Eco-efficient Solutions in the Finnish Metallurgical Industry

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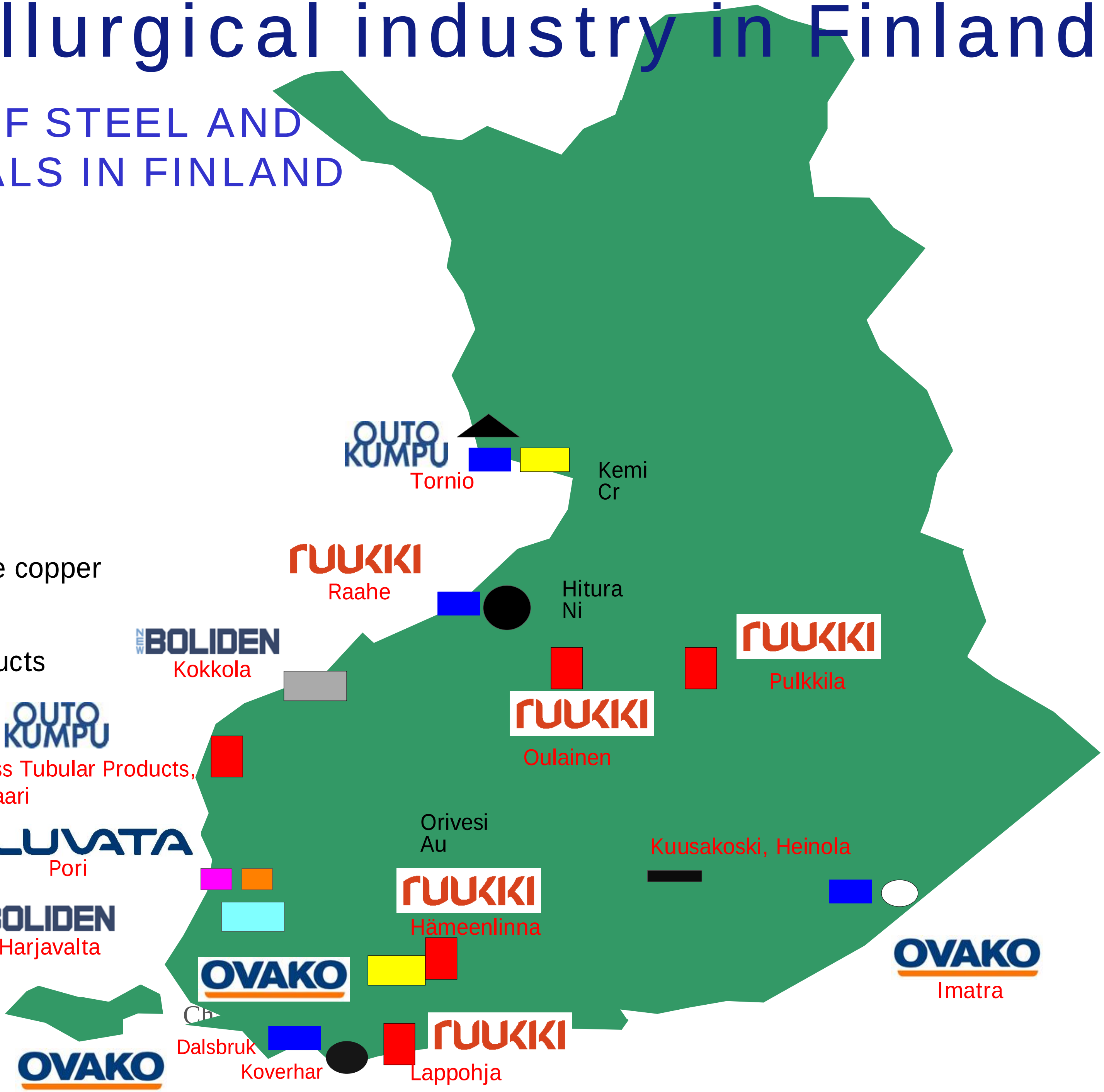
Structure of the presentation

1. Metallurgical industry in Finland
2. Eco-efficient features in the Finnish metallurcigal industry
3. Harjavalta industrial park
4. Outokumpu flash smelting technology
5. Ferro-alloys technologies of Outokumpu
6. Extraction of iron with low carbon dioxide emissions

1. Metallurgical industry in Finland

PRODUCERS OF STEEL AND COLOUR METALS IN FINLAND

- Steel billets, BOF
- Steel billets, AOD
- Steel billets, EAF
- Hot rolling mill
- Cold rolling mill
- Pipe factories
- Aluminium
- Nickel and coarse copper
- Cathode copper, copper half-products
- Electrolysis
- Zinc



METALLINJALOSTAJAT
09/2006

2. Eco-efficient features in the Finnish metallurcigal industry

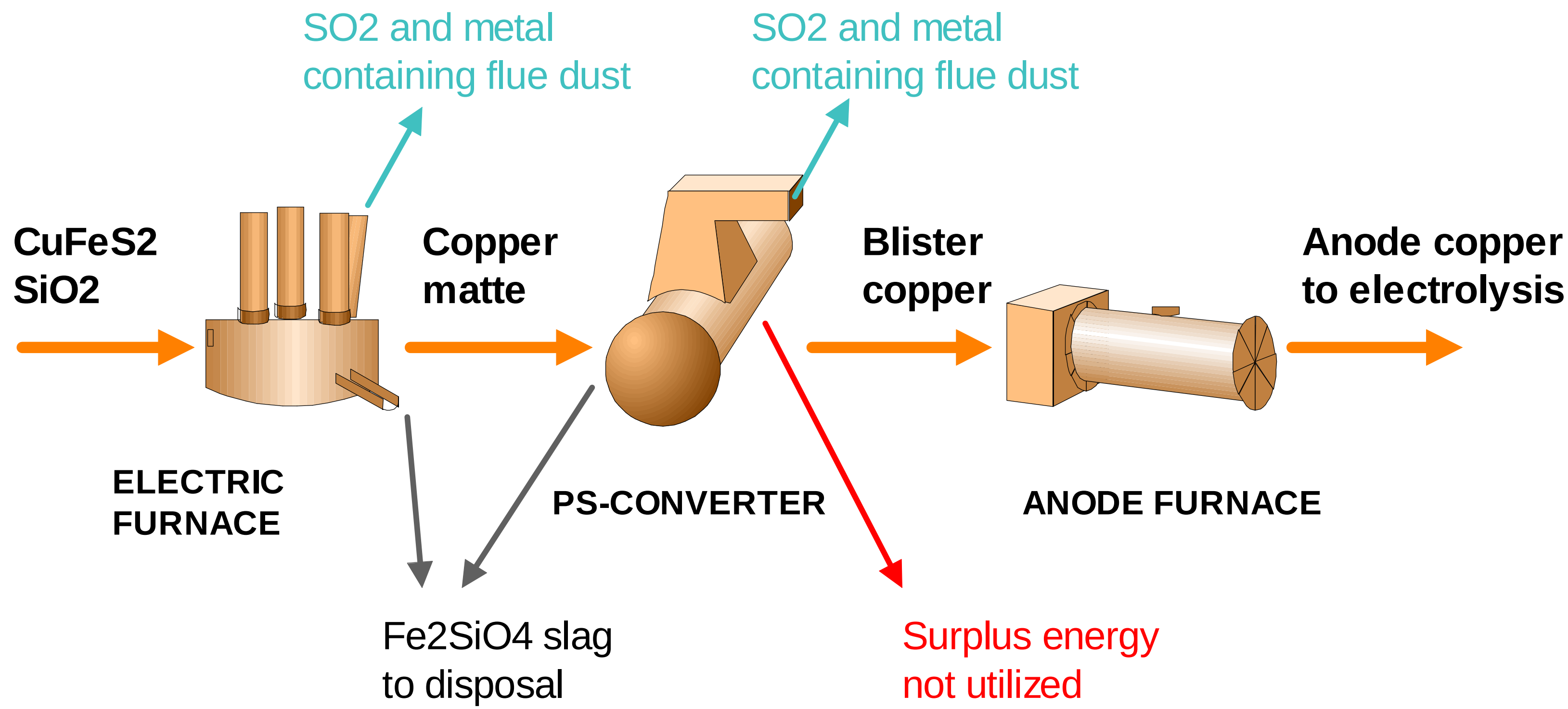
- Conservation of energy and intelligent use of non-fossile energy sources
- Minimizing the impact on the environment; air, water, soil
- 6 BAT´s = Best Available Technologies
- ASM Historical Landmark Award for the Outokumpu Flash Smelting Process in 2002
- About 50 % of the World copper and 30 % of nickel is produced by Flash Smelting

3. Harjavalta industrial park

The history of Harjavalta industrial area

1944 Copper smelter is moved from Imatra to Harjavalta

1945 The start up of the Outokumpu copper smelter



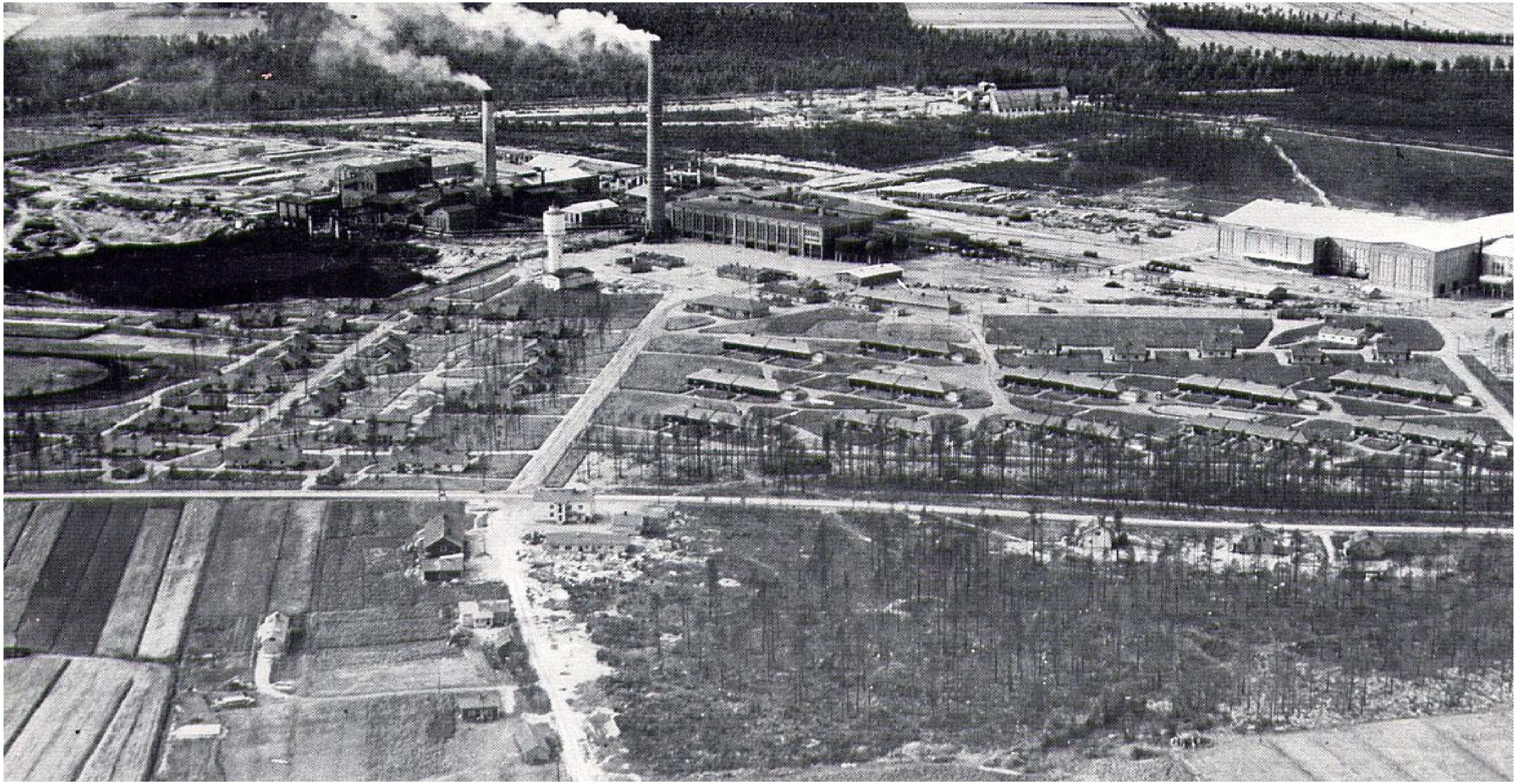
The Harjavalta copper smelter before Flash Smelting

The history of Harjavalta industrial area continued...

1944 Copper smelter is moved from Imatra to Harjavalta

1945 The start up of the Outokumpu copper smelter

1947 The start up of the Kemira sulfuric acid plant



The history of Harjavalta industrial area continued...

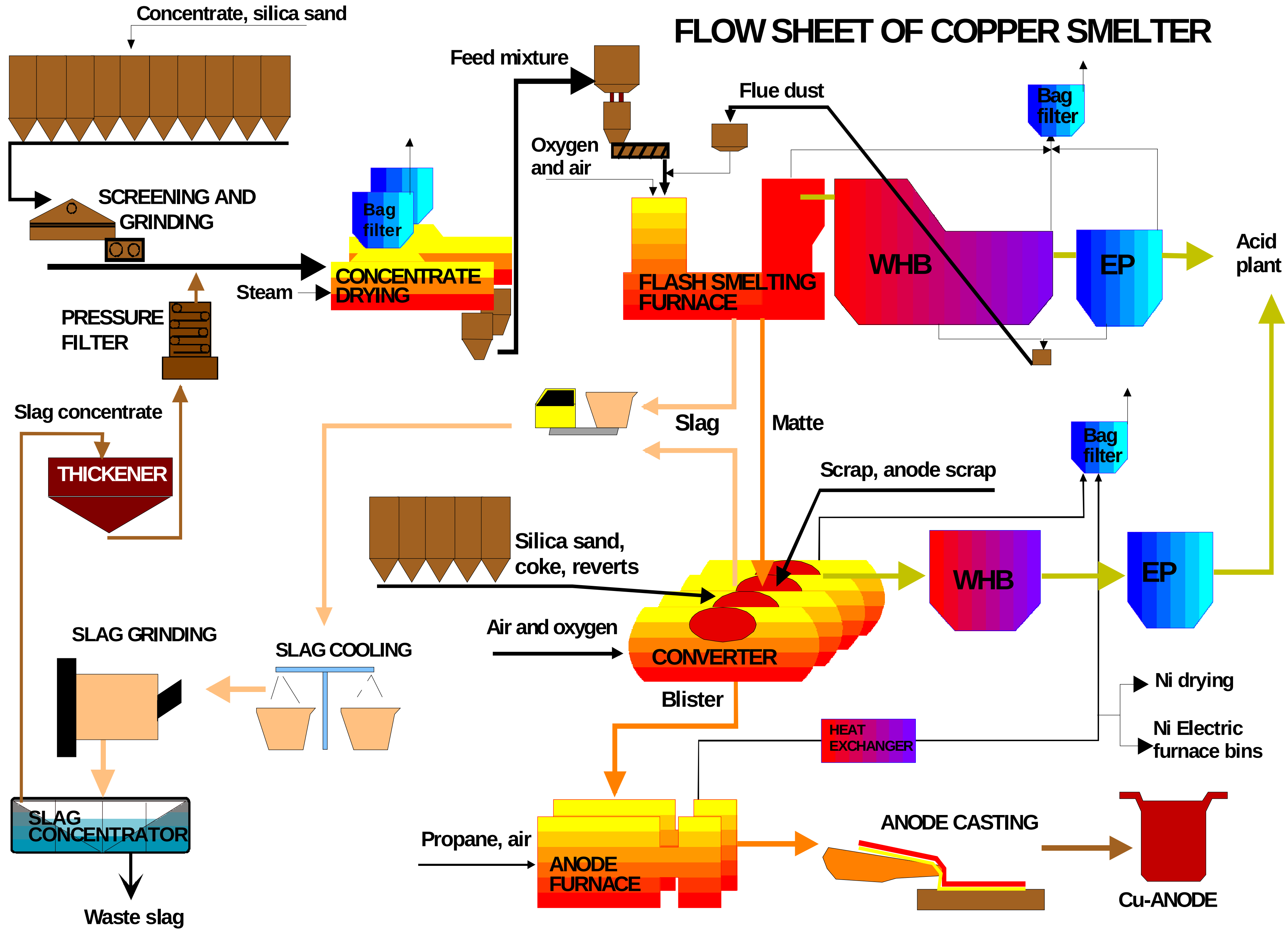
1944 Copper smelter is moved from Imatra to Harjavalta.

1945 The start up of the Outokumpu copper smelter

1947 The start up of the Kemira sulfuric acid plant

1949 The start up of Outokumpu copper flash smelter

FLOW SHEET OF COPPER SMELTER



The history of Harjavalta industrial area continued...

1944 Copper smelter is moved from Imatra to Harjavalta

1945 The start up of the Outokumpu copper smelter

1947 The start up of the Kemira sulfuric acid plant

1949 The start up of Outokumpu copper flash smelter

1959 The start up of Outokumpu nickel flash smelter

1971 The start up of the oxygen plant

1995 The start up of AGA hydrogen plant

1995 The start up of Direct Outokumpu Nickel process (DON)

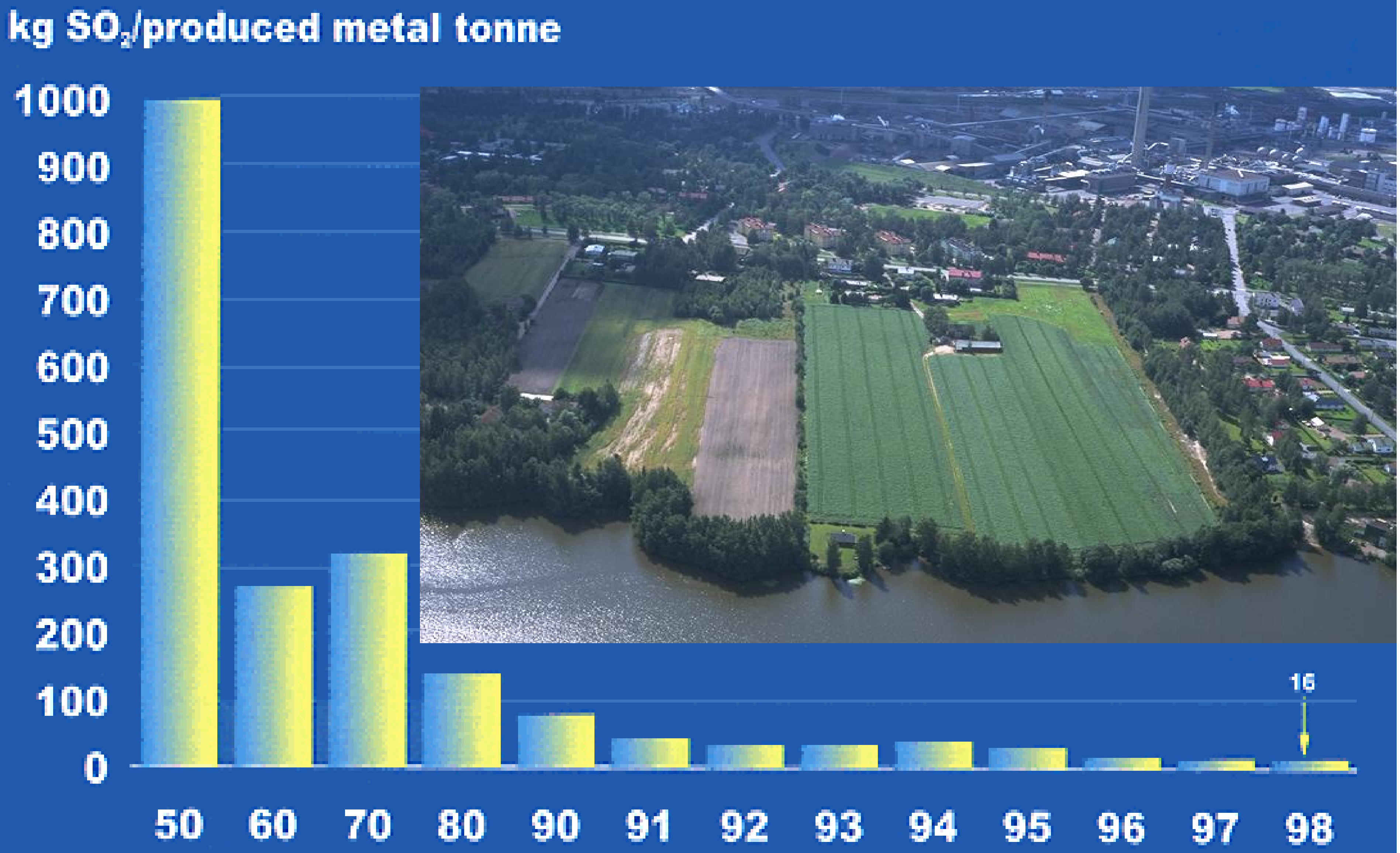
2000 OMG Harjavalta Nickel Ltd is founded

2000 Porin Lämpövoima Ltd starts the energy production

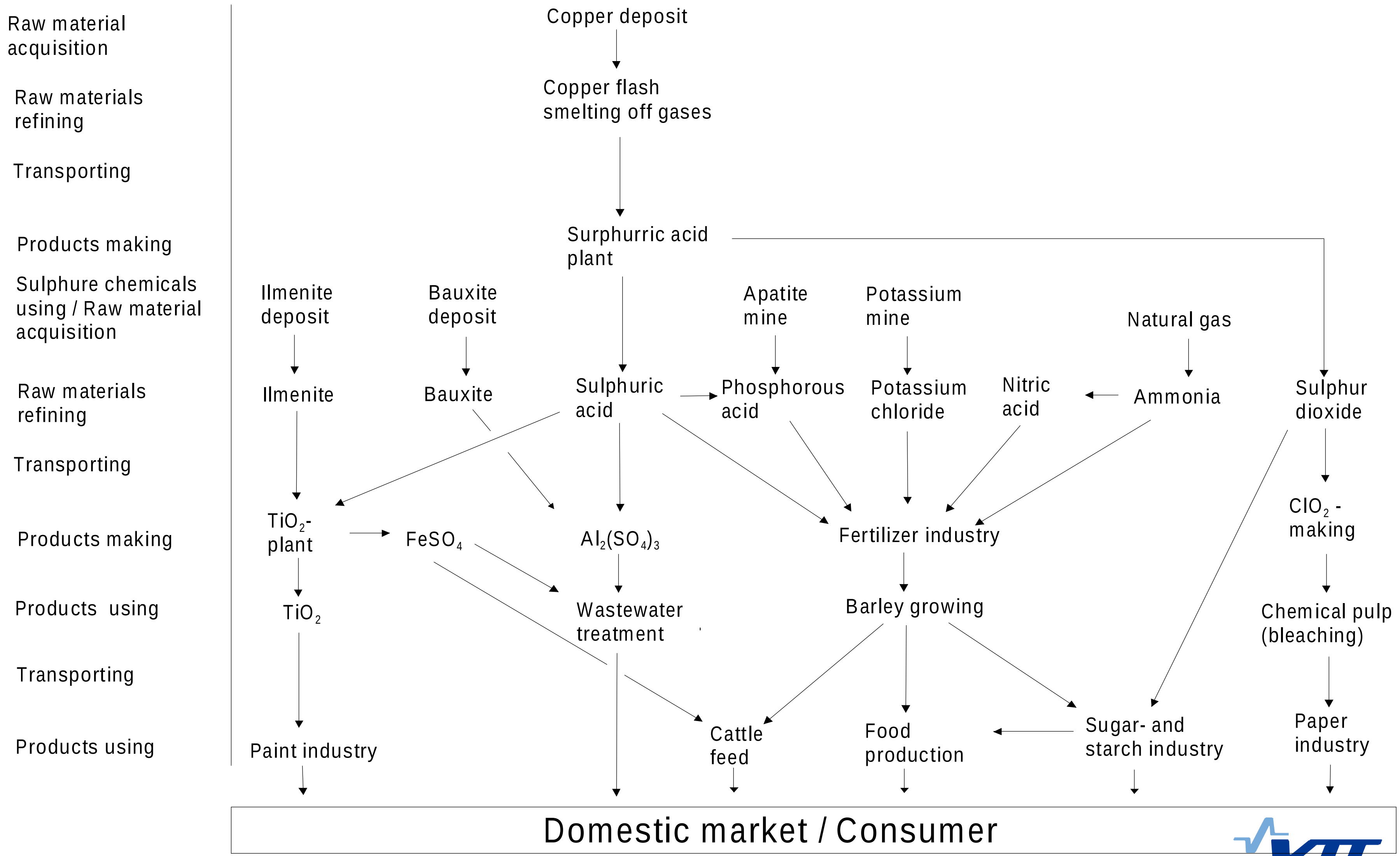
2002 OMG starts the nickel chemical production

2004 Boliden Harjavalta Oy is founded

SPECIFIC SULPHUR DIOXIDE EMISSIONS at Harjavalta

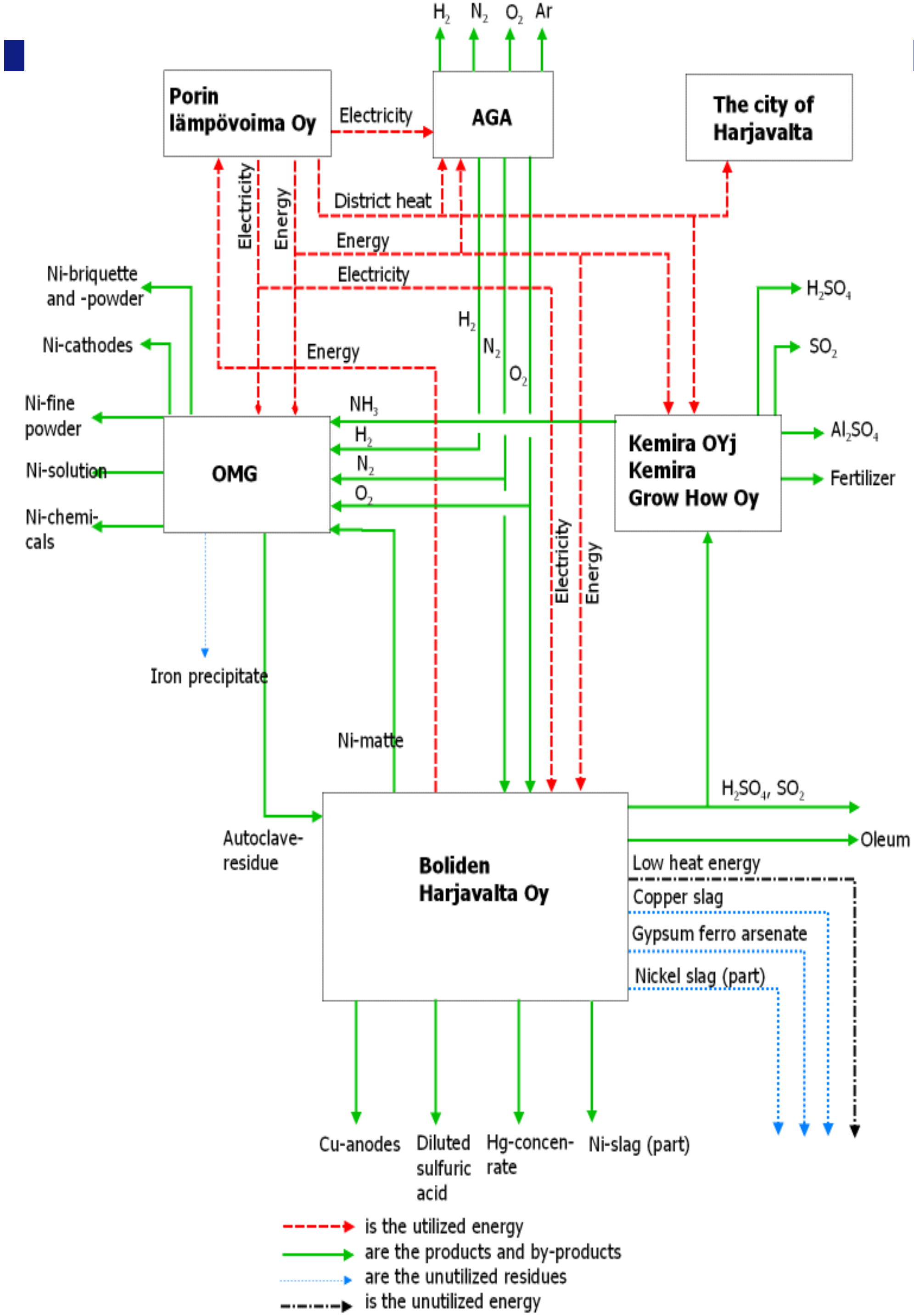


The utilisation chain of sulphur starting from a copper mine to sulphur dioxide, sulphuric acid and ending at consumer's dinner-table



Product and company diversity progress 1945 - 2005

Year	Company	Products
1945	Outokumpu	Anode copper
2005	Boliden	Anode copper, nickel matte, sulphuric acid, sulphuric dioxide, oleum, granulated nickel slag, diluted sulphuric acid, mercury precipitate.
	OMG	Nickel cathodes, nickel briquettes, nickel powders, nickel fine powder, nickel solutions, nickel chemicals, ammonium sulphate and cobalt sulphate solution
	Kemira Oyj	Aluminium sulphate
	Kemira GrowHow	Urea phosphate, different kinds of fertilizers, urea
	AGA	Gaseous oxygen, hydrogen and nitrogen, liquid oxygen, nitrogen and argon.
	Porin Lämpövoima	Process steam, high temperature steam, process energy, district heating energy, raw water, salt-free and precipitated water, electric energy and compressed air



Material and energy exchange of Harjavalta Industrial Park

ADVANTAGES:

- Environmental and recycling benefits
- Better energy efficiency
- Better product diversity when different companies can concentrate to their own core know-how areas
- Marketing and logistic benefits
- Improved safety activity
- Image factors
- Cultural differences is a positive factor in co-operation

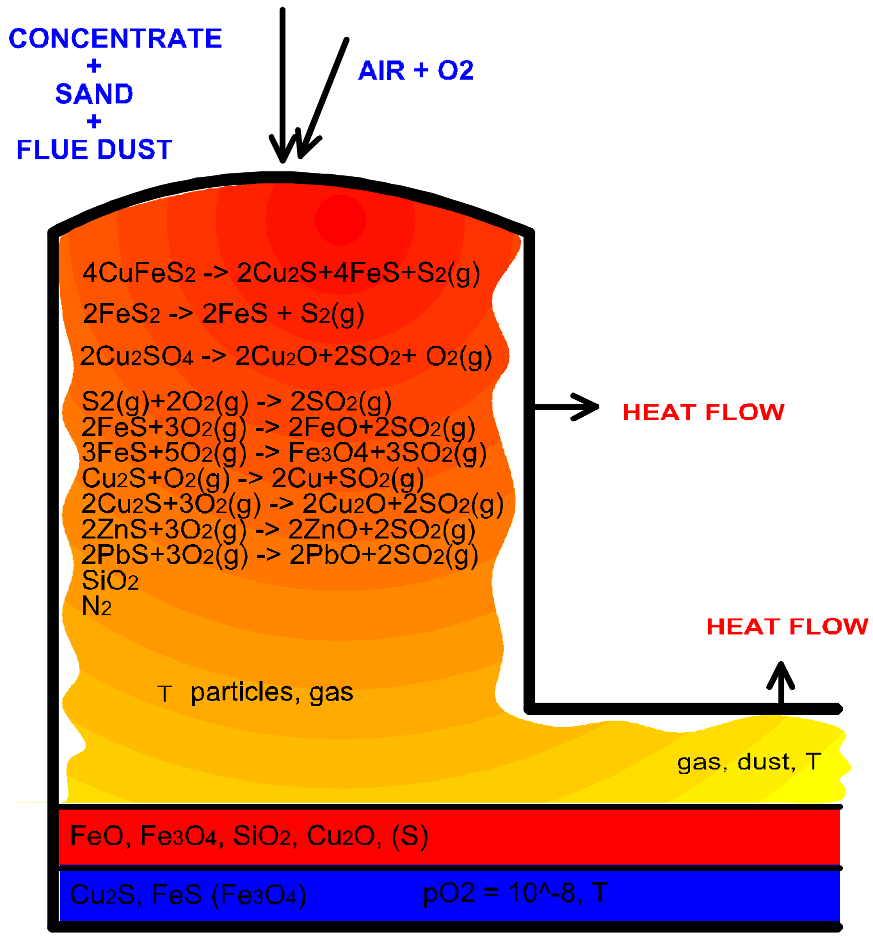
How to govern the eco-efficiency of the activities in an industrial park?

- There is no umbrella organization to govern the activities of individual companies in the park
- The overall supervision is carried out by the environmental authorities
- They have the final decision making power in environmental permissions and they also monitor the emissions from various sources in the park

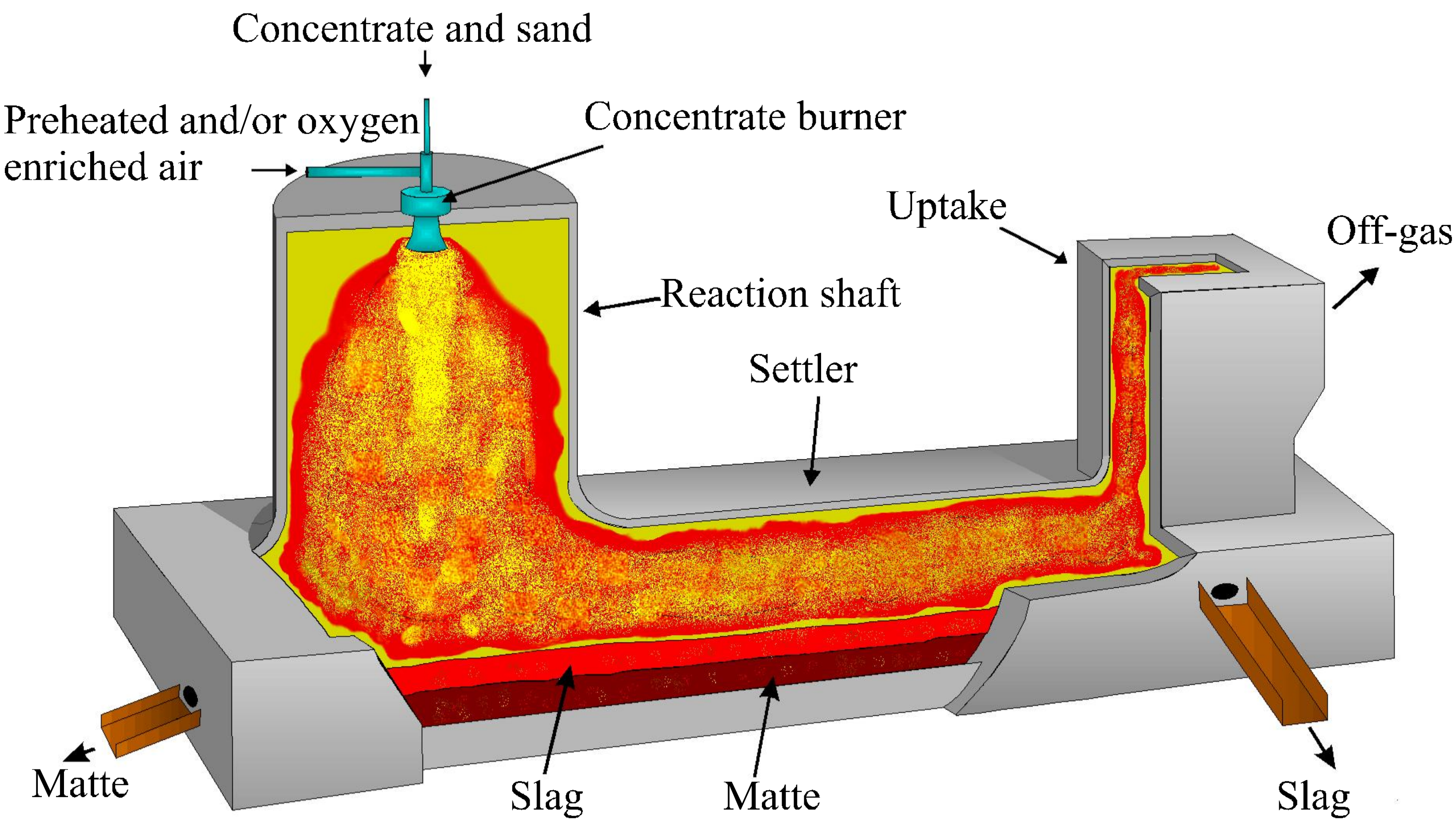
4. Outokumpu Flash Smelting Technology

Theory of Flash Smelting - reactions

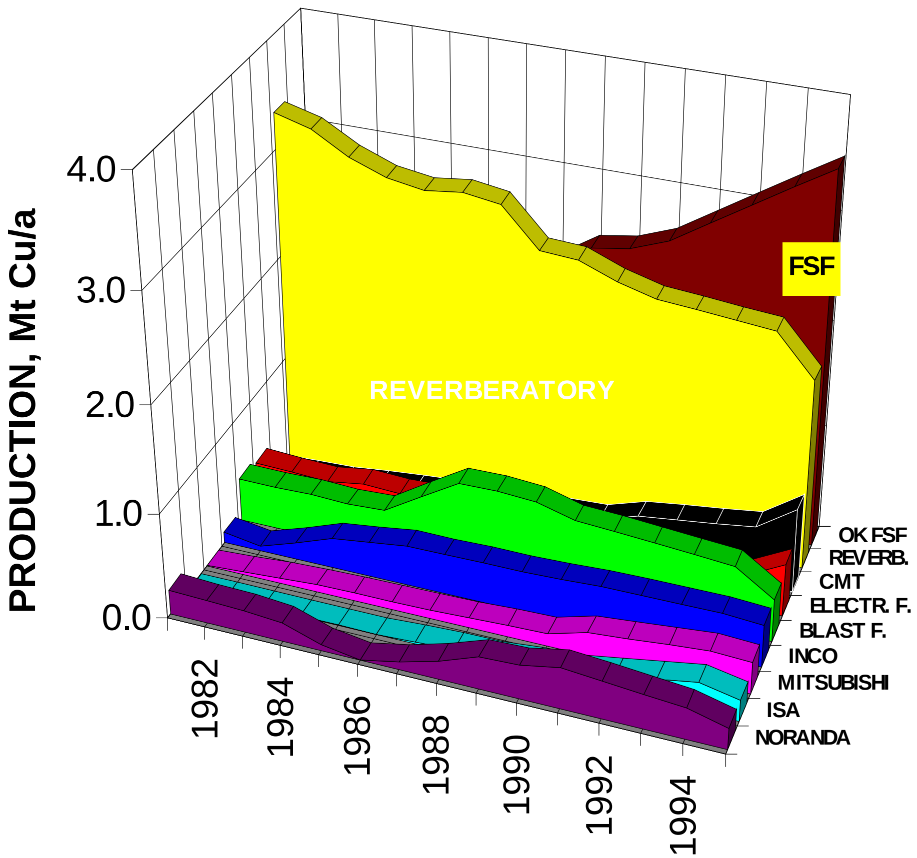
- Dissociation reactions – endothermic (require energy)
- Oxidation reactions – exothermic (produce energy)
- Oxidation reaction are not completed, the degree of oxidation depends on the amount of available oxygen.
- Iron sulphides are oxidized easier than copper sulphides.



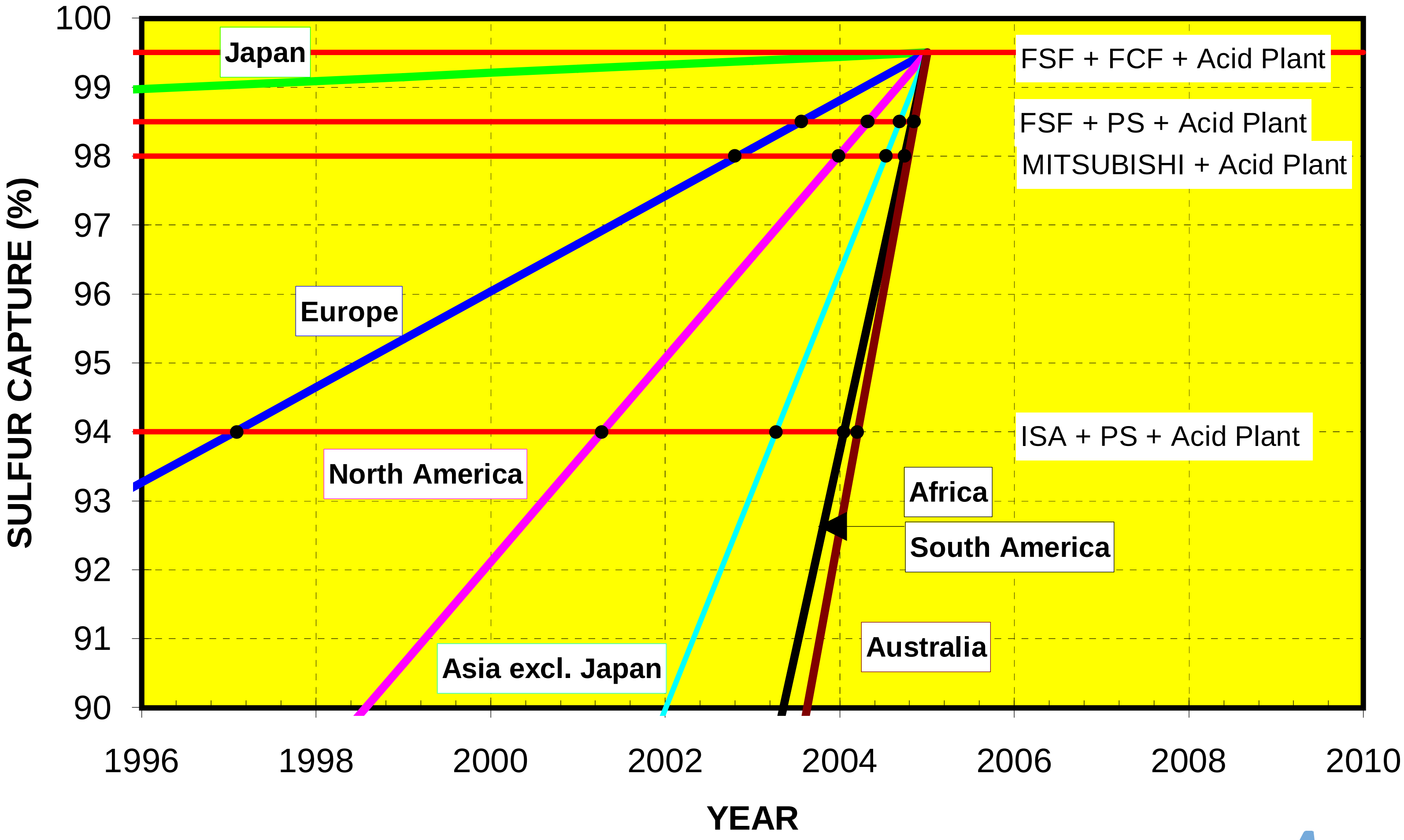
Flash smelting furnace



Cu production by process

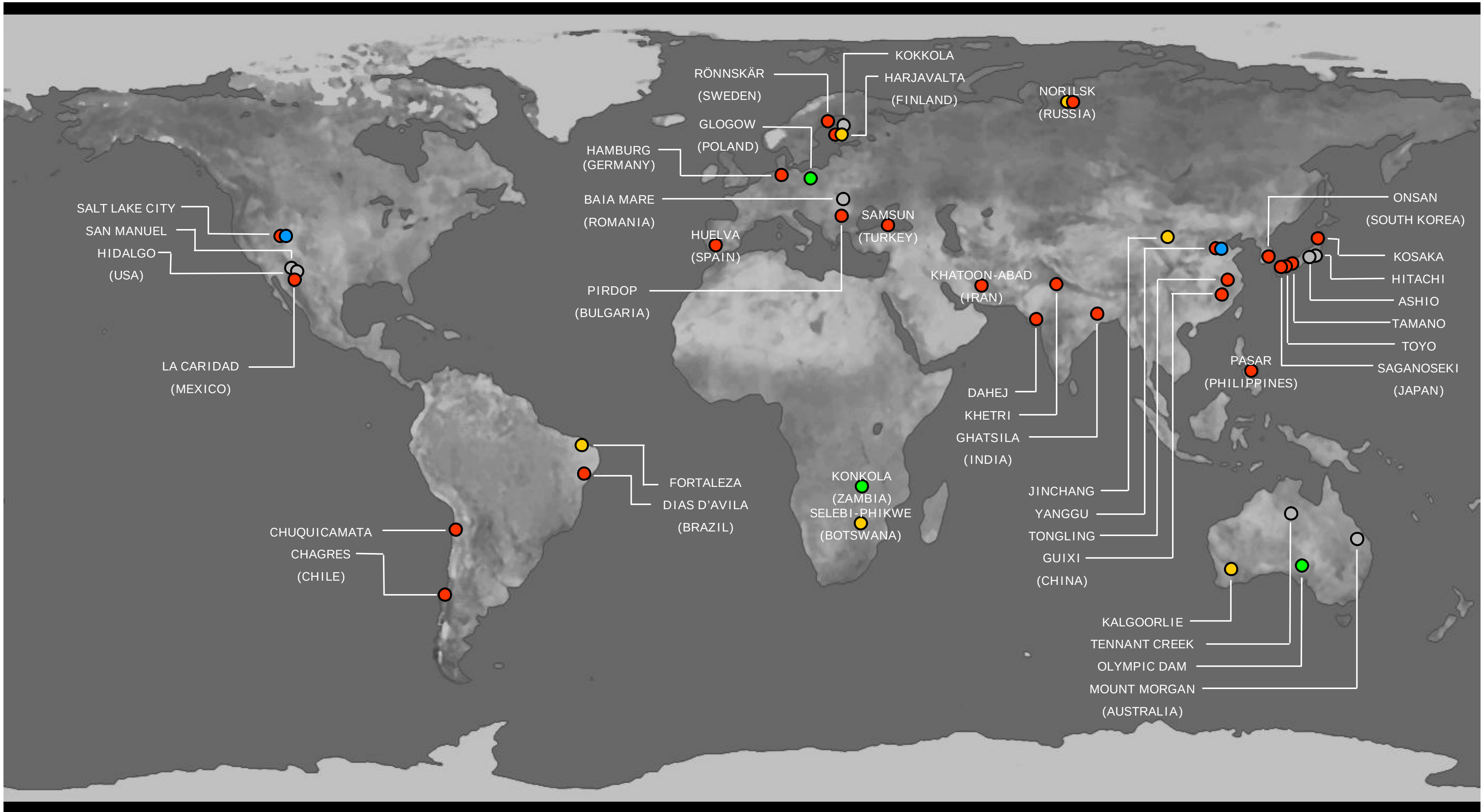


Sulfur Capture in Copper Smelters (Forecast)



Flash Smelters around the world

Cu SMELTING
Cu CONVERTING
DIRECT TO BLISTER
Ni SMELTING
NOT IN OPERATION



Flash Smelting & Flash Converting References 1/3

1.	Outokumpu Oy, Harjavalta, Finland	Cu smelting	1949
2.	Outokumpu Oy, Harjavalta, Finland	Ni smelting	1959
3.	Furukawa Co Ltd., Ashio, Japan	Cu smelting	1956
4.	Outokumpu Oy, Kokkola, Finland	Pyrite smelting	1962
5.	Combinatul Chimico Metalurgic, Baia Mare, Romania	Cu smelting	1966
6.	The Dowa Mining Co Ltd., Kosaka, Japan	Cu smelting	1967
7.	Nippon Mining Co Ltd., Saganoseki, Japan	Cu smelting	1970
8.	Sumitomo Metal Mining Co Ltd., Toyo, Japan	Cu smelting	1971
9.	Hindustan Copper Ltd., Ghatsila, India	Cu smelting	1971
10.	Peko Wallsend Metals Ltd., Mount Morgan, Australia	Cu smelting	1972
11.	Hibi Kyodo Smelting Co Ltd., Tamano, Japan	Cu smelting	1972
12.	Norddeutsche Affinerie AG, Hamburg, Germany	Cu smelting	1972
13.	Nippon Mining Co Ltd., Hitachi, Japan	Cu smelting	1972
14.	Western Mining Corporation, Kalgoorlie, Australia	Ni smelting	1972
15.	Karadeniz Bakir Isletmeleri AS, Samsun, Turkey	Cu smelting	1973
16.	Peko Wallsend Metals Ltd., Tennant Creek, Australia	Cu smelting	1973
17.	Nippon Mining Co Ltd., Saganoseki, Japan	Cu smelting	1972
18.	BCL Limited, Selebi-Phikwe, Botswana	Ni smelting	1973

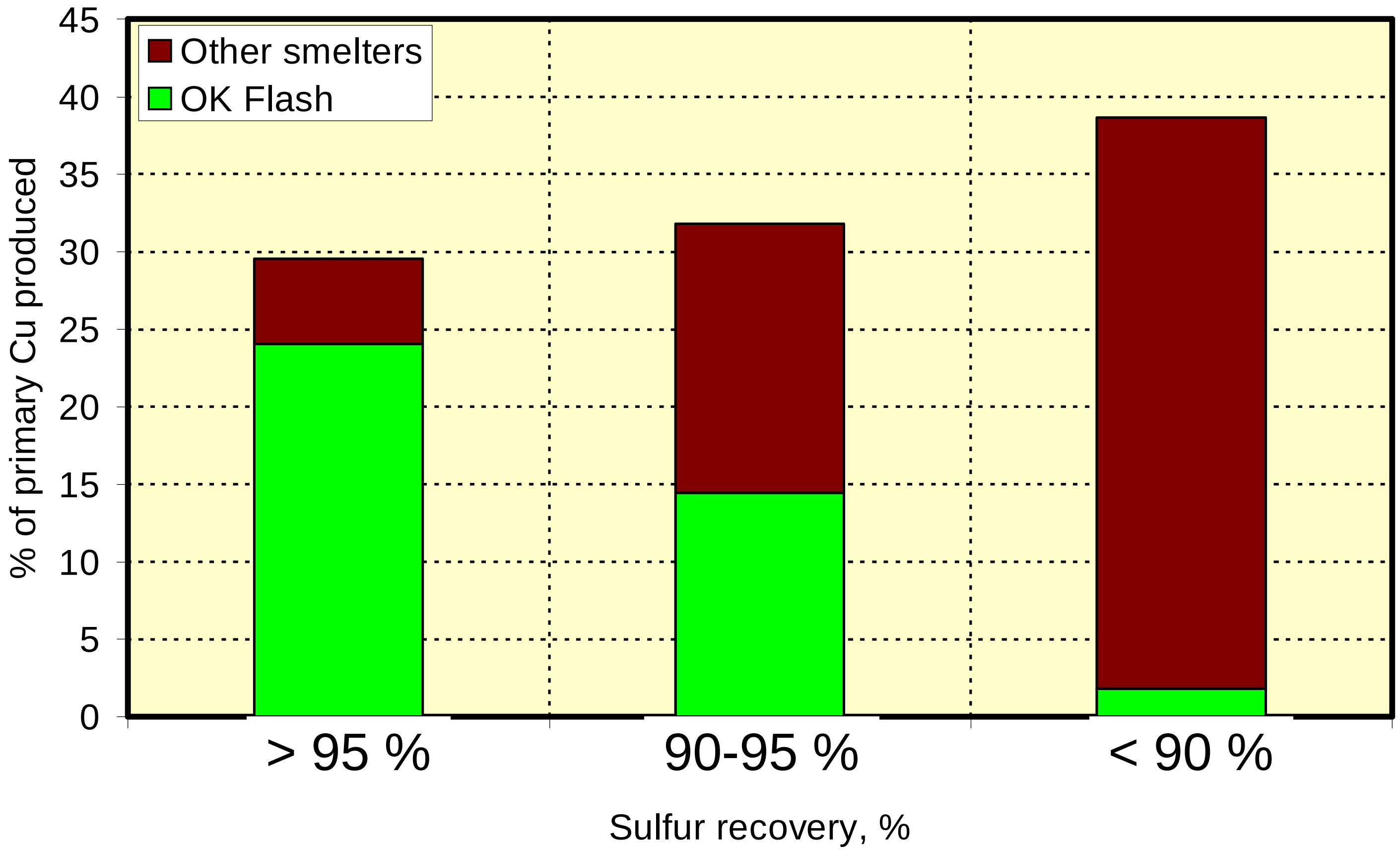
Flash Smelting & Flash Converting References 2/3

19.	Hindustan Copper Ltd, Khetri, India	Cu smelting	1974
20.	Rio Tinto Minera SA, Huelva, Spain	Cu smelting	1975
21.	Phelps Dodge Corporation, Playas, USA	Cu smelting	1976
22.	Gécamines, Luilu, Zaire	Direct to blister	
23.	Kombinat Górniczo-Hutniczy Miedz, Glogow, Poland	Direct to blister	1978
24.	Korea Mining & Smelting Co Ltd., Onsan, South Korea	Cu smelting	1979
25.	Norilsk Mining & Metallurgical Co, Norilsk, Russia	Ni smelting	1981
26.	Norilsk Mining & Metallurgical Co, Norilsk, Russia	Cu smelting	1981
27.	Caraíba Metais SA, Camacari, Brazil	Cu smelting	1982
28.	Philippine Associated Smelting & Refining Co., Isabel, the Philippines	Cu smelting	1983
29.	Jiangxi Copper Corporation, Guixi, China	Cu smelting	1985
30.	Mexicana de Cobre SA, El Tajo, Mexico	Cu smelting	1986
31.	MDK G Damianov, Srednogorie, Bulgaria	Cu smelting	1987
32.	Codelco, Chuquicamata, Chile	Cu smelting	1988
33.	Jinchuan Non-ferrous Metals Co, Jinchang, China	Ni smelting	1992
34.	Magma Copper Co., San Manuel, USA	Cu smelting	1988

Flash Smelting & Flash Converting References 3/3

35.	Roxby Management Services Pty Ltd, Olympic Dam, Australia	Direct to blister	1988
36.	Compania Minera Disputada de las Condes SA, Chagres, Chile	Cu smelting	1995
37.	Kennecott Utah Copper Corp., Salt Lake City, USA	Cu smelting	1995
38.	Kennecott Utah Copper Corp., Salt Lake City, USA	Cu converting	1995
39.	Jinlong Copper Co Ltd., Tongling, China	Cu smelting	1997
40.	Indo-Gulf Fertilisers & Chemical Ltd, Gujarat, India	Cu smelting	1998
41.	Mineraçăo Serra da Fortaleza Ltda, Fortaleza, Brazil	Ni smelting	1998
42.	WMC Resources Ltd, Olympic Dam, Australia	Direct to blister	1999
43.	Boliden Mineral AB, Rönnskär, Sweden	Cu smelting	2000
44.	Southern Peru Copper Corporation, Ilo, Peru	Cu smelting	
45.	Southern Peru Copper Corporation, Ilo, Peru	Cu converting	
46.	National Iranian Copper Industries Co., Khatoon Abad, Iran	Cu smelting	2004
47.	Yanggu Xiangguang Copper Co., China	Cu-smelting	
48.	Yanggu Xiangguang Copper Co., China	Cu-converting	
49.	KGHM Polska Miedz S.A., Glogów, Poland	Direct to blister	
50.	Jiangxi Copper Corporation, Guixi, China	Cu smelting	
51.	Konkola Copper Mines Plc., Zambia	Direct to blister	

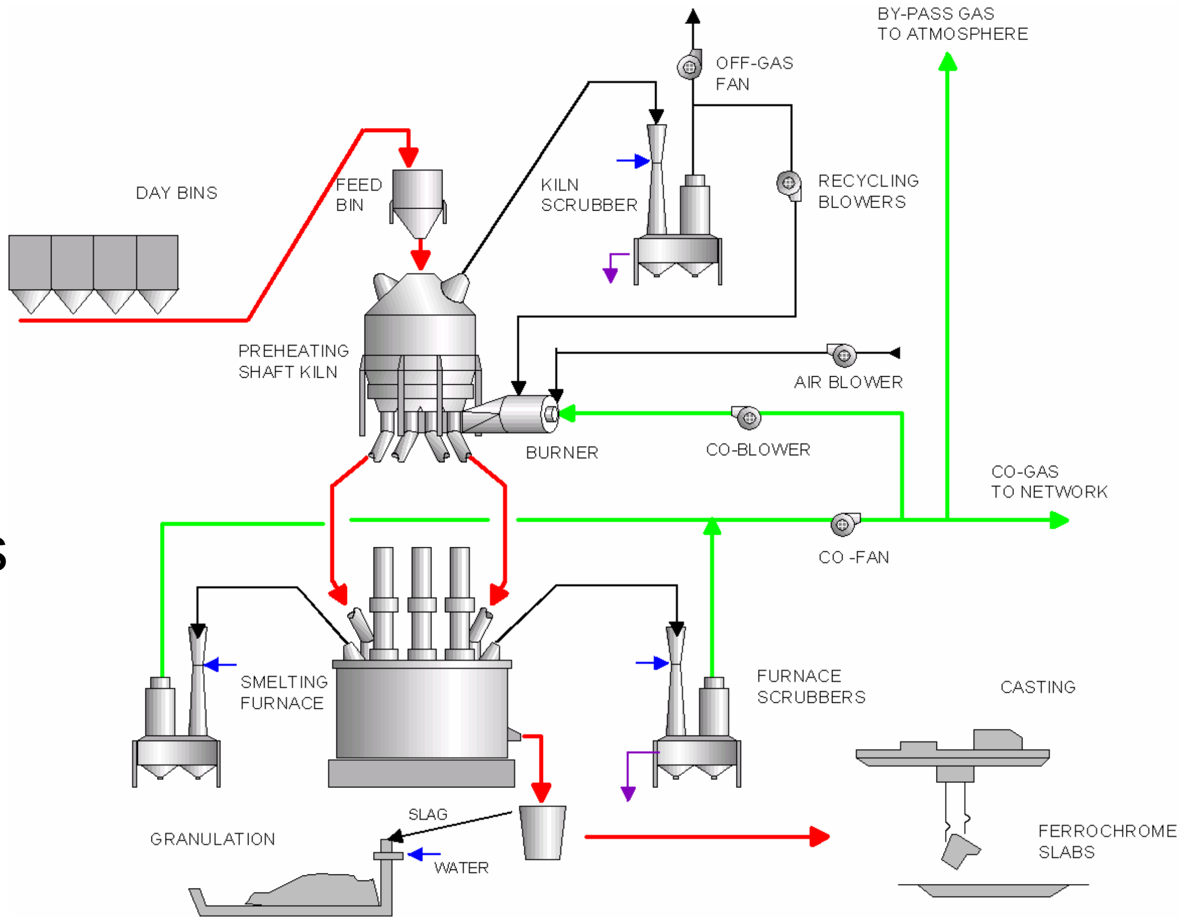
Relative amount of copper produced in smelters ("pure FSF" vs. others)



5. Ferro-alloys Technology of Outokumpu

Outokumpu FeCr smelting process

- Based on pellets.
- Furnace charge is preheated in stationary shaft kiln.
- Smelting furnace is closed and sealed.
- CO-gas is cleaned and utilized in the plant and outside.



Outokumpu Tornio Works

- Full capacity after last expansion:

FeCr	270 000 tons
Slabs	1 600 000 tons
Coil products	1 200 000 tons
of which:	
Hot rolled	300 000 tons
Semi-cold rolled	150 000 tons
Cold rolled	750 000 tons

- Specialized in:
  - Custom-made volume production in selected product areas
  - Supplying cost efficiently high quality volume products
  - Using best available technology
  - New products from RAP line
- About 2 300 employees

The most integrated stainless steel works in the world (Outokumpu Tornio works)

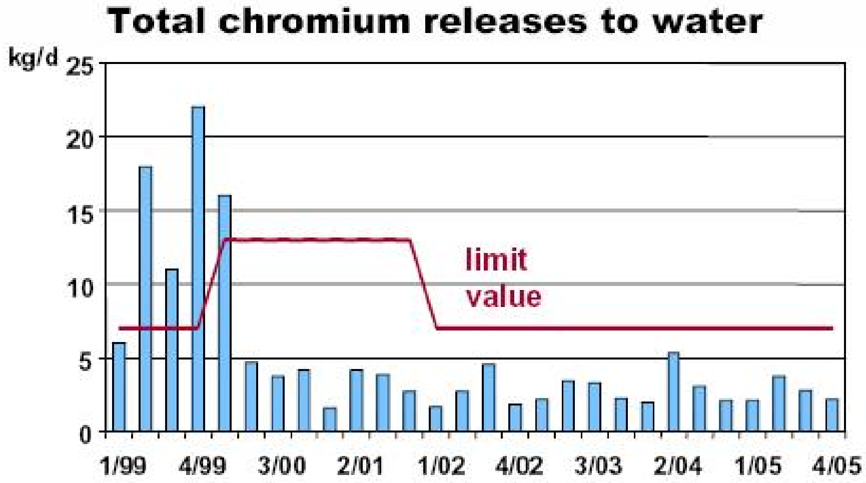
- Own chrome – safe supply
- Stable FeCr quality
- Liquid FeCr and use of own CO saves primary energies
- FeCr-converter increase melting capacity and saves energy
- Hot slab charging in Hot Rolling Mill
- Short processing time and lower logistical costs
- Savings in product handling
- Integrated southbound and northbound logistics
- Terneuzen Mill close to main markets

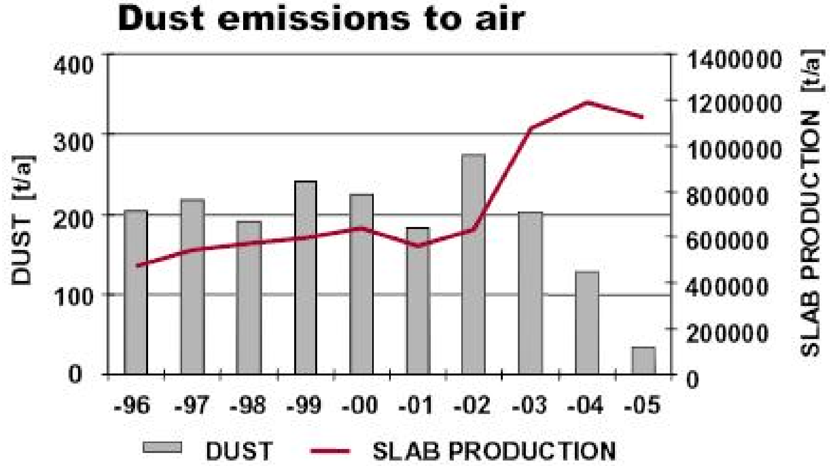


Main principles of environmental management

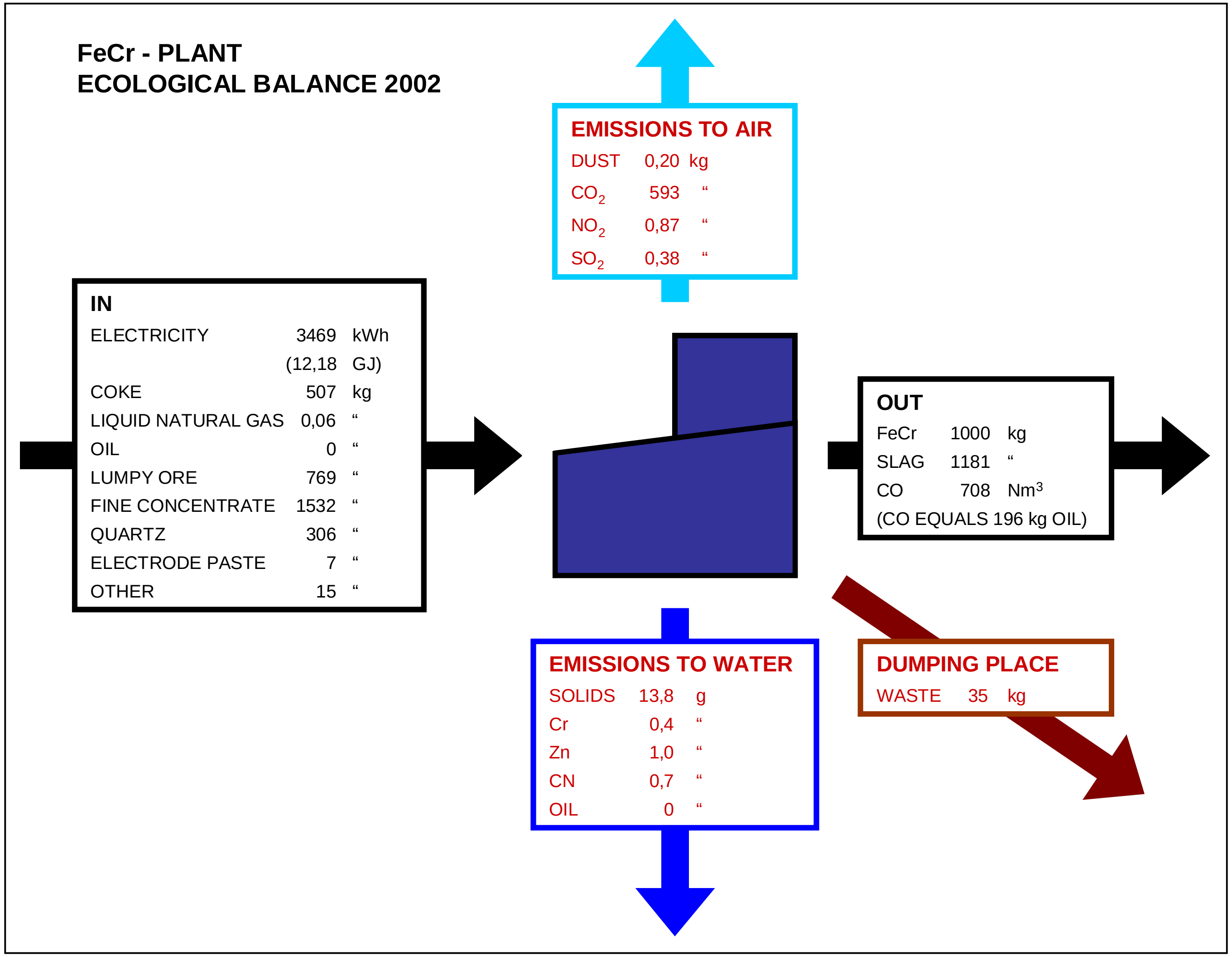
- Improvement of material efficiency and utilization of byproducts
- Improvement of energy efficiency
- Continuous improvement: ISO 14001 and R&D as tools
- Utilization of best available technology (BAT) to keep the emissions at low levels
- Active co-operation with authorities

⇒ Aim is to be the best in eco-efficiency

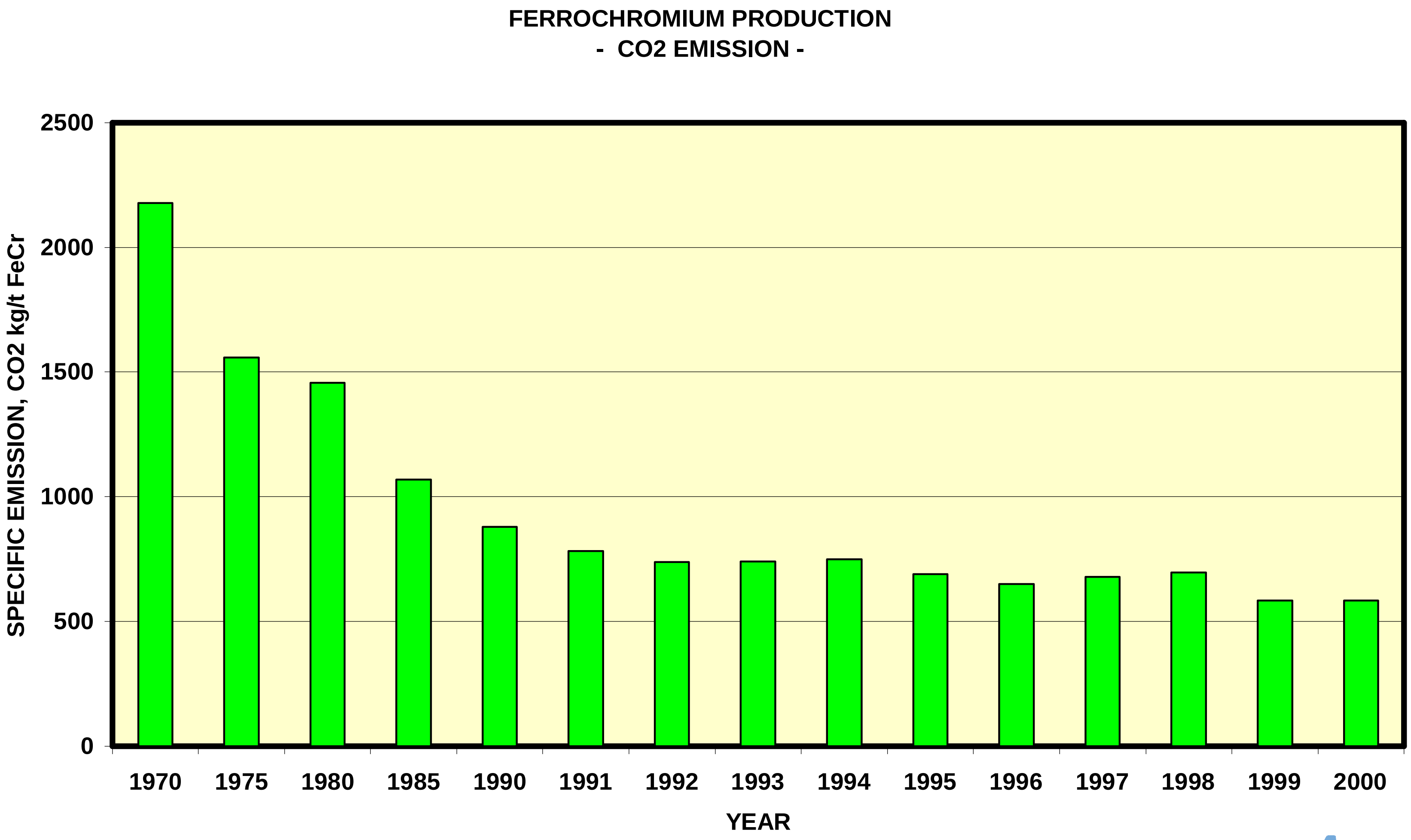




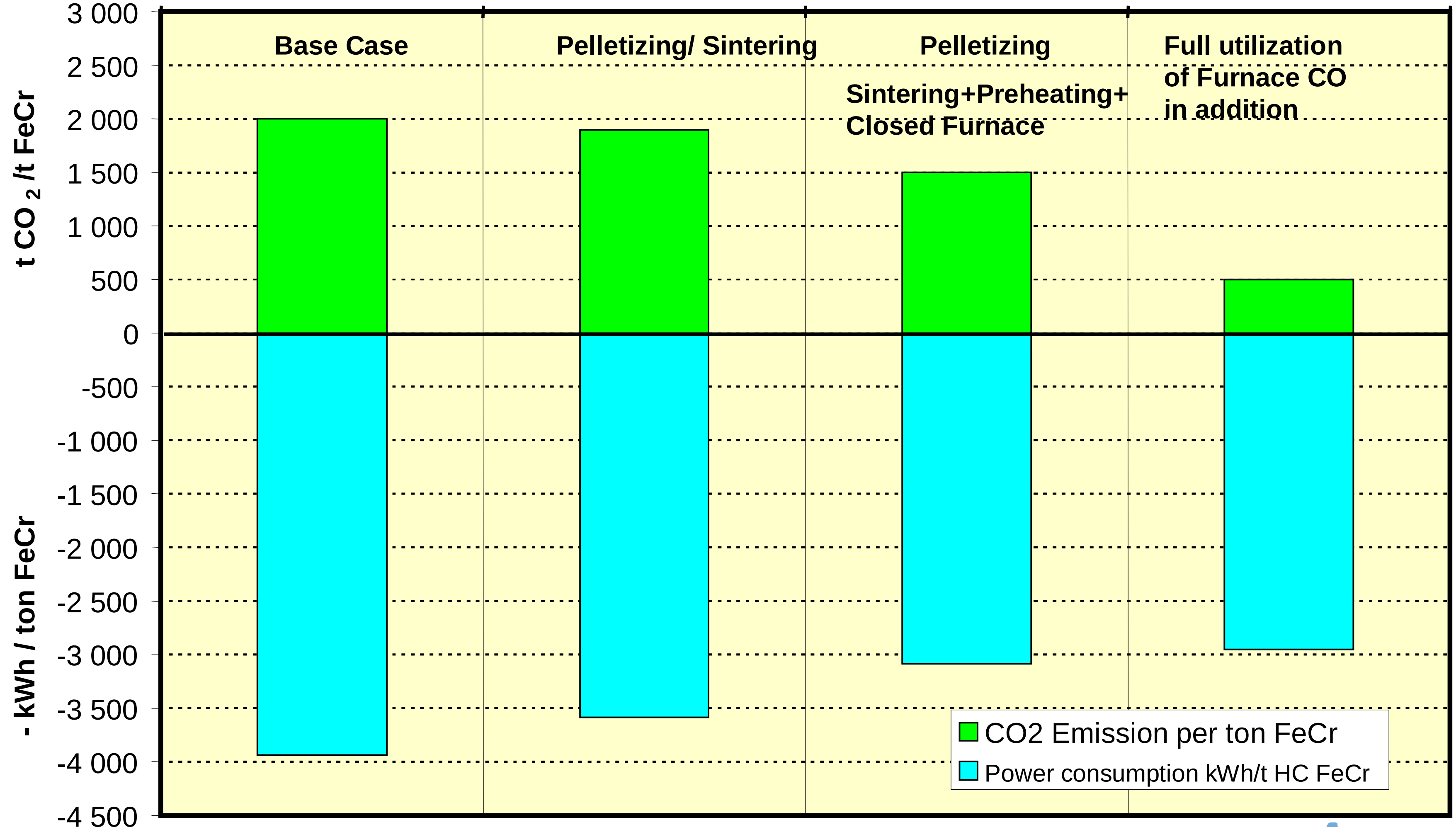
The ecological balance of Tornio FeCr -plant



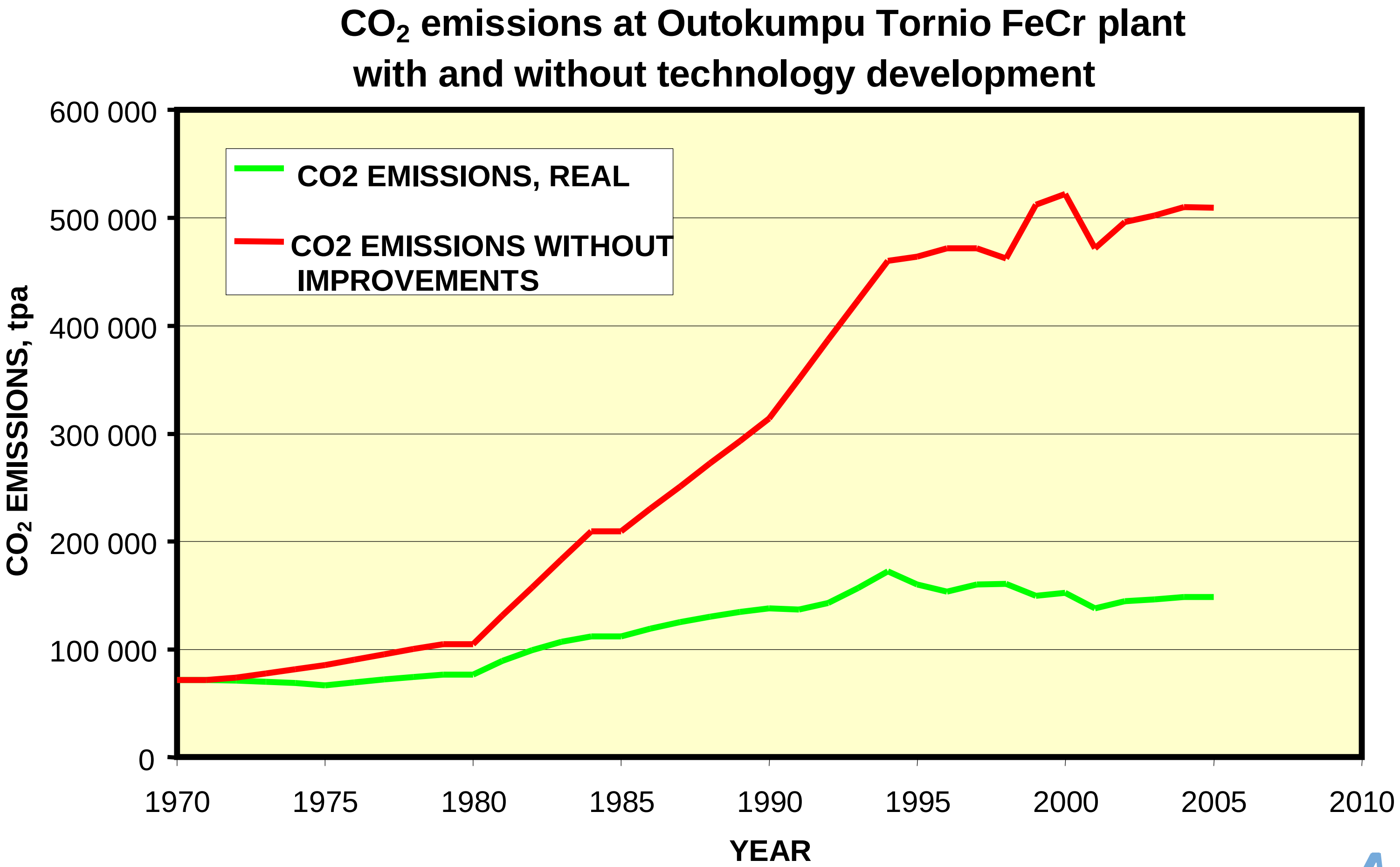
Specific CO_2 emissions at Outokumpu Tornio FeCr Plant, kg CO_2/t FeCr



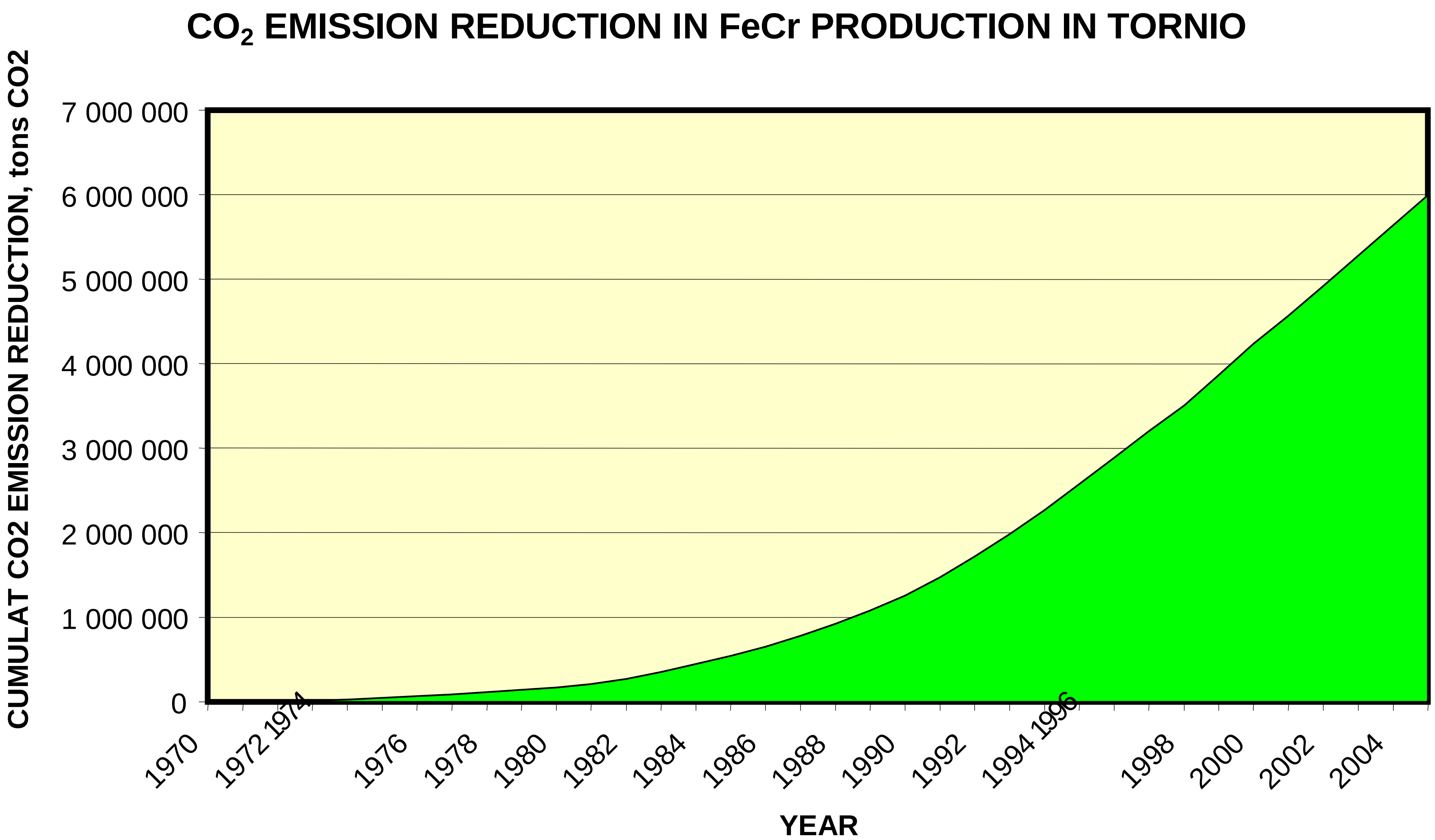
Effect of Technology development on CO_2 emission and power consumption in FeCr production



Without technology development the CO_2 emission level at Outokumpu Tornio FeCr plant would be more than 3-fold compared to the present actual figures



Effect of technology development on cumulative CO_2 emission reduction at Outokumpu Tornio FeCr plant

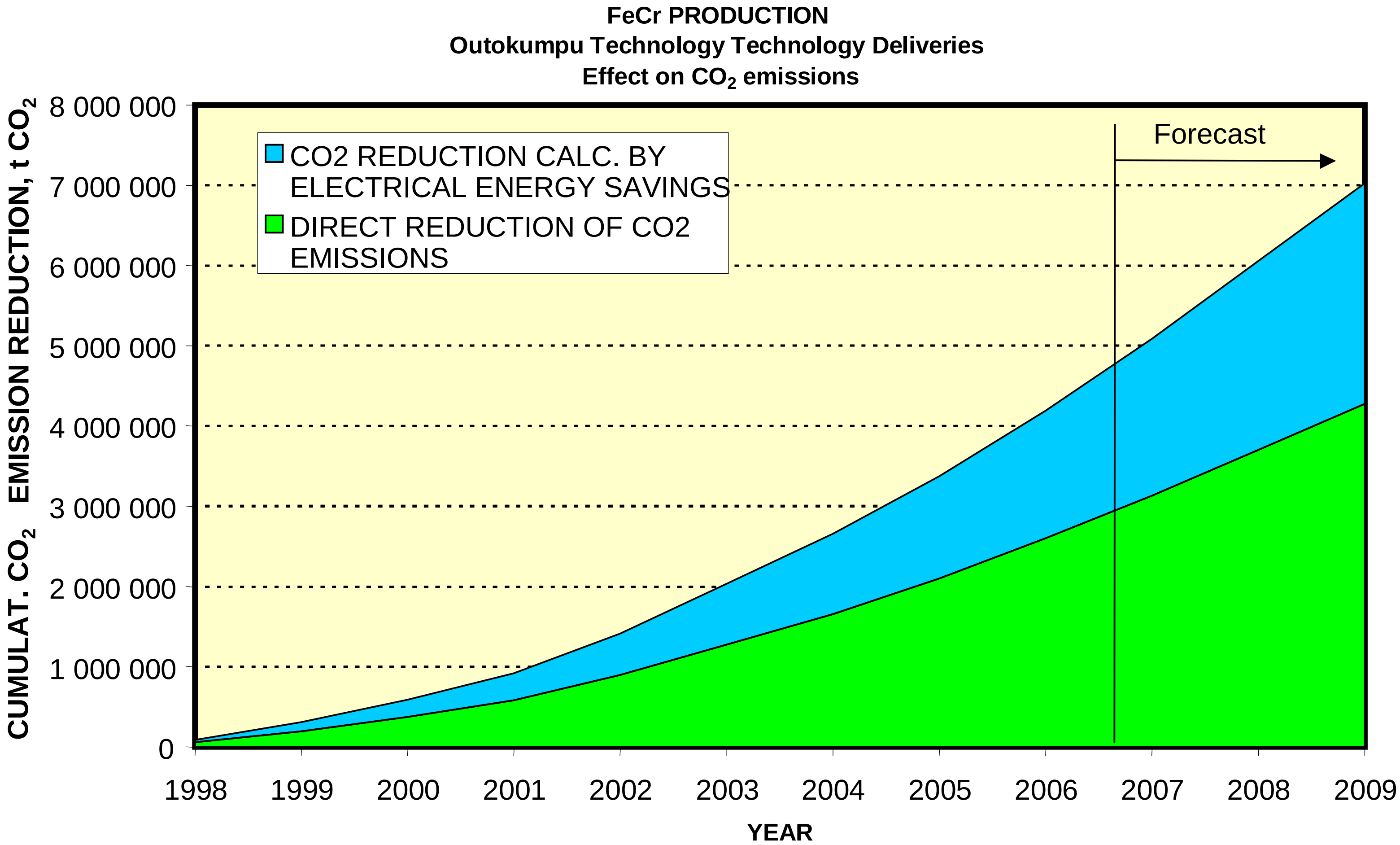


Outokumpu Technology's latests FeCr technology transfer project references

Ferrometals	1998	South Africa
Hernic	1999	South Africa
Assmang	2001	South Africa
Tubatse	2002	South Africa
SA Chrome	2002	South Africa
Hernic 2	2005	South Africa
Donskoy GOK	2005	Kazakhstan
IFM	2007	South Africa
Xstrata Wonderkop	2007	South Africa

- Already now about 5-7 million tons less CO_2 emissions

Estimate of cumulative CO_2 emission reduction in FeCr production in South Africa achieved by utilization of Outokumpu technology



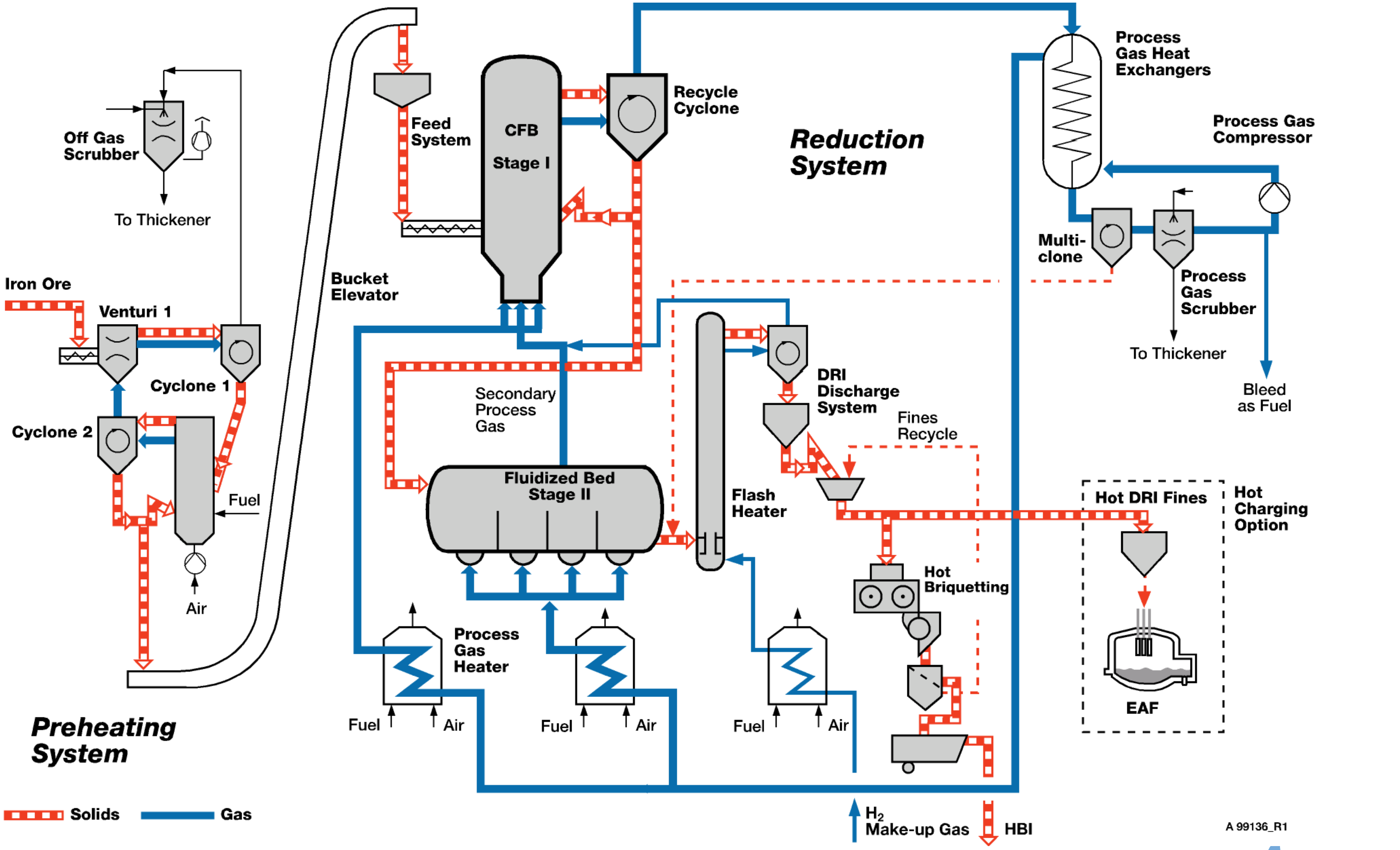
6. Extraction of Iron With Low Carbon Dioxide Emissions

Reduction of iron ores

- **Conventional blast furnace reduction of iron oxides**
  - Pelletizing
  - Sintering
  - Coking
  - Oxygen removed as CO_2
  - 95 % of primary iron production
- **Direct reduction by natural gas**
  - Oxygen removed as H_2O+CO_2
  - 3-4 % of primary iron production
- **Direct reduction by hydrogen**
  - Oxygen removed as H_2O
  - 1-2 % of primary iron production

View of Circored plant in Point Lisas, Trinidad

Circored® : Gas Based Direct Reduction of Iron Ore Fines



Basic reactions in the bath