Energy Efficiency of Metals Production Industry in Finland

Motiva

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Introduction

- Study financed by the Finnish Energy Authority
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- Study carried out by government owned sustainable development company Motiva Oy in 2020
- Report available on Motiva's website

energy authority Technology Industries of Finland Metallinjalostajat NEW BOLIDEN outokumpu OVAKO SSAB

Objectives

How the energy efficiency of energy-intensive metals production industry in Finland compares to other countries?

Which factors affect the comparisons of countries and individual plants?

Which factors which may lead to misinterpretations in any simplified country or plant comparisons based on energy efficiency indicators?

Approach

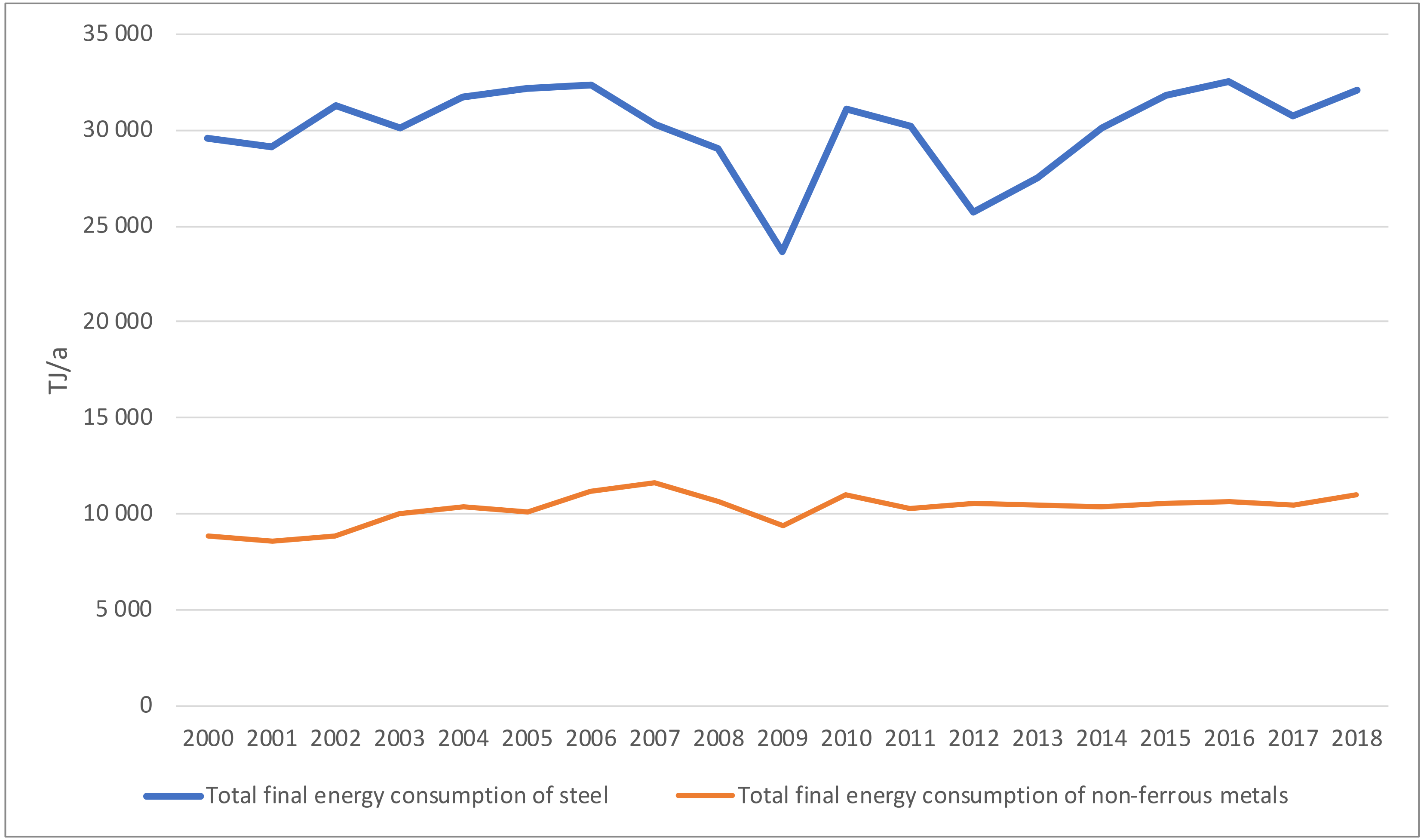
1. Collection of indicators and data
   - Odyssee energy indicator database
   - Procured data from Wood MacKenzie
2. Interviews
   - Participating industries: Boliden, Outokumpu, Ovako and SSAB Finland
   - Academia: Aalto University, University of Oulu
   - Other: Metso Outotec (technology supplier), Statistics Finland
3. Analysis and conclusions

Background data

Industry Structure

Company	Products and production capacity	Raw material	Processes
SSAB Europe, Raahe	Steel (2 800 kt in 2018)	Imported concentrate	Oxygen
Outokumpu, Tornio	Stainless steel (slab capacity 1 600 kt per year) Ferrochrome (530 kt per year)	Share of recycled steel up to 90%; chrome mine in Keminmaa	Electric
Ovako, Imatra	Steel (on average 240 kt per year)	100% recycled steel	Electric
Boliden, Kokkola	Zinc (291 kt in 2019)	Both domestic and imported concentrates	Roaster and direct leaching Electrolysis
Boliden, Harjavalta	Copper (120 kt in 2019), nickel (26 kt), silver (62 000 kg) and gold (2 500 kg)	Both domestic and imported concentrates	Flash smelting
MMC Norilsk Nickel: Harjavalta Nickel	Nickel (capacity 65 kt per year)	Both domestic and imported concentrates	Hydrometallurgical from nickel matte
Terrafame, Sotkamo	Nickel (27 kt in 2019), zinc (55 kt), cobalt and copper	Terrafame mine	Heap leach

Total Final Energy Consumption of Metals Production in Finland



Decline in energy consumption of steel production in 2008-2012 was due to smaller production volumes.

Note: Energy consumption for steel production includes Nace classes 24.1, 24.2, 24.2, 24.51 and 24.52.
Sources: Odyssee Database November 2020

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Energy Efficiency Policies for Energy Intensive Industries

Voluntary energy efficiency agreement scheme

- In operation since 1997
- Savings from measures implemented in 2017-2019 totalled 290 GWh/a in 2019 in metals production industry; corresponding investments were 30 million euros

Voluntary energy audit programme (replaced in 2015 by mandatory energy audits)

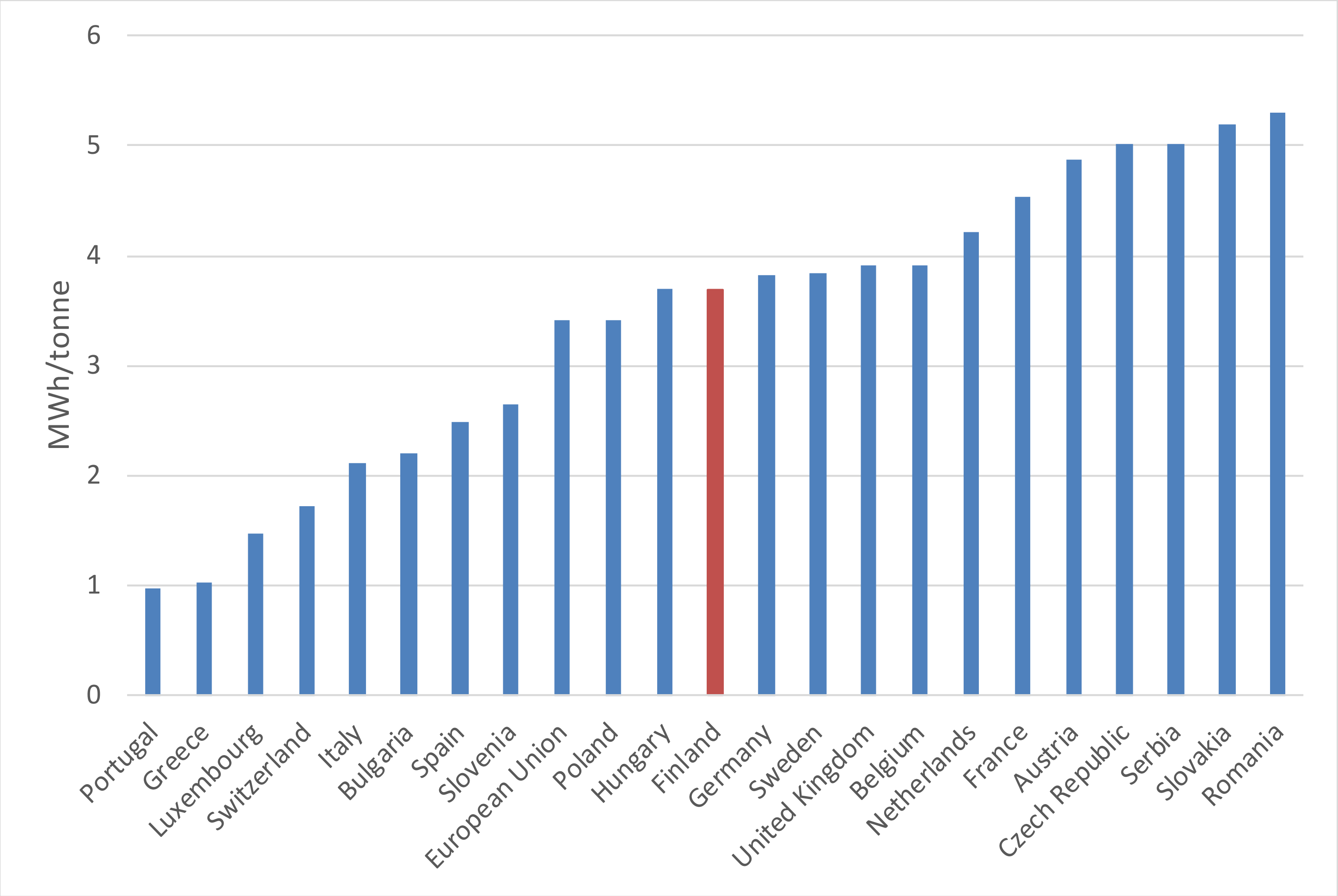
EU Emissions Trading Scheme

Pollution Prevention and Control (IPPC) Directive

Taxation is used as an steering instrument

Odyssee Data
- National Level Data

Specific Consumption of Steel Production in Europe in 2018



The figure does not take into account the profoundly different energy consumption by electric and oxygen steel production routes.

Note: Energy consumption of steel production includes Nace classes 24.1, 24.2, 24.2, 24.51 and 24.52.
Source: Odyssee Database November 2020

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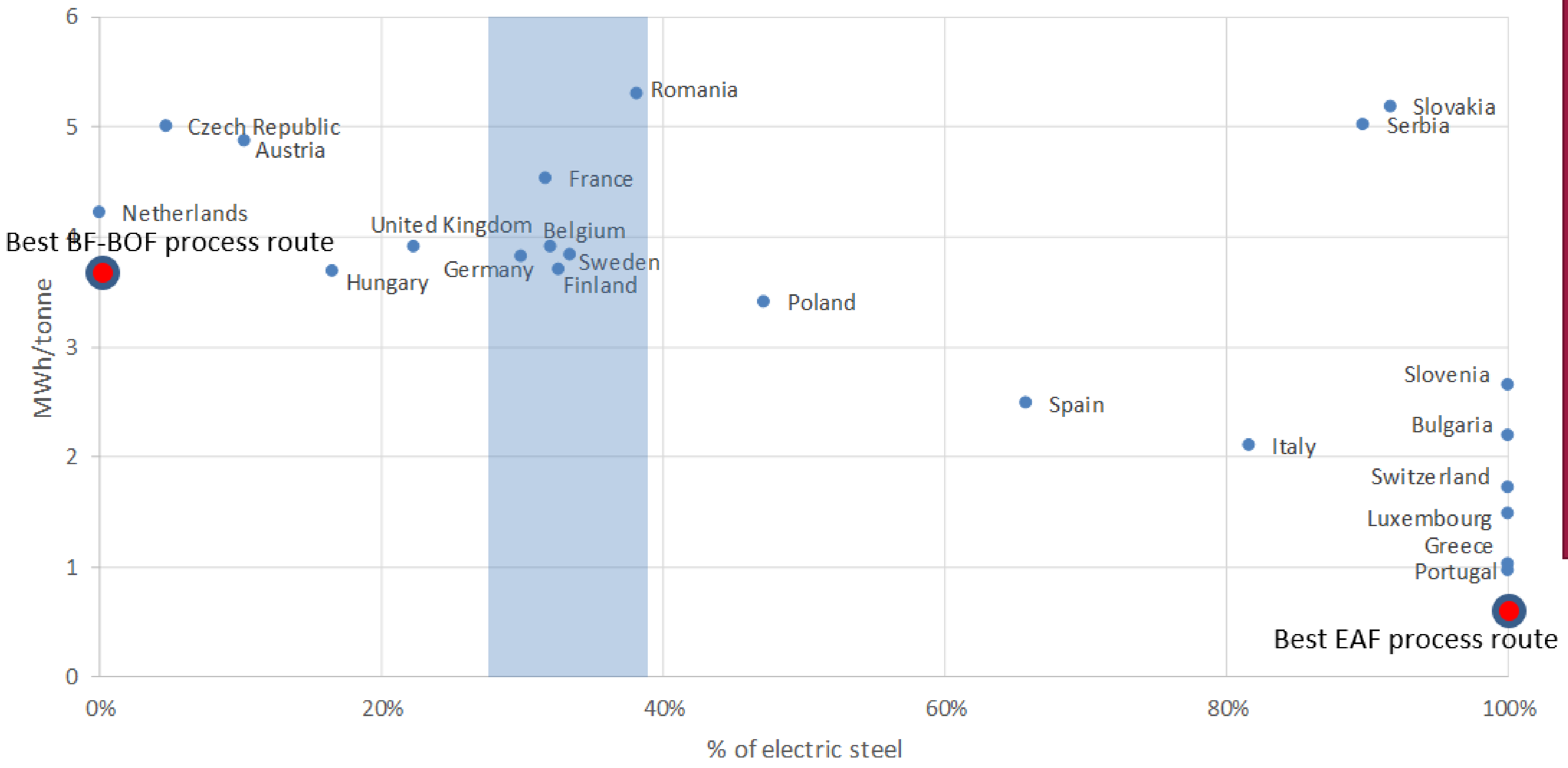
Specific Consumption of Steel Production by the Production Route in Europe in 2018



Compare only countries where the share of electric steel is about the same. One third of steel produced in Finland is electric and Finland ranks the best among similar countries. Note: Energy consumption includes stainless steel and ferrochrome production, production of some metal products and thermomechanical processing which is not related to the production of crude steel. These blur the results.

BF-BOF: blast furnace, oxygen steel
EAF: electric steel
Source: Odyssee database November 2020

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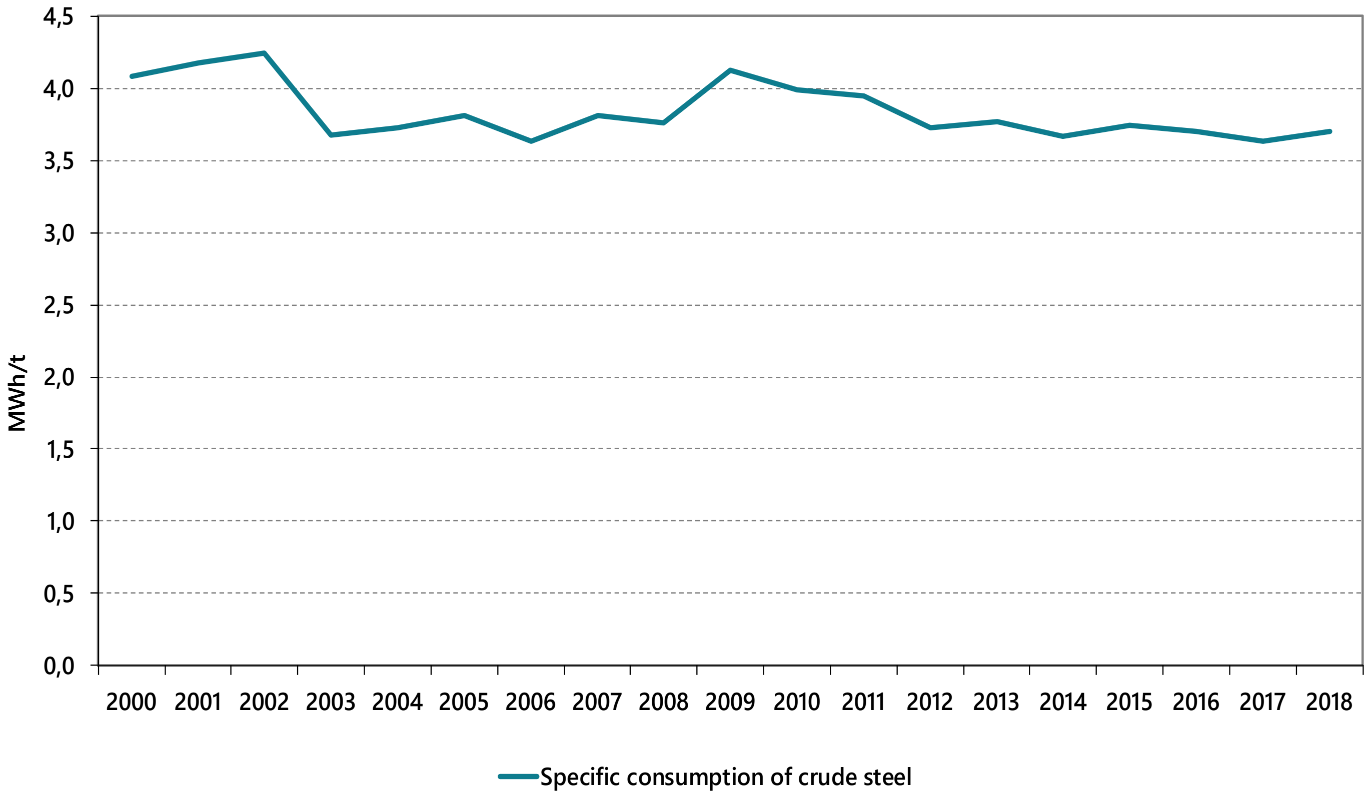
Energy Intensity of Primary Metals Production in Finland

Strong peak in 2009-2011 was due to the drop of value added, not increase of energy consumption. Energy intensity does not measure energy efficiency and should not be presented as such.

Sources: Odyssee Database November 2020

Specific Energy Consumption of Crude Steel Production in Finland



While energy intensity – along with value added – went roller coaster in 2009-2011, specific energy consumption remained relatively steady.

Note: Energy consumption includes also stainless steel and ferrochrome production and production of some metal products.
Source: Odyssee database
November 2020

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Major Issues in Odyssee Data and Indicators on Crude Steel Production

- Specific consumption (MWh/tonne) at the national level does not take into account the shares of oxygen and electric steel production routes. Difference in the consumption is 500-700%.
- Energy consumption data includes energy consumption not related to crude steel production: 1) other mills producing e.g. tubes or pipes, 2) thermomechanical processing (e.g. rolling) at steel mills not related to crude steel production (impact can be up to +50%),3) ferrochrome and stainless steel production.
- Statistical boundaries such as industry structure is a major factor. Outsourced sub-processes are not included in the consumption. These can be, e.g., oxygen plants, lime production, sintering or compressed air summing up easily 20%.
- Fuels used for the production of sold heat are not reduced from the energy use of the industrial sub-sector.
- Macroeconomic situation affecting plant utilization rates, plant sizes, load sizes and product mix (quality of products and the volume of the product mix) all have a considerable impact on energy consumption.

Wood MacKenzie's Data
- Plant Level Data

Comments on Wood MacKenzie's Plant-Specific Data

- Energy consumption data of a given metal integrate or plant includes all energy consumption within the site regardless of ownership of the sub-processes (i.e., energy consumption of contractors is included).
- Some outliers removed (see notes in the following figures) to make them readable.
- Plant-level data is better for comparisons than aggregated national data, but also there are uncertainties related to reporting. In addition, factors like macroeconomic situation, plant size and product mix still apply.
- Finnish metals producers rank high in the global data (Note: Sold heat or steam is not credited):
  - SSAB Finland is the second best among other oxygen steel plants
  - Ovako is 28th among electric steel producers, i.e., in the better end of the mid-range (no heat sales)
  - Boliden's copper production in Harjavalta is 34th, i.e., in the mid-range
  - Boliden's zinc production in Kokkola is the second best

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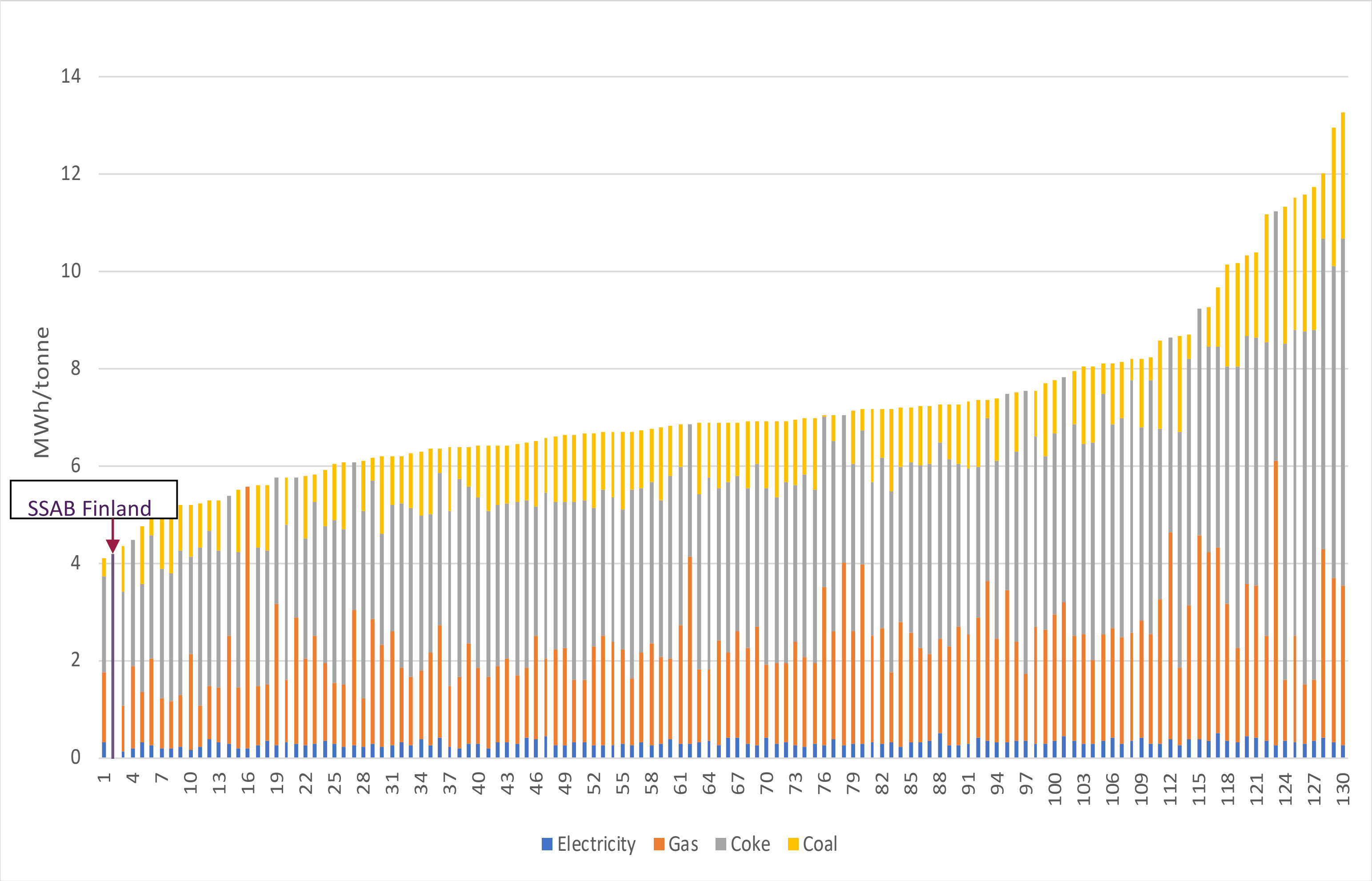
Specific Consumption of Oxygen Steel Production in 2018



SSAB Finland's blast furnaces are among the most efficient in Europe.

Note 1: Two low-end producers removed due to clear data errors. 15 high-end producers removed for readability.
Note 2: System boundary is set at the production of **crude steel** i.e., thermomechanical processing (e.g., rolling) is excluded. Outsourced on-site sub-processes are included.
Sources: Wood MacKenzie and SSAB Finland

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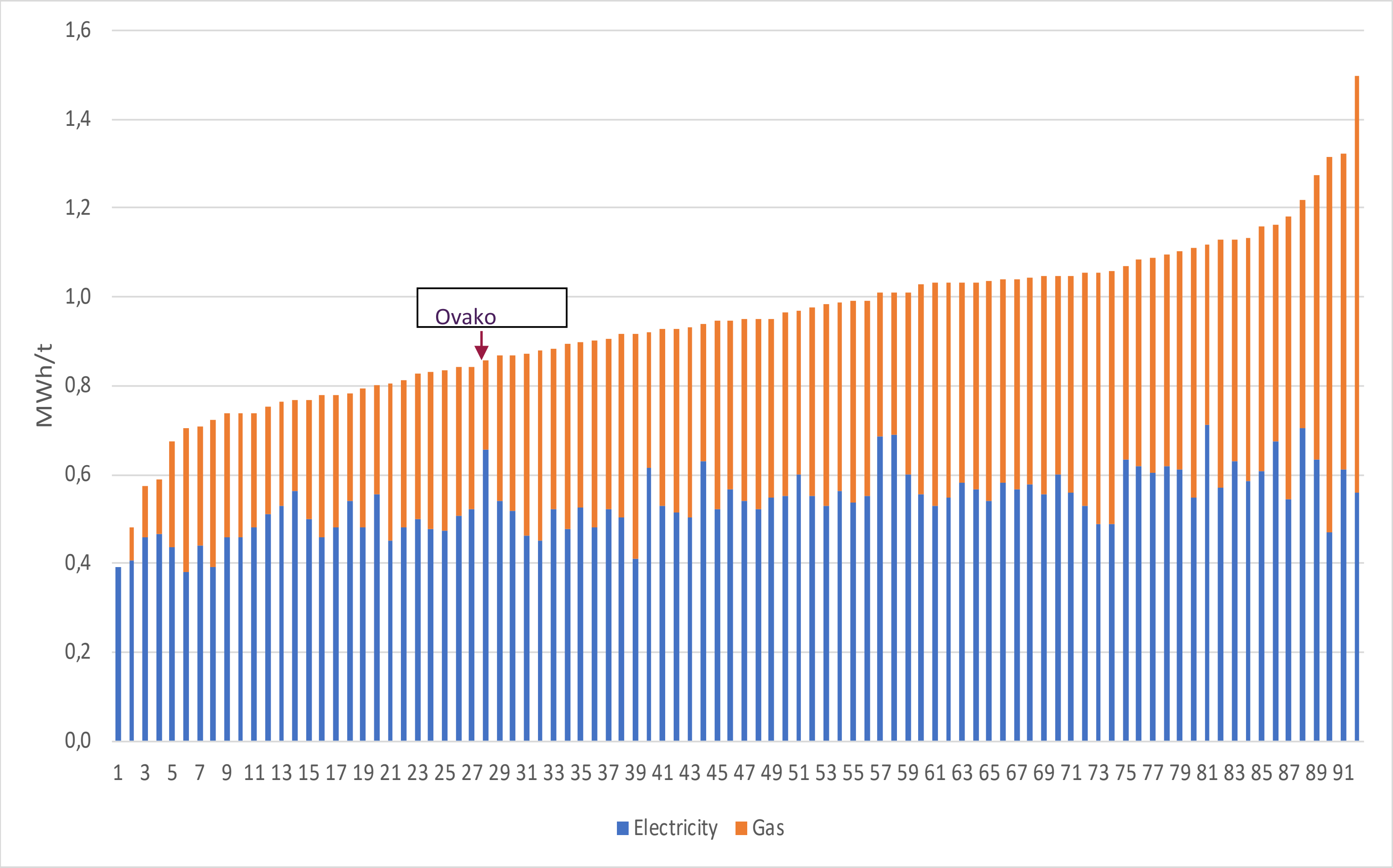
Specific Consumption of Electric Steel Production in 2018



Steel melting shops can be composed of different sub-processes making comparisons difficult. Ovako's rank is affected, e.g., by the relatively small charge size in the EAF.

Note 1: 16 high-end producers removed due to readability.

Note 2: System boundary is set at the production of **crude steel** i.e., thermomechanical processing (e.g., rolling) is excluded. Outsourced on-site sub-processes are included.

Sources: Wood MacKenzie and Ovako

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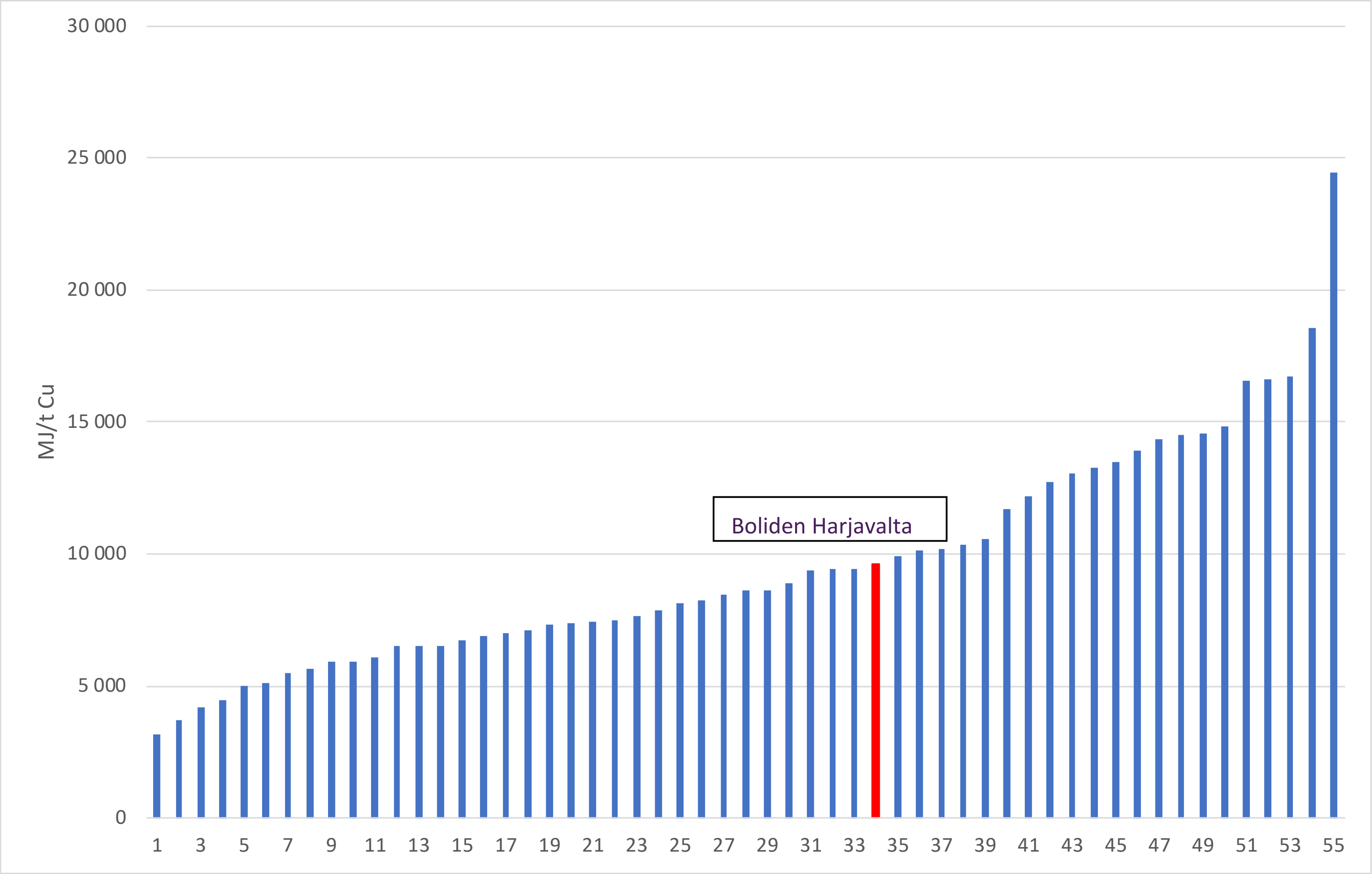
Specific Consumption of Copper Production in 2018

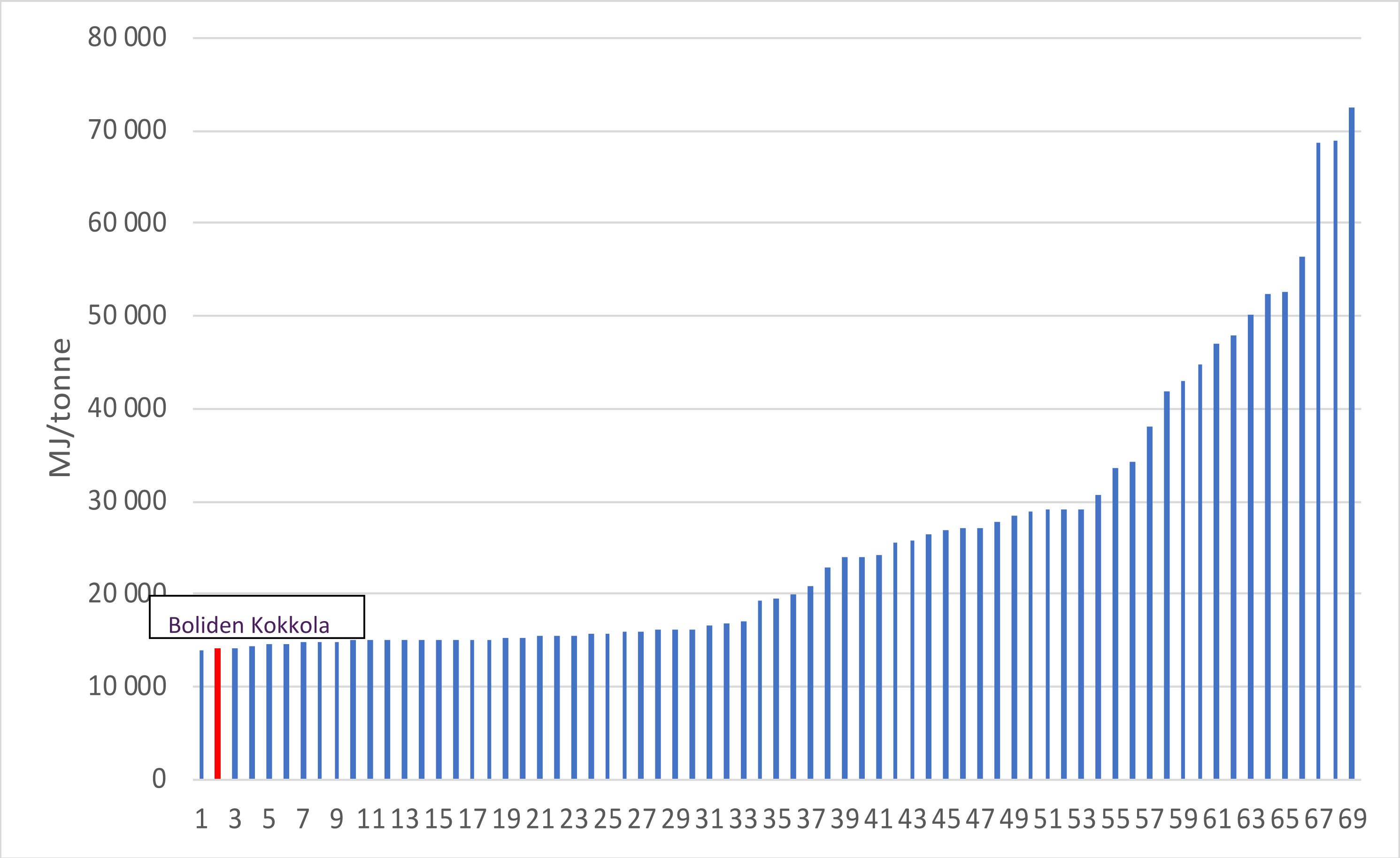


The figure does not take into account heat sales from Boliden Harjavalta. Taking heat sales into account would reduce Boliden's specific consumption by over 60%.

Factors affecting ranking of plants are use of recycled copper, difficulties in allocating energy consumption in multi-metal plants, and possible inclusion or exclusion of exothermic energy or electrolysis.

Source: Wood MacKenzie

Specific Consumption of Zinc Production in 2018



The figure does not take into account Boliden Kokkola's heat sales. Taking heat sales into account would reduce Boliden's specific consumption by over 20%.

Source: Wood MacKenzie

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Interviews

Interview Topics

- Which sub-processes are most significant in terms of energy consumption?
- Which factors have an important impact on energy efficiency?
- What is the overall energy efficiency level of your company compared to competitors?
- Which factors can make comparison of countries or companies difficult regarding this metal?
  - E.g., what are the company-specific or country-specific features regarding energy use or energy efficiency?

Interview Highlights – Common Findings

- A lot of attention has been payed on heat recovery. Recovered heat is used in the plant or sold to other users which is possible due to the location close to other industries and local towns using district heat. Some additional heat sales could take place if there was more demand for heat.
- Interviewed metals producers have actively implemented energy efficiency measures but the attention today is more on GHG reduction by different means along with other sustainability goals such as efficient use of raw materials.

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SSAB (iron ore based steel making in Raahe)

- No own sintering process since 2012; own sintering would add at least 10% to the final energy consumption
- The SSAB plant in Finland, like most European steel plants, is relatively old but continuous investments have been made to modernization.
- Blast furnaces have been among the five most efficient ones in Europe but small charge size reduces energy efficiency
- Dry quenching is an energy saving sub-process - a Finnish invention - allowing the production of ultra-high strength steel products with high elongation directly from hot rolling without cooling between process steps.
- SSAB will replace use of coke in steel production by carbon-neutral electricity and hydrogen based HYBRIT process in the Raahe plant by 2029.
- Sells 200 GWh/a district heat and steam.

Ovako (recycled steel based steel making in Imatra)

- The combinations of different sub-processes in melting and secondary metallurgical processing among EAF producers vary quite a lot making comparisons of different steel plants quite challenging.
- Ovako is not bulk producer but producer of specialized products for demanding uses.
- Factors reducing energy efficiency are small EAF charge size and huge number of end-products.
- In rolling the heavy bar mill is extremely efficient because of direct charging at hot temperature (BAT level technology).

Outokumpu (ferrochrome and stainless steel production in Tornio)

- Unique integrate with no benchmarks globally. Molten ferrochrome is fed to the steel melt shops which significantly reduces energy consumption.
- The integrate is largest single electricity user in Finland.
- The RAP line (rolling, annealing and pickling) is state of the art enabling a more integrated rolling process and larger production series.
- Outokumpu is implementing a digitalization project which, among other benefits, helps to optimize energy consumption.
- Sells about 360 GWh/a carbon monoxide from ferrochrome production to a power plant and lime producer and sells about heat 25 GWh/a. 100 GWh/a recovered heat from rolling is fed to area heat network withing the integrate. Only minor additional heat recovery potential exists in the utilization of side-streams.

Boliden (copper and nickel production in Harjavalta)

- Calculation of specific consumption of different metals is very complicated in a multi-metal factory.
- The plant is relatively old but sub-processes have been subject to continuous renovations.
  - E.g., the electrolysis started using acid-proof steel sheets (permanent cathode) instead of starting sheets made of copper in 2007, which alone reduced electricity consumption by 20%.
- The exothermic flash smelting process releases more energy than it consumes oil.
- Annual heat sales are about 330 GWh to a near-by industrial park and for district heat.

Boliden (zinc production in Kokkola)

- The sulphur dioxide produced in the roasting process is captured in a sulfuric acid plant in an exothermic process, i.e. excess heat is produced. Sales of steam and district heat are about 380 GWh per year.
- In electrolysis, energy efficiency depends on the size of electrodes which reduces the electric current density (A/m2) and consequently energy consumption. Kokkola plant uses relatively high current density to maximize the production volumes.
- Using of recycled zinc does not necessarily reduce energy consumption because it is oxidized requiring reduction where coal is needed.

Recommendations

Recommendations

Country comparisons based on aggregated data should not be made at all because with the data available the information value is zero.

- For example, data on steel produced with the oxygen and electric production routes should not be summed up at the national level and never mixed with stainless steel or ferrochrome production.
- Country data (e.g. Odyssee data) is best at monitoring development within one country.

More transparency towards uncertainties is needed in any analysis.

Production of metals (e.g. crude steel) should be distinguished from the production of metal products in analyses.

Given the importance of waste heat recovery in energy policy, this should be made more visible in analyses, reporting and statistics.

More attention should be paid to multiple benefits (e.g. GHG emissions, use of raw materials and waste reduction) to understand the wider sustainability implications, not just energy efficiency.

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Thank you!

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