

ANNEX

Atlas of Energy Efficiency Brazil | 2019

Indicators Report



Empresa de Pesquisa Energética

International
Benchmarking
chapter by



International
Energy Agency

Energy Efficiency Benchmarking and Indicators

Explanatory Notes (Anexo)

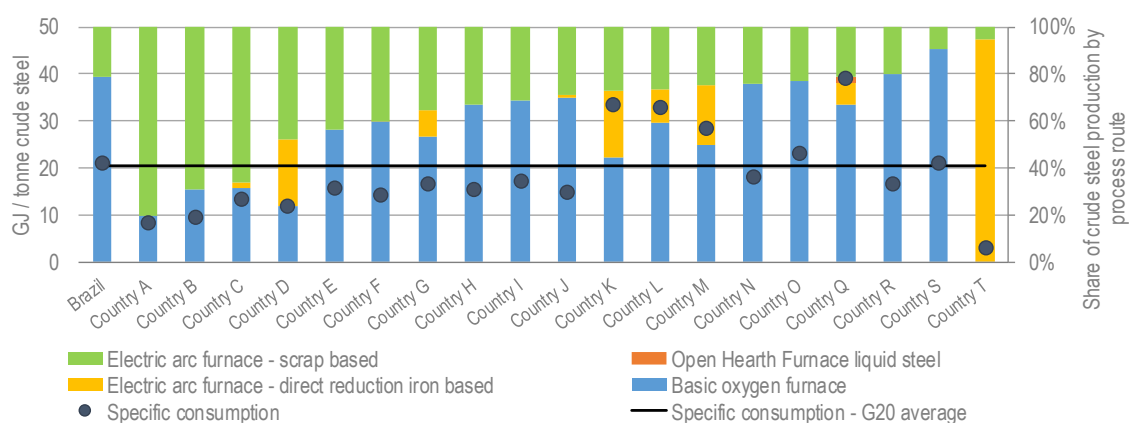
The current work on energy efficiency indicators and benchmarking carried out by the IEA was initiated under the request from Japan's Ministry of Energy Trade and Industry (METI) under G20 presidency of Japan in 2019. This work was then pushed further and served as basis for the IEA's collaboration with EPE.

This document complements the chapter on benchmarking for industry. It provides the following information for each industrial sub-sector's indicators analysed:

- Methods and boundaries
- Data sources
- Reference year of most recently available data
- Considerations when comparing countries and regions
- Data limitations

Iron and Steel

Specific consumption Indicator: specific energy use per tonne per of crude steel and share of crude steel production by process route in 2017



Methods and boundaries:

Reported aggregated specific consumption is calculated by dividing the final energy demand related to iron and steel, blast furnaces and coke ovens as reported in the IEA Energy Balances by total production of crude steel as reported in Table 1 of the Worldsteel Steel Statistical Yearbook 2018.

Final energy demand includes the following categories from the IEA Energy Balances: 1) iron and steel, 2) blast furnaces, and 3) coke ovens. These categories are defined as follows (as per World Energy Balances 2019 Edition: Database documentation, http://wds.iea.org/wds/pdf/WORLDBAL_Documentation.pdf):

1) Iron and steel: ISIC Rev. 4 Group 241 and Class 2431.

As defined by the UN International Standard Industrial Classification of All Economic Activities, Rev. 4

(https://unstats.un.org/unsd/publication/seriesm/seriesm_4rev4e.pdf) [Extracts]:

Group 241 = Manufacture of basic iron and steel:

This class includes operations of conversion by reduction of iron ore in blast furnaces and oxygen converters or of ferrous waste and scrap in electric arc furnaces or by direct reduction of iron ore without fusion to obtain crude steel which is smelted and refined in a ladle furnace and then poured and solidified in a continuous caster in order to produce semi-finished flat or long products, which are used, after reheating, in rolling, drawing and extruding operations to manufacture finished products such as plate, sheet, strip, bars, rods, wire, tubes, pipes and hollow profiles.

Group 2431 = Casting of iron and steel

This class includes the casting of iron and steel, i.e. the activities of iron and steel foundries.

*The full list of specific activities covered can be found in the ISIC guide referenced above.

- 2) Blast furnaces:** Includes the production of recovered gases (e.g. blast furnace gas and oxygen steel furnace gas). The production of pig-iron from iron ore in blast furnaces uses fuels for supporting the blast furnace charge and providing heat and carbon for the reduction of the iron ore. Accounting for the calorific content of the fuels entering the process is a complex matter as transformation (into blast furnace gas) and consumption (heat of combustion) occur simultaneously. Some carbon is also retained in the pig-iron; almost all of this reappears later in the oxygen steel furnace gas (or converter gas) when the pig-iron is converted to steel. In the 1992/ 1993 annual questionnaires, Member Countries were asked for the first time to report in transformation processes the quantities of all fuels (e.g. pulverised coal injection [PCI] coal, coke oven coke, natural gas and oil) entering blast furnaces and the quantity of blast furnace gas and oxygen steel furnace gas produced. The Secretariat then needed to split these inputs into the transformation and consumption components. The transformation component is shown in the row blast furnaces in the column appropriate for the fuel, and the consumption component is shown in the row iron and steel, in the column appropriate for the fuel. The Secretariat decided to assume a transformation efficiency such that the carbon input into the blast furnaces should equal the carbon output. This is roughly equivalent to assuming an energy transformation efficiency of 40%.

- 3) Coke ovens:** Includes the manufacture of coke and coke oven gas

The aggregated energy specific consumption related to the implementation and adequate operation of best available technology (BAT) is calculated for each country by applying the BAT

energy specific consumption for each process step within each process route to the share of production by process route in 2016 in that country. The BAT energy intensities have been compiled by the IEA from a variety of sources and reviewed by industry experts. The aggregated energy specific consumption considers the country's distribution of crude steel production by process routes (blast furnace [BF]-basic oxygen furnace [BOF], direct reduced iron [DRI]-based and scrap-based electric arc furnace [EAF]; the open hearth furnace share is divided between the BOF, DRI and EAF production categories given that it could likely be replaced). BAT energy specific consumption covers from iron ore preparation to the liquid steel stage, i.e. it does not include energy used in semi-finishing and finishing processes (e.g. casting and rolling), nor energy used by captive utilities. However, the reported aggregated energy specific consumption includes energy consumption related to captive thermal utilities when the steam output is used on-site and energy consumed in semi-finishing and finishing processes.

Share of crude steel production by process route is calculated by applying the distribution of plant capacity data by technology in a given country to the production in the same country as a proxy. In the case of the DRI-EAF route, a material loss of 5% is assumed when converting sponge iron to liquid steel.

Data Sources:*Aggregated Energy Specific consumption and Production*

Final energy demand from IEA World Energy Balances (2019),
<https://www.iea.org/statistics/balances/>

Crude steel production from Worldsteel Steel Statistical Yearbook (2018),
<https://www.worldsteel.org/steel-by-topic/statistics/steel-statistical-yearbook.html>

Reference year of most recently available data: 2017

Considerations when comparing countries and regions:

The aggregated energy specific consumption of steel production is highly dependent on the process routes used, with primary routes (BOF, DRI and OHF) consuming considerably more energy than secondary steel production through scrap-based EAF. Crude steel production in an electric arc furnace using scrap is 60% to 70% less energy-intensive than primary production. Regional limitations of significant scrap availability at a competitive cost, as well as differences in the quality of raw materials and energy prices are the main factors impacting on the distribution of production routes' shares by country.

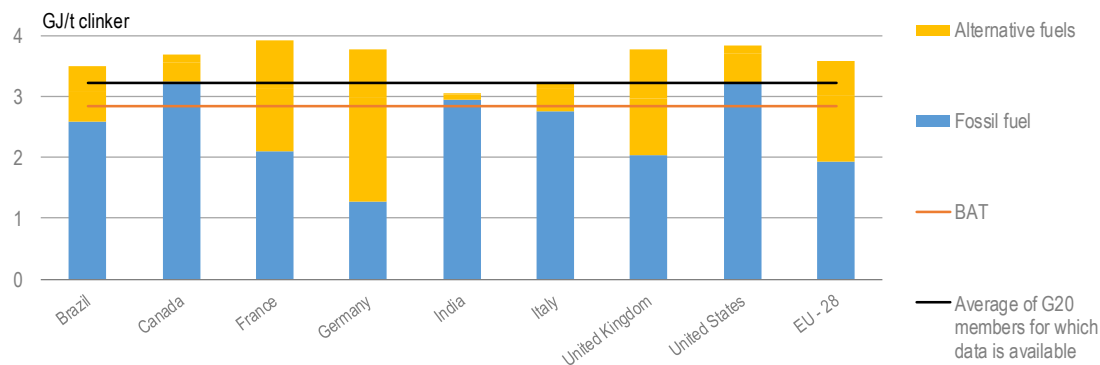
Data limitations:

Data on energy consumption by process route is not currently publically available. This data would enable direct regional comparison of the energy efficiency within each process route to identify areas for improvement at the process technology level.

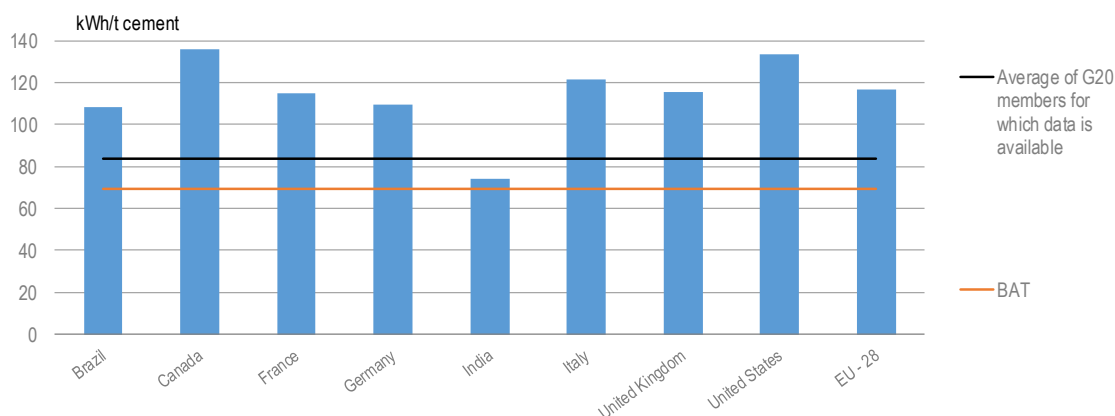
Improved country reporting would be needed to provide more accurate data on energy specific consumption in this sector.

Cement

Specific consumption Indicator: Final thermal energy use per tonne of clinker by fuel type in 2017



Specific consumption Indicator: Electricity use per tonne of cement in 2017



Methods and boundaries:

Both thermal energy specific consumption and electricity specific consumption are reported for the countries covered by the Cement Sustainability Initiative (CSI) Getting the Numbers Right (GNR) Emissions Report. Since not all countries are individually reported by CSI, regional data are also shown. Waste as displayed in the graph (in alternative fuels) includes both biogenic and non-biogenic wastes.

The reported data from CSI adheres to the CSI Cement CO₂ and Energy Protocol.

Thermal energy specific consumption of clinker production includes fuels (excluding electricity) used for raw material preparation (grinding, homogenizing, drying or slurring) and pyroprocessing of raw material in cement kilns (pre-heating, calcination, clinkering, and cooling).

Thermal energy consumption for clinker production excludes drying of fuels and is reported as category 25aAG in the CSI GNR. The proportion of each fuel category, reported as category

25aAGFC in the CSI GNR, is applied to the total thermal energy consumption to arrive at energy consumption by fuel type.

Electricity consumption of cement production includes electricity used for raw material preparation, clinker pyroprocessing, and grinding and blending clinker with other mineral components to make cement.

Electricity use for cement production correspond to category 33AGW of the CSI GNR.

BAT energy specific consumption are based on information reported by experts in several studies, noted below.

Data Sources:

Energy specific consumption (both thermal and electric)

Cement Sustainability Initiative (2018), Getting the Numbers Right Emissions Report 2017, <https://gccassociation.org/gnr/>

Production

United States Geological Survey (USGS) (2019). Mineral Commodity Summaries, Cement, <https://www.usgs.gov/centers/nmic/cement-statistics-and-information>

BAT energy specific consumption

European Cement Research Academy (ECRA) and CSI (2017), Development of State of the Art Techniques in Cement Manufacturing: Trying to Look Ahead, https://ecra-online.org/fileadmin/redaktion/files/pdf/CSI_ECRA_Technology_Papers_2017.pdf

WBCSD (2018), Low carbon technology roadmap for the Indian cement sector: Status review 2018

LBNL (2008), World best practice energy intensity values for selected industrial sectors.

Reference year of most recently available data: 2017

Considerations when comparing countries and regions:

Regional factors such as moisture content and burnability of raw materials, typical clinker composition and average capacity of cement plants affect the thermal specific consumption of clinker; additionally, thermal energy specific consumption typically increases with use alternative fuels, and clinker substitutes (such as blast furnace slag and calcined clay).

Regional factors such as product fineness requirements and the hardness of raw materials and fuels affect the electricity specific consumption of cement.

Due to the variability of these local factors, the energy intensities shown for aggregated regions may not accurately represent that the energy intensities of each individual countries.

Data limitations:

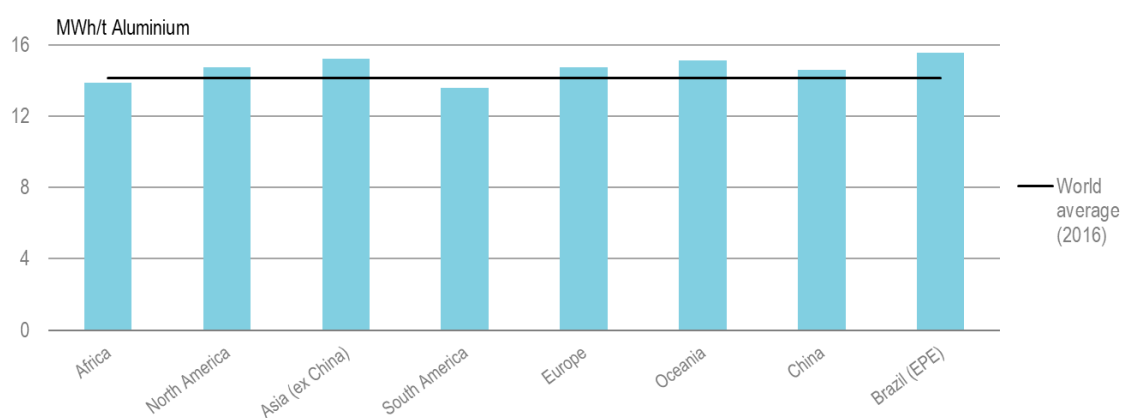
Data on thermal and electricity intensities is not available for all individual countries.

Additionally, the GNR covers only a proportion of cement producers in each country or region, as follows:

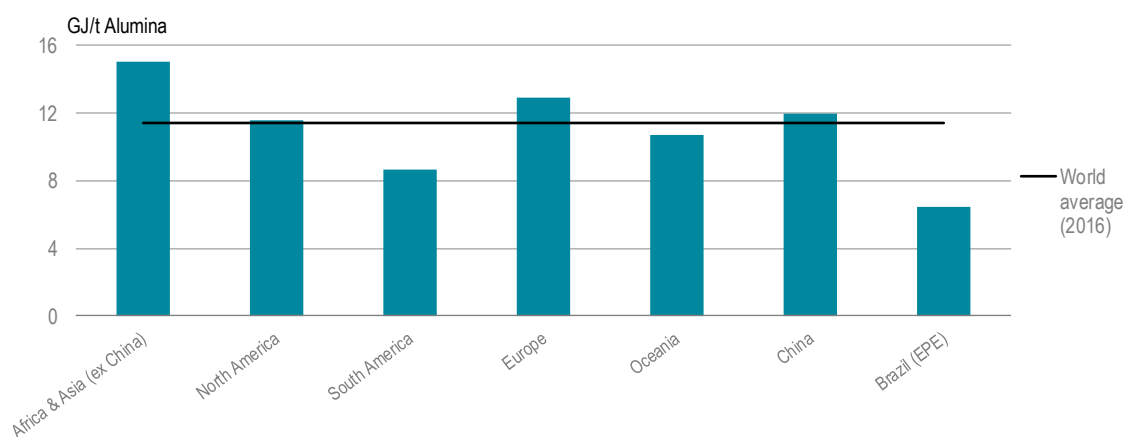
Region	Coverage in 2017
Brazil	68%
Canada	100%
France	100%
Germany	100%
India	53%
Italy	81%
United Kingdom	94%
United States	82%
EU - 28	90%
World	19%

Aluminium and Alumina

Specific consumption Indicator : Electricity use per tonne of primary aluminium in 2016



Specific consumption Indicator : Energy use per tonne of alumina 2016



Methods and boundaries:

Electricity specific consumption refers to the electricity specific consumption for primary aluminium smelting reported by the International Aluminium Association (IAI). The energy specific consumption is the AC power used for electrolysis by the Hall-Héroult processes per tonne of aluminium production. As defined by IAI: “The AC value refers to the power consumed by facilities for the smelting process including rectification from AC to DC and normal smelter auxiliaries (including pollution control equipment) up to the point where the liquid aluminium is tapped from the pots. It excludes power used in casting and carbon plants.”

Energy specific consumption for alumina refers to energy for alumina production reported by the International Aluminium Association (IAI). It is the energy consumed within the plant perimeter by bauxite refining processes (including calcination) and by those auxiliary operations on site which are directly connected with the total production process per tonne of alumina produced. It comprises the energy used by plants which produce an average of 90% or more of their total output as metallurgical grade alumina, and the energy associated with the production of metallurgical alumina at other plants where it is possible to allocate energy consumption. Plants producing metallurgical alumina from nepheline ores or other non-bauxitic sources (e.g. fly ash), which globally contribute less than 1% of production, are excluded due to processual and by-product differences and thus incomparability of energy intensities.

Regional data is shown, as country-specific data is not available (except for Brazil). Regional definitions are as follows. Further, IAI states that, “The data included in this IAI Statistical Report have been derived from voluntary reports of IAI Member and non-Member companies. Sources outside the industry or estimates are used for ‘World’ and ‘China’ regions only. ... An asterisk [below] indicates that smelter energy specific consumption data were not reported to the IAI by the company or companies producing primary aluminium solely within that country; these constitute the estimated part of the ‘World’ average, where data is available.”

- Africa: Cameroon, Egypt, Ghana, Mozambique, Nigeria, South Africa
- Asia (ex China): Azerbaijan*, India, Indonesia, Iran*, Japan, Kazakhstan, Malaysia*, North Korea*, Tadjikistan, Turkey
- China: China

- North America: Canada, United States of America
- South America: Argentina, Brazil, Venezuela
- Europe: Bosnia and Herzegovina*, Croatia*, France, Germany, Greece, Iceland, Italy, Montenegro, Netherlands, Norway, Poland*, Romania*, Russian Federation, Slovakia, Slovenia, Spain, Sweden, Ukraine, United Kingdom
- Oceania: Australia, New Zealand

BAT electricity specific consumption is that reported by IAI for China in 2015 (as the lowest reported operational value achieved). The value is slightly lower than the 13600 kWh/t found in LBNL (2008), World best practice energy specific consumption values for selected industrial sectors.

For Brazil energy production and energy use for alumina refining and primary aluminium smelting, data was provided by EPE.

Data Sources:

Electricity specific consumption for primary aluminium smelting and energy specific consumption for alumina refining

World Aluminium (2019), International Aluminium Association (IAI) Statistics, data issued 21 October 2019. <http://www.world-aluminium.org/statistics/>

Data for Brazil :

Empresa de Pesquisa Energética (EPE): Energy Research Office of Brazil – available for 2016

BAT energy specific consumption

World Aluminium (2018), International Aluminium Association (IAI) Statistics, data issued Nov. 20 2018. <http://www.world-aluminium.org/statistics/>

LBNL (2008), World best practice energy intensity values for selected industrial sectors

Production

For alumina : World Aluminium (2019), International Aluminium Association (IAI) Statistics, data issued 21 October 2019. <http://www.world-aluminium.org/statistics/>

For primary aluminium : United States Geological Survey (USGS) (2018). Mineral Commodity Summaries, Aluminium, <https://www.usgs.gov/centers/nmic/aluminum-statistics-and-information>

Reference year of most recently available data: 2016

Considerations when comparing countries and regions:

In addition to primary production, aluminium can be produced through secondary production using recovered aluminum scrap. Secondary production is much less energy intensive than primary production. However, secondary production is not considered in the regional energy specific consumption data shown here due to data limitations.

The regionally aggregated energy intensities shown may not accurately represent that the energy intensities of each individual country.

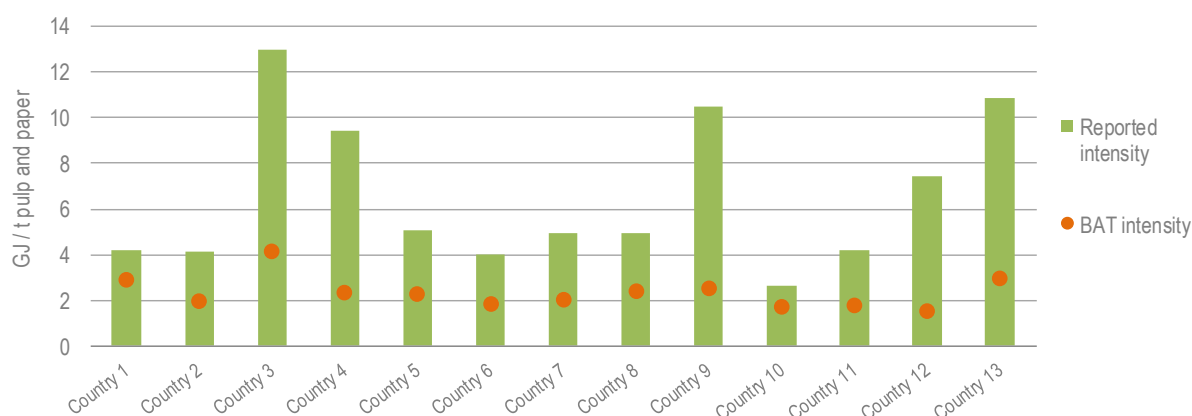
Data limitations:

Country-specific data on primary aluminium and alumina energy specific consumptions is not publically available. Furthermore, public data on the energy specific consumption of secondary aluminium production is not available.

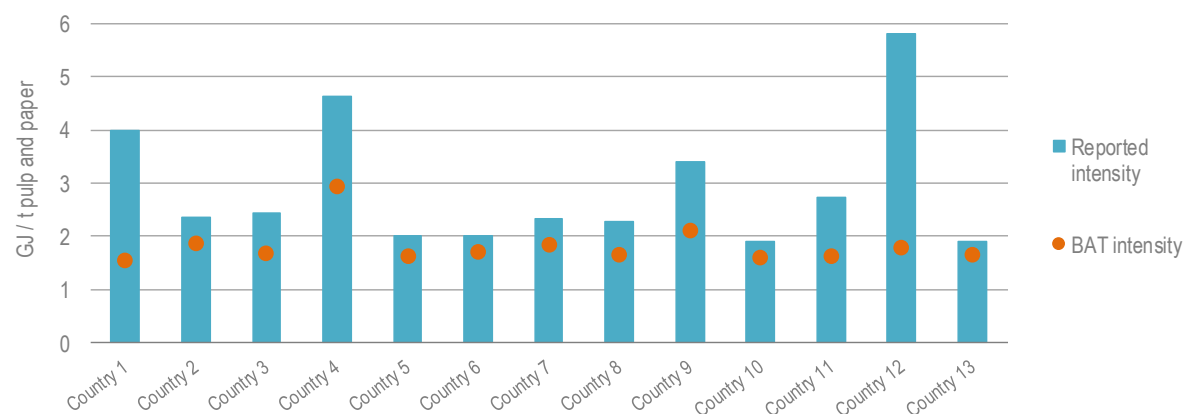
In the IEA Energy Balance, energy consumption for aluminium is reported by countries within the non-ferrous metals sub-sector. Given that aluminium energy consumption is not reported separately, it is not possible to calculate energy specific consumption of aluminium production using this data.

Pulp and Paper

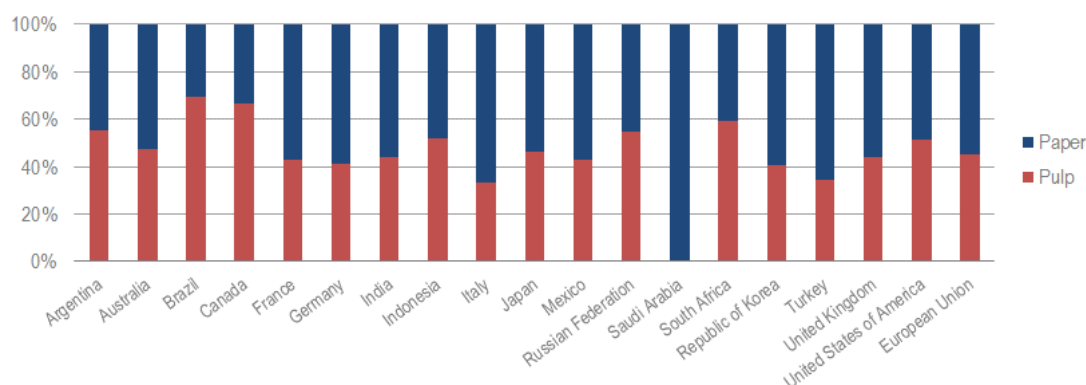
Specific consumption Indicator : Thermal energy use in pulp and paper production per tonne of pulp and paper in 2016



Specific consumption Indicator : Electricity use in pulp and paper production per tonne of pulp and paper in 2016



Production Graph: Shares of pulp and paper production in different countries in 2016



Methods and boundaries:

The reported thermal energy and electricity intensities are calculated as paper, pulp and printing energy consumption reported in the IEA World Energy Balances divided by total production of pulp and paper as reported by UN FAO, supplemented by RISI data. Many countries appear to have energy data reporting problems for the pulp and paper sector, particularly smaller producers. As such, only a selection of countries are shown, whose data appears to be more robust.

Reported energy specific consumption includes the following category of energy consumption from the IEA Energy Balances: paper, pulp and print. This category is defined as follows (as per World Energy Balances 2019 Edition:

Database documentation, http://wds.iea.org/wds/pdf/WORLDBAL_Documentation.pdf):

Paper, pulp and print: ISIC Rev. 4 Divisions 17 and 18.

As defined by the UN International Standard Industrial Classification of All Economic Activities, Rev. 4

(https://unstats.un.org/unsd/publication/seriesm/seriesm_4rev4e.pdf) [Extracts]:

Division 17: Manufacturer of paper and paper products

This division includes the manufacture of pulp, paper and converted paper products. The manufacture of these products is grouped together because they constitute a series of vertically connected processes. More than one activity is often carried out in a single unit. There are essentially three activities: The manufacture of pulp involves separating the cellulose fibers from other impurities in wood or used paper. The manufacture of paper involves matting these fibers into a sheet. Converted paper products are made from paper and other materials by various cutting and shaping techniques, including coating and laminating activities. The paper articles may be printed (e.g. wallpaper, gift wrap etc.), as long as the printing of information is not the main purpose.

Division 18: Printing and reproduction of recorded media

This division includes printing of products, such as newspapers, books, periodicals, business forms, greeting cards, and other materials, and associated support activities, such as bookbinding, plate-making services, and data imaging. The support activities included here are an integral part of the printing industry, and a product (a printing plate, a bound book, or a computer disk or file) that is an integral part of the printing industry is almost always provided by these operations.

Processes used in printing include a variety of methods for transferring an image from a plate, screen, or computer file to a medium, such as paper, plastics, metal, textile articles, or wood. The most prominent of these methods entails the transfer of the image from a plate or screen to the medium through lithographic, gravure, screen or flexographic printing. Often a computer file is used to directly “drive” the printing mechanism to create the image or electrostatic and other types of equipment (digital or non-impact printing).

This division also includes the reproduction of recorded media, such as compact discs, video recordings, software on discs or tapes, records etc.

This division excludes publishing activities.

*The full list of specific activities covered can be found in the ISIC guide referenced above.

Paper production from FAO is the sum of the following categories:

- newsprint (item code 1671)
- Printing and writing papers, uncoated, mechanical (item code 1612)
- Printing and writing papers, uncoated, wood free (item code 1615)
- Printing and writing papers, coated (item code 1616)
- Household and sanitary papers (item code 1676)
- Case materials (item code 1617)
- Cartonboard (item code 1618)
- Wrapping papers (item code 1621)
- Other papers mainly for packaging (item code 1622)
- Other paper and paperboard n.e.s. (not elsewhere specified) (item code 1683)

Pulp production includes the following FAO categories:

- Mechanical wood pulp (item code 1654)
- Semi-chemical wood pulp (item code 1655)
- Chemical wood pulp, sulphate, unbleached (item code 1662)
- Chemical wood pulp, sulphate, bleached (item code 1663)
- Chemical wood pulp, sulphite, bleached (item code 1661)
- Dissolving wood pulp (item code 1667)
- Pulp from fibres other than wood (item code 1668)
- **Recovered fibre pulp: data on recycled pulp production is complemented with information from RISI.

The BAT energy specific consumption was calculated by applying BAT energy intensities (from a variety of sources compiled by IEA) for each type of pulping process and each type of paper production to current production levels in the country, adding the resulting energy consumption to achieve a BAT-based total sector energy consumption, then dividing this by total production of pulp and paper.

Data Sources:

Energy specific consumption and production

Final energy demand from IEA World Energy Balances (2019), <https://www.iea.org/statistics/balances/>

Pulp and paper production data from UN FAO (2016), FAOSTAT: Forest Production and Trade, <http://www.fao.org/faostat/en/#data/FO>

Data for recovered pulp production penetration complemented from RISI (2016) Paper mills asset database, <https://www.risiinfo.com/service/mill-data-costs/asset-database/>. (Proprietary purchased data).

BAT energy intensities

JRC (2015), Best Available Techniques (BAT) Reference Document for the Production of Pulp, Paper and Board - Industrial Emissions Directive 2010/75/EU

LBNL (2013), Analysis of Energy-Efficiency Opportunities for the Pulp and Paper Industry in China

Fleiter, et al. (2012), Benchmarking energy use in the paper industry: a benchmarking study on process unit level, Energy Efficiency 6, pp.49-63.

US EPA (2009), Energy Efficiency Improvement and Cost Saving Opportunities for the Pulp and Paper Industry: An Energy Star Guide for Energy and Plant Managers

NRCAN/Paprican (2008), Benchmarking Energy Use in Canadian Pulp and Paper Mills

LBNL (2008), World best practice energy intensity values for selected industrial sectors

TAPPI (2005), Pulp and Paper Industry Energy Best Practice Guidebook

Reference year of most recently available data: 2016

Considerations when comparing countries and regions:

In the absence of separate energy consumption data for pulp and paper, the indicator is difficult to compare across countries. Pulp production tends to be more energy intensive than paper production, which means that countries producing more pulp than paper will tend to have a higher energy specific consumption with the combined indicator. Additionally, there is considerable variability in the energy specific consumption of different pulping methods and of producing different types of paper.

Data limitations:

The lack of separate energy consumption for paper, pulp and printing is a considerable limitation for useful comparison of energy intensities, given the differing typical energy intensities of pulp and paper production, and that printing is a separate activity.

Additionally, energy intensities vary considerably according to the type of pulping used and the type of paper product produced. Ideally energy intensities would be compared for each pulping process and each type of paper product, rather than an aggregation of all pulp and all paper production.

It appears that many countries may be under-reporting energy consumption in this sector, given that their reported consumption was considerably lower than calculated BAT energy consumption. As such, only a selection of countries are shown in the comparison.