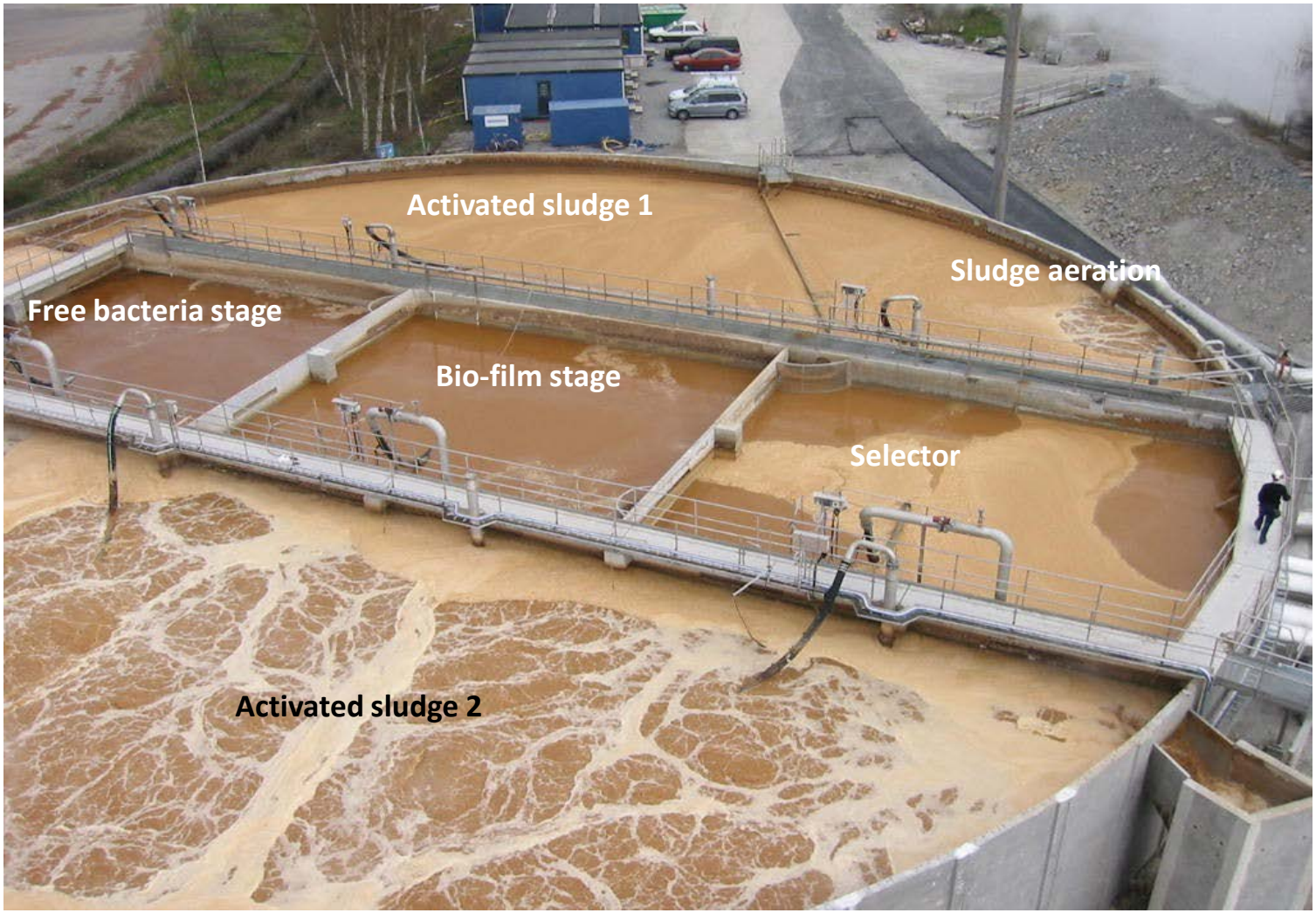
High reduction of BOD, 90 - 99 %

Normally low content of suspended solids in effluent, 10 - 40 mg/l

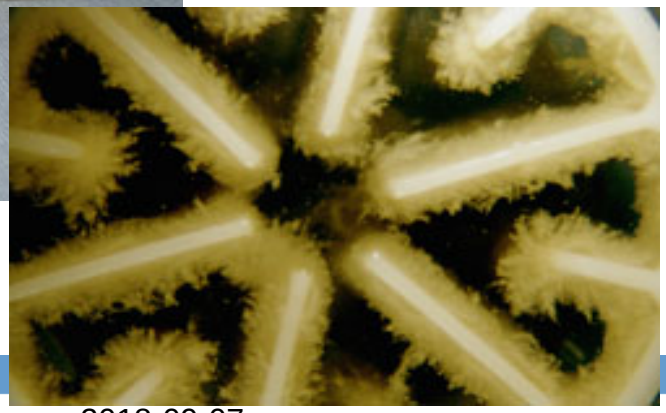
Relatively low operation cost (sludge production and energy)

Insensitive for disturbances

Södra Cell Mörrum



Bio-film carrier - Natrix®

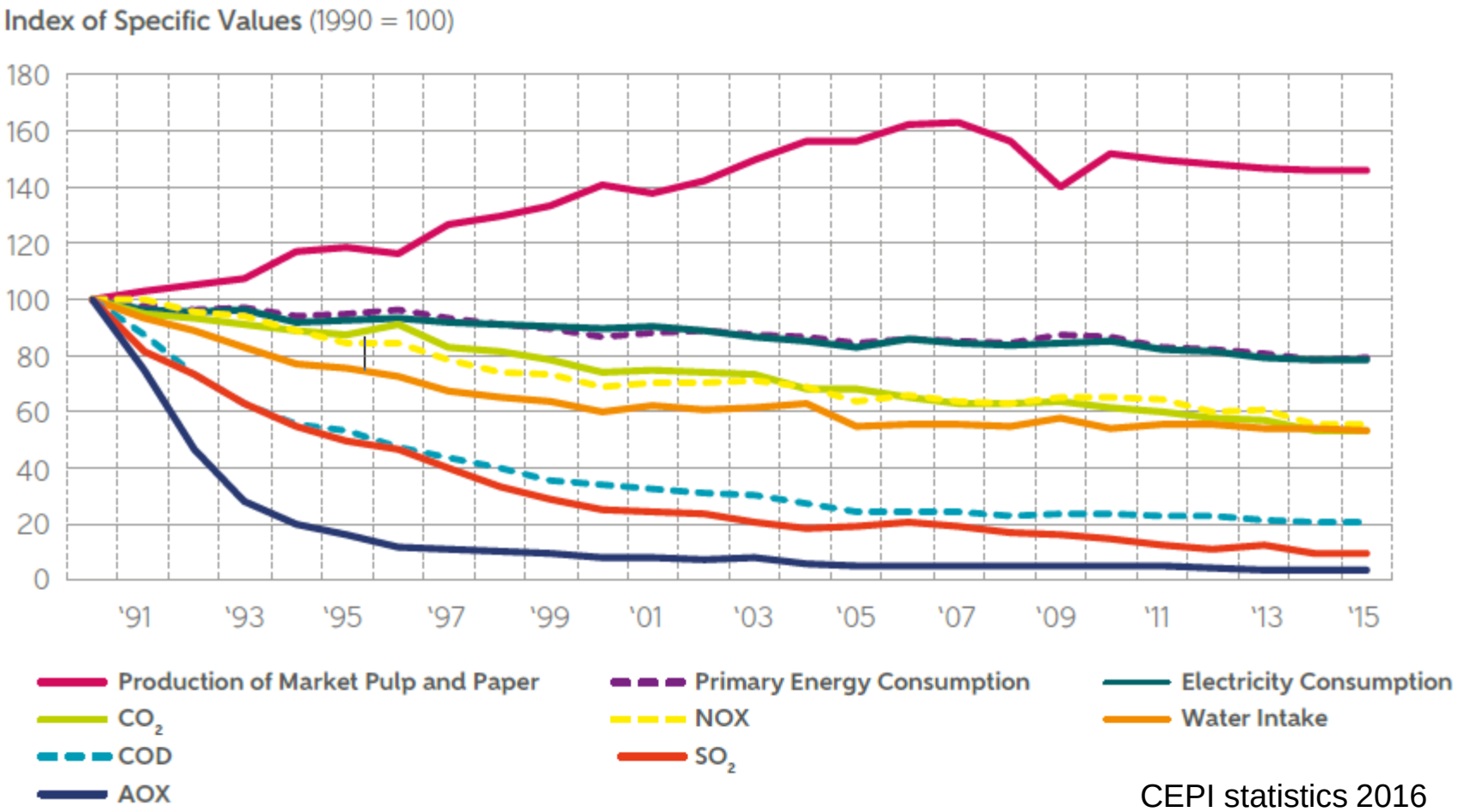


Bio film carriers

Over time focus have shifted between different environmental problems – BAT is a moving target

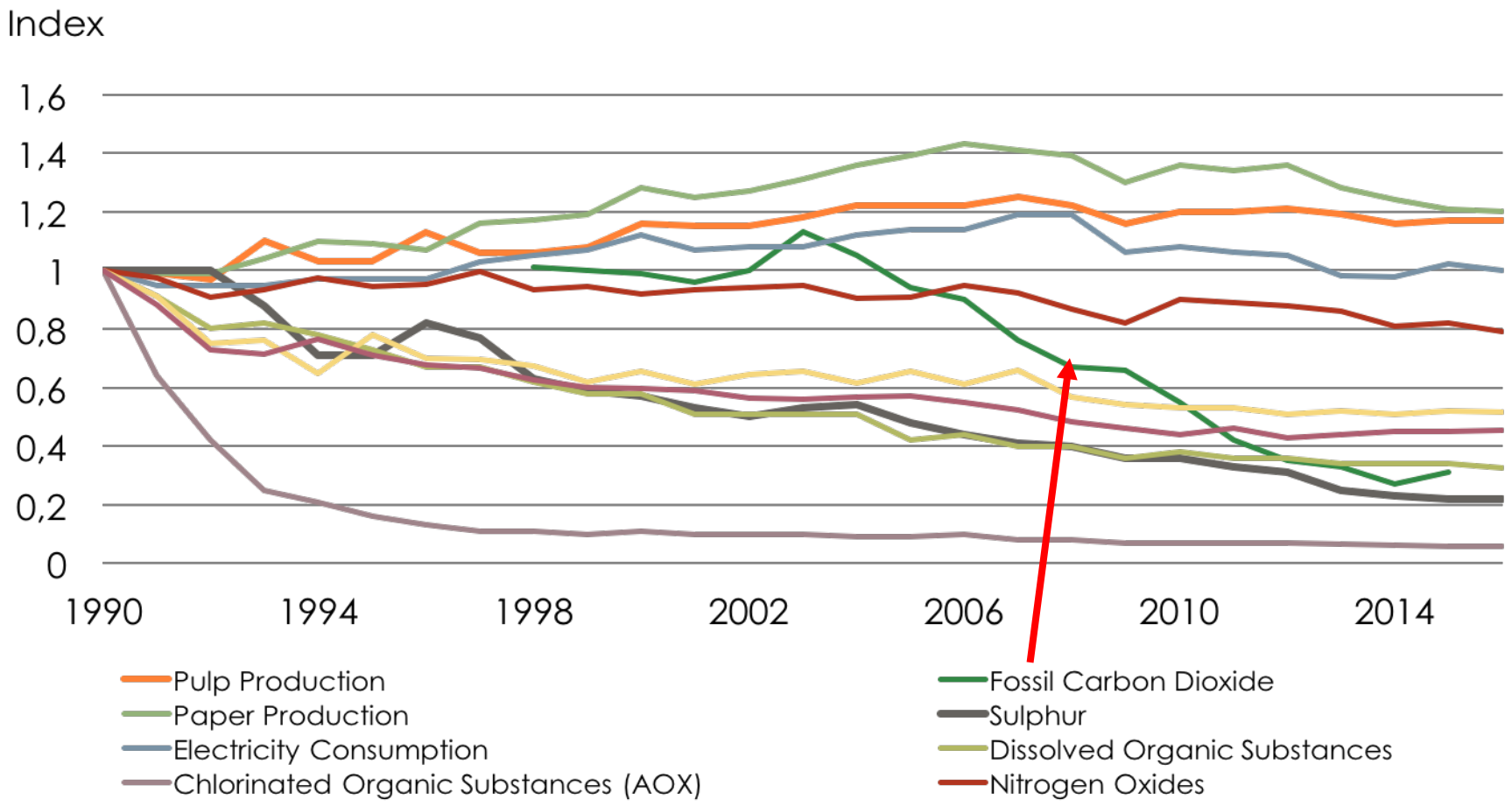
1970's	1980's	1990's	2000's	Future
BOD				
Fibres				
Smell	Smell	Smell	Smell	
SO_2	SO_2	SO_2		
Hg				
Toxicity	Toxicity	Toxicity		
	COD	COD		
	AOX	AOX		
	Dioxins	Dioxins		
		NO_X	NO_X	
		N and P	N and P	
			CO_2	
			Energy	

Increased production and reduced emissions
- European Pulp and Paper Industry

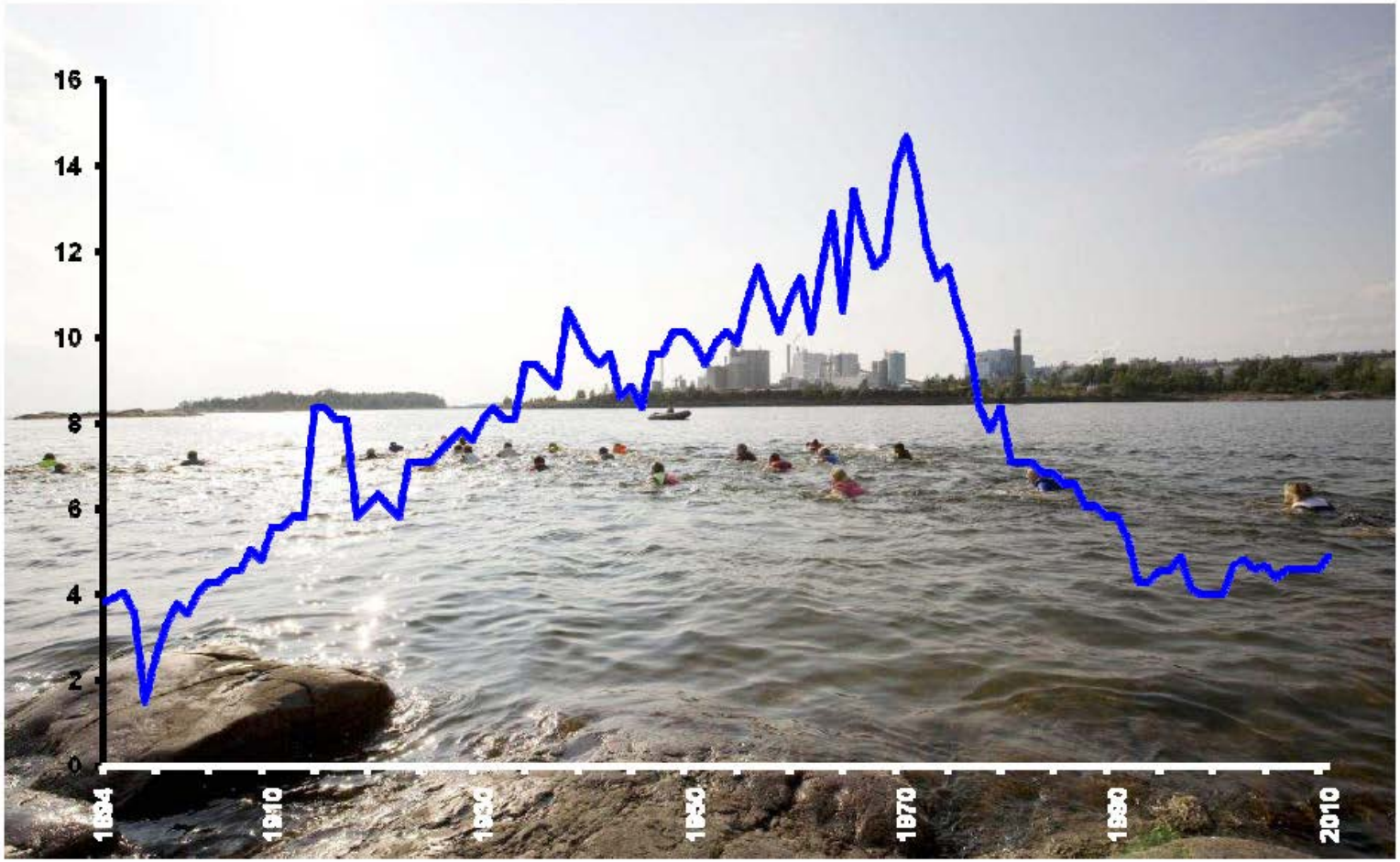


CEPI statistics 2016

Higher Production and Lower Emissions Sweden 1990-2016



The quality of the water in Lake Vänern is as good as in the late 19th century (TOC mg/l)



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